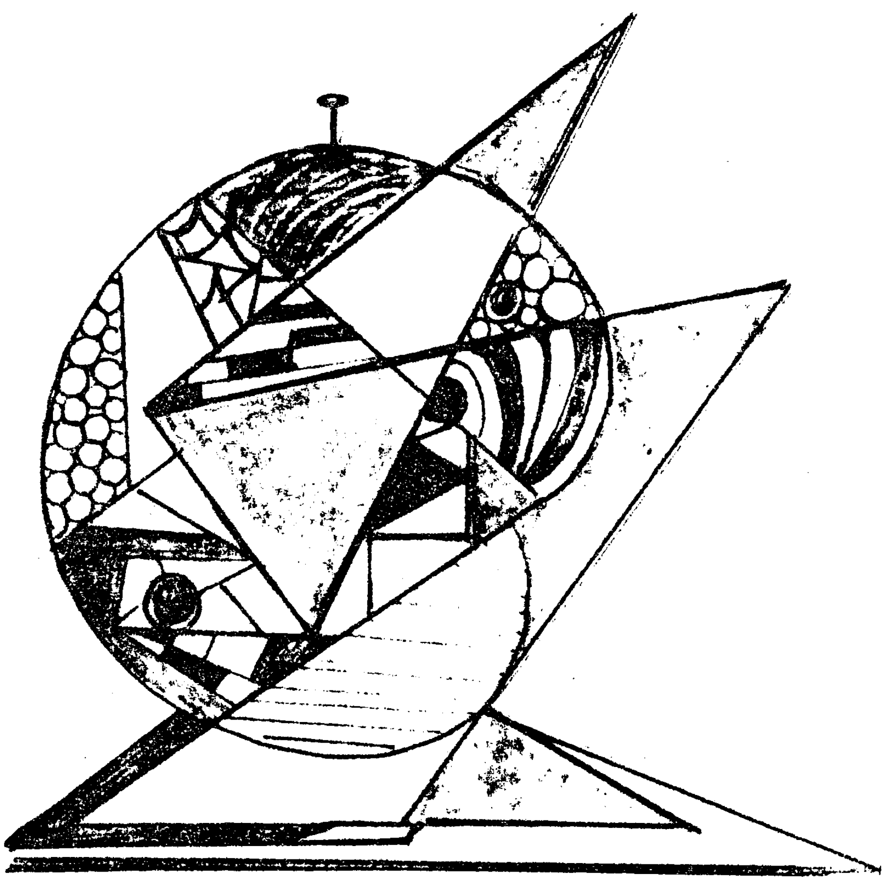
$0.25

THE AUSTRALIAN EEB

→ COMMONSENSE ELECTRONICS

FEBRUARY 1970 VOL. 6, No. 1 P. 1



-by Alice

CONTENT:

NEXT MONTH: (Late, as usual)

--A Nice HI-FI Amplifier System, I. (Essentially an introduction to a series on OTL Comp. Symm. Amps.)

--Power Supply Design, II. Simple.

--Transistor Ignition which uses the car's own coil. Vy convenient.

--SCR 2-period timer (if room).

-- And the Rest, as usual.

PHOTOPHONES FOR THE AMATEUR

-- M.J. Groth (VK5DZ)

More Modulated Light Communication*

History

The transmission of the human voice by means of a modulated light beam was first performed by Mr. C.A. Brown of London, in the year 1878. A paper was published by Alexander Graham Bell in 1881 describing his research in the field. The photophone is only two years younger than the telephone, invented by Bell in 1876.

The telephone has become universally accepted, and for the last fifty years has been the main form of vocal communication by electrical means; while the photophone has remained a scientific toy, used briefly by the German army in the world wars. This is understandable since photodetectors of reasonable sensitivity have been a product of solid state research. The advent of transistors, and semiconductor photodetectors has enabled photophones to be built which are comparable in size and power consumption to a telephone, and there has been a revival of interest in the photophone as a short range communications device.

Some time ago, I decided to conduct some experiments in the field of optical communications, and to construct a usable photophone myself. An appeal for information submitted to the VK5 Journal resulted in several replies, mainly from local amateurs. After examining the various forms of apparatus, and a lot of talking, I repeated several of their experiments myself and came to the conclusion that there was a lot of work to do in this field of communications.

Systems

I decided to use the red —infra red section of the spectrum, since most semiconductor detectors respond to the near infra red. This meant using incandescent globes as the source, and a phototransistor as the detector. Fluorescent tubes could be modulated to 30 Kc/s, but they had a stepped response to the supply voltage, and tended to exhibit negative resistance regions. They also generated a lot of noise and were difficult to focus. They generated most of their light in the blue —ultra violet region of the spectrum, and produced little response with a germanium photodetector. The photomultiplier was unsuitable since it amplified the ambient light, and saturated in very low levels of daylight. Photomultipliers are also hard to obtain at a reasonable price, and require 1000 volts supply.

Light Detectors

The first detector I tried was an OC71 without the paint. The detector was very noisy, though quite sensitive. The minimum detectable signal flux was 12 microwatts. An OCP70 wasn't much better. The sensitivity was high enough but the noise level was too high. However an OAP12 photodiode operating in a photovoltaic mode was slightly less sensitive but had a very low noise level. The minimum detectable signal flux was of the order of 10^{-10} Watts, using a six stage transistor amplifier. This detector can detect with a 3" lens, a Sodium vapour streetlamp at three miles. Light dependent resistors have a high sensitivity but their response time is too long, and they cannot respond above 150 c/s.

Light Sources

The main type of source used by the earlier experimenters was a 240 Volt 15 Watt light mounted in a car headlight reflector. Experiments with this type of source showed that it reproduced signals up to about 10 Kc/s, if some treble boost was used in the receiver. The globe was biased with 200 Volts DC. However the beam was very broad and the power

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* See also: "Modulated Light Communication," by K. Burlinson and R. Averay, EEB, August 1968, p.89. Other references at the end of this article (p. 21-2).

consumption was too heavy for a portable unit.

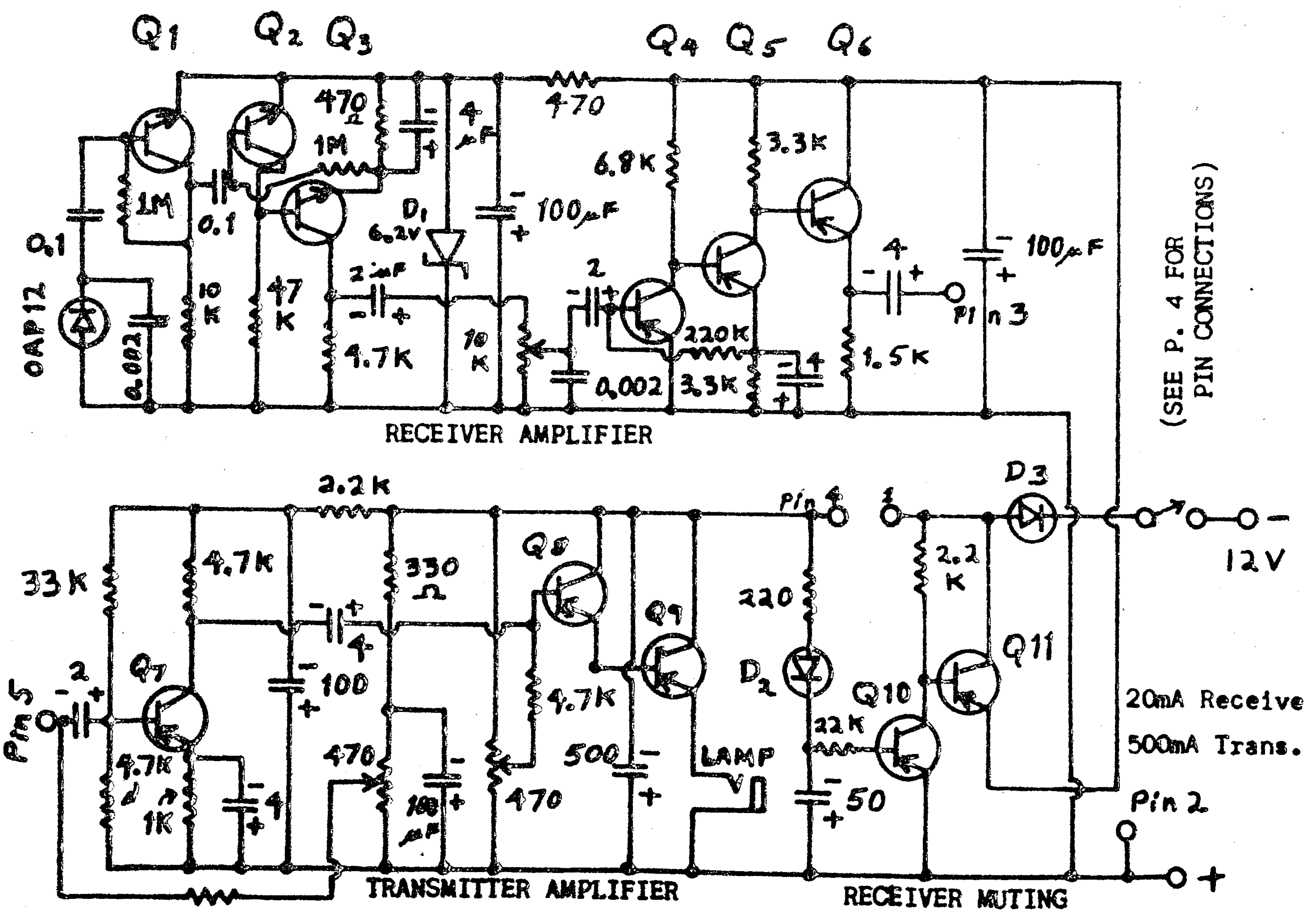
After experiments with several types of globe, I decided to use a 4.8 Volt prefocus torch globe in a three cell torch as the source. The frequency response was good enough for speech though not for music, but the light could be focussed into a very good beam, which gave a good signal strength at the other end. It was decided to use an OC26 (equivalent 2N250, etc.) as the modulator, the lamp acting as the load. The OC26 was used as an emitter follower in order to simplify the driving circuits.

Various electrochemical contrivances were made during the investigations, for the purpose of impressing modulation on a parallel beam of light, generated by a car headlamp in a projector housing. They all proved to be a failure, as I have no facilities to perform precision work.

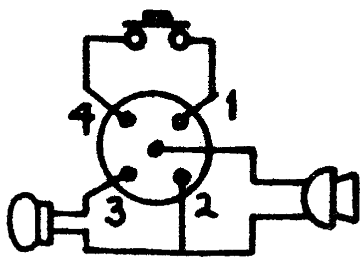
The Photophone

The short range photophone is a very simple unit in design, consisting of a photodiode, a low level audio amplifier, a modulator, and a cheap torch. None of the sections is at all critical, but the following points should be kept in mind, especially if you haven't built a very high gain amplifier before. The voltage gain of the receiver amplifier is about 10^9.

1) Build the amplifier in a straight line, using a printed circuit or matrix board. Use heavy guage wire for the supply rails, and plenty of decoupling capacitance.
2) Earth the positive supply rail at the output end only. If you earth it at both the output and input ends you will undoubtedly get current loops which cause instability.
3) Keep all output leads clear of the input, and use shielded cable to connect the photodiode to the amplifier. Try to mount the amp input as close as possible to the diode.
4) A metal box is not necessary if the amplifier is not too large, but do not omit the r.f. bypasses across the diode and the gain control.
5) When soldering components into circuit, don't overheat, particularly transistors.



CIRCUIT OF THE VK5DZ PHOTOPHONE



WIRING OF MODIFIED TELEPHONE HANDSET

Q1,Q2,Q3: BC108 or similar. Low noise types only, silicon.
Q4,Q5,Q6: OC44N or similar low noise medium gain, germanium.
Q7,Q8,Q10,Q11: OC44, OC70, 033, or any general purpose type.
Q9: OC26, AD139, AD140, AD149, 2N250, 2N301, or any 3-5Amp Pwr.
D1: Any 6 to 9 volt Zener diode.
D2: OA91 or any low power diode.
D3: Any silicon diode of PIV 24V + & 500 ma forward current.

The receiver muting switching system is designed to have a fast attack and a slow decay. The transistors can be any PNP out of the junk box. I used an OC45 for Q10 and an old OC72 for Q11. The system is necessary since the voltage flucatuations from the power transistor will cause the unit to motorboat.

The Optical System

The actual box containing the unit is governed by the lenses available. A 3" or 4" magnifying glass will make a good lens for the receiver. A focal length of 6" to 8" is desirable. Too short a focal length will reduce the interference rejection ability, and the rays will arrive at the detector in a cone of angle greater than that accepted by the diode. Too long a focal length on the other hand will make aiming too difficult and at close ranges the image of the lamp will be too large. It is desirable to make provisions for placing an opaque cover over the lens, when not in use, and a stop with a 1" aperture for use at short ranges. ((Ed. NOTE: Some mask around the edge of the lens might also be advisable for collimation if stray light is likely to be strong.))

Companion Unit

The other unit was constructed in a similar way, but using a 7" lens salvaged from a school rubbish pile. The increased size of the lens has only a small improvement on the performance of the unit, with a considerable increase in size and weight. The lens used in the small unit came from an old opaque-copy projector. The lens and housing are all from the one unit, and were made by Grubb brothers of Dublin in the year 1761. I think the grinder would rotate in his grave if he knew what they were being used for. The focussing wheel is not necessary, as the focus is constant for distances exceeding 50 feet. ((Keep your Photophone away from collectors of antique high quality lenses! ..RLG.))

Conclusions

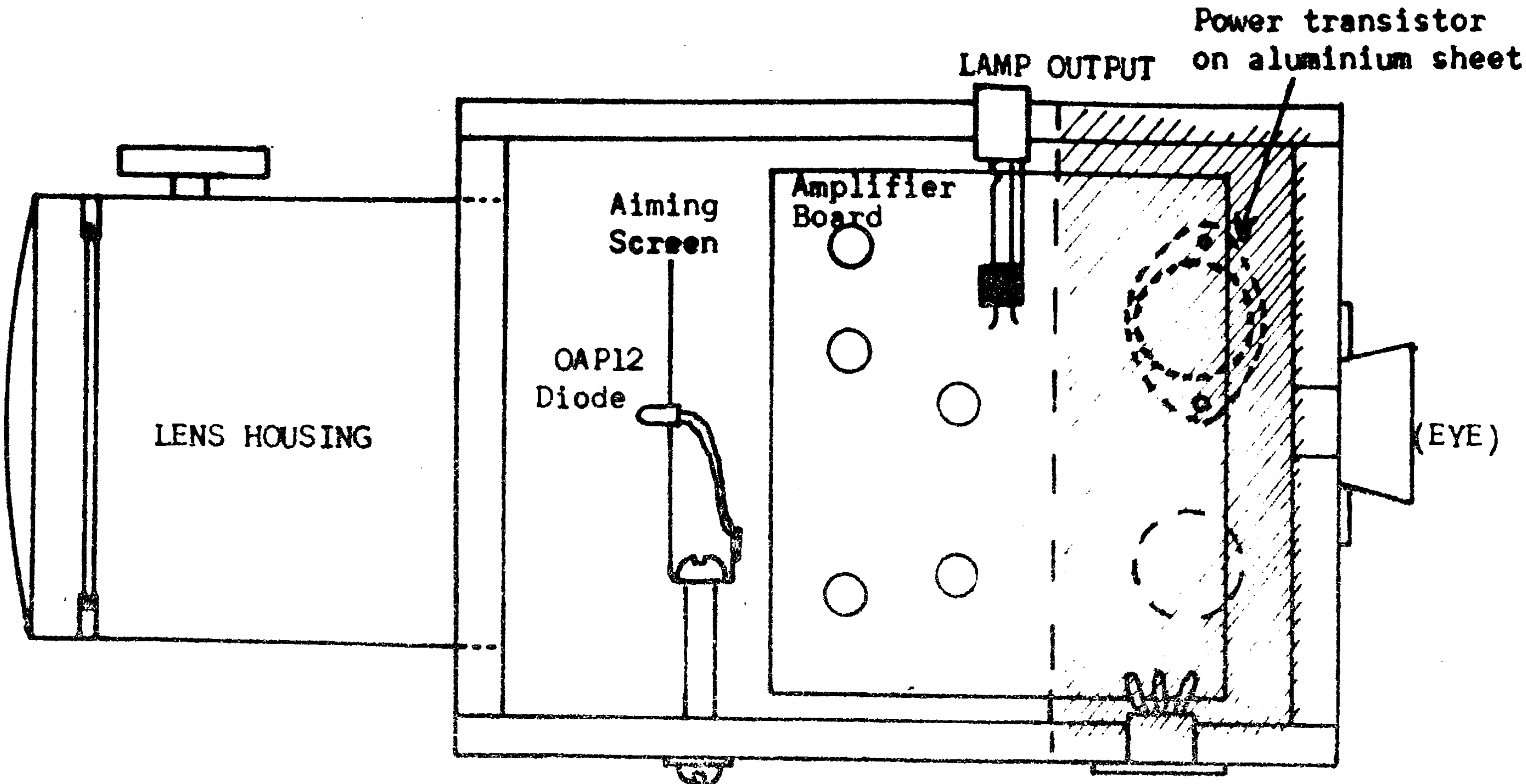
The only original thing about the unit is the aiming screen, which I feel is about the best way of doing it. The drawings are for a general guide only, as each constructor will wish to modify it to suit the lenses and amplifiers he has available. If the unit is mounted as shown, with the axis passing through the centre of gravity, then the device will point in whatever direction that it is set. A certain amount of friction is desirable. See P.5

The photophones work equally well in daylight as at night, since the amplifier only responds to the fluctuations in light intensity. AT ALL COSTS DON'T LET THE SUN SHINE DOWN THE LENS, OR YOU WILL HAVE A COOKED DIODE.

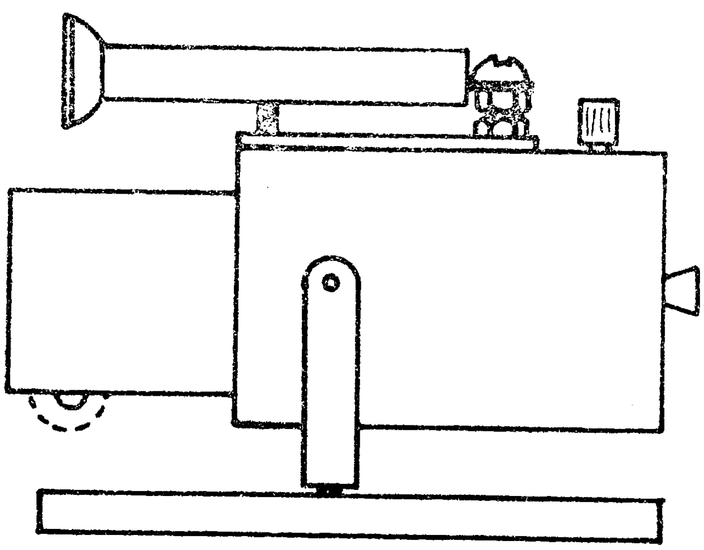
This unit is very crude and the transmitter is very inefficient, however it is the simplest to construct and use, for a short range unit. The unit will run for ages on a set of 8 torch cells, as the receiver draws only 25 ma, and the transmitter about 500 ma. The range of my pair is in excess of 1000 yards, however they work well for ranges of 100 yards up. For shorter ranges the lens needs to be stopped down, to reduce overloading of the preamplifier.

Physical Layout drawings are shown on P. 5, and **References** continued on P. 21.

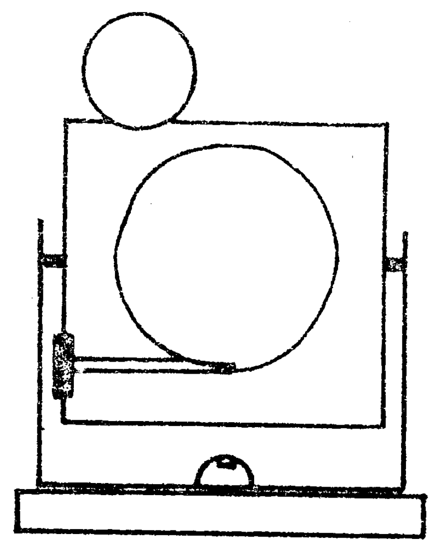
SKETCH OF THE PHYSICAL LAYOUT USED IN ONE UNIT:



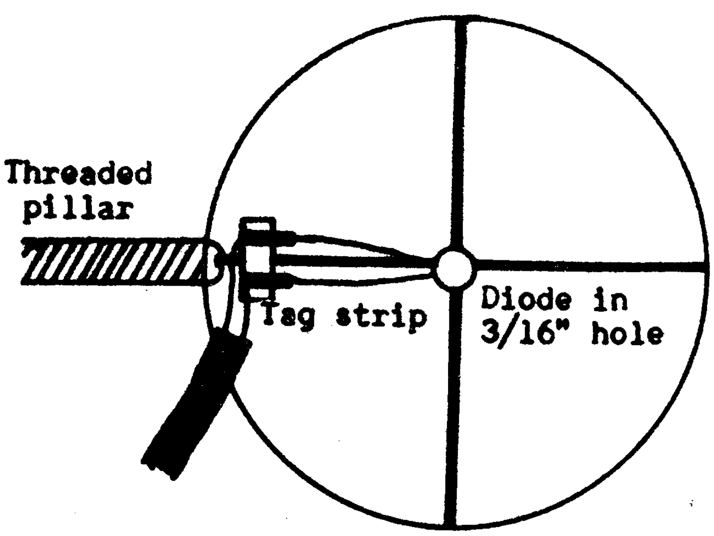
TOP VIEW (36% of actual size)



SIDE VIEW (18% of actual size)



FRONT VIEW



At left:
AIMING SCREEN
(plastic typewriter ribbon case with bottom roughened with steel wool)

(70% actual size)

((EEB Ed. Note: The odd proportions of actual dimensions come from the fact that the author's drawings were reasonable fractions of scale, but here we have reduced them by about 30%))

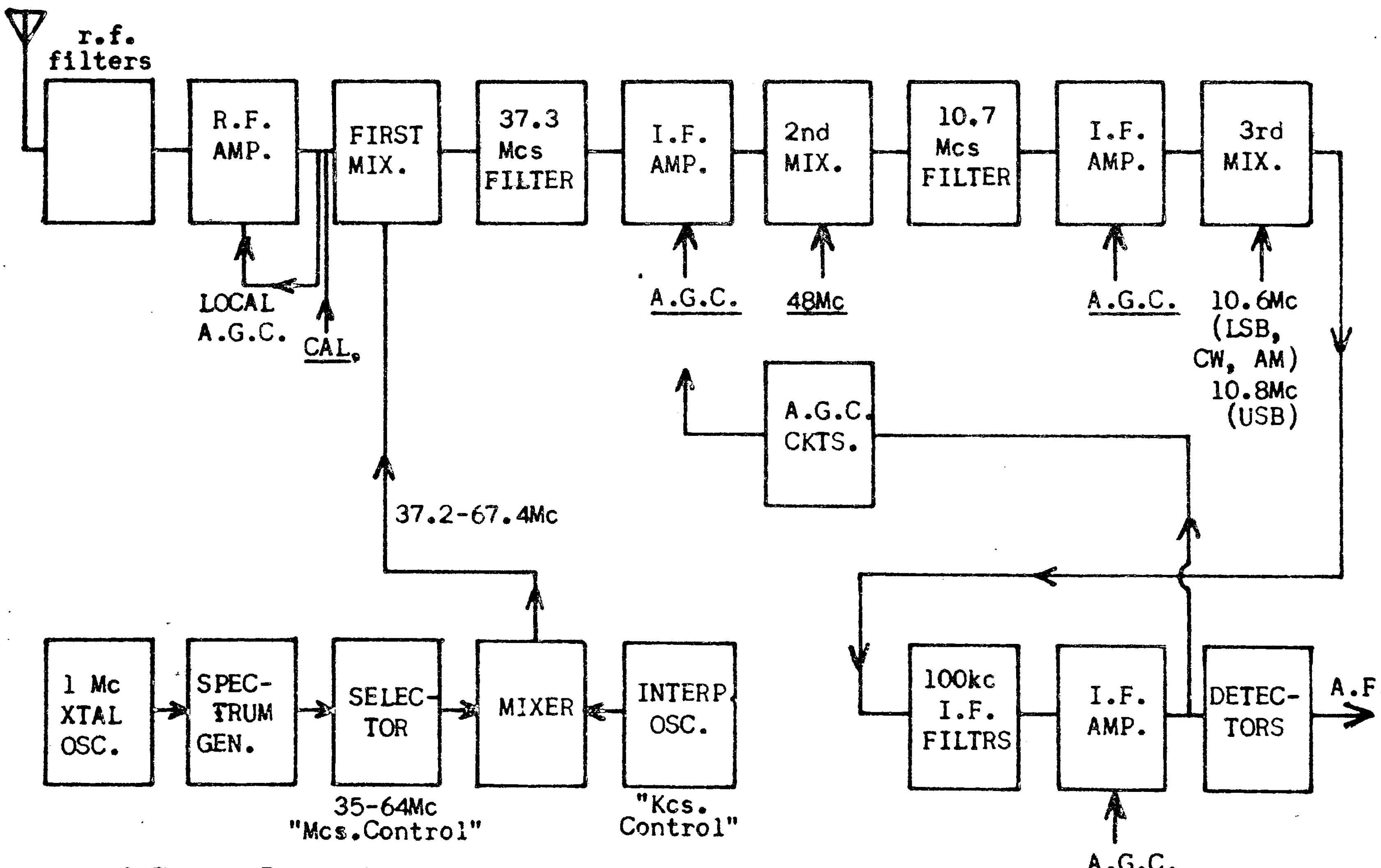
FURTHER NOTES ON HIGH QUALITY RECEIVER DESIGN

K.A. Harding (VK2)

Your series on receiver front-end design is very interesting. Part 6 in the April 1969 issue, together with Rick Matthews' article "Simulated dual-gate F.E.T." are of special interest in this "solid-state" age. (The April issue discussed the "Hydrus" Receiver)

The Plessey PR155

Some two or three years ago Plessey Electronics released the all solid state model PR155 communications receiver. In November 1966, "Electronics Australia" published a brief review of the RX adapted from an article in "Electronics Weekly" issue No.294. Whilst it hasn't been possible for me to get a copy of this English publication, I did manage to get a brochure from Plessey. The receiver is a jolly complex piece of equipment, allegedly containing some 160 semi-conductors. No circuit details are available, but a block diagram may help:



Principal Circuit Properties

The following brief details may be of interest:

1) Continuous coverage -60 kc to 30.1 Mcs in 1 Mcs "bands".
2) Triple conversion - The 3 IF Frequencies (37.3 Mc, to 10.7 Mc, and 100 kc) are all fixed and protected by selective filters. The first I. F. filter has 12 kcs bandpass. (The mixers incidentally are balanced 4 diode arrangements.)
3) "Band-switching" via a stabilised master oscillator phase-locked to the harmonics of a 1 Mcs crystal controlled oscillator. "Kilocycle" tuning is via the interpolation oscillator covering 2.3 - 3.3 kc. This latter oscillator is a linear, permeability-tuned device.
4) There are 8 sub-octave bandpass filters ahead of the R.F. amplifier -They are automatically selected by the "Megacycle control".
5) A wide-band R.F. amplifier has its own local A.G.C. This is claimed to allow the stage to handle 1 Volt R.M.S. whilst limiting output into the first mixer to a level compatible with

good cross-modulation and intermodulation performance. (Herein may be a clue for all prospective designs.)

6) Plug-in shielded modular construction throughout - modules are inter-connected by co-ax cable. (An interior photograph of the RX looked like the beginnings of a rats-nest!)

7) 2nd and 3rd mixer conversion signals, and the 100 kc injection signal to the product detector are derived from the 1 Mc reference oscillator via multipliers and dividers.

Performance

Here are some performance figures quoted by the manufacturers:

1) Frequency stability: long term better than 30 cps, short term better than 5 cps/hour } at constant ambient temperature

2) Sensitivity: typical performance at 15 Mc:
   S.S.B.: with 3 kc filter -carrier on / carrier off ratio greater than 20 dB for 1 µV.
   C.W.: with 300 cps filter - carrier on / carrier off ratio greater than 26 dB for 1 µV.
   High impedance input A.M. with 6 kc filter 4 µV for 10 dB S+N/N ratio.

3) Noise factor: typically 9 dB 200 kc - 30 Mc.

4) A.G.C.: entirely automatic control within 4 dB for approximately 120 dB change in input level.

5) R.F. input: 75 ohm or high impedance unbalanced. Can accept up to 6 V input without damage!

6) Spurious response to external signal: better than 60 dB down for signals less than 200 kc off tune. Better than 100 dB down for signals more than 200 kc off tune.

7) I.F. rejection: better than 70 dB.

8) Image rejection: better than 80 dB.

9) Internally generated spurious signals: below receiver noise over range 400 kc - 30.1 Mc except at 1 Mc and 21.4 Mc.

10) Blocking: typical performance is with RX tuned to any frequency, 3 kc bandwidth, wanted signal lmV 30% modulated, unwanted signal 10 kc removed at 100mV; then reduction in wanted output is not more than 2 dB.

11) Cross modulation: negligible, with conditions as for blocking.

Conclusions

Obviously this RX is a complicated way of getting very good performance, but I think that the principles and techniques involved may be of interest in showing what at least one manufacturer is doing.

The combination of:

(a) R.F. bandpass filters,
(b) special local A.G.C. on the R.F. amplifier,
(c) narrow pass filters following the 1st and 2nd mixers,
(d) the high first I.F.

appear to be the key factors for the "front-end".

Derivation of conversion signals for the mixers and the product detector from the stable 1 Mcs reference oscillator very neatly gives accurate wide-band switching and carrier re-insertion. (This would please the S.S.B. gang!) At the same time this would overcome the problems of drift that would be inevitable with separate oscillators.

Variable Selectivity Crystal Bandpass Filter?

Now for a query. A friend told me that some 4 or 5 years ago "Amateur Radio" published details of a local amateur built RX that incorporated a variable selectivity crystal filter in the 2nd I.F. stage. Whilst he didn't have the circuit, he recalled that it was referred to as a "Telefunken" type filter.

It was apparently like two "H.R.O. type" single crystal filters, one before, and one after the first low-frequency I.F. amplifier. Phasing condensers set the maximum bandwidths, and variable selectivity was obtained by detuning the relevant I.F. coils. The valve, crystal

(continued on P.10)

REVIEW (by RLG): 73 Dipole and Long-Wire Antennas, by E.M. Noll, W3FQJ (Sams) ($4.50 in U.S.A., appreciably more in VK or ZL unless ordered directly*)

This is another book by the author of that very good one on FET's which we have mentioned several times here**. The price is steep for only 160 pages, but they are well packed with highly practical material, in some respects far more than in the Handbooks, and seems worth it, even though I deplore the increasing tendency toward higher prices from publishers. By the time books pass through the Middlemen in England and in Sydney, the prices become absurd.

Price notwithstanding, this book makes a worthwhile addition to the library of an experimenter, because it puts together in one cover a large amount of information of a practical sort, on construction of antennas. The author says:
"An often-heard comment of the present is: 'The days of amateurs building and operating their own equipment are a thing of the past.' To a great extent this is true, since the advent of sophisticated single-sideband equipment has convinced many hams that construction of their own gear is no longer practical."

I can't imagine a better argument against Sideband Technology and the Sideband Mentality it engenders. Fortunately, W3FQJ has set out to do something about it:
"The one big exception to this approach to amateur radio is in the field of antennas. The amateur, at very little expense ... can indulge in experimentation and building antennas sometimes with startling results.
"73 Dipole and Long-Wire Antennas is the first of a series of books which can make the hobby of amateur radio more than an operational spectator activity. Each antenna described in this book was constructed by the author, without assistance, and a minimum of tools and equipment was used. You can do the same, and use the world as your testing ground.
Many of the antennas described in this book compete with, and sometimes surpass, the performance of commercial beams. A number of new approaches in the construction of the basic long-wire antenna types are detailed ..."

The one criticism I might have about this book is the fact that in a number of the diagrams the coaxial cable is shown feeding the antenna directly; when a balun is used, it is ordinarily for purposes of impedance matching rather than balance. It seems evident, however, that most of this was for purposes of simplification of diagrams, since the author states that
"A balun ensures more favourable line conditions and less disturbance of the antenna radiation pattern, and helps in establishing a more favourable standing-wave ratio over a wider span of frequencies, as compared to the dipole-direct-to-coaxial-line method of connection." See also 'Antenna Dilemma' discussions in 1969 EEB's.

In the rear of the book are seven Appendices, covering a variety of useful instruments and techniques, for measuring velocity factor, resonance, radiation resistance, and some antenna tuners. Of particular interest is a brief description of the 'Antenna Noise Bridge', the most useful device since the Wheel. I have been particularly intrigued by it ever since I saw it described fully in QST (Dec. 1967), and have planned an eventual EEB article on it for Someday. Unfortunately, it was not practical to include full details for constructing the Noise Bridge, in this book, but I enthusiastically recommend it to you, as found in the abovementioned QST article, and in 73, March 1969.

Also relevant to the subject are the following interesting references:
"Some Thoughts on V-V Beams for 14 and 21Mc," by C. Whalley, VK6KK, AR, June 1968.
"The World with a Triangle," by W. Salmon, VK2SA, AR, October 1968, April 1967.

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* About $US4.57 including post, ordered from FAA Bookstore, Postal Station 18, Oklahoma City, Oklahoma, 73169, U.S.A. In VK, obtain U.S. dollars from any big bank.

** The book is 'FET Principles and Practice' and is also well worth getting. $US5.50 from same supplier.

"Antenna Theory in Practice," by R.H. Fransen, VE6TW, CQ, Sept. 1968 **(This is an absolute Must for anyone interested in Real Truth in Antenna Systems; he helps to explode the SWR-Myth, and if there are any people who still think that baluns are pointless, VE6TW will enlighten them fully.) (Like unto this:)**

"S.W.R. Indicators, Fact or Fiction," by VK2JR, AR, early 1968.

"Antenna Fact and Fiction," by D. Ehrhorn, K6CTV/4, 73, Dec. 1963.

"Antenna Feedpoint Investigation," by F. Johnson, ZL2AMJ, CQ, March 1968 (using an r.f. bridge and a Smith Chart, greatly improved antenna performance may be obtained by judicious cutting here and there, and maybe adding some reactance as appropriate.)

See also the June 1968 issue of Break In, and May 1969 issue of 73, both of which feature a number of antenna articles; the collection in 73 is particularly nice.

See also the most interesting antenna review article: **"A survey of high-frequency Amateur Antennas, with special emphasis on a new family of antennas.." by W2WLR, Ham Radio, 4/69, p28.**

CONTENTS of Noll's book comprise essentially: (Compressed here, for space)

I. REGULAR AND MODIFIED DIPOLE ANTENNAS

Half-Wavelength Dipole	Single and multiband dipoles for various bands.	Folded Dipole and balun
Line Tuned Dipole		Inverted Dipole
Dipole and Balun	Lamp-Cord Dipoles	Multiwavelength Dip., etc.

II. INVERTED-VEE ANTENNAS (Abbreviated here, 'IV')

Centre-fed Long Wire IV's	Multiband Lond Wire IV	Various bands, IV's
2-band End Tuned IV	All Band IV	W3EQJ Special All Band IV.

III. LONG-WIRE ANTENNAS

Centre-fed, End-fed, Multiband 'WAS Special', Random Wire/tuned, Resonant/random...

IV. VEE-BEAM ANTENNAS (this is my favourite) (Abbreviated here, 'V')

End-fed Inverted V	Multiband Conical V's	Multiband Short V
Multiband V's	Various Horizontal V's	Multiband Long V
Odd-wavelength V's	Tilted Short V	V and Inverted Dipole

V. LONG VEE-BEAM ANTENNAS (ah lovely, I have the room for these now)

Horizontal, Horizontal various bands, with Tuners, Sloping types.

VI. RHOMBIC ANTENNAS (I don't have THAT much room!)

Various bands, various wire arrangements, resonant, terminated, etc.

VII. VERY LONG LONG-WIRE ANTENNAS (Ed must certainly have patient neighbours)

Two-bands, End-Tuned, Multiwire type, Multiband with Tuner, Long-Path/Short-Path...

VIII. SPECIAL VEES AND RHOMBICS

160-M Two-Mast Inverted Vee	Two-Mast Vee Beam	Two-mast Rhombic (yes!)
10-160M End-Tuned Ditto	Multimast switchable Ditto	Short Squared Rhombic

APPENDICES:

- Antenna Noise Bridge.
- How to measure velocity factor of transmission line with an Antenna Noise Bridge.
- Cutting Half-wave sections of transmission line using the Antenna Noise Bridge.
- Cutting antenna to resonance with an SWR Meter ((Noise Bridge better? -- RLG))
- Construction of a line tuner.
- Antenna tuner for long-wire Vees and Rhombics.

Altogether: a practical and simply presented book which brings a number of conventional and some unconventional designs into one place, with practical comments. The book is fully illustrated, including numerous photos. We were going to reproduce one of them here, but this presents technical difficulties, and the item at the right is submitted for your consideration instead!

"The antenna here is rather unusual."

December, 1969 • CQ • 65

LETTERS: Antidisestablishmentarianism??

Keep up the good work, except in one respect. You are terribly cockeyed with regard to the A.R.R.L. I suppose its part of the current Uni students anti Establishment complex. But be objective. Take a critical look at QST and 73. There is more in the latter, but 90% is junk. The closest parallel I can think of is between Elliss' Psychology of Sea and the True Love magazine. And tell Mr. Ferris to try the 3N140 as per the Handbook. None of his horrible theoretical predictions seem to come true (EEB, Dec. 1969, P.137).

-- P.J. Kelley, Brisbane, Qld.

Mr. Ferris Replies:

Excepting the neutralising circuit which is unquestionably superfluous, sure ARRL's ckts will work, and probably still will if half the connections are reversed, and even if the whole front end is thrown away and replaced with a crystal set, it will still work. The important point is 'how well'. The literature published by those who are in a position to know, says that where cross modulation, intermodulation, and harmonic responses in 3N140/141 front-ends are concerned, the difference in performance between optimum and arbitrary operating points may be orders of magnitude. When it is remembered that even when at their best these FETs do not yet satisfy exacting modern requirements, any further deterioration in performance is serious.

Looking at things from another point of view, when their widespread influence is considered, ARRL have a tremendous responsibility to publish the best circuits, at least as alternatives. After all, they have very nearly achieved the first maxim of propaganda: to be accepted universally and followed blindly'. As there is as yet little alternative information about these new devices outside scientific circles, this was an outright mistake and most inadvisable ((Ed Note: Here I have toned Dick's youthful enthusiasm down a bit)).

EEB is not unduly biased against "The Radio Amateurs Handbook", nor are we suffering from chronic disestablishmentarianism; vis. the favourable reception given "The Radio Communication Handbook". What is true is that the "Amateurs Bible" is like an American car: glossy on the outside, but fragile when you kick it.

-- R.H. Ferris, Dynnyrne, Tas.

((Ed. Note: some of the new British cars aren't so hot either.... By the way, there is no such thing as an "EEB policy". There are only the opinions of the people who see print here. If someone has something to say, let him say it. If it is moderately technical I'll print it, even if I disagree with it. Of course there is a risk that one of us may comment on it, as above, but we all have fun there -- and you are of course free to contribute further details. In this case Mr. Kelley has replied with an interesting and good letter which need not be printed here. But we shall work up something later on the S.W.R.-meter query he poses.))

Receiver Design (continued from P.7)

and tuning condensers were tapped down the coils to varying degrees. A 4 gang differential condenser was used for the detuning. For each crystal, one gang tuned the input coil above resonance and the second gang tuned the output coil below resonance. As far as he could recall, the writer claimed that he had used this arrangement for I.F.s from about 150-1500Kcs.

Maybe one of your informed readers knows something of this system, and could shed further light on it. If it could be made to work satisfactorily at higher frequencies (e.g. 5 to 9Mcs) then this would be helpful in a single conversion RX, from A.M. to CW selectivity at the turn of a knob. At first sight the 4 gang differential condenser sounds formidable but two gangs would be easily coupled, and it shouldn't be too difficult suitably to couple 4 single gangs via pulleys and string or chain. This is easier than the filter calculation mathematics..

"Luminary: One who throws light upon a subjuct; as an editor by not writing about it." -- A. Bierce

EDITORIAL; RLG

Addenda to this Issue: (1) Page one: no doubt the chronometer theme has something to do with the long hours her CM spends on the Inside Pages;never mind, it will be better in future. (2) I think that D2 on P. 3 is backwards; muting wouldn't work the way it is shown. (3) Those roundish blobs on P. 18 are the letter "e"; sorry about that, better next month... (4) P. 21, 22: Jan 1970 issue of P.E. has full instructions for making holograms (3-dimensional photos!) from Laser. (5) Those prices on P. 22 are Trade, of course. We have not yet published characteristics of several photoemitters available here, because we are waiting for price information Hope to have in the April issue. (6) P. 23: Auto-Call is EDITED by KØNL, not Published. Ordinarily it would hardly matter, but it does in this instance, because of the curious nature of American "Ham" politics. All we are likely to reproduce from A-C will be humour, but there are lots of interesting politics discussed in its pages too, even some technology too.

The New EEB

All right, here is the New Improved EEB, sort-of. I don't think it will destroy the Old EEB, whatever that is. For example: a friend in America said there was no point in sending him EEB, "because there are already so many elaborate technical journals available here on request either free or at little cost." He obviously missed the point. We have no interest in competing with those free and elegant journals. Ours is merely a voice for experimenters in an uncluttered (?) informal commonsense-- sometimes -- format. I don't think that many of those elegant journals fill that pigeonhole.

Or: consider the Technical Review in Collector & Emitter recently, where W5JJ referred to our 1969 controversy about unbalanced antenna feeder saying "My personal opinion on the matter is that very few radio amateurs possess measuring equipment sufficiently accurate to detect any difference -- so why work up a royal sweat over it?" Our Asst. Ed., Rod Reynolds sez "Well, superficially Carl is correct, but again the point is missed. We can tolerate inefficiency, but not maloperation. If we don't aim for the right conditions, the errors will multiply alarmingly; we already have enough of them by accident without adding more. But in fact we are not talking to the modern amateur who tends, for the most part, to be an Appliance Operator. We are talking to the follower of the old tradition who invented all these things in the first place -- some of whom still exist in the world."

Well, there is more, including some pregnant points raised recently by "A", but it is all in much the same vein. EEB is a big ball of wax, and we refuse to worry about lumpy corners. For beautiful and effective mags, see the numerous publications abounding on the Newsstands.

As for our new format, I think the uplift is only skin-deep, but it was prompted by various problems with ancient machinery. The present arrangement will look nicer after we solve several problems. Except for the present issue in celebration, the word-number is comparable to the previous format, to keep costs down and readability up. (CONT. P.14)

((Postscript: Since this is being printed in March, Kitsets (obverse) offer no doubt extendd))

ADVERTISING

Personals: 5c per line, approximately.
Commercials: 10c per line or
40c per vertical inch.

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 (Editorial, continued; ah, much much easier to type it on this side!)

EEB will continue to be odd, maybe interesting, sometimes insulting, even useful -- but it will look better. On the other hand, I refuse to be a slave to a system for its own sake. For example we are printing this Editorial and the Adverts on the old blotter paper, and maybe will publish whole issues that way sometimes (in the new format), particularly if I happen to run out of money. EEB staggers on.

Problems

The December 1969 issue was also a Headache. It was too long, the typiste was unavailable, and Graham had to print each page as I typed it. Graham came in with a striken look on his face. I said "The electronic stencil ripped." No, he said, the paper was shredding. Greatly relieved I adjusted the ("automatic") machine. The coup de grace came the next day when I came in to do the addressing; I found a note: "Leo, this will make the day for you. I finished the last page and realised it was upside down....." None of which matters much, but it does explain why the last page of the December issue was upsidedown!.... By the way, we omitted to mention that on the figure on p. 136, the angle between the AD axis and the lines OB or OC has to be 60°. Please note that on your December copy NOW.

As for the present issue, the problems we have had would have to be seen to be believd. One Editor wrote, encouragingly, that we should find that it would be much easier to do Offset than Duplicating. Hah. I suppose it may, eventually, but omigawd it was tough this time. Please excuse the uneven blackness of the print on these pages; it was not the fault of our excellent printer, but several problems we encountered in arranging contrast. The next issue will be 100% more readable (at least the printing will!), I guarantee it (maybe). It will also not be as late as this issue (probably), Postal Strikes allowing. We had a lovely time trying to get the March typescripts into the hands of our typiste, Margaret, whilst solving the frantic problems of producing the February lot.

Confusion "rains" supreme

Many people who deal with EEB suspect that our small bureaucrasy is highly confused, but some have had an opportunity to verify it recently. We sent out some December renewal notes in February in a panic (during the abovementioned Mess) to a number of people. It was only after they were posted that we realised with horror that they were "December 1970." You see, the years come so fast nowadays, and they change numbers so often that we get confused. We received some indignant replies to this manoeuvre, which we deserved. Please accept our sincere apologies.

Bound Vol V (1969) is almost ready; please be patient. Several items had to be reprintd. Overseas subscribers: We charge more for everything not necessarily to get rich off of rich foreigners, but because the postal rates overseas are significantly higher; no bulk rates!

REGULATED LT POWER SUPPLY DESIGN

by R.L. Gunther

Part I: Basic Emitter-follower Configuration

The conventional emitter follower regulated LT power supply ought to be simple to design, but the exact form the supply will take may depend on the use to which it will likely be put. A special purpose supply can be built fairly easily and cheaply. A truly general purpose power supply providing well regulated power over a wide range of voltage and current can be a fearsomely complicated device, as you can see from perusing any standard reference on the subject (for example, 'Design of Regulated Power Supplies,' by I.M. Gottlieb, publ by Bobbs-Merrill/H. Sams; The G.E. Transistor Manual; or any of the many handbooks and manuals on transistorised circuits.)

I have built several power supplies for research equipment, but find it hard to imagine a circumstance requiring the elaborate designs I have seen. On the other hand, I have seen in the Australian (and other) periodical literature the design for power supplies with more transistors than needed for the job, or with ones that were inappropriately rated for power. Therefore I should here like to discuss a few simple yet versatile arrangements, and the principles behind them. Armed with this information it will not be necessary to scan the literature for just the right kind of power supply .. you can design simple varieties yourself, as appropriate.

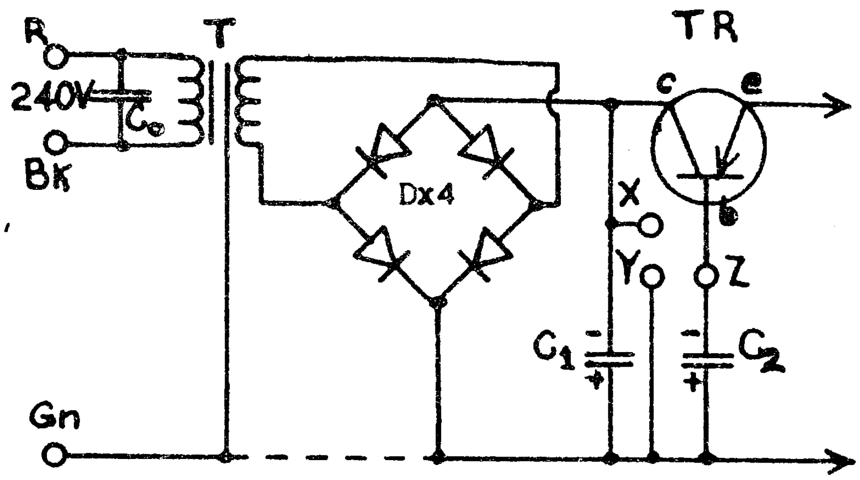

FIG. 1: Basic Power Supply

The Basic Circuit

The basic circuit is the familiar one of Fig. 1. The transformer in this instance was a standard 240V pri to 18V/1.5A sec, therefore giving about 25V peak to the filter, C_1.

C_o is about 0.015μF/600V for transient protection. It is not critical, and ought to suffice with good reliability if D is rated at 100PIV (or more). If D is 50PIV, some what more reliable suppression of switching transients can be obtained by putting a resistor, R_o (not shown), in series with C_o, and using the following relationships (ref: Miniwatt Digest, July 1962): $C=(200I_e)/V$, μF. $R=150/C$, ohms, where V is the RMS primary voltage, 240V in this instance, and I_e is the magnetising current (pri RMS current when no sec. load). For this transformer, I_e was measured at 85mA, so optimum C_o would be 0.07μF, and R_o=2.2K. The larger C plus R gives more effective transient suppression at lower frequencies because of the larger C, while the R prevents shock-excited resonance of C with the transformer (ref: EEB, 1968, P. 21, 31). It is, however, important to use the correct values of C_o with R_o. Otherwise it is better to use the single condenser of lower value (not more than 0.025μF).

D can be anything as long as it has PIV 50V or more (as per above discussion), and the appropriate current rating. In this case it was 0.75A, giving a total of 1.5A, with 100cps ripple.

TR can be any transistor having BV_{cbo} voltage rating of 40V or more, and current and power rating as appropriate for load. In this case a 2N2560 was used, Germ., having a P_C of 20W (at 25°C case), and I_C=3A max. Computer type 033 would also suffice for very low power applications. In the discussion to follow here, it is assumed that the gain of each transistor is known. This is necessary for intelligent circuit design, but is very easy to measure. The current gain of the transistor should be measured at the approximate load maximum current to be used, because it can vary quite a bit for germanium types (less for silicon). This is shown in Fig. 2 (p.16) for the 2N2560 used, and can be considered fairly typical. Other transistors usable in this circuit could be OC26, 2N250, 2N1038, etc. etc., depend-

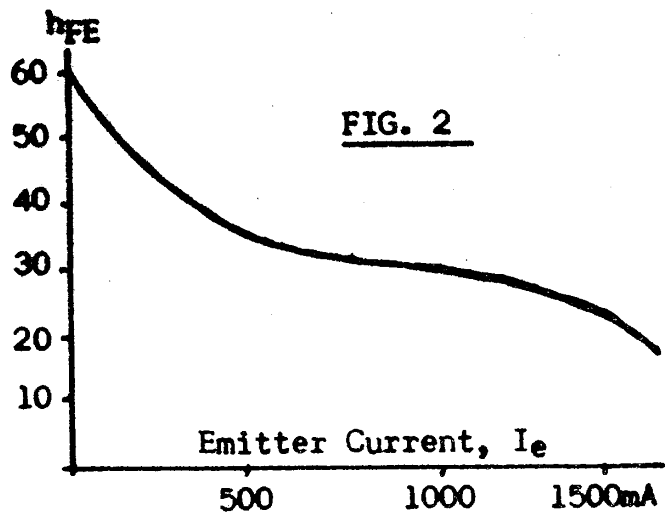

FIG. 2

ing on power rating. Circuit board TO-5 type transistors could be used if power output will be low; these should not be forced to dissipate more than a hundred milliwats, but this can be increased severalfold by heat sink (e.g. strapping the transistor body to chassis*). An NPN transistor would have output positive with respect to common line, but if the secondary of the transformer is isolated, this should not matter.

The connections X, Y, and Z are left open, because various kinds of control circuits can be inserted there, and their characteristics comprise the main part of this article. Output is available in the polarity shown when transistor is PNP. The positive line has been shown connected tentatively to the mains earth line, but of course this is not necessary if the requirements for the power supply dictate otherwise. For a truly general purpose power supply, perhaps neither side of the output should be earthed, just in case. The earthed portion of the transformer represents the electrostatic shield, sometimes useful in isolating the output from high frequency noise from the mains.

Mechanical Details

Mechanically, the power supply was built on a 3x5in chassis, 2in high, but of course any convenient mounting arrangement can be used. The transformer was mounted on top of the chassis, but with a larger chassis the transformer could be placed inside, for a neater and safer geometry.

The question arises: how to mount the power transistor? If it is mounted directly to the chassis, one must take care not to make accidental wrong contact between the chassis and other circuits (e.g. earth). On the other hand, if the transistor is mounted on a separate heat sink, that is also bulky, and the caution about avoiding accidental contact still applies. So I decided to mount the transistor directly on the chassis, with a daub of silicone grease between surfaces. It is possible to avoid this problem by using mica insulating washers, and that would undoubtedly be practical in this instance as long as one does not make the transistor dissipate more than abt one third of its rated power. But I do not like mica washers, and prefer to get the maximum power dissipating ability from any given hunk of metal.

For 10W of power dissipation, one ought to have at least 10sq in of heat sink on each surface (e.g. one flat piece of metal, 1/16th in or thicker, 4in x 2-1/2in), or 20 sq in altogether. The 3x5x2 chassis serves this purpose, because its outside surface area is 47 sq in, assuming the inside surface is unavailable because of lack of circulation. The extra area is useful for the heat dissipated by diodes and transformer. A few holes drilled in the chassis are not a bad idea, to help air circulation inside.

If the collector of the power transistor is connected electrically to the chassis by virtue of being bolted to it, it is desirable to mount the transformer on flat fibre insulating washers, if optimum use is to be made of the electrostatic shield. If this doesn't matter, the transformer is simply bolted to chassis.

A Simple Low Ripple Power Supply

Ignoring the transformer and diode bridge (which remain the same in each circuit), Fig. 3 (P.17)shows the simplest type of regulated supply configuration. R_b determines the base current of the transistor, therefore its emitter current. And here we shall get involved with

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* Be sure to check whether any of the transistor's leads are also connected internally to case. Sometimes the collector is, sometimes the base, sometimes neither. For detailed characteristics of computer transistors, see Amateur Radio, Aug. 1969, Dec. 1969.

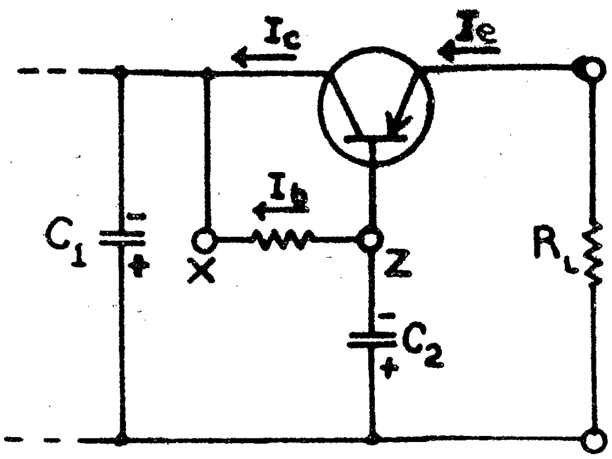


FIG. 3: Simplest regulated supply

a little simple algebra. It involves only the basic relationship for transistor gain, and Ohm's Law, and is necessary for basic design. I shall use h to indicate current gain, as abbreviation for h_{FE}.

We then have $I_c = hI_b$, which says simply that the current output from emitter is the amplification times the current input (to the base). But, base current depends on the voltage drop across the base resistor. Ignoring the small voltage drop (about 0.3V) between base and emitter, then, if we assume $I_e = I_c$, approximately,

$$I_b = \frac{E_c - E_e}{R_b} \qquad \text{Whence,} \qquad I_c = h\frac{E_c - E_e}{R_b}$$

Thus,

$$E_e = \frac{hR_L E_c}{R_b + hR_L} \qquad \text{Or,} \qquad E_e = \frac{E_c}{R_b/hR_L + 1}$$

where E_c is collector voltage to common, E_e is emitter voltage to common, etc., as obvious. Now, these equations define the circuit fairly closely. If R_L decreases, so must E_e. In fact, if you take the resistance of the transistor from collector to emitter to be about $R_{ce} = (E_c - E_e)/I_e$, you can show that $R_{ce} = R_b/h$. If R_b is constant, and if the gain is constant, this means simply that the transistor acts as a resistor. Then why not use a heavy resistor instead? Because the resistance of the transistor is controlled by I_b, thus by R_b which is appreciably larger than R_{ce}. Since we want to use this circuit to filter out hum, this allows aconsiderably smaller value of C_2 than would be necessary if it were just placed across the load. This will be shown by comparison of Curves A and H in Fig. 10 or Fig. 16 next month. (See also the Discussion of Fig. 9).... I have determined the performance of this circuit in some detail, and it will be worthwhile to study it in terms of characteristic curves.

Effect of Ripple on Maximum Output

Fig. 4 (P.18) shows the effect of loading, and of the input filter condenser (C_1) on the collector voltage of the transistor. The collector current of a transistor tends to be largely independent of collector voltage, but E_c, the average d.c. voltage, is important because it determines the maximum output that can be obtained. The actual output at the emitter will be several volts less, because it takes a few volts between collector and emitter to operate the transistor, particularly if the input ripple is high. This input ripple is here shown as e_c, the peak-to-peak ac (100cps) voltage appearing at the collector. Now this parameter is interesting, because it limits the maximum output that can be obtained with not-excessive ripple. For example, say that we want to take 1000mA from the supply having $C_1 = 750\mu F$. The average collector voltage has fallen to about 18V, and ripple is 7V. That means that the collector voltage swings from 14.5V to 21.5V each cycle. If a saturation voltage of, say 1V, is assumed for the transistor, the maximum possible output at the emitter is then 13.5V. (Actual V_{sat} is about 0.7V, but several volts across the transistor will allow it to control ripple better. The above calculation is merely illustrative.) Remember that the transistor cannot deliver more voltage than available from the supply. You can reduce R_b to get apparently more output, but it won't be d.c. For $C_1 = 150\mu F$, on the other hand, the 13.5V maximum output level is reached for a load of 275mA, rather than 1000mA.. It is evident that the larger is C_1, the more output can be obtained from the regulated supply; in this case a maximum of about 24V with several thousand μF at C_1. It seems reasonable, therefore, to make C_1 only as large as necessary. If most applications will take less

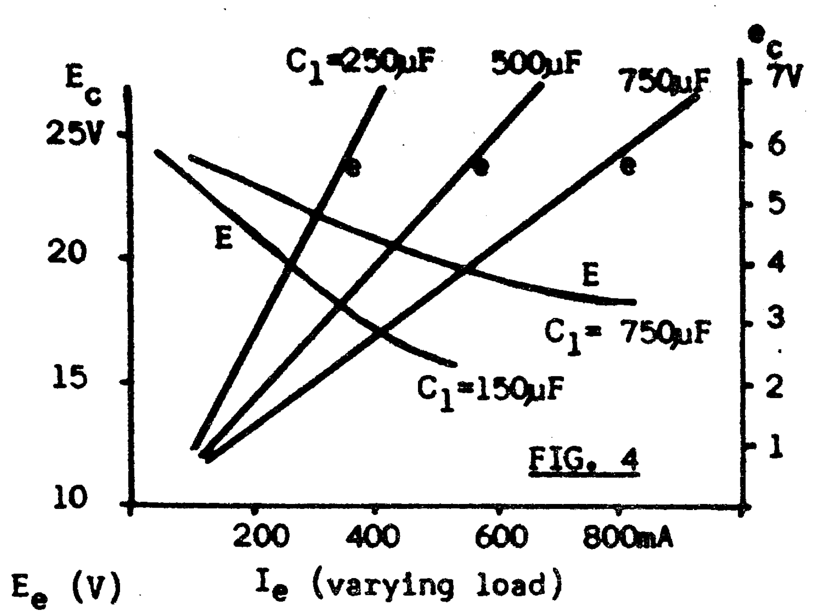


FIG. 4

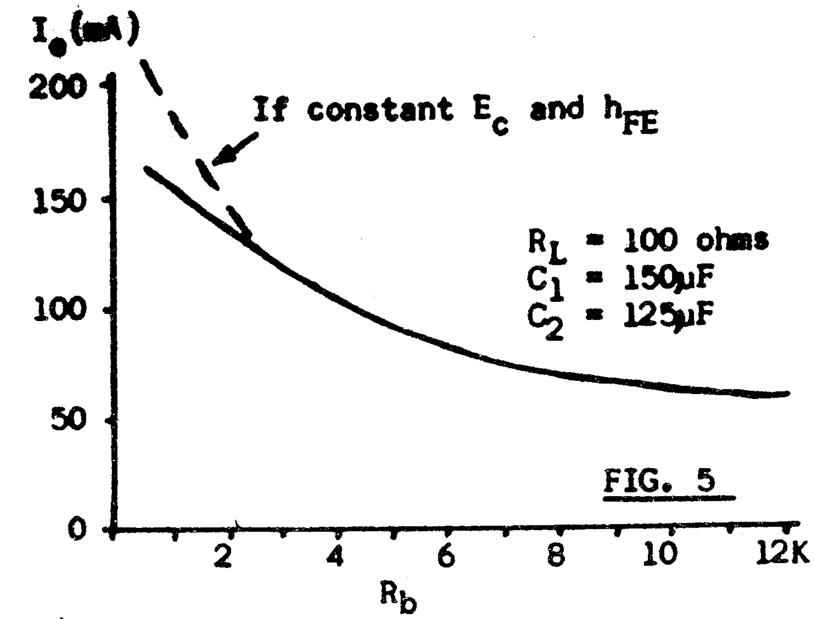


FIG. 5

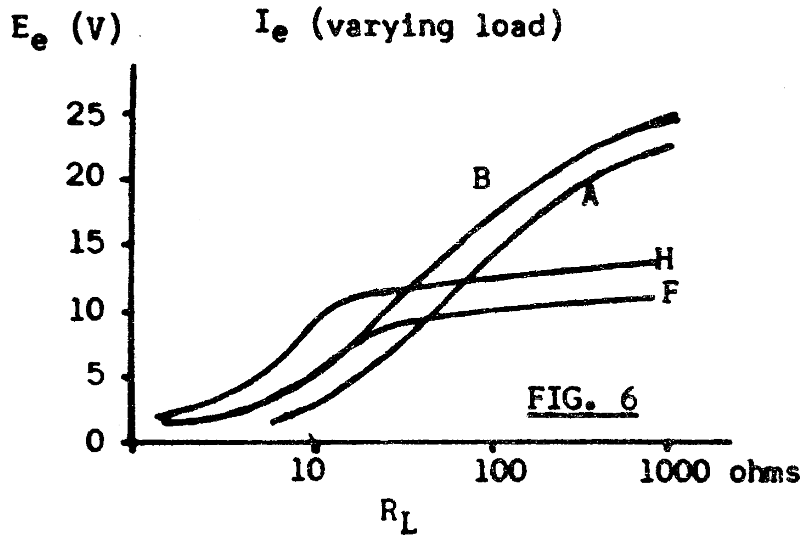


FIG. 6

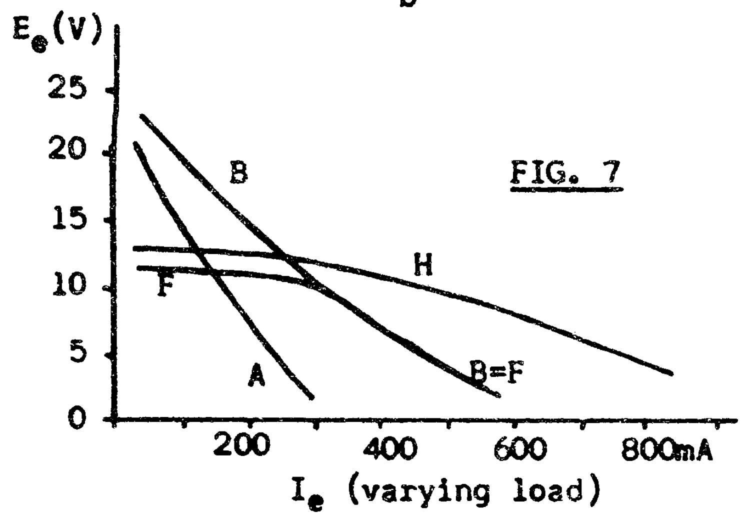


FIG. 7

than 100mA, it is a waste of money and space to make C_1=2000µF. You can see why a truly 'general purpose' power supply must be generously designed. Consider only the fact that the 25V input level requires a voltage rating of 25V for C_1, preferably 50V. A 2000µF condenser at 50V is a formidable item indeed.

Fig. 5 shows what happens if R_b is made variable. As explained above, this is equivalent to a variable resistor in place of the transistor, but in this instance the control need only handle very small current, and need be much smaller. The actual value of resistance for a given output will, of course, depend on the gain of the transistor and value of load resistor, as described for Fig. 3.

Load Regulation and transistor Power Rating

In Figs. 6 and 7, the supply constants remain the same, but now the load resistance is varied. Curves A and B are derived from Fig. 3, but the others will be discussed later. Curve A is with R_b=3.9K, and Curve B has R_b=1.5K ohms. The shapes of the two curves are similar, and the essentially resistive nature of the transistor is clearly seen. In Fig. 7, the curves are not straight as they would be for pure resistance, because the gain of the transistor and the collector voltage are decreasing as load current increases. The effect is not great, however, and the equations of Fig. 3 ought to be a good basic design procedure.

Now, it is worth noting that as the load resistance decreases, and the load current increases (see Fig. 7), the decrease of voltage across the load is accompanied by corresponding increase of voltage across the collector-emitter of the transistor. This means that as the load increases, the power dissipated by the transistor increases. The maximum power that can be dissipated by the transistor is reached when the output is shorted. In this case, with Curve A, that is about 22V x 300mA = 6.6W, which is not unreasonable for a transistor rated at '20W'. (Remember that is at 25°C case, and the transistor is not

just going to sit there cooly while you pump watts into it, heat sink notwithstanding.) But for Curve B, this rises to 13.2W which is rather high. An OC26 or other 30W transistor might be indicated. Ultimately, however, Grandma's test must triumph: feel the transistor case after a few minutes of operation at the maximum likely dissipation, and reduce power if it is too hot to touch comfortably (that applies to Germanium. For silicon, where operation can be acceptable at temperatures exceeding the boiling point of water, I'm not quite sure what Grandma would do; perhaps spit on it??).

Well, it seems unlikely that one would operate a power supply in a thoroughly shorted condition for any length of time. When output across the load begins to appear as R_L goes up, the transistor power dissipation decreases rapidly, since (from the discussion of Fig. 3)

$$P_c = h_{FE}\frac{(E_c-E_e)^2}{R_b}$$

(where P_c is the power dissipated by the collector junction of transistor)

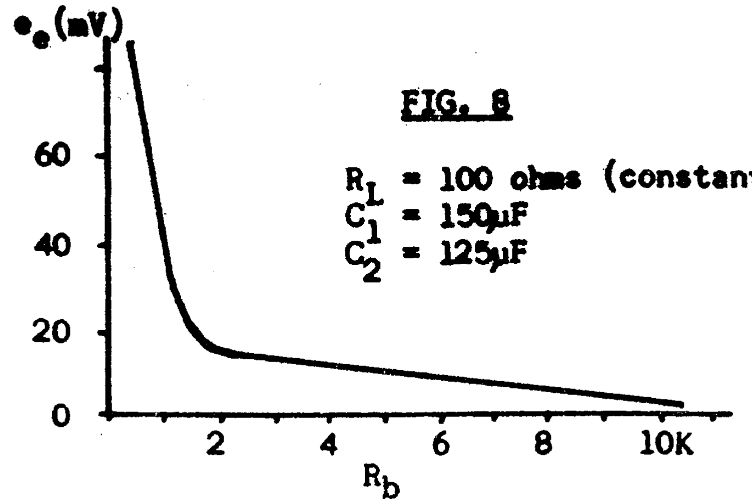
On the other hand, it is important to realise that the circuit of Fig. 3 has an interesting built-in safety feature: if R_b is sufficiently large, it is impossible to overload the transistor. For example, let us say that in this instance we wanted to limit the maximum emitter current to 3 Amperes. That would mean that the collector would have to dissipate about 30-40W (depending how low E_c dropped), but that would be conceivable for a brief interval. Assume E_c=13V, h_{FE}=15, I_e=3A (these are guesses, but ought to be about right for that heavy a load). Then, from the discussion of Fig. 3, $3A = 15\frac{(13-0)}{R_b}$, whence R_b=65 ohms. This means that if R_b is 65 ohms (or more), it will be impossible to ruin the transistor if the output is briefly shorted. This is considerably easier and simpler than elaborate circuits for preventing damage due to overloads, and it is more reliable than fuses; unless one uses a special fuse like the 'Amp Trap', the semiconductor may perish before the fuse does. It is also possible to use a small resistor in series with the collector to protect the transistor. More about that later.

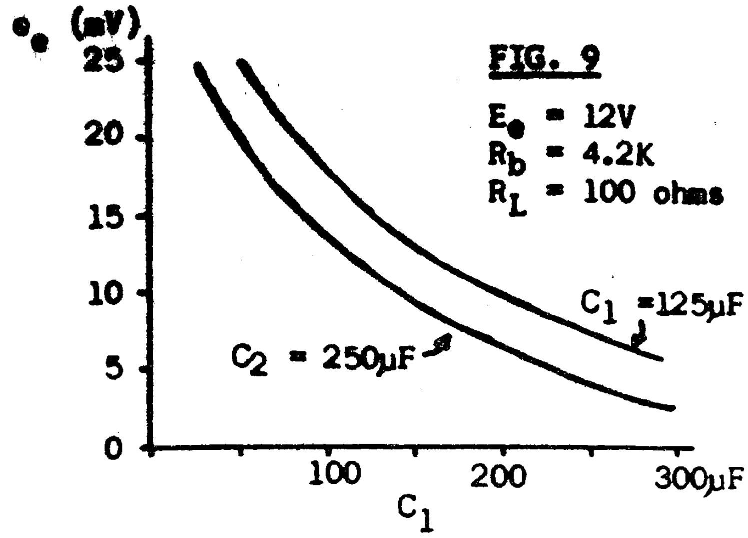
It is true that Fig. 3 has its limitations for the supply of constant voltage with slowly varying load, but systems I shall describe later will be adaptable to the use of this automatic overload protection feature, while embodying the advantage of regulated constant output.

Capacity-multiplication

The circuit of Fig. 3 has a characteristic of considerable value, in addition to the variable-resistor property described. Since R_b is high for a given emitter current, the capacity C_2 is more effective than when used as 'brute force' filter, e.g., at C_1. In fact, the circuit of Fig. 3 is referred to as a 'capacity multiplier'. As far as the load is concerned, the effective filtering capacity is about $C_2 \times h_{FE}$. If C_2 is 250 µF, the current gain is 50, then the equivalent filter condenser is about 12,500 µF (or 0.0125 Farads!). This begins to be interesting when one looks at the size and cost of 12,500 µF/25V electrolytics!

This is shown in an interesting way by Fig. 8(P.20). It should be read in connection with Fig. 5. As R_b is increased, the output voltage (or current) falls slightly, but the output ripple (e_e, peak to peak) falls very sharply up to about 2K, and then only slowly as R_b is increased. The more penetrating amongst you may make a quick calculation and realise that at 100cps, 125 µF has a reactance of only 13 ohms, and that the ripple ought to start falling sharply at a much smaller value of R_b (where $X_c \ll R_b$), perhaps 100 ohms. I am told that this discrepancy is due to the fact that the traditional formula for reactance, X_c= 1/2pifC applies only for a sine wave, whereas the ripple waveform is most definitely not sinusoidal. Therefore, for practical purposes the determination of sufficient value of R_b for a given C and ripple must be done experimentally. In practice one chooses R_b to give desired output voltage for a given load, and increases C_2 until output hum is low enough. Fig. 9 (P.20) shows how the output ripple is decreased by increasing C_2, but also shows





that output ripple is decreased by C_1 as well. Thus, C_1 not only determines the maximum output available (as per discussion of Fig. 4), but also output ripple, as one would expect. C1 and C2 thus work together to reduce output ripple, as they would in any pi-type low pass filter, but the combination of C2 and TR makes it easier. This is shown dramatically by the fact that if only C1 is used for filtering, without aid of the transistor, the ripple across it is still 50mV when C_1=10,000µF (point H in Fig. 16)! Note that in Fig. 9, the improvement from doubling C2 is not as great as in increasing C_1 over the same range, i.e. from 125µF to 250µF. From a practical point of view, therefore, a reasonable value for C1 and C2 might be 150µF each, for the other parameters shown.

Dynamic Voltage Regulation

Not only does the C2+TR combination filter out ripple, it also acts as a true electrolytic would, in regard to a.c. load variations. It seems to store energy, and maintain a constant output voltage even though the load current varies over a wide range. But it does this through conventional emitter-follower action, not by storing energy directly. At audio frequencies, the condenser C2 takes an appreciable time to charge or discharge, so it tends to act as a zener for a.c., and keep the base voltage constant. Variations in load which would tend to change emitter voltage are fed back by virtue of the heavy negative feedback inherent between base and emitter, so that output voltage is kept constant. The effect would be similar to the Curve F in Figs. 6 and 7, though this curve is actually the one for the circuit using a zener in place of C_2 (Fig. 17) (next month). At high currents, the regulation worsens because the capacities of the voltage stabilising element are strained. This can be improved by using a larger C2 or more zener current. The latter would, for example, have the effect of extending the flat part of the F curve further to the right in Fig. 7.

Thus, we can see that the circuit of Fig. 3 (with Fig. 1) is quite adequate to provide an effective method of controlling output, and of providing highly effective ripple filtering using relatively small condensers, as long as the load is constant, or varies at an a.c. rate rapidly enough to be controlled by C2. In subsequent discussions I shall examine systems which give constant output even with slowly varying d.c. loads.

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APPLE DRINK FROM WASTES

Take any quantity of peels and cores (from left overs after making pies, etc), pour boiling water over them until well covered, let stand until it ferments, stirring from time to time. Strain, sugar to taste, and bottle. Must be well corked. In warm weather it is ready in a day or two, longer in cold. A lovely drink, but don't leave it too long in the bottles. One simple way to keep pressure from getting out of hand is to put the bottles in the refrigerator after a suitable number of days. A simple way to determine this is to put remaining bottles in the fridge when a given bottle shows reasonable pressure (viz. head). Alcoholic content is negligible.

REFERENCES: Visible Light and Infrared Light (continued from p. 5)

((These references have been compiled by the EEB Editor from among the vast literature on this subject, and are merely items which happened to be at hand; other material can be found easily from consultation of circuits books and various Application Notes of the semiconductor manufacturers, e.g. Siliconix, below))

"PhotoFET Characteristics and Applications", by Mark Shipley, Solid State Design, April 1964 (also available as Siliconix "Magazine Reprint". Write on Company Letterhead: Siliconix Incorporated, 1140 West Evelyn Avenue, Sunnyvale, California 94086, U.S.A.). "The Photosensitive FET combined the circuit and device characteristics of a photodiode and a high-impedance low-noise amplifier." Its bandwidth is 1.1 to 0.4 microns, which means that it covers both the visible and infrared regions, but no spectral curves are given ((We have sent for the price* and technical specifications)), but sensitivity is specified at 1.2 microamps/mw/sq.cm. at 0.9 microns, and the information given implies a broad spectral response. The transient response is not as good as that of a photodiode, but undoubtedly quite adequate for our purposes. The sensitivity and Sig/Noise is not as good as that of a photomultiplier, but the quantum efficiency of the PhotoFET is better; i.e. its photocurrent is higher for a given input radiant power level. At low frequencies the current amplification of the two devices is comparable (which is VERY interesting!), but the dark current of the PhotoFET is higher; the minimum light-intensity must be higher for Sig/N. Finally the PhotoFET can be biased to give independence from temperature variations! * #U.S. 14

"Variable Frequency Tuner for the Visible Light Band", by J.A. Gupton, Jnr, W4AML, CQ, Jan & Feb 1969, p.16 & 18 respectively. Uses a photomultiplier valve. A very interesting pair of articles to which enthusiasts are warmly recommended. The first article discusses light, the detector, and the circuits (mostly transistors). There is, however, an error on p.22 of the January article; The equation should read: Density in db = 10 log (100/Transmission %). We note, however, that in conventional photometry, "Optical Density" is commonly referred to a scale where OD = - log (Transmission %/100). W4AML's Density is actually a measure of attenuation referred to power. For example, at the half power point, T = 50%, and Density = 3db, i.e. 3db attenuation, or the half-power point. The author also points out that "A low sensitivity (0.001 watt) photodiode can be homebrewed by removing the metal top of most any PNP or NPN transistor case, then using the base and collector leads to from the diode. The best photodiode action is obtained by using audio power output transistors such as the 2N250 ((=OC26, etc)), 2N1183, or 2N455." "There are a number of commercial photodiodes available that have a sensitivity of 5×10^{-7} watts or better. Calibration and spectral response curves are supplied with the commercial photodiodes as well as circuit diagrams for construction of measuring devices using the photodiode." He points out that Cadmium-Sulfide photocells are the lowest priced sensitive photocells suitable for a detector, with sensitivity in the range of 10^{-9} watt (550mu), but Groth (P.2 here) points out that LDR's have inadequate frequency response, so what is the use of all that sensitivity? Part II of Gupton's article describes the construction, calibration, and operation of the monochrometer to tune the light frequencies.

Certainly if sensitivity is desired, the Photomultiplier or PhotoFET are the items of choice. If, in addition, the light source is a Laser, prodigious ranges can be achieved, as illustrated by some of the systems tested by the Australian Post Office (see Australian Telecommunications Research last year). Experimenters wishing to test the effectiveness of a Laser for this purpose might be interested in an article on the construction of a simple tube-type Laser in the December 1969 issue of Popular Electronics (U.S.); in addition it is possible to use Ga-As Laser Diodes, specifications for which will appear in the April EEB. Whilst the radiation from the tube used in the PE article, and that coming from the diodes is very weak, we disagree with the author of the former who claims that it is "safe" to look into the weak beam. We (RLG & RAJR) believe that it is inadvisable to look into ANY laser beam; even if not strong enough to burn, it could possibly damage eye nerves!

Personal Communication from J. A. Gupton, Jnr, W4AML. He suggests that yellow green light is most suitable (555mu) for detectors and the human eye. He goes on to suggest that:

"Quartz lamps are available up to 1000 watts and can be modulated with audio. These lamps do not blacken with age, and maintain full intensity right up to the very end ((not only is their output considerable, but they could probably be modulated to much higher % level than incandescent lamps -- RLG)). Edmund Scientific Co., 101 East Gloucester Pike, Barrington, New Jersey, is an excellent source for optics and lamps for this type of projecting ((But overseas orders have to be sent through: Sigma International, Inc., 13A East 40th St., New York, N.Y. 10016, U.S.A. Since they have a $25 minimum order policy, it might be wiser to work through some American agent, e.g.: FAA Bookstore, Attn. C.C. Drumeller, W5JJ, Postal Station 18, Oklahoma City, OK73169, U.S.A. -- RLG)).

"Skips are possible with photocommunications. Weather requirements demand a temperature inversion, a strata of warm air with cold air under and above the warm level; like the mirrage in the desert. Photocommunications beams will bend under these conditions." We are most grateful to OM Gupton for this information.

Photocommunication is also possible using pure infrared (not merely the byproduct of an incandescent lamp). The BPX25 has high sensitivity as a detector, and is available in Australia from Mullard or Phillips; it will also work at visible light frequencies. The following references are typical:

"Infrared Communication", Mullard Outlook, Vol. 11, No.2, March/April 1968, p.24. Circuits are given for producing infrared with a CAY12, and for detecting it with a BPX25. And a lens and mirror system. A very ingenious circuit is provided for "coding" signals so that incident light does not affect the system. The CAY12 photoemitting diode is expensive, namely $45 (Plus tax), but the 101CAYA (described below) is merely $37++. We have just received word that Ga-As diodes are available in the $15 price range from Radio Parts P/L in Melbourne; specs & details in the April EEB... The BPX25 for Rx costs only $2.76++.

"Infrared Detectors at Work", Mullard Outlook, Vol. 11, No.3, May/June 1968, p.24. A number of infrared detectors are listed, the most useful of which are presumably the PbS type operating at 300°K (room temperature). Prices range from $13 (+25% tax) for the 119CPY, through $22 (+ only 15%) for 61SB, to $215 (+15%) for RPY57! But for modest sensitivity, the abovementioned BPX25 does a fair job at much lower cost. Ask for Specs Sheet.

"Low Cost Light-Beam Infrared Communication System", Mullard Outlook, Vol. 11, No.5, Sept.Oct 1968, p.53. Another system is described using the photodiode 101CAY for transmitting (three transistor circuit), and the BPX25 for receiving (two transistor preamplifier circuit). At 600 feet the beam is only "a few inches wide". The (developmental) 101CAY passes 20mA unmodulated. This varies by ±10mA for a 150mV peak signal, -3db at 80kc. A three-stage amplifier is necessary to obtain sufficient drive from a crystal microphone input. Two transistors bring the output from the BPX25 to headphone level. A one-lux input produces output voltage of 400mV peak, -3db at 4kc. The optical system is a 3" dia f2 condenser from an enlarger, with the transmitter and receiver semiconductors at the focal point. See also Mullard publication "Mullard Range of Infrared Detectors"

We might note here that although the output of a photodiode is considerably less than an incandescent light source, it can be modulated more fully, giving more useful light intensity and therefore a much higher signal/noise ratio for a given level of light output. See, however, the note by Gupton (Personal Comm.), above, about the use of high intensity quartz lamps for visible light use. Infrared light communication has certain advantages, to be sure, but lens systems can be awkward (though Gupton says that glass lenses can be used for the near-infrared), and very sensitive detectors are necessary for good DX.

In the Mullard Outlook, Vol. 12, No.1, Jan/Feb 1969, is a note that the Postmaster General requires an operators licence to operate light-beam communications legally. Presumably this is not a necessary requirement in non-British countries.

Postscript: In reference to Lasers, essential reading is "CAUTION LASER" by L. B. Lloyd, Popular Electronics, Dec. 1969, p. 41. PE will also feature Laser Communication articles in 1970 issues, and is recommended reading for anyone interested in this subject.

THIS IS THE EEB, an "Electronics Experimenters Bulletin," featuring commonsense electronics (at least), practical and impractical. It is printed every month EXCEPT Jan, Jun, Sep, & Nov. Articles are by Staff or Readers. We are interested in semiconductors, but anything interesting about nearly anything technical will be considered. The EEB is read mostly by amateurs and other experimenters. If you have a technical fact or opinion, this is your opportunity to tell it to others.

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MISCELLANY

Owing to a Miscalculation, we seem to have some extra room here. We submit the following: (all plagiarized from AUTO-CALL, published by KØNL).... A woman complained to the telephone company that men in her back yard were using profanity, so the President asked for an investigation. Came the answer: "There was no profanity. The situation was this: A man up on a pole was soldering wires and a man stood at the foot of the pole under him. The man at the foot of the pole said, 'Horace, you really ought to be a little more careful with that pot of hot solder up there. I do believe you have just tipped over the whole pot and it fell on my shirt front and trousers.' " (June 1968)..... This man says to the father, "Did you meet your son at the airport?" "Nope," says the father, "I was acquainted with him some years before that." (June 1968)...... Highway sign: If you must kill yourself, get off the road..... Teenage girl (to boy friend): "Of course Dad doesn't mind our being alone together. He thinks you're a girl."......... One of our readers informed us that this column would be read long after Shakespeare, Kipling, Milton, and Browning are forgotten -- but not until then....(Sept 1968)..... The school of experience would be more pleasant if there were a vacation once in a while...... (There are several more beauties, but I don't know that I could dare to print 'em!)

QUO££ "I£HOU£ DOMM£N£ (That's supposed to be Quote Without Comment, but looks pretty that way)

"If I would have no time to do my hobby properly, there would be something wrong with my way of life, with most likely serious consequences. What does it matter if it takes two years to complete a home-made rig, as long as I learn what an Amateur should know about electronics today? How long does it take a university graduate to gain professional experience? We and he can never afford to stop learning. After all, I did not want to excuse my laziness or inability to learn and to understand present day Amateur Radio techniques, with the popular QSO saying: 'I have no time to roll my own these days!'"

-- H. F. Ruckert, VK2AOU, Amateur Radio, Oct. 1968, p. 6.
Extract from: "SSB Transmitter -- an Amateur Engineering Project."

February 1970

THE AUSTRALIAN EEB
P.O. BOX 177
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THIS IS THE EEB: an "Electronics Experimenters Bulletin." It is published about eight times per year and is devoted to "Semiconductors and Other Conductors." It appeals to electronics enthusiasts who are willing to believe in Ohm's Law, and who have an elementary background in electronics.

The EEB covers a large range of subjects through constructional articles or discussions. Articles are written by staff or by readers.

The EEB is a voice for experimenters who have ideas to share with others. The style is informal, and the entire approach is commonsense: If a part gets too hot it is passing too much power, no matter what the Book says. Or: if a signal is unhearable, there is little point in increasing amplification!

FINALLY, however, the EEB is indefinable, there are few rules. It just staggers on from one month to the next. For some reason a number of readers seem to be enthusiastic about it. You are invited to join them.

WE ENCLOSE a sample issue to show a typical EEB, maybe; it is only one of many. Some issues are "better" (for you) than others. Please note that although we have changed to a better printing process this year, we have every intention of keeping the style and coverage exactly as before.

EEB is published as a hobby; it is late every month (dependably so), and our paperwork is a shambles. If you subscribe or order back issues, we'll get around to you in Due Course, probably about a month (longer during the months when we don't publish: Jan, June, Sept, & Nov.), so please be patient.

We conduct no Consulting Service (we don't know the answers either), but we do encourage readers to join the Wireless Institute of Australia, wherein can be found much competent help and encouragement; write P.O. Box 36, East Melbourne, Victoria 3002, Australia for details on joining the W.I.A. They also publish "Amateur Radio," an excellent electronics magazine sent to all members.

MONEY: we need it to run EEB, lots of it, but there hasn't been any left over yet. Subscription rates are shown in the enclosed copy. If you are outside of Tasmania, please an extra 5c to your cheque to keep our State Government wealthy (wealthy like EEB). Postal Orders are better, but then the 5c goes to Canberra; you can't win. Please don't send cash.

THERE ARE still some copies of the 1968 Bound Vol. IV left. Overleaf is a brief list of topics covered. If not satisfactory your money will be refunded cheerfully, though we have yet to find any that was not satisfactory! The Annual Index of Vol. V (1969) is also enclosed.....

$0.25

THE AUSTRALIAN EEB

→ COMMONSENSE ELECTRONICS

MARCH 1970 VOL. 6, No. 2 P. 25

-- by Joan B. Machinchick, courtesy of Auto-Call (9/67)

CONTENT:

NEXT MONTH (APRIL):

- -- More HIFI.
- -- SCR Pulser.
- -- Another Transistorised Ign
- -- Windscreen Wiper Delay Ckt.
- -- Interpreting CRO Curves.
- -- More about Power Supplies.
- -- Recipe. (If room)
- -- A Special Frequency Comparator

A NICE HI-FI AMPLIFIER SYSTEM, Part I.   -- A. Whittingham (VK2)

The Preamplifier for this amplifier is diagrammed in fig. 1, and the printed circuit layout in fig. 2. In view of the small number of interconnections in the latter, an alternative would be to use matrix board, and make the connections with wires.

The first stage is bootstrapped to raise input impedance. The next stage is in the tone control circuit, using a feedback system. A negative-feedback tone control has inherently lower distortion than the standard filter-type. The last stage has been added to give sufficient drive for the Power Amplifier. It is unbypassed, to help reduce distortion. In my setup a piece of Veroboard was used, 3½" x 2¼". The circuit in fig. 1 is drawn backwards, so that the transistors are the right way round when mounted on the board. Note that some components are mounted directly on the Bass and Treble controls.

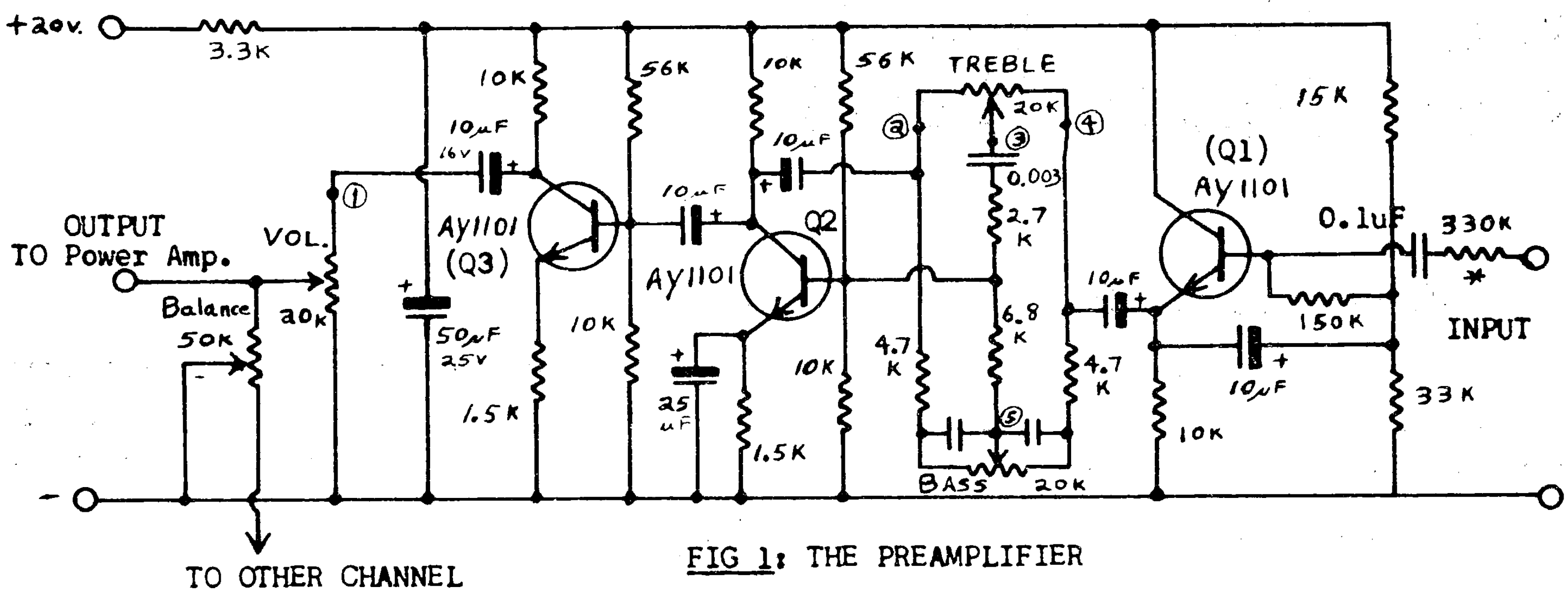


FIG 1: THE PREAMPLIFIER

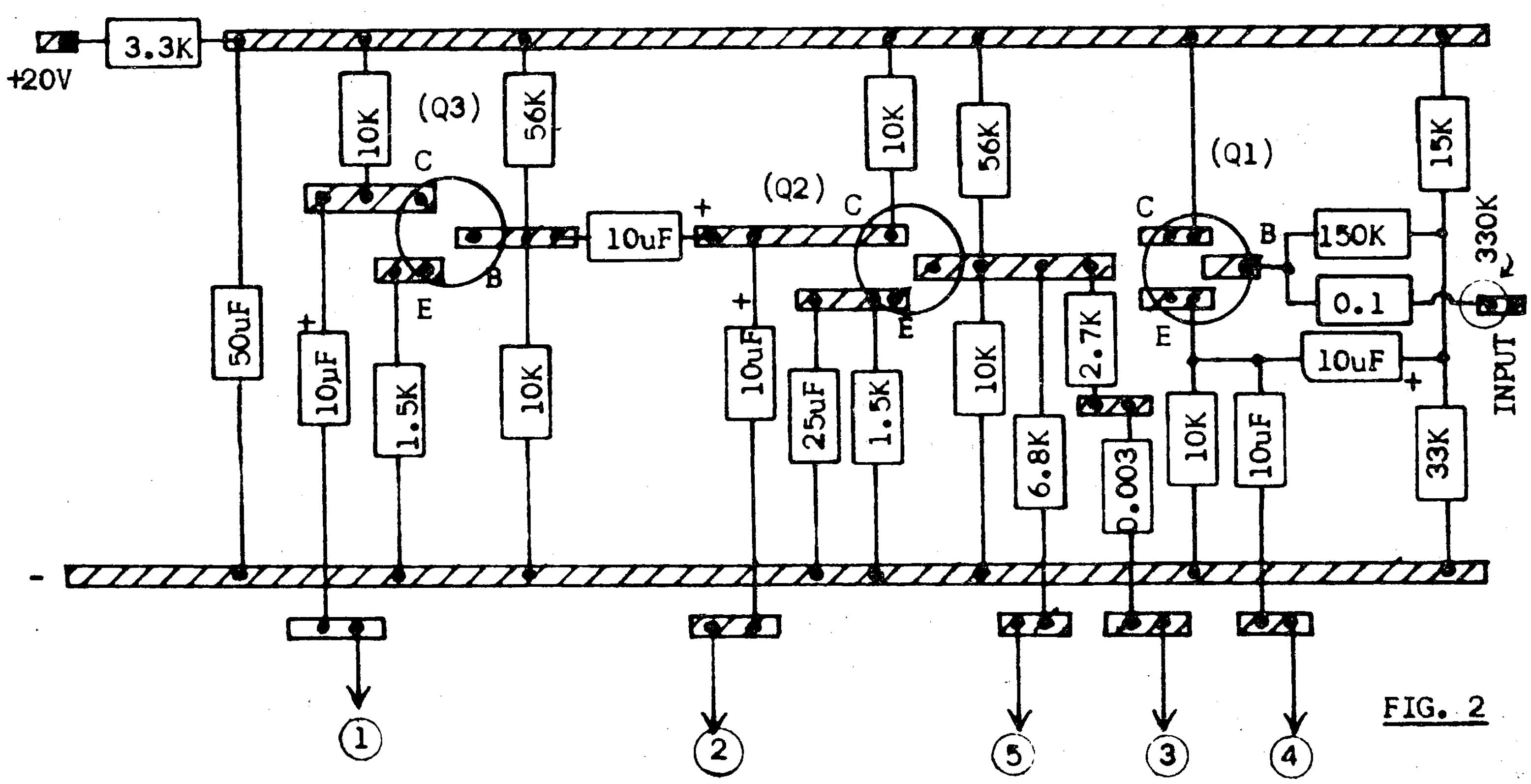


FIG. 2

Some components are shown laying lengthwise on the board for clarity; in practice these can be placed on end if room requires. Allow the pigtails to span three holes, and cut away the copper strip inbetween. Also, any spare Veroboard copper strips running through should be lifted on one end and peeled off to prevent feedback. Have a good look at the strips, and if any spare pieces exist, peel them off. The layout is a top view; any strips shown in fig. 2 are really underneath, but drawn this way to show where the strip has to be cut. When the modules are inserted in place on the chassis, the component side is facing toward the front, and the Input end is on the left near the selector switch. In the Tone Control circuit, two 4.7K resistors and two 0.1µF condensers are mounted directly on the Bass and Treble controls. Only one channel is shown; the other one is exactly the same if stereo is desired, except that only one Balance Control pot is used. The other controls are dual ganged pots. If only monaural operation is desired, the Balance Control pot can be omitted.

The Power Amplifier

((Editor's Note: For this system you can use any small standard complementary symmetry power amplifier with about 1 V sensitivity and several watts output, as desired. The original amplifier used here was the 3 W Simplified Fairchild design, but we are not including it here, because of several important modifications required to make it give performance we consider acceptable. This will be described in detail in the May and July issues (June is one of our now-standard non-publishing months). If anyone is impatient to construct the power amplifier before then, you can write to EEB, but we note that any of the ordinary Fairchild, Philips, or Mullard OTL designs will be satisfactory.))

The Power Supply

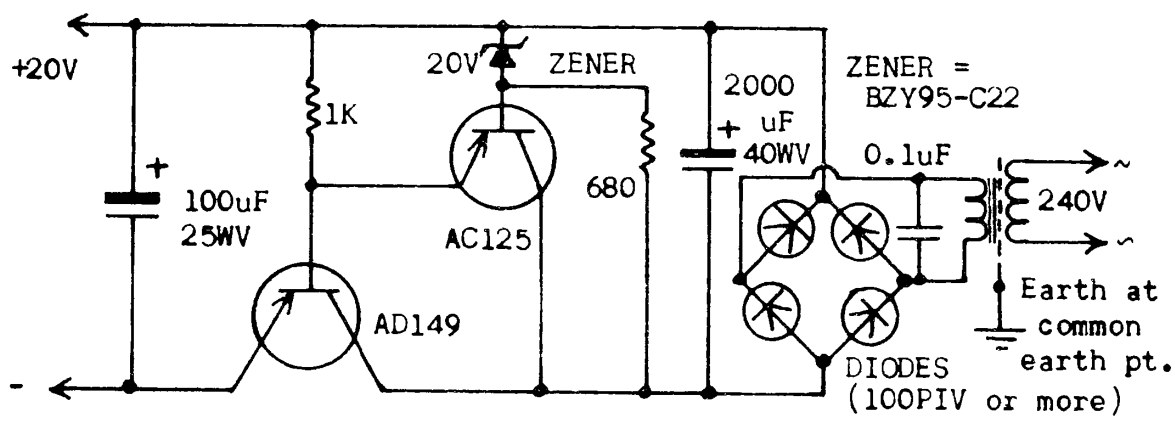


FIG 2: Power Supply Ckt. (Will also power the Power Amp.)

The supply is regulated to 20V d.c., and is suitable for powering the Preamplifier of fig. 1 and a 3W Power Amplifier. Alternatively the power supply shown on p.82 of the August 1969 EEB may be used. In the supply shown here in fig. 3 I used a Ferguson Transformer PX602, but any transformer may be used giving about 24 V rms at an amp or two. I also had good results from a trannie out of an old battery set which had a vibrator supply; the primary becomes the secondary, and the former secondary is fed with 240 V giving a nice 24 V out. Those kinds of transformers have reasonably heavy windings, as they operated on 2 to 4 Amps. Obtain the transformer before starting on the chassis, as it may not necessarily fit with the dimensions given. Silicon diodes with rating of 100PIV/0.8A are satisfactory. The condenser across the secondary is insurance against transient surge voltages. Alternatively a 0.01µF can be used across the primary, but then it should have a voltage rating at least 800V for a 240V rms mains supply.

Adjustments

Running a phono into the input, use a record with a fair bit of strings in it, such as one by Mantovani, and alter the input resistor (marked with asterisk in fig. 1) until the highest notes are clear and free from any trace of distortion. I am using 330K in my unit. When you have this right, alter the feedback resistors in the power amplifier until you have the power you want without any trace of distortion at full volume. It all depends on the pickup cartridge in use. When the amplifier is used with a Radio Tuner, if two amps are used in stereo the output will be about the same as with the phono, because the signal is split up into both channels thus lowering the input voltage.

If no input resistors are used in fig. 1, severe background noise and distortion will be evident, and treble control turned right up will overload the following stages. If a Radio Tuner overloads the amplifier when the latter is adjusted for phono pickup, it will be obviously desirable to attenuate the tuner output as suitable.

I am using an RCS transistor wideband tuner with a whistle filter, and the results are very good, except that the highs are down a bit. Next month: cabinet and chassis details.

A VERSATILE TRANSISTORISED IGNITION SYSTEM -- L. E. Thomas (VK6)

Nowadays everyone knows that transistorised ignition systems are desirable. They are, but are you using the best type? Are you happy with your transistor ignition? You shouldn't be, it's probably the most inefficient part of the electrical system of your car.

Consider the standard ignition system on a car. Typically it takes about 4½ Amps, 4 Volts is dissipated in a ballast which is shorted for easy starting, 8 volts is actually used at the coil. A total dissipation of 54 Watts, 36 of which are actually used to produce the spark. A T.I. system using a Ro-Fo coil takes 10 Amps (despite the maker's warning that no more than 7 Amps should flow through the primary). With this current a ballast of about 0.8 ohm is necessary. This means that 8 V is dissipated across the ballast.

Also about another 1.5 V is lost in the switching unit, leaving us with 2.5 V for the coil, or 25 Watts. Any attempt to bring the current down to the maker's recommended 7 Amps only makes the position worse, and results in unsatisfactory running.

The position is very similar with the Hi-Fire coil. I purchased a commercial unit, which, I was horrified to find, passed 7 Amps through the points with a 1.5 ohm ballast in circuit. This leaves about 2 V for the coil and switching or 14 watts.

All of these units gave about the same results. Hard starting in cold weather, an improvement in high speed running, and a slight improvement in petrol consumption on long runs, but some were as good as the standard ignition in slow speed traffic conditions. None gave any point wear. (Ed. Note: I got good high engine speed results from a transistor ignition with 1:400 coil, but poor low speed and rotten idling performance on a VW).

Why not combine the higher power efficiency of the standard coil with the more efficient switching of the transistor unit? The main obstacles in the past have been:-

1) The high back EMF generated across the primary of the coil would quickly burn out the transistor.

2) If we protect the transistor with a zener, the back EMF is too small to allow the standard coil to generate enough voltage to break down the spark gap.

The circuit enclosed was designed to overcome this, and has so far done over 4,000 miles without trouble. In comparison with the other systems, this gives equally as good high speed running with economy, and vastly improved low speed running, with a reduction of about 6% in petrol consumption. The larger number of components cost more than in other circuits, but one does not have to purchase a coil; proper transistor ignition coils are not cheap. As the coil current is held to the same value as in the original arrangement, no relays are necessary.

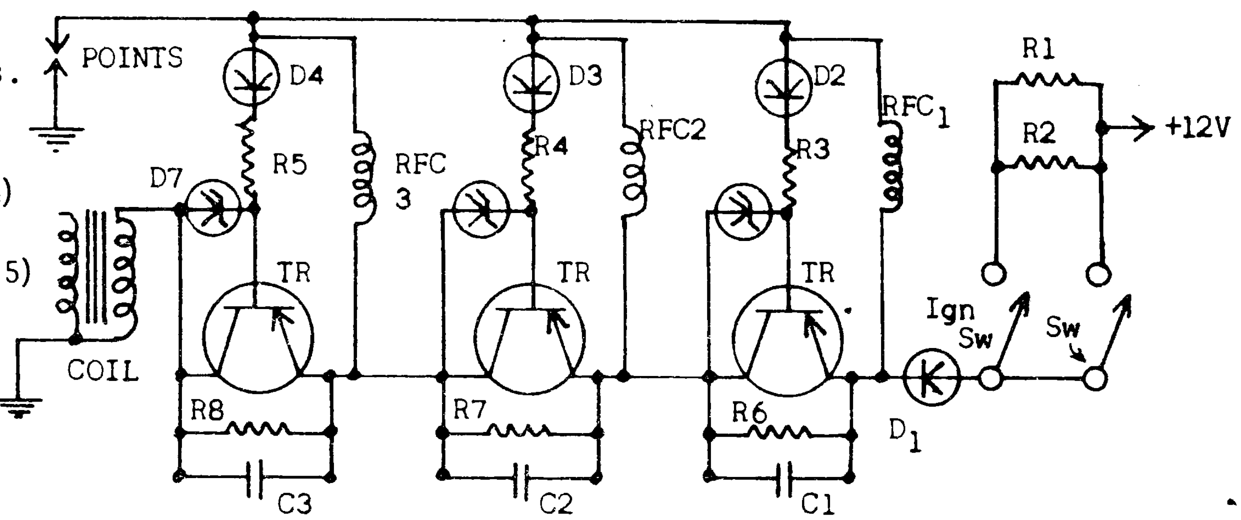
As you can see from the diagram, the transistors in series merely act as a high current switch, keyed by base current passed through the distributor contact-breaker ("points"). R3-5 merely limit the base currents to a safe value. D2-4 ensures that no reverse voltage is applied to the bases. The shunting resistors and condensers help take care of switching transients, and the zener diodes do the rest. D1 also helps remove transients from the transistors. The RF Chokes must have a resistance between 30 and 33 ohms. If they have a lesser resistance, a series resistor should be used to bring them to the right value. They can actually be replaced by a 33 ohm resistor, each, with some loss of efficiency.

A word now about the transistors. The ones I obtained were "OC28" from Custom Electronics in Adelaide (who advertises in Electronics Australia Classifieds). Subsequent to building this unit I tested BVces of two more "OC28" transistors, and found them to be 175 V and 168 V. This means that you need probably use only two such transistors in series, with zener diodes of about 125 V each; probably safe to use 150 V zeners if rated at 10W (available cheaply from Solid State Sales Co., P.O. Box 74, Somerville, Mass., 02143, U.S.A.). On the other hand, I tested three 2N174 type transistors, and obtained voltage ratings of 64, 68, and 80 volts. Therefore it is definitely wise to test BVces of the transistors you obtain, and get zeners to match (at about 80% of BVces). This is done easily by shorting base to emitter of the transistor, and applying voltage from collector to emitter until current is about 5mA (for power transistors; 100 µA for small transistors). That is BVces. By testing the voltage yourself you ensure best reliability, maximum performance, and the minimum necessary number of transistors and components in the circuit.

When setting the unit up, measure either the current through the coil before installing the unit, or the voltage across the coil. These conditions should be simulated after installing the unit, by adjusting R2. The starting switch which shorts the ballast can still be used, as the current with no ballast is well within the capabilities of the transistors.

The unit was mounted on a flat aluminium case, 6" x $4\frac{1}{2}$" x $1\frac{1}{2}$", and this served quite well as a heat sink; in operation the transistors get barely warm to the touch. In contrast, by using a relay and heavy wiring when the Ro-Fo unit was used at 8 Amps, the transistors got a lot hotter than I liked; under those conditions one would need a finned heat sink. Although results with the Ro-Fo coil were better than with a conventional single-transistor unit, they were no better than mine using the standard coil.

R1: Existing Ballast.
R2: Additional Ballast.
R3-5: 8.2 ohms, 10W each.
RFC1-3: A few mH, 33 ohms.
C1-3: 200pF.
D1: 300V, 10A (e.g. BYY24)
D2-4: 400V, 1A (e.g. BY114)
D3-7: Zener diodes, 5W, 75-85V (e.g. BZY95/C75)
TR: OC28, 2N1100, etc.
Sw: Regular switch or relay shorting ballast for starting.
Coil: standard ignition coil!



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TRANSFORMER REJUVENATION -- H. Bracken (VK7BR)

When transformers have stood about for a long time, particularly in a humid environment, they absorb moisture. If the transformer is used under conditions which cause it to heat up, quite a lot of heat can be produced inside even though the core may appear to get only warm. If this happens, steam can actually be produced inside, which takes off the insulation, with results which can be imagined. It leads to reduced reliability, usually at times which are the most annoying. The difficulty can be overcome by these simple procedures:

1) Use a resistor to load the transformer slightly so that it warms up only a bit. A suitable load might be 10% of rated value. Continue for a day or two.

2) Better: Put the transformer in a warm oven overnight. The right temperature is about 180-200°F. It can be tested by using a piece of "Empire Paper" by adjusting to a temperature which does not scorch the paper.

3) Best: Warm in oven, as in (2). Then put transformer in warm Glycol about 24 hrs, and leave transformer in it another 12 hrs or so. The right temperature is the one which does not scorch the Empire Paper. It is best to find this by heating the Glycol in a separate container, and then turn the heat back until no scorch. Note the temperature on a thermometer if possible, and maintain it at that temperature for the required time with the transformer immersed.

These procedures would be unnecessary for potted transformers, but it is desirable to ascertain whether the transformer is truly potted. Some units are merely enclosed but not impregnated.

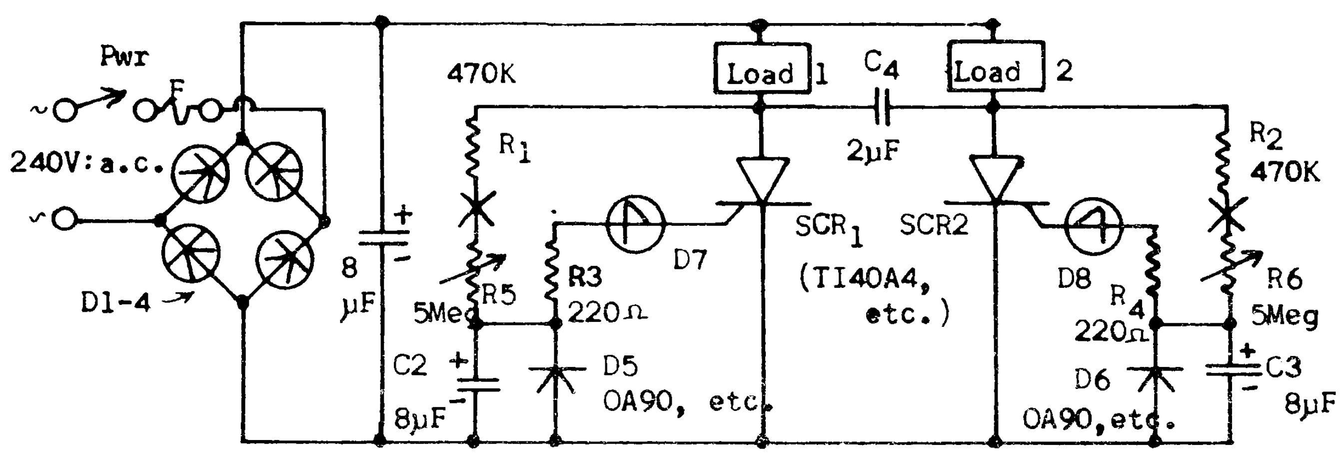
Editor's Note: I can verify the existence of this problem. Recently at Work we had a transformer failure due to operation after a prolonged "off" period.

Postscript: Empire paper can be obtained from motor-winding firms. Glycol soaking and baking is also excellent for "chattering" transformers, particularly when the noise cannot be eliminated by screw tightening. And it also improves insulation. Don't strip the threads; bake in glycol.

SCR TWO-PERIOD TIMER -- E. Kershaw (VK3)

This device is designed to switch on two loads alternately for independently controlled short periods, as for example in a signal flasher. The circuit was privately developed for demonstration purposes. Although it has been built and tested it has been kept relatively simple so as not to obscure the principle of operation. This led, for example, to charging of gate capacitors directly from the high voltage rather than dividing it down to a lower voltage first (which would give longer on-times).

The d.c. is obtained from the mains through a bridge rectifier; an isolation transformer is essential until the circuit is completed and safely boxed. In any event, however, remember that high voltages are involved, and they can be lethal. The values chosen are suitable for a 230V a.c. supply, and the SCRs and bridge rectifiers must be rated to handle the maximum load current; they should have PIVs of the order of 600V absolute maximum, appreciably higher for the SCRs if the loads are capacitative or inductive. Presumably lower supply voltage could be used for lower voltage loads, by altering all circuit values appropriately.



NOTES: C1, C2, and C3 may be (good quality) electrolytics, but not C4. C4 is good quality paper or oil type. Do not increase C2 & C3 to obtain longer times without reading text (below). D5 & D6 may be any silicon or germanium diodes rated for 100PIV, or zener diodes, as described below. D7 & D8 are Texas Instruments Shockley Diodes with a breakover voltage of approximately 32V. They can be obtained cheaply from Radio Parts P/L in Melbourne, but neons would probably work, with suitable adjustment of circuit parameters. Load-2 may be a dummy load, if desired, so that both the on and off period of load-1 may be controlled.

Operation

Each SCR is fired by a gate pulse. These pulses are obtained by using SCR anode voltage to charge up a condenser (C2, C3) via a variable and limiting resistor. If, say, SCR-1 is conducting, anode voltage is low (1 or 2V) and C2 does not charge appreciably. If, however, the SCR is not conducting, anode voltage is that of the supply, say 330V. This will charge C2 through R1 & R5. When C2 reaches breakover voltage of D7, the latter will break over and will pass current through the limiting resistor R3 and the gate of the SCR, firing it. Recharging cannot occur while the SCR is on, but can take place on the other SCR which duly fires. When it does its anode drops from full supply to 1 or 2V, and C4 passes this negative change as a pulse to the anode of the ON SCR. This reverses the applied voltage, and the SCR stops conducting. This process repeats automatically. D5 & D6 prevent the reverse voltage appearing at the gate circuit, by shorting the condensers C2 & C3 during the reverse voltage cycle.

Since the charge on C2 or C3 is discharged through the respective gates, increasing the value of capacitance could result in prohibitively high peak gate currents. If higher values of C2, C3 are desired for longer ON times, it is recommended that D5 & D6 be replaced by zener diodes (say 50 to 100V), so as to reduce charging voltage. Alternatively, R3 and R4 may be increased to limit peak gate currents to safe values. For given values of C2 & C3, this could most simply be accomplished by decreasing R3 & R4 from some high resistance to values which give reliable ON triggering. If a CRO is available, more flexibility of design would, of course, be obtained by measuring peak voltages across R3 and R4, and calculating the peak gate currents; maximum peak gate currents should be kept well within the manufacturer's rating.

For faster times, C2 & C3 may be reduced to lower values, say of the order of 0.1 to 1.0μF. As a 2-period timer, time ON was 0.5-2.5 sec, approximately. Operation as a delay timer (1-5 sec) is possible, but it requires a DPDT switch which switches the timer on in one position, and in the other (off) position places a discharge resistor across the 8μF to give consistent timing.

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Review: SERVICE VALVE AND SEMICONDUCTOR EQUIVALENTS, Sixth Edition (RLG)
-- Compiled by G. R. Jessop, G6JP (R.S.G.B., 1967). Stg 5/- plus about 1/- post.

This is the reference book for all Junk Collectors. In my Junk Collection there exists a number of rather nice looking valves and tubes with enigmatic type numbers. From time to time I have been able to find out what some of them could do, by occasional reference in the periodical literature, or by trial and error. Now for the first time here is the cross-reference list to describe the lot, and it has been most rewarding.

For example, I have some lovely surplus bottles labelled "VT-4C". It isn't likely a G.P.O. valve, because the Jessop book starts with VT10, so it must be an American U.S. Signal Corps Valve, since a British type would be in the "CV" section. Lo and behold, it is a "211", a curious valve indeed. Of course I knew that just from looking at its massive carbon anode, but it was nice to know for certain. Less obvious was a "VT-129," a 304TL; it could have been 304TH. I had no idea what was a "VT-204", but this book tells me it is a 3C24/24G, a very nice EIMAC triode which can take 1500V on the anode, which then lights up in the most charming manner --- and that is quite all right --- and which is much easier to use than an 807 or 6146. Sure it takes more drive and requires neutralisation; so what? Once you have done that, it is done, and you need not chase numerous parasitics every time a fly buzzes too closely; and you just try tuning the output tank of a tetrode under full screen voltage. If not close to resonance to begin with, you'd best approach it fast, or replace your valve.

There are about 50 pages of CV valves; amazing the British needed so many more than the Americans. Some of them won't tell you much without cross reference to the Philips or Babani Manuals; for example a CV1028 is actually a 220VSG, made by Cossor (the address of each manufacturer is given in the reference part of the book) so what? But the CV2842 is a 6C4WA, which I can recognise with pleasure.

A thoroughly useful book, and one which should form a basic part of the library of every Junk Collector. Order through the WIA or NZART, or direct from RSGB as detailed in the Oct. 1968 EEB.

One thing I do not understand: from the lists it seems evident that both the British and the Americans thought it sufficiently important to designate part numbers for a number of valves of such extreme antiquity (e.g. 24A, 01A, 76), that we should certainly have lost the War if we had installed them in equipment. Why then, were they given VT or CV numbers?

xxxxxxxxxxxxxxxxxxxxx

QUOTES WITHOUT COMMENT

You're an engineer on a train travelling south. It is going at a speed of 60 miles per hour. It must travel through a tunnel one mile long. How long does it take to go through the tunnel? The train makes six stops for passengers; you see business is not so good. And it makes one stop for water. The fireman's name is Mike. What is the engineer's name?

Now if you feel you should register a complaint on these railroad jokes (?) take it up with the president of the railroad. It's easy to find him -- just follow his tracks. ((Auto-Call, July 1969, p.17))

ORDERS FOR YESTERDAY MUST BE PLACED BEFORE NOON TOMORROW. ((Note on our printer's door))

To Strengthen Weak Chests: Take one tablespoon lime water and one yolk of fresh egg beaten together half an hour before breakfast every morning. If unpalatable add a little ground cinnamon. This is very good, but works for men only.

LETTER: R.S.G.B. Membership

Thanks for the kind words on the Guide to Amateur Radio reviewed last year in EEB. A new edition has been published, and is available from the Society.

One correction: The membership application form in the Guide is for U.K. members only. For our overseas readers whom we assume to be of the highest integrity we do not have to ask for a sponsor. It is a form requiring only name and address, one of which I enclose ((see below)). Members needed, no experience necessary.

-- R. Stevens, G2BVN, Romford, Essex, England.

((Membership in the Radio Society of Great Britain also brings the monthly Radio Communication, which has been mentioned frequently in these pages, and which was reviewed in "Periodicals of Interest" in the September 1969 EEB. It is often well worth reading. -- Ed.))

RADIO SOCIETY OF GREAT BRITAIN

(Incorporated 1926)

Patron: H.R.H. THE DUKE OF EDINBURGH, K.G.

APPLICATION FOR OVERSEAS CORPORATE MEMBERSHIP

Radio Society of Great Britain, 35 Doughty Street, London, W.C.1, England.

I hereby apply for election as a Corporate Member of the Society and enclose a remittance for £2. 10s. 0d. being the amount of my first annual subscription.

I, the undersigned, agree that in the event of my election to Membership of the Radio Society of Great Britain, I will be governed by the Memorandum and Articles of Association of the Society and the rules and regulations thereof as they now are or as they may hereafter be altered; and that I will advance the objects of the Society as far as may be in my power; providing that whenever I shall signify in writing to the Society addressed to the Secretary that I am desirous of withdrawing from the Society I shall at the end of one year thereafter after the payment of any arrears which may be due by me at that period be free from my undertaking to contribute to the assets of the Society in accordance with Clause 8 of the Memorandum of Association of the Society.

Date .... **Signed** ....

PERSONAL DETAILS TO BE COMPLETED BY THE APPLICANT.
(PLEASE USE BLOCK CAPITALS)

Surname ....

Forenames (in full) ....

Address for all correspondence ....

....

Nationality .... Age (if under 21) ....

Current Call-sign (if any) .... Previous Call-sign(s) (if any) ....

Details of previous membership (if any) ....

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"A remittance for 50/- or its equivalent should be remitted with this Application Form", which we take to mean about $A6, $NZ6, or $US7. For the benefit of our American readers, by the way, we might translate the last sentence at the right as: "This magazine is tremendous! with lots of good dope for everyone." And virtually all of the regular publications of the RSGB are first class, the most noteworthy being Amateur Radio Techniques ("Technical Topics"), The Radio Communication Handbook, Radio data Book, and VHF Handbook. These have been reviewed from time to time in these pages (See 1968, 1969 Indices)

EDITORIAL: — R. A. Reynolds [VK7ZAR]

"Aliis licet; tibi non licet"
[[All is licit, except what is illicit]]

Television Servicing?

We have received for publication, an article on the repair of the elementary faults in Television Receivers. We do not feel we can publish it, for several reasons based on my own observations, following some ten years as a TV repair Technician in both small and large TV repair organisations.

"Obvious Faults"

My own feelings on this subject are that "amateurs" should not repair other peoples' or even their own TV sets. However, at the outset I will modify this rather sweeping statement by adding that an experimenter who understands the general principles of a TV receiver may be sufficiently equipped to handle the types of repairs that involve only unit replacements such as valves, and possibly the more obviously faulty components. Such an understanding of the subject does not require the publication of articles covering specific faults.

On the other hand, it is very important to know when a fault _is_ obvious, and when it is not. Unfortunately, it often happens that the competence of the novice in such matters is inversely related to his confidence. Only after he has attacked the set with great enthusiasm, does it begin to occur to him with dawning horror that all is not always as it appears, as the above aphorism [in its correct translation!] implies.

Favourite locations for the attention of enthusiasts are the tuned circuits of the set; everyone knows that "a radio can be improved by peaking-up." A TV set is not a radio. I have seen a lot of sets come into the shop with misaligned tuners or i.f.s. In almost every case of a set requiring such alignment, it turns out that Mr. so-and-so, a "ham" from down the street has had a go at it. Ham indeed. It is very rare that adjustments to the tuned circuits are needed as the consequence of a "fault." Once touched, these adjustments cannot be reset without complex equipment. If they are "peaked up" the only result will be noise.

Obscure Faults

These are more common than generally thought, and the job is better left, not only to a practiced TV Tech, but one who is well versed with that particular make of set. If this is followed, your set will be repaired, disturbing no more of the set than is necessary. There are a number of cases in popular TVs where a Tech familiar with those sets, will be aware of a modification that can be done to the set to improve or correct the performance. The trained

[continued overleaf]

ADVERTISING

This Page: Personal = 5c/line, Commercial = 10c/line or 40c per vertical inch. We guarantee nothing..............

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EDITORIAL [continued from p. 33]:

Tech will do these mods almost without thinking, and his experience is worth the service cost for this fact alone.

More could be said on this point, but it should be obvious that the cost of the once-a-year call that most TVs get is a lot less than the cost of the trouble that may follow well-meaning meddling, to say nothing of the degredation in performance due to a maladjustment.

Electric Cooking

A vital aspect of "home repairs" is SAFETY. The "dreaded EHT" can give you a decent boot, and literally send you flying, thus saving your skin. Because of this, the EHT is not ordinarily as dangerous as other sources of voltage within a TV, which are often treated with less respect. There were some early sets that had a live chassis, that is 240V mains, depending on the polarity of the power point, and nearly all sets have about 260V floating around somewhere with high available current. These voltages allow you to get a good hold on a chassis or wire and will not throw you clear at all well. They are quite exposed, and cause more injuries around the shop than the occasional kick from the EHT. As the old saying goes, electric cooking is a slothful process.

Incidentally, I recently threw out a new "insulated" screwdriver that flashed over within the plastic handle on the EHT of a set that normally runs 24KV on the Ultor. The TV Trade is rich in horrifying tales; take my word for it: a TV set abounds in lethal traps.

<u>Obscure EHT</u>

Among all the fields of home "repair" it is most difficult to dissuade the enthusiast from meddling with the HT and EHT supplies. After all, there are many complicated things happening in a Telly, but voltage -- well now, there is one thing one can understand. May I beg to differ? Again there are many tales one could tell, but let me mention a few not-so-obvious complications:

1] "To restore EHT, replace the 1S2 or 1B3." This is fraught with potential problems. The very process of making the replacement or of testing the filament circuit with an ohmmeter can crack old insulation, and release a host of troubles to supplement the original ones.

2] The very process of testing for HT or EHT by various shorting or arcing techniques can cause damage to circuits.

3] A defective item in a power system often interacts with others. A shorted power diode can cook electrolytics, and conversely; together they can ruin a transformer. Unthinking substitution of defective components can be hazardous unless the whole relevant section of the circuit is examined; this is done automatically by an experienced technician.

<u>DEATH</u>

The Implosion, the TV Tube going up. It doesn't happen very often, but when it does, it is usually due to careless handling, and more than one trained TV technician has been killed by a big tube. To illustrate, a Tech at a college in Australia was actually cut in two by a tube that he was carrying across the room, and there seemed to be no obvious reason for it to go off; he was wearing leather gloves and leather apron, and carrying the tube in the correct position. The trouble may have been related to an inadvertent scratch, or seemingly insignificant strain or jar. Furthermore, the time of implosion may [or may not] be considerably later than the initiating event. One classic story involves the 24" tube in an old set which went off in the middle of the night. The room in which it was sitting was demolished utterly, including a brick wall which fell into the room!

[continued overleaf]

Modern sets and tubes are built rather more stoutly, but the risk to anyone who mucks about inside the cabinet is formidable, particularly in older sets. Perhaps you know which set is "older" and which isn't. Is it worth it if you were wrong??

Epitaph

Thus, in the interest of: 1] Your own safety,
2] The performance of your set, and
3] Long-term economy,

don't try to repair any TV unless you really know what you are about.

Note by the Editor:

These are not the imprecations of a stuffy businessman; they are hard reasoning from an engineer with considerable experience of servicing, AND of imaginative workbench experimentation. He knows when to "muck about" the workbench, and when not. If you take his advice, no matter how "simple" the job may seem [what is ever simple?] you will save yourself a lot of trouble — and maybe your life as well.

MORE EDITORIALISING — RLG

Vol V, 1969 is now ready, and we have been posting it to people who have requested it; thanks for your patience in waiting. But this matter of Bound Volumes is getting out of hand. It is a big job and big expense, and it takes about two years to go through a run of only a hundred copies. Yet I see no alternative, because if we don't bind the copies people will request a whole years worth of copies at a time; if we don't print back numbers it seems hardly fair to people who joined with EEB later.

One thing seems certain. We shall have to gather an anthology of the best articles from the first five years of our publishing, because [at this date] only Vols IV and V are yet available, and people are truly holding the out-of-print volumes they have. Repeated advertisements for obsolete volumes meet with no response at all. Amazing.

But the production of a proper Anthology will be an immense task, if only to keep the total size down to a reasonable level. Even for only ten articles per year it would still probably exceed 250 quarto pages. A run of 500 copies would cost about $750. Who can afford that kind of investment? I can't, nor can EEB. Perhaps we shall find someone willing to invest in the enterprise and gather a profit from the sales — in due course.

REGULATED LOW VOLTAGE POWER SUPPLY DESIGN, Part II (D.c. stabilised supplies) -- RLG

In Part I of this article I described the basic relationships found in the standard emitter-follower regulated power supply. A working circuit, fig. 3 is repeated here (p.39). Specific components have been introduced between points X, Y, and Z. These will be altered in the present design. Part I described this simplest circuit, which produced very low ripple, and had good dynamic output voltage regulation as long as C2 was sufficiently large. But it suffered when it fed an amplifier with a very good low frequency response, particularly if the amplifier was not very stiffly decoupled to supply voltage in its early stages -- as I verified in trying it on an ordinary OTL high-fidelity amplifier. The voltage "sighed" up and down slowly, at about one cycle per second, even though C2 was 250µF. This is obviously highly undesirable.

Consider now, the following coding chart for the various curves:

CURVE	FIG.	C1, µF	C2, µF	Rb	R1	R_L	Ez
A1*	3	150	125	3.9K		100	
A1	3	750	125	3.9K		100	
A2	3	750	250	3.9K		100	
B	3	750	0	1.5K		100	
C	10	750	250	0	2K	100	
D*	10	250	150	560	2K	100	
D**	10	250	150	560	2K	16.7	
D***	10	1000	125	47	2K	16.7	
D	10	750	250	560	2K		
E	10	750	250	0	10K		
E*			125		25K		
F1	17	750	0	1.5K			12V
F2	17	750	250	1.5K			12V
G1	20	750	0	1.5K	100 (see text)		
G2	20	750	250	1.5K	100 (see text)		
H (see text)		10000	-	-			

From this chart we may see that increasing C1 (of fig. 3) from 150µF (curve A) to 750µF (curve A, fig. 11) increases very considerably the ripple-reducing abilities of the circuit for reasons described previously: the transistor acts like a condenser multiplier, but is not a condenser. It cannot store charge, and it can reduce ripple only when C1 keeps collector-emitter trough voltage from falling too low. Therefore there is a minimum value necessary for C1, which depends on the load current and on the minimum collector-emitter voltage necessary for the transistor to retain amplification control.

A Variable-output d.c. stabilised supply

In fig. 10 is shown an improved variation of the circuit of fig. 3. Although it suffers from somewhat higher ripple (compare curves A and D in fig. 11), it provides continuously variable output from OV to a maximum which depends on the load (c.f. fig. 4, last month), and the output voltage is remarkably well stabilised, even for slowly varying d.c. loads (figs. 13 or 15; compare curve A with curve C). It is also better regulated when the whole pot, R1, has a lower resistance (curve C of fig. 13) than a higher resistance (curve E). All this with Rb = 0.

Now, if Rb is inserted in fig. 10, ripple is reduced (curve D vs C in fig. 16), but regulation is worsened (fig. 15). Comparison of curves E and D show that lower R1 (curve D) improves regulation (fig. 15), but increase ripple (fig. 16), as one might expect from the higher parallel bleed current and lower series resistance provided by the lower value of R1. If we increase Rb to reduce ripple, we worsen regulation, as described above. If we want a ripple as low as curve A (fig. 16), we have to accept a regulation equally poor (fig. 15). How can we meet these contradictions? The clue is in the lowered ripple when R1 is increased.

Improved Variable Output

The system shown in fig. 14 is capable of overcoming these contradictions at the cost of an extra transistor, which can be called TR2. The load of TR2 is now the base of TR1 in parallel with Rb′ of fig. 14. TR2 must be able to pass the entire base current of TR1, plus some for Rb′, and this could amount to 100mA for heavy load, depending on amplification factor of TR1. This would strain the capabilities of a small transistor, and it would be better to use one similar to TR1, with a smaller heat sink. But of course this depends completely on the power levels involved, and the necessary power ratings can be determined, as usual, merely with Ohm's Law and the formula for transistor current gain.

Transistor Power Ratings

For instance, imagine that load is 1000mA maximum at 12V maximum d.c., and that d.c. supply to TR1 is 23V. Say that current gain of TR1 is 50 at this current*, and that of TR2 is 75 at its actual collector current. Power dissipation across TR1 is 12V x 1A = 12W. So TR1 here should be rated for 30W, say, with at least some 15 sq. in of heat sink, black, with silicone grease etc. Base current of TR1 will be 1.000mA/50 = 20mA. Say we allow another 10mA or so through Rb' (= 560 ohms) in fig. 14, so the total collector current of TR2 is 30mA; trace it out yourself. Power across it is then 12V x 0.03A = 3.6W, and it would be reasonably convenient to use a transistor for it similar to TR1, but with say 5 sq. in of heat sink. Since the collectors of both transistors go to the same place, the same sink can be used, and for example the one advertised by Fietz in the October and December 1969 EEBs would be quite adequate; its 56 sq. in (total) area is about triple the minimum mentioned here, and would be nice so that the transistors would not get particularly hot.. Base current of TR2 would be 30mA/75 = 4.0mA, which is now not particularly much for R1 to handle; 25mA of bleed through R1 would suffice (R1=1K).

If load were only say 10mA, power dissipated by TR1 would now be only 12 x 0.01 = 0.1W, and any 500mW transistor would do, e.g. 2N3638, with no heat sink, or perhaps only a "cogwheel" type sink attached. With a current gain for TR1 of about 30, collector current of TR2 (using similar reasoning to above) would be less than 1mA, with collector dissipation less than 10mW; any small transistor would do, like 033 or AY1101.

I have not used the basic formulae here (e.g. p.17, 19 last month), with elegant substitution in scientific manner, but rather the above more rambling discussion, because that is the way that I actually do it. I don't sit down and work out the various formulae, or look them up; too much trouble. I only know E = IR and Ic = h_{FE}Ib, and of course P = EI. From these, everything can be worked out by common sense.

Short Circuit Protection

In Part I of this series I showed how fig. 3 circuit could automatically protect itself against output short circuits. This occurs because the voltage regulation at the base of the transistor is poor when subjected to d.c. loads. The automatic protection feature is retained as well in fig. 10, if Rb is large enough, but it fails in fig. 14, because R1 provides a 'stiff' voltage at the base. Output short circuits will pour vast quantities of current through the transistor(s), with much gnashing of teeth (yours). What to do? There are several possibilities:

1) Use the Crowbar type protection. Crude but effective although somewhat complicated. When you short the output a special component (usually an SCR) shorts the supply in front of the regulating transistors, and blows a fuse.

2) The Latching Type. When you short the output, a special circuit turns off the regulating part of the supply, or limits its maximum power dissipation automatically. Although the circuits can get involved, these are the best general ways of doing it.

Both of these methods are discussed in the list of References which will appear as Part III of this series. (A simple method is described in Popular Electronics, March 1970, p. 54)

3) Put a resistor (which I shall here call R_S) in series with the collector of the series-regulator transistor (e.g. TR1). Even cruder, and remarkably effective -- up to a point. I wish to say a few more words about this third method. In addition to limiting the short-circuit power dissipation of the transistor to a reasonable value, R_s also reduces collector-emitter power dissipation under normal working conditions. This follows logically, since a given current drain will produce some drop across R_s and some across the transistor (where all was across the transistor previously). This allows a smaller transistor power rating to handle a given current output.

As with all good ideas there are limitations to this. There is a minimum voltage (e.g. about 1V) which must appear across the transistor (e.g. TR1, TR2), or it won't work. It takes a little more (e.g. 2V) for it to work better; see the characteristics curves of Ic vs Ec for any transistor.

If you insert R_s, collector-emitter voltage (E_{ce}) will decrease (for a given value of load curr-

(continued on p. 40)

* Owing to nonlinearity, current gain can be different at different collector currents, and any practical designs should be based on actual gain. This can be measured easily at real current levels by a simple test setup described in the article "Transistors on Computer Boards", by R. L. Gunther, Amateur Radio, December 1969. The circuit is one developed by an EEB Associate, Les Yelland, to whom I give full credit.

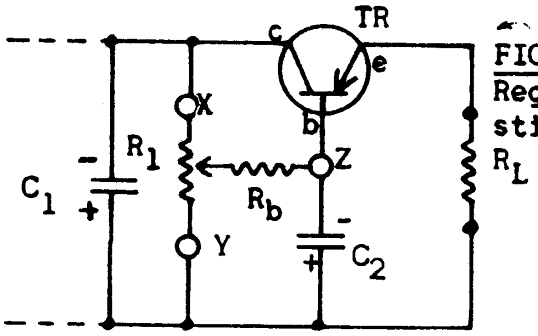
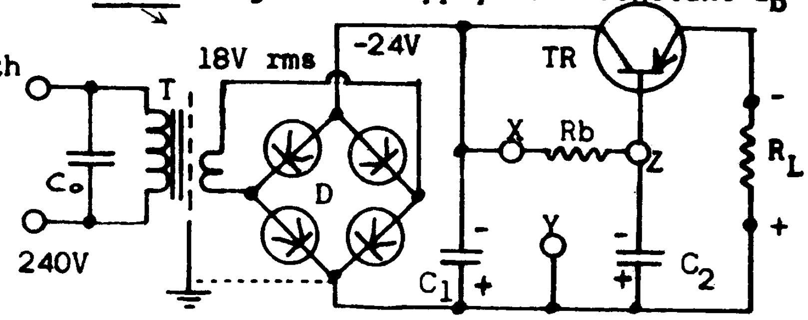


FIG 10:(left) Regulator with stiff E_b



FIC 3: Regulated supply with constant I_b

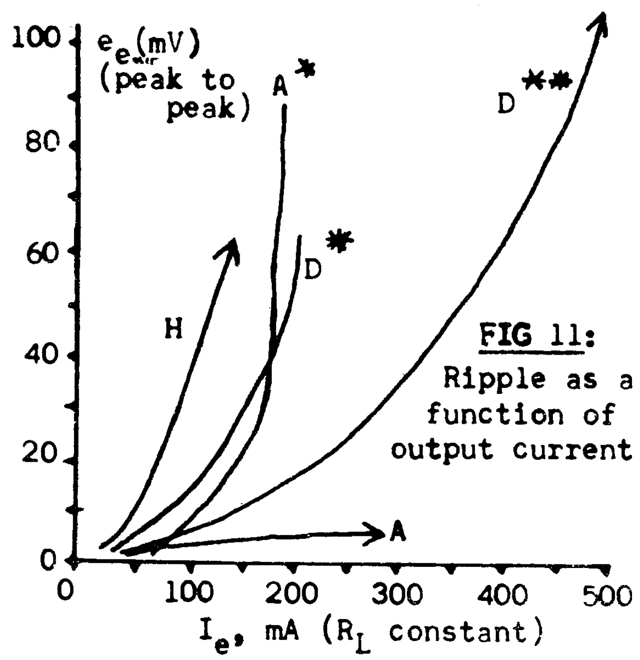


FIG 11: Ripple as a function of output current

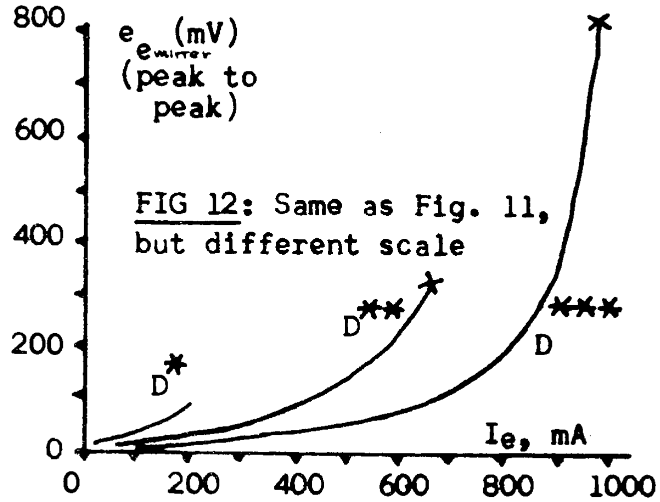


FIG 12: Same as Fig. 11, but different scale

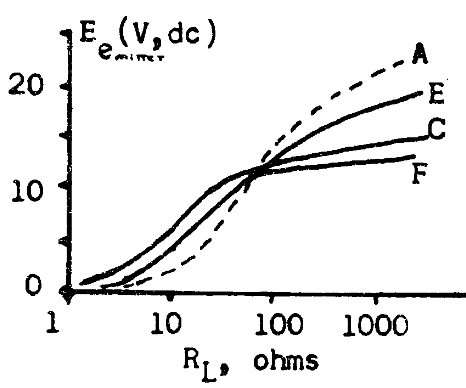


FIG 13 (left): Emitter voltage as a function of load res.

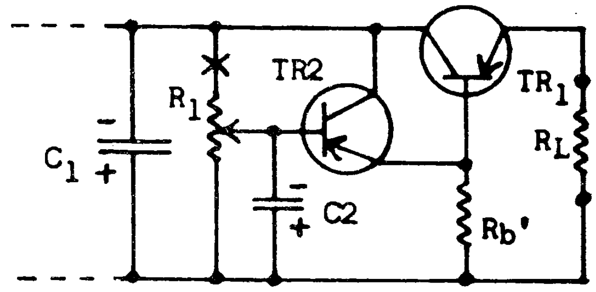


FIG 14: Regulator with amplified base bleed; lower ripple.

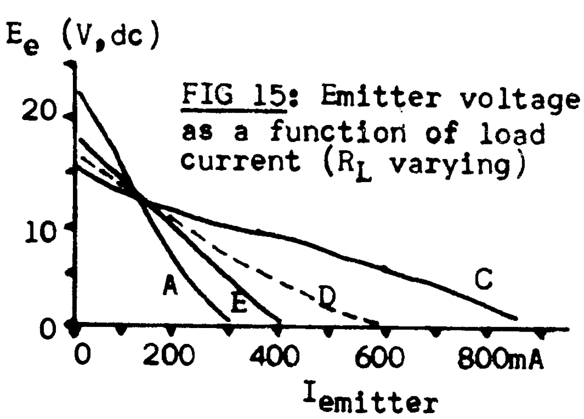


FIG 15: Emitter voltage as a function of load current (R_L varying)

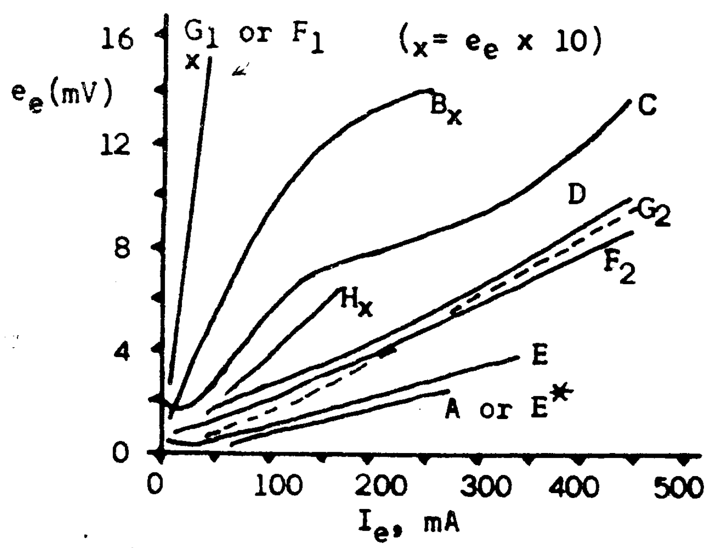


FIG 16: Output ripple as function of load current

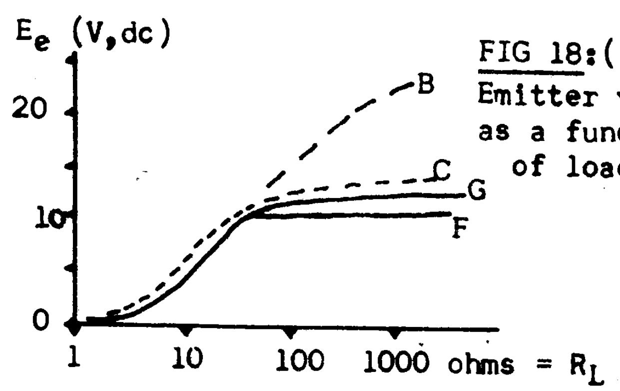


FIG 18:(left) Emitter volts as a function of load res.

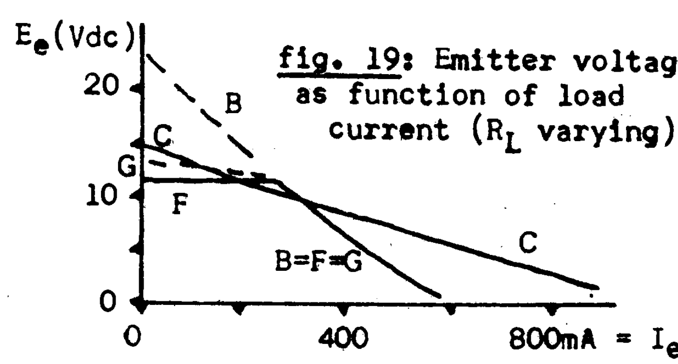


fig. 19: Emitter voltage as function of load current (R_L varying)

ent). If the load is too high, this E_{ce} will decrease too far. As series resistance, R_s increases, maximum permissible I_L is reduced. The optimum value of R_s will depend on supply voltage from the rectifier, and the load current maximum. So, as a rule of thumb, you might increase R_s at maximum load current (I_L) until output voltage starts to drop, then use a bit smaller R_s.

But it is not even that simple. Remember that a transistor doesn't imitate a condenser exactly? If there is ripple in the collector circuit, it will get passed on to the output if the trough voltage falls low enough. How low? Where collector-emitter voltage falls below minimum. So you can see that R_s restricts the ripple-reducing range of the transistor, because the transistor (in any series-regulator circuit) reduces ripple by virtue of its amplification; if E_{ce} falls low enough it won't amplify. Another way to look at it is that TR1 is an emitter follower. If the base voltage is held constant, so will emitter voltage -- as long as TR1 can amplify.

Therefore the introduction of R_s will increase output ripple at highish currents unless additional power supply filtering (C1) is used. You could add another condenser at the output end of R_s, but this would be relatively an inefficient way to go about it. R_s has its uses, but one must face its limitations manfully (etc. as the case may be): Start with small R_s, and at maximum load current increase R_s until output ripple (observed on CRO or by ear) starts to increase appreciably. Choose a smaller value of R_s to install -- remembering that it has to dissipate all that power that the transistor now doesn't. It calls for an R_s of healthy power rating -- usually made most simply by winding your own out of oxidised resistance wire.

But this puts a lot of heat into your chassis, and that brings its own problems. Nothing is simple. A power supply designed around the series-resistor principle will be presented by Les Smith (VK2) in due course as part of this Power Supply series.

<u>Resolving ripple vs regulation-control</u>

To return to the original point, before the dissertation on power rating etc., fig. 14 is an improvement over fig. 10, because we have substituted TR2 for Rb, thus separating the bleed and filter functions. In fig. 10 the bleed was provided by R1, and hum filter by C2 working against Rb and R1; increasing Rb reduced ripple but worsened regulation. Now in fig. 14, the hum filter is essentially R1-C2 and the inherent constant-current property of TR2, while the bleed is TR2 plus Rb′.

R1 can now be made appreciably larger than if TR2 were not used, because it needs only to pass the lower base current of TR2, some 5% to 25% of Ib_1, depending on regulation desired. As curve E shows compared with D in fig. 16, this lowers ripple, because of the longer time constant of the filter R1-C2. Indeed it becomes comparable to that of curve A (from ckt of fig. 3) when R1 is increased from 10K to 25K (curve E*). But now in addition we obtain the improved voltage regulation shown by curve F (figs. 6, 7, 13), because we have separated the bleeder and filter functions of R1.

The bleed is provided by the current through TR2 and Rb′, and this can be increased considerably, depending on current gain of TR2; if necessary it is even possible to cascade more transistors in the same emitter-follower configuration, and each one stuck in front dissipates even less power..

Rb′ should have a value which draws 10% to 100% of Ib_1 at maximum output, depending on regulation desired. It should be noted, however, that the bleed current though Rb′, for a given amount of regulation, does not have to be nearly as high as though TR2 were a resistor, because the transistor, TR2, is a <u>constant current</u> device. For the same reason, the high ripple at the collector of TR2 does not appreciably affect the output, because emitter current of TR2 is controlled almost completely by its base. Remember that a transistor behaves much as a pentode valve, and collector (therefore emitter) current is largely independent of collector voltage. And since the emitter of TR1 (in parallel with Rb′) acts as an unbypassed emitter load for TR2, the effect of variation of Ib_1 is resisted by the usual degenerative feedback inherent in the emitter resistor of an emitter-follower. It could be noted that an additional filter condenser could be placed across Rb′ to lower ripple still further, but whether this is worth the trouble will depend on the current gain of TR2 and the amount of ripple permitted. There may be some disadvantage in adding such a parallelled capacitance because of behaviour of the regulator to high frequency components of load variation, but this can be resisted by a small (e.g. 1µF) condenser placed at the output of TR1. The phenomenon of dynamic regulation involving various frequencies of load current will be discussed in a forthcoming <u>EEB</u> article.

↳ May 1970

When to be elaborate

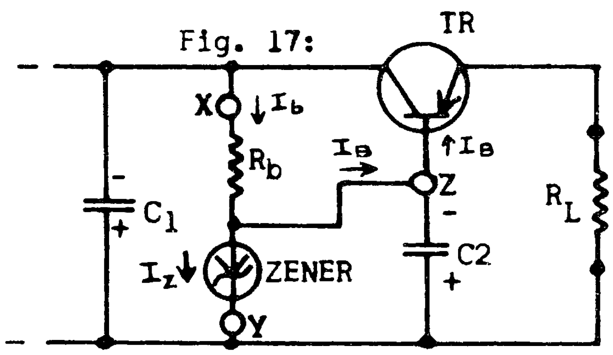
Thus, for smooth voltage control with fairly good regulation and low ripple, the circuit of fig. 14 is better than fig. 10. It can be made still better by inserting more cascaded emitter-followers in front of TR2, or by inserting a resistor at point "X" and putting a zener diode across the potentiometer -- thus better stabilising the supply against mains voltage variation. Still lower ripple is obtained with fig. 17, or better regulation with fig. 20, still better regulation and lower ripple by various modifications of fig. 20, still better by adding more amplifiers (e.g. the conventional emitter-coupled configuration, etc.), and so forth.

When is a given degree of refinement necessary? One of the main points of this article is to point out that it is often not necessary to have nearly as elaborate a power regulation system as the books indicate. It depends on the amount of ripple and of regulation you are willing to tolerate, how much the load varies (and at what frequency), how much the mains supply varies, whether there will be wide temperature fluctuations in the environment, etc. For most experimenters, hi-fiers, and amateurs, a simple circuit, based on one of the circuits described here will suffice. The actual choice of which circuit to use may be a thorny one, but figs. 14, 17, or 20 will suffice in most cases. Where simple condenser-multiplication is desired for a load varying only at an audio rate, even fig. 3 is adequate. Or, for example, fig. 3 is fine for a load which is constant but which requires good d.c. With an understanding of the basic idea of these circuits, you can always improve a given circuit as necessary to achieve the performance required.

Zener Control

When a supply is to be used with fixed output voltage, the circuit of fig. 17 gives remarkably good results, for all its apparent simplicity. It gives very good voltage regulation (curve F in the figures), with low ripple, low complexity, and relatively small bleed in the base circuit. For lower current drains, indeed, you could omit TR entirely, and take your output from the zener (and C2). The transistor allows the use of a much smaller value of zener power rating, for a given load. Thus, fig. 17 can be considered a "zener multiplier", as fig. 3 was a "condenser multiplier". But fig. 17 has the advantage that the output is excellently stabilised right down to d.c. as well. Its only disadvantage is that the output voltage is fixed. But if you wanted a general purpose supply over a range of voltages, you could save yourself quite a lot of trouble by using this circuit with a multi-pole switch and a variety of zener voltages (and values of Rb). Most of the time you do not need continuous control, but only a range of voltages. By recognizing this you can get good performance without fuss.

Fig. 17:



For design, Rb should be chosen to give a zener current of at least 100µA when the load is heaviest, and the zener diode should be chosen to dissipate sufficient power when the load current is least. This, again, is not a difficult calculation if you remember that as far as the zener is concerned, the transistor base looks like a resistor whose resistance is current gain times load resistance: $R_B = h_{FE} \times R_L$, where R_B is my symbol for the apparent base resistance. The problem then resolves to a simple one with voltage dividers.

If the resistance of the base is represented by R_B, with current I_B, and if the current through Rb is I_b, then: $I_b = I_z + I_B$, where of course I_z is the zener current. Then $I_z = I_b - I_B = I_b - (I_L/h_{FE})$, where I_L is load current, through R_L..... To save us from a sea of algebra, let us consider a typical example:

Assume: TR = OC26 or equivalent
h_{FE} = 25 at Ic = 1 Amp, 40V @ 0.1 Amp.
Ec = 18V at 1 Amp, 24V @ 0.1 Amp.
Max I_L = 1 Amp, Minimum = 0
E_z = 13V (a so-called "12V" zener)

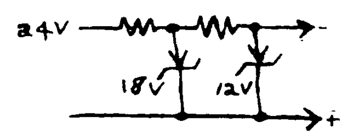
Then: At maximum load,
$I_B = I_L/h_{FE}$ = 1000mA/25 = 40mA = I_B
$I_b = I_z + I_B$ = 0.1mA + 40mA = 40.1mA
$E_b = E_c - E_e$ = Ec - Eb (approximately)
= 18V - 13V = 5V.
$R_b = E_b/I_b$ = 5V/40.1mA = 120 ohms, about.

At minimum load, e.g., 0mA, the current which was going into the base must now go into the zener: $I_b = E_b/R_b = (24 - 13)/120$ ohms = 92mA. (The extra 52mA comes from the higher Ec occurring without load.) Then, power dissipated by the zener is: P_z = 92mA x 13V = 1.2W maximum. A BZZ23 or OAZ231 would serve admirably, or whatever they call them nowadays; they have a 1.5W maximum working rating. I should make a special note here to our American readers: If a part is specified to dissipate 1.2W, the American value to count on is 10W, or perhaps 5W for the part rating, depending how hot you want it to run. Australian and British readers can buy the 1.5W zener as long as there is plenty of air around it; safer to tie a "flag" type heat sink to the diode, or even to tack it down to the chassis.

For the same circuit, if the maximum current were, say 300mA load, as for an OTL medium power amplifier, I_B = 7.5mA, I_b (max load) = 7.6mA, E_b = 10V, R_b = 1.2K; I_b (min load) = 9.2mA, and Pz = 120mW. So you might use an OAZ273 (0.23W, 25mA max rating), if you choose a 13V one from a stock -- because the Ez tolerance allows values from 9.4V to 15V. Or an OAZ242 (5.6V, 5%) in series with an OAZ245 (7.5V, 5%). The actual number doesn't matter, and you can ascertain your needs in co-operation with a catalog -- or what the local store has to offer. It is, in my opinion, more sensible to buy a fistful of zeners at each voltage range, test them yourself (say, at 1mA), and label each with its exact voltage. You may end up with enough zeners to last for years, but you will be pleased to be able to depend on them when you need them. I decided on this when I bought a "12V" zener once, got it into the circuit, and found to my horror that it was actually 17V. Beware of bargains -- or at least test them before using.

It should not be overlooked that the base-emitter junction of silicon (not germanium) transistors usually makes an excellent zener in the 6-7V range, with a power rating of perhaps 300mW for ordinary small types. This can be useful when you salvage transistors having only a defective collector-base junction, or indeed, when the transistor costs less than an equivalent zener diode. But you should measure the zener voltage of the reverse-biased base-emitter junction (at 1mA) to make sure. Surplus silicon transistors are not always reliable for this service, particularly when they test at Ez of 10V or more.

Note from fig. 16 (curves F1 and F2) that for reasonably low ripple, it is still necessary to use C2, even with the zener, because the condenser has appreciably lower dynamic impedance (e.g. 16 ohms for 100uF at 100cps) than the zener (e.g., 200 ohms). If you use a zener rated at a higher wattage, of course the dynamic impedance will go down, but the cost will go up; it depends on the degree of voltage regulation (and ripple) you want. One neat trick is to cascade zeners to achieve a remarkable degree of regulation: This doesn't necessarily improve the regulation with respect to <u>load</u> variation (that depends on zener impedance and/or C2), but it does wonders for supply variation, and that includes ripple.



In all of these discussions it is assumed that you have measured the d.c. supply voltage over the range of loads likely to be used, and the gain of the transistor similarly. This is not difficult (it has been described in <u>EEB</u>), and leads quickly and easily to the design of a suitable power supply. It is gratifying to design one, build it, and have it work as planned. And the only tools you need are Ohm's Law, the formula for transistor gain, and a smooth slide rule. The simple fact is that it will often take less time to do this than to build at random and spend many hours trying to get the circuit to work by trial and error -- or to take a similar one from the Literature and get it to work the way you wish.

Brain is more efficient than muscle. Sometimes. (To be continued)

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

<u>RECIPE</u>: Ginger Beer without the "Plant".

Pour a bucket of boiling water on four pounds of sugar, 2 oz cream of tartar, 2 oz of ground ginger. Stir till dissolved, put into a five gallon cask and fill it up with cold water, add a teacup of yeast and a tablespoon of lemon extract. For those unfortunates who do not have a cask, the mixture may be bottled, but be sure to tie down the corks (or use crown caps). As time goes on, the pressure builds up in the bottles, and this may be determined by head developed when they are opened. When it becomes alarming, drink the remaining bottles, or put into a cold fridge.

QUOTE WITHOUT COMMENT

"In summing up, let's say that the Editor of this type of publication should never lose sight of the fact that he is writing to a group of whom he has personally met but a scattered handful. He must present his material in a manner which will please those of all age groups, all political, religious, race, and other distinctions and above all, not embrace any of these subjects whereby the least taint of controversy may appear evident."

-- H. Pyle, W7OE, in Amateur Radio News Service Bulletin
August 1969, p. 17 (Discussing "Mail Order Club Paper")

LETTER: The Uses of EEB

I should like to say that you are better served by using offset for your journal. It is, however, not the look of the thing which makes EEB what it is; it is the way it is all written -- not presented. If you hold exactly to your present policies of presentation and editorship I could see no answer to any challenge: your present way, the magazine obviously just happens. If you start polishing it all up you will finish-up with a hard-to-maintain standard which will take many hours to square-up, and to have it all just-so will become the expectation of your readers.

On the other hand I don't agree with W7OE's prescription ((see above Quote)). If you say just the right thing, your paper will have no sting. You don't have to say, "I hate ....." But at the same time you don't have to be a yes-man. I think that if you set out to dodge "...the least taint of controversy" you will be doing yourself a disservice, or rather EEB a disservice. Yet, to use Pyle's words again you can do all this "...in a manner which will please those of all age groups.." You know what I mean. Tease a bit, taunt a bit, tantalize. And please criticise a lot. By doing so you will draw wrath and argument; that keeps things alive!

-- R.A. Tarrant, Pymble, N.S.W.

((I'm certainly glad that all that comes naturally to me; it would be an awful chore to manufacture it. OM Tarrant has several more things to say in complimentary vein, for which we thank him -- and also the rest of you who have written with your various frank comments. -- RLG))

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→ cheer up, it's still April. The April issue should be out in about a fortnight.

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THE AUSTRALIAN EEB

→ COMMONSENSE ELECTRONICS

APRIL 1970 VOL. 6, No. 3 P. 45

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CONTENT:

NEXT MONTH: May
-- Regulated Power Supply
-- Another Windscreen Ckt
-- FET Q-Multiplier
OTL Power Amp. Design --
Noisy Pots --
-- Review
-- Fun & Games

NOTE: These plans are always tentative. Anything can happen from one month to another.

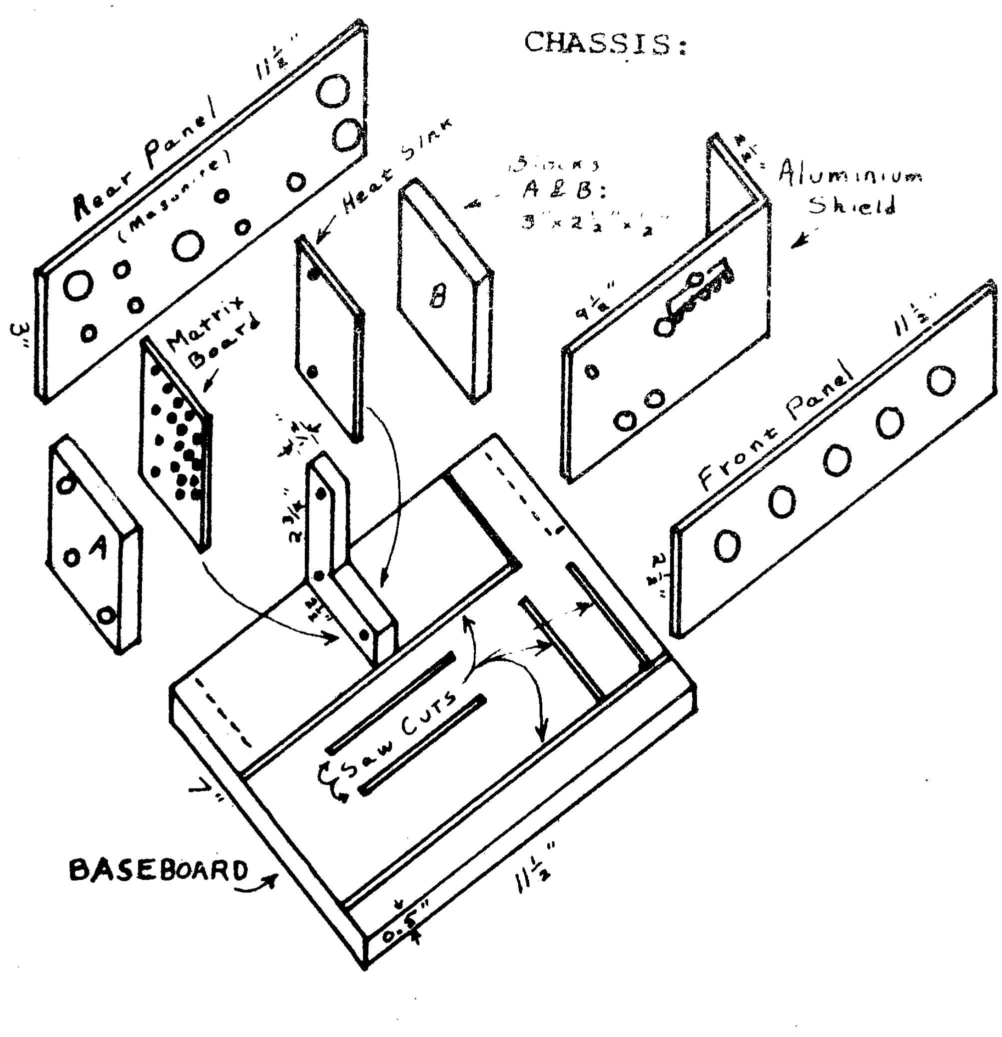
A NICE HI-FI AMPLIFIER SYSTEM, Part II -- A. Whittingham (VK2)

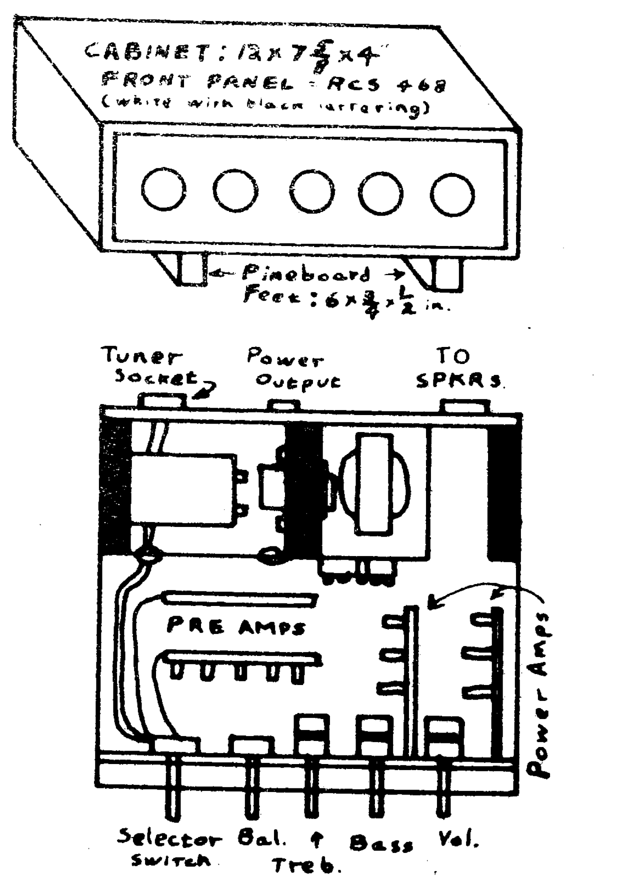
In last month's article was described the preamplifier, and next month the whole situation of simple OTL output amplifiers will be examined by various people. The fact is, however, that my system uses the simplified Fairchild 3W thing, and I find it satisfactory. This article completes description of my system by presenting a few of the mechanical details of putting it together. Most EEB articles do not include this sort of information, but it can't hurt once in a while as a general guideline.

The diagrams presented here are reasonably self-explanatory. The cabinet is made of Masonite glued together without using nails. Selley's AQUADHERE PVA wood-working glue works well. It will glue nearly anything, but note that it is a pressure, not a contact cement. Use plenty of glue. Hold the cabinet together with two bands of string right round, and screwed tight with a stick. After about 15-20 minutes when glue is setting, square it all up and leave it overnight. DON'T TOUCH until morning. Round all corners off, sandpaper and paint with oil-based blackboard paint, which dries a dull black. Use at least 2 coats, and rub back with a soft cloth when dry. Use a bit of tooth paste as cutting compound if no proper compound is available.

Now just a few words about internal construction, as illustrated in the diagrams. The base, blocks A & B, and L-shaped bracket are made of 1/2 inch Pineboard. Make saw cuts 1/8" deep for the aluminium shield, and the four modules. The front cut is made 1/4" deep and wide enough to take the front panel on which the controls are mounted. This panel is set back 1/2" from front of chassis so that only the control spindles poke through the front of the cabinet. The chassis slides into the cabinet like a drawer and is secured by two wood screws from underneath, and hidden in the feet. When assembled, drill 1/2" holes right through from underneath for vent holes. The rear panel does not reach right to the top of the cabinet, so allowing warm air to escape. The rear masonite panel is flush-mounted with glue against the rear of the chassis.

When completed with the front panel and white and gold knobs this unit has a really professional look. In fact, friends found it hard to believe it was not a commercial kit ((High praise...? -- Ed.)). Controls from left to right are: Selector Switch, Balance (for stereo), Treble, Bass, and Volume.





SCR PULSER -- L. J. Yelland (VK3)

The device shown in Fig.1 is a simple one which may be used as a low frequency pulse generator or slow sweep for an oscilloscope. The output signal is shown in Fig.2. The operation of

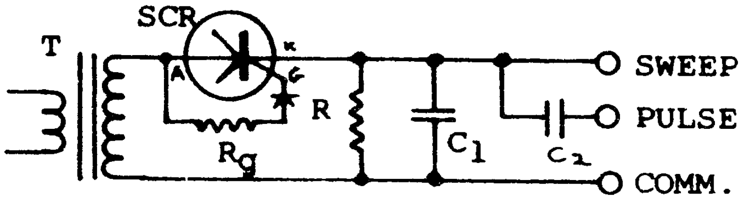


FIG. 1: The Pulser

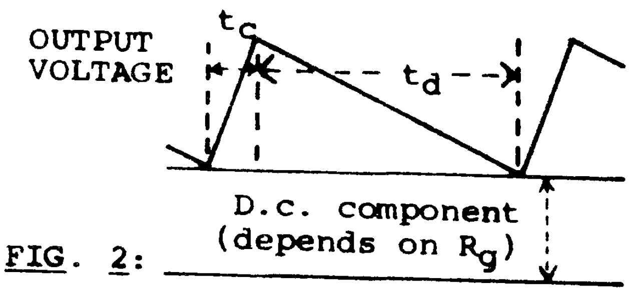


FIG. 2:

this circuit is rather interesting. Suppose that the secondary of the transformer, T, gives 7.1V RMS, therefore 10V peak, and that the SCR triggers at 1mA. Make $R_g \leqslant E_{max}/I_g$, where E_{max} is the peak secondary voltage, and I_g is the gate current to fire the SCR. In this case, we make R_g a bit less than (10V/1mA) = 10K, or 8.2K, so that the SCR only triggers when the input potential approaches E_{max}. When this happens on the first positive half cycle, condenser C_1 is charged rapidly through time, t_c, raising the cathode to 10V, and the SCR turns off when input voltage falls below about this value. This leaves C_1 charged; it discharges slowly through R during time, t_d. During the negative half cycle of the input voltage, the SCR acts as a simple back-biassed diode, and will not conduct. Note, however, that this is the same case as a half-wave rectifier with condenser input filter, and the PIV rating of the SCR and diode must be at least <u>twice</u> the peak input voltage (plus 50% for safety).

Thus, by suitably arranging values of R and C_1, the decay time can be controlled; t_d will, of course, also be affected by the load. The repetition rate will be a maximum of 50cps, and a minimum of anything you like, depending on values of R and C, and load. If more power is required in the output, C must be increased. If the load is a grid, C can be made small. If R is made, say 10 Megs, it will take an interminable (sic) time before the cathode voltage is again reduced to zero so that the SCR can be triggered again.

The rise time, t_c, is practically that of the SCR, because it is affected only by transformer leakage reactance and IR drop; the latter will be low if load light.

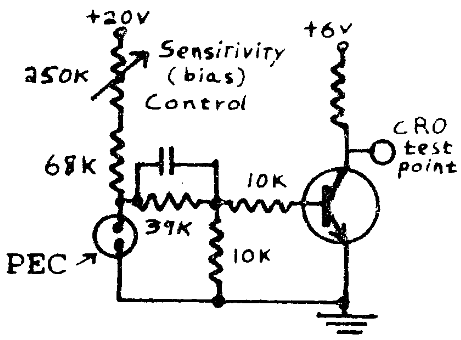
If it is desired to have a linear decay trace, e.g. for CRO sweep, it is not practical to use all of E_{max}, because the tail of the curve is drawn out. If R_g is made, say 5K in the above example, to use 1/2 E_{max}, the decay curve is much straighter; as with all sawtooth sweep systems, the less of the trace you use, the more linear it is. For really high quality you might want to use only 0.1 E_{max}, and supply an amplifier. But the interesting thing about this circuit is the fact that since an SCR (like a thyratron) is a high voltage device, you could use an HT supply, an HT-rated SCR, and still obtain appreciable voltage output even though only a small portion of the discharge cycle were used. Note, however, that there will be a certain maximum peak current which the gate of the SCR will withstand, and this must not be exceeded -- therefore the value of R_g must not be too low. Consult characteristics sheets for ratings; to a first approximation, 1A SCR's have peak max I_g = 100mA, while 4.7A SCR's have a value of 2Amps, absolute maximum. With a low value of R_g, the SCR will trigger some time before E_{max} on the first positive half-cycle, but thereafter will trigger at the peak each time; the output will be reduced, because the SCR will trigger again at a higher decay voltage... If it is desired to retain the slow sweep but eliminate the d.c. component, output may be taken from the 'pulse' terminal if C is large.

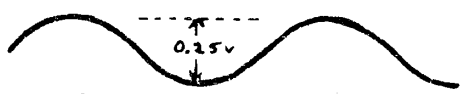
In addition to a slow CRO sweep, output may be taken from the 'Pulse' terminal, which will result in a differentiated wave as shown in fig. 3 (p. 48). The pulse so obtained will be sharper and lower amplitude, as C is reduced, or as load is increased. In this application it is excellent for driving counters, or as a "ding-bell" when fed via a relay into a bell (with contact breaker shorted out), or for a slow flashing light.

A typical application of the oscillator is shown in fig. 4. It was used to test electric counters, but could be used for any application which requires control by a relay. The relay is a "PMG" type generally available from disposals sources. Repetition rate was two per second. Parts values are uncritical, though Rg may want to be adjusted for individual SCR's (<u>Continued</u> bottom p. 48):

WHEN NOT TO INTERPRET CRO CURVES -- by a Fully-qualified Uninterpreter (VK3)

The input circuit is as shown in the diagram. Bias is achieved through variable resistance to 20V and modified by any leakage through the photoelectric cell ("PEC"). The CRO is connected to the collector as shown, indicating rectification ripple in the HT supply when in the quiescent state. This is the top curve. By adjustments to the bias pot, or by masking light on cell partly, the other two curves are obtained. In the case of the lowest one, the transistor is obviously saturating where the curve flattens out. Therefore one concludes that the middle curve, with the spikes given by less bias, was caused by "bottoming" of the transistor to its critical cut-off point, and that oscillation about that point caused the spikes.

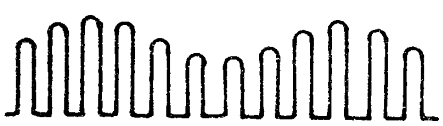




Amplified a.c. ripple (100~), near max sens'r.

Less bias than above.


More bias. Tr saturates here


Normal count pulses (1.75V, Max)(½ scale)

Sound reasoning? Perhaps, but WRONG. This situation arose on an actual engineering design, and is one more illustration of the fact that in electronics nothing is simple.

By apparent logic one can arrive at all kinds of conclusions to explain phenomena, but when one puts them to a practical test (when this is possible), the logic often fades, and then where do we place our fulcrum?

In the equipment under test, the mains transformer had a 0.01µF/1000V condenser across its primary to lessen mains transients. This was faulty to the extent that, at the peaks of the a.c. a very small ohmic current would flow for just an instant of time. This caused transients to appear in the output, but it was so small that it only appeared at the most sensitive setting of the transistor bias.

On removing said condenser, the spikes disappeared. Presto. This defect was discovered due to the noise in a nearby radio receiver when the counter was turned on. The noise disappeared when the condenser was removed. So the coupling condenser has now been removed from the PEC circuit, and it is again direct-coupled so that slow passages of the mask across the cell will cause counts.

It is indeed possible to perform all manner of wonderous Automatic Operations by the use of electronic sensing and feedback systems, but the more cleverly your device performs its tricks, the more talented it becomes at developing sophisticated "bugs". They can only be chased by alternate doses of testing and deep thinking. Then more tests (of the right kind), and more thought. The latter is the hardest part, and in consequence many an experimenter wastes hours or days mucking about with ohmmeter and soldering iron, while a bit of doodling and Ohm's Law might reveal the answer.

SCR PULSER (continued from p. 47):

SCR is 0.8A type, 1mA gate sensitivity, also uncritical (NOTE: American rating for an 0.8A SCR is "1.6A"). Figures 3 & 4 are shown here:

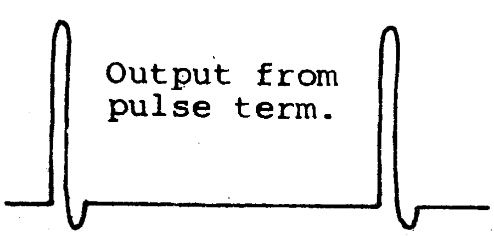


FIG. 3

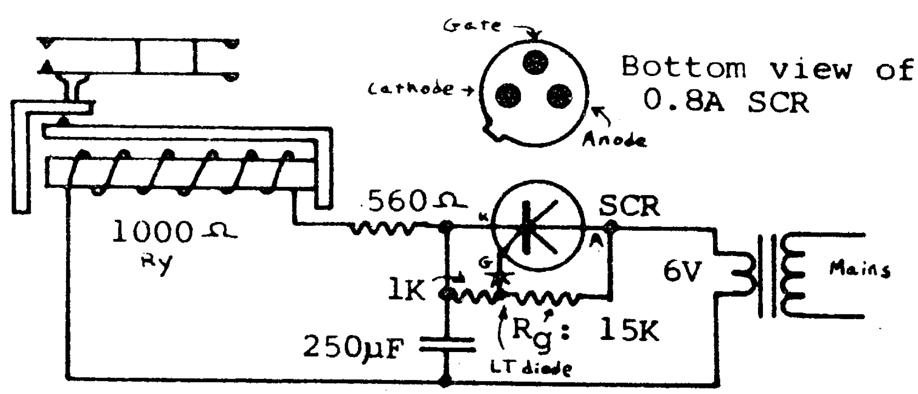


Fig. 4: Relay control by pulser

ANOTHER SERIES-TYPE TRANSISTOR IGNITION

-- K.H. Vieritz (VK4)

I have been using for some time a transistor-switch ignition system on my Morris Elite, rather like the circuit shown by L.E. Thomas in the March 1970 EEB, but slightly simpler. The one I use came from Heathkit, and the circuit is shown in Fig.1 here. The transistors are only "80V" rated, and the zeners 56V 1W, but the coil is a Mallory which is stated to have a specially high turns ratio. Presumably a similar circuit could be used with a conventional coil by using transistors with higher voltage ratings (say, 2N1100, OC28, etc.) and zeners to match; perhaps yet one more transistor could be added in series, in similar configuration.

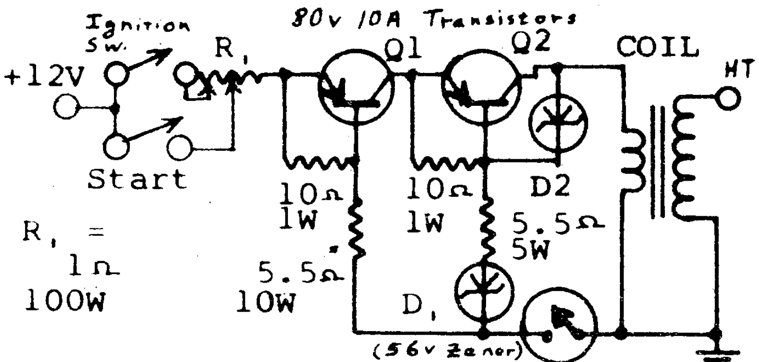
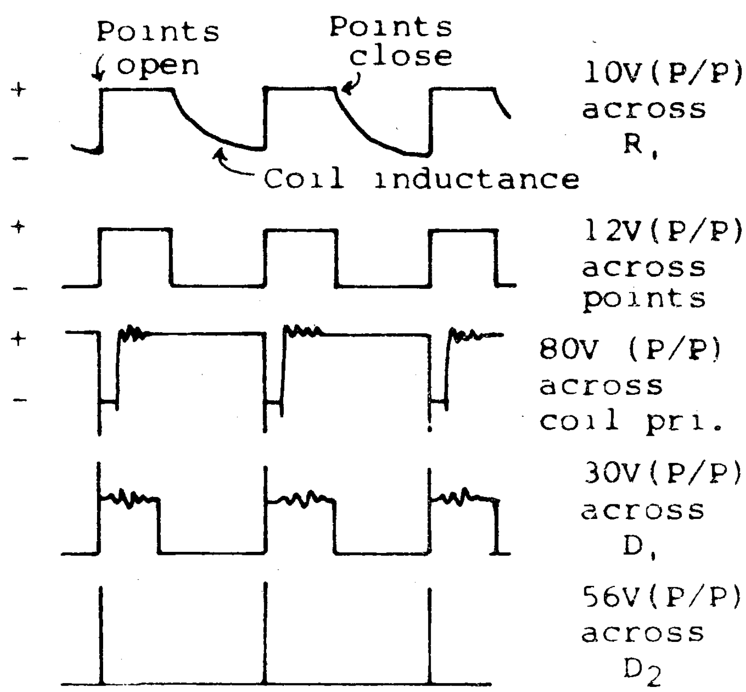


FIG. 1: The Circuit



Old-time readers of EEB will in fact remember that late in Volume I (1965), was presented a nice simple transistorised ignition by G. Van Leuven. The one shown in Fig.1 is essentially the same, but it is protected by zeners and has two transistors in series for more output. It might be of interest to examine the waveforms from this circuit. Judging by the trace across D1 and D2, both transistors must be functioning, although the two traces are entirely different. Apparently D2 turns on Q2 at 56V, and the remainder including the arcing time of the plug and the ringing time of the coil appear at the base of Q1.

The points current was measured at 700mA with this system, which is some tenfold improvement over the conventional value with ordinary coil. The points gap I am using is 0.01", with gap for the spark plugs of 0.04".

Now I did have one curious problem with this system, and my solution is undoubtedly going to startle some readers. After a few hundred miles of running with this system, I got considerable migration of metal across the points. A small crater soon appeared in one contact, and a corresponding lump on the other. Certainly this was also happening before on the standard ignition, but only much worse. This was my main reason for changing to the T.I., to get away from cleaning the points every few thousand miles to keep top performance (and of course to get the better high-speed performance from the T.I.).

My good wife suggested, "Isn't there some other metal you could use for points?" To cut a long story short my car has now done about 40,000 miles quite successfully on a set of silver-tipped points.. I simply ground off the rivetting of the tungsten points and punched them out and rivetted back silver tips removed from an old relay.

Experts have told me that silver won't work, it will hammer out, break up, but as yet the car hasn't missed a beat. Last inspection of the points showed barely discernable migration of the silver, and some wear on the fibre rubbing block. If the fibre block holds out I can't see why my points won't see this engine out. After all, reputable starter manufacturers use a contact of this size in a starter suitable for a 5HP three phase motor which could have a starting current of 40A, and they guarantee 10 million operations.

Like everyone else the EEB Editor was appalled by the use of silver points and suggested a current amplifier, but why bother? Since my system works in spite of what all the experts say, I think I will just have to hammer along on silver points to see what happens.

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

What to do about Burnt Saucepans

This is probably the most practical item ever to appear in these pages. To fix a burnt saucepan, melt fat in it, and keep it melted until the burn softens.

THE LEGAL POSITION ON LIGHT-BEAM COMMUNICATIONS -- Staff

The comment at the foot of p.22 of the February 1970 EEB prompted the following questions to be asked of the Postmaster General's Department:

1) What is the Departmental ruling on the use of wide-band (Full Visual) communication using audio modulation as regards use by Amateur Radio and non-licenced personnel?
2) What is the Departmental ruling on the use of Narrow Band Laser Communications?

The answers as reproduced here have been paraphrased heavily from the legal form, in the interests of intelligibility. The position is that Section 6 of the Wireless Telegraphy Act forbids:

A) The building or use of any equipment for wireless communication, transmitting or receiving -- unless duly authorised by licence or permit.

B) The actual operation of such equipment for wireless communication, transmitting or receiving -- unless duly authorised by licence or permit. Penalty under the Act: $1000 or imprisonment with or without hard labour for a term not exceeding five years.

By communication is meant any or all systems which use electricity for communicating messages without a continuous metallic connections (e.g. see Mullard Educ. Service Bulletin, Jan 21, 1970). Note, however, that the Department interprets "electricity" as meaning essentially any form of electromagnetic radiation, thus including photophones and torch light CW. We note that the latter may be defined as Carrier Wave Modulated Broadband Emission in the 5×10^{-5} cm band (or 600 THz, where 1 THz = One million megacycles per second).

This interesting situation arose in 1966 when radio amateurs were restricted to a maximum frequency of operation of 22,000Mc, where previously they had had a blanket cover for frequencies above 30,000 Mc. Now, the more inclusive regulation even covers Laser beams, e.g., when used for surveying. It certainly covers visual communication, even without the use of electricity (e.g. by sun flashes with a mirror). It even covers passive networks such as in a Crystal Set.

= =

Lest you think that this situation applies only to radio waves or light beams, the whole Wireless Telegraphy Act is worded so loosely that it may be interpreted to cover everything else, inasmuch as the Department has a complete monopoly over communications.

For instance, the restriction could well cover communication between two boys with tin cans and taut wire, or by any other method you may care to devise. It would seem, therefore, that this also includes loud-hailers, lighthouses, car headlamps flashing bright to dim (transmission), photocell-operated automatic headlamp dimmers (receiving & transmitting), house lights flashing to a neighbour, the action of opening your eyes (setting up and operating receiving apparatus of electromagnetic waves using electricity), or verbal conversation between individuals. Note, however, that under emergency conditions where human life is threatened, any form of communication available can be employed. NOTE: The use of automobile horns is covered (in some States) by local police laws, not by the Wireless Telegraphy Act.

This matter becomes rather involved, since the Law restricts communication across common boundaries (e.g., between your house and neighbour's), but not necessarily within your own property. It would seem that this signifies that it is quite legal to talk to your neighbour without licence or permit when he is on your own property, but that the use of energy-containing sound waves to communicate with him when he is on his own side of the fence is an offense unless covered by licence or permit by the Australian body which has an absolute monopoly of ALL communications by any means whatsoever. If said body protests that this is an absurd interpretation of the Law, we should not be quick to disagree, but it would follow only from a Law which was itself absurd, and could be interpreted absurdly by the Judiciary. Who, indeed, is to interpret where to draw the line on communications between individuals?

What hath God wrought?

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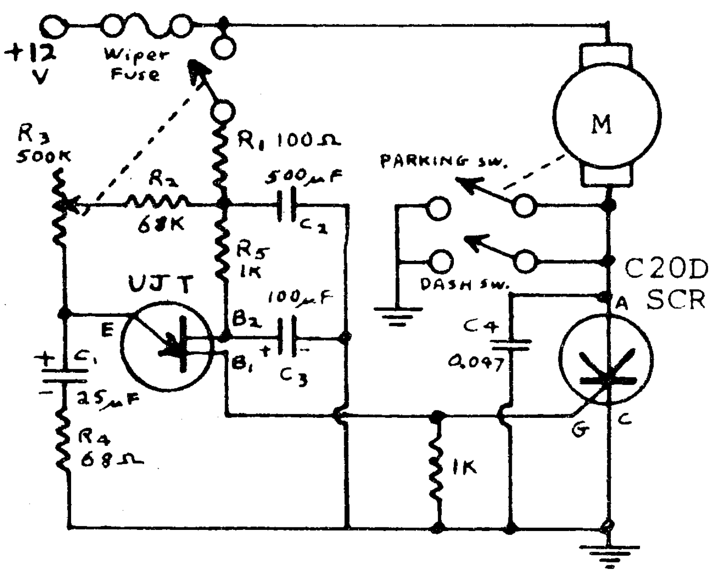
LETTER: Concerning C-D Ignitions

I have been using an SCR ignition circuit in my Honda 5800 for the last year; the only problem is that wear in the points change the timing, not surprising with 8500RPM, but annoying. I should like to replace the points with an electronic sensing circuit, possibly a lamp-photocell circuit, but I would appreciate any advice from anyone who has tried that type of device, or who has some ideas about it.

-- G. Cohen, VK3ZVG/T, 39 Quandong St., O'Connor 2601.

WINDSCREEN WIPER DELAY SYSTEM -- L.E. Thomas (VK6)

This circuit simply turns on the wiper at its regular speed, but with pauses between wipes. This is useful for spotty light rain which does not necessarily justify constant motion of the wipers, even at low speed. I have in fact seen several devices on the same general lines as this one, but none of them pay sufficient attention to suppressing the spike which occurs when the parking switch opens and closes.



In this case the whole unit is mounted near the wiper motor, and the control, R3 bearing SPST switch is mounted on the dash. This system is completely compatible with the original. When the Delay system is off, wiper control is effected by the usual dashboard switch. To operate the Delay, the usual switch is kept off, and the pot switch is turned on.

It is important that the pot be so connected that minimum resistance is in the circuit when it is first switched on, to reduce initial turn-on delay. The operation of the circuit itself is simple enough: The condenser C1 charges up to the trigger voltage of the UJT, thus triggering it and the SCR which then starts the motor. The parking switch inside the motor unit then comes on, keeping the motor on and turning the SCR off. When the motor has completed a cycle, the parking switch opens, and the unit is ready for another cycle of operation when C1 reaches the critical voltage, etc. C4 is to suppress transients, and C3 provides trigger current for the SCR when the UJT fires.

The EEB Staff are presently working on a modified circuit using regeneratively connected NPN + PNP transistors in place of the UJT, but have not yet perfected it.

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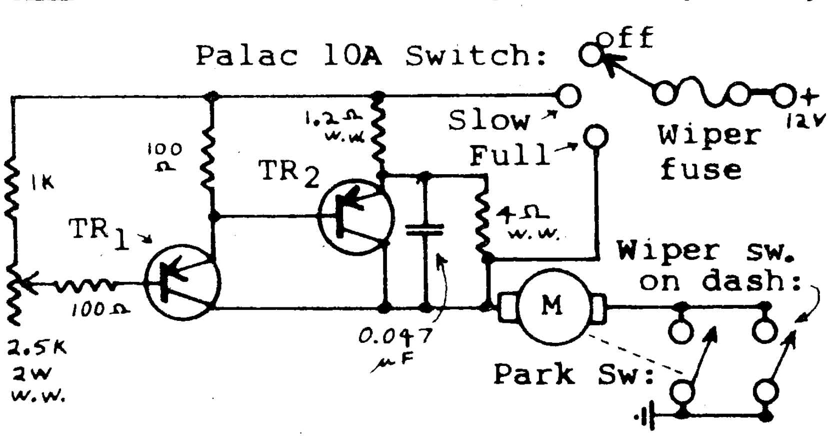
CONTINUOUSLY VARIABLE WINDSCREEN WIPER SPEED CONTROL -- R.L. Gunther & G.R. Johnson

We have, however, perfected a useful alternative system which controls the wiper speed continuously, as desired; it is good for light but persistent rain. The ideal system uses a switch which allows operation either normally, with delay, or with speed control. The delay circuit can be the one described above, or an alternative one using relays, which will appear in next month's EEB. The circuit below is spectacularly uninspired, since it consists merely of a common emitter stage acting as a variable resistor, and a common collector stage which allows reasonable current through the pot, R2. But it works, so here it is. The circuit is designed so that minimum speed is still fast enough to provide reliable operation, and to keep transistor dissipation down to a reasonable value. It is possible to use an emitter-follower configuration to feed the motor, but that has other problems. TR1 is a 2N1038 or any transistor rated for a couple of watts, and TR2 is an OC26 type, or 2N250 or 2N301 or any type rated for a half-dozen watts. Both were mounted on a Fietz-type heat sink (see Adverts, Oct & Dec 1969 EEB), which was ample.



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To Tan a Sheepskin

Soak skin in water till quite soft, then remove all fat and flesh. Half fill a kero tin with finely chopped wattle bark, fill the tin with hot water, and let stand for two days. Reduce liquid to the colour of weak tea, and put into a tub to cover the skins well. Turn skins every day, and when the liquid gets too weak, add more. Continue for about 3 weeks. Do not make the solution too strong, or it will harden the skins.

LT REGULATED POWER SUPPLY DESIGN, Part III -- RLG

The material I have been discussing in this series may well look familiar to a select group of people to whom a preliminary version was distributed several years ago, but here I have tried to organise the subject rather better. I must again emphasize that this discussion is by no means exhaustive; the subject of regulated power supplies is unbelievably vast, with a plethora of books and a constant supply of periodical articles about it. I attempt here only to look at a few of the very fundamental aspects of series-transistor regulators, and how they affect regulation and ripple. If you wish a good practical circuit, there are literally hundreds from which to choose; this series will finish with a typical list of references in which further information may be found. But in my articles you may find value in a direct commonsense approach; the important thing is to examine how each circuit piece affects (1) regulation, and (2) ripple (hum).

In the first two parts I examined the simple "capacity multiplier" circuit (fig.3), its advantages and its limitations -- not the least of which is the fact that the hum-reducing ability of any series-transistor regulator depends on the purity of the d.c. supplied to it. You know, it is rather like the situation with a refrigerator: it works very well in cold weather, and rather less well in hot. If you feed a series regulator with raw d.c., you will find that as soon as you draw some current the transistor runs out of collector-emitter voltage at the troughs of input voltage, and the hum appears at the output. So, a certain amount of brute-force filtering ahead of the regulator allows it to do its job quite a lot more efficiently.

I have also examined alternatives to the simplest system, described by figs.10 and 14, showing how good d.c. load stabilisation could be provided, while retaining reasonably good ripple-filtering, by isolating the base of TR1 from the stiff voltage source, and by use of an extra emitter-follower (yes yes, I know about Darlington, but it is still an emitter-follower). The trouble with fig.14 (Part II of series), of course, is the fact that as the R1 slider is advanced, the ripple is increased, because the resistance between C1 and the supply has been reduced. The simplest way to meet this problem is to insert a conventional one- or two-stage zener regulator at point "X" in fig.14, thus feeding R1 with a potential which is not only considerably reduced in ripple, but which also increases independence of the system from input voltage variations; in Australia that is no joke,* where the 240V mains have been known to drop to 180V or LESS during a day now and then. It is, of course, possible to feed R1 from the emitter of TR1, rather than its collector, as Horwitz and others have pointed out, but that brings its own problems. Even the simplest design is a maze of compromises, and that is what makes this subject so interesting.

When a zener is used, it can be valuable to shunt it with an electrolytic condenser, to reduce ripple still more, because a normally small size zener does not have as low an impedance as a goodish-size electrolytic at 100 cps. There is a limit to this, though, because even if you feed the base of TR2 (fig.14) with pure d.c., you will still get some ripple fed through the transistors, simply because they do not have infinitely high collector resistance; a variation in collector voltage will still cause some variation in collector (therefore emitter) current -- another good reason to provide a fair bit of pre-regulator filtering, e.g. via C1. The point about the effectiveness of shunting a zener by an extra condenser is well made by comparing Curves F1 and F2 in fig.16 of last month's article, consulting the Coding Chart and fig.17 circuit for details.

The Voltage Regulation Curves

Referring again to the figures presented in February and March, the voltage regulation picture presented in figs. 6, 7, 13, 15, 18, and 19 are essentially self-explanatory, and should be studied to examine the performance of the various circuits for different loads. Each circuit was adjusted arbitrarily for an output of 13V at 120mA initially, except for the zener one (fig.17), which gave essentially the zener voltage, as shown; the actual output is, of course the zener voltage plus the base-emitter junction voltage of about 0.3V for germanium, but the latter is small and for practical purposes can be ignored.

It is particularly interesting to follow the zener Curve F in figs. 18 & 19, to the point where it joins Curve B, showing the point where the zener loses control of output, whereupon the circuit behaves like fig.3 rather than fig.17. You can see that a smaller value of Rb extends the range of currents over which the zener controls output, by rotating the Curve B anticlockwise; or clockwise as in Curve A, when Rb is larger. But as always there is a payment: when Rb is smaller, the zener

(continued p.57)→

ADVERTISING

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3 Watt RMS AMPLIFIER: Taken from September issue of Electronics Australia. Unit is suitable for connections to Ceramic pick-up, etc. The output impedance is 8 - 15 ohms, while the input sensitivity for full output is 150mV. Supply voltage is 18 V. The unit is on a printed circuit board 2¾" x 4½". Special prices as follows:

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PART-PAK SPECIALS: ¼W resistor paks, contains 3 resistors of the 57 different values between 10 ohms and 1M - a total of 171 resistors. Special price $4.50 . Polyester Capacitor Pack, contains 3 capacitors each of the 45 values between 3.3pF and 0.47uF. A total of 135 capacitors [3.3pF - 820pF 100V ceramics]. Special price $7.95

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[Advertising continued overleaf]

EDITORIAL -- RLG

"Nil bastardo carborundum"
["only the best ardour endures"]

Yes, yes, I know, the print is too light on several pages in this issue. Its not the fault of our excellent printer. Its due to the fact that we were experimenting with the idea of reducing the size of print for Letters and Miscellany. We now admit that the letters of the latter are too small to read comfortably, but there has to be a first time for everything. The print for the regular stuff had to be light so that the small letters would not ink in. Live and learn. I had a long editorial prepared discussing the interesting things we are encountering in the photographic process, but the adverts have crowded it out. Suffice to say that there are several ways to do it, and we have learned carefully all the wrong things not to do. The only thing I know for certain is that both Rod and our printer have complained how much work it is, so I'll try to set up the copy better. We shall also have to desert the special grey draughtsman's paper Ian has been using for diagrams, because it doesn't photograph well. Everyone else says that it does, but it doesn't. But I think we shall take Dick Ross's advice and use extra reduction for diagrams; it will make them easier to draw, and -- important for me -- easier to label... EEB staggers on. Circulation is up to about 650 now; tell your friends.

Say, I wonder whether anyone has figured out why people will answer an advertisement, say most enthusiastically that they will be right over to look at It, and then never show up! This has happened so often to us that I'm sure there is some deep principle involved....

Overseas readers: Have you seen Australia's great Barrier Reef, her green spacious smog-free cities, her thriving fishing industry, her native animals, her beautiful fields of fruit? No? You'd better hurry.

Quote without comment [from a correspondent]: "... So if you have some small project that you may be interested in, let me know and I'll see what I can do [but I shall be getting married in July and can't be sure what amount of time this will take]."

Another Quote: "Abner was seated at his wife's sickbed weeping uncontrollably, when his wife, mustering the dregs of her strength, drew herself up to one elbow. 'Abner,' she whispered, 'Abner, I cannot go to my Maker without confessing my misdeed.' 'Not now,' muttered the stricken husband, 'Not now, my dear. Lie back and rest.' 'I Cannot,' she cried, 'I must tell you, or my soul will never know peace. I have been unfaithful to you, Abner. In this very house, not one month ago..' 'Hush, dear,' soothed Abner, 'I know all about it, why else have I poisoned you?'" [-- Isaac Asimov]

IN EVENT OF NUCLEAR ATTACK: [1] Bring family into one room. [2] Shut windows.
[3] Turn on gas. [4] Lie down.

current will be greater at low load currents, thus requiring a zener having higher wattage rating. Of itself this is not necessarily bad, because as I have mentioned the higher wattage zeners have lower dynamic resistance and are therefore better regulators. RAJR says, "This is a good reason not to economise on zeners. Flea-power or disposals zeners usually give poor results, and for what does one buy a zener if not for voltage regulation?" For ordinary medium-power series-regulator type supplies, the 3-5W zener (American = "10" W) is better than the 300mW (American 1 W) size even though the design may require only the latter value.

It is also interesting to see that Curve H which represents the simple Brute Force power supply with a 10,000 µF filter, provides remarkably good voltage regulation over a wide range of loads (figs. 6, 7), as good as that of fig.20 (Curve G), but not as good as that of fig.17 (Curve F). But its disadvantage is seen in figs. 11 or 16, as enormous ripple voltage. This could be reduced by using a choke in the usual pi filter configuration, but the transistorised system gives good results in a much smaller (and cheaper) package.

Still further improved variable-output: the Feedback Regulator

The trouble with a circuit of the fig.14 type is that however you vary the voltage, and however low you (try to) keep the ripple, the ability of the circuit actually to keep the output voltage constant depends on the gain of the series transistor, and this is limited. Control systems which give better regulation, and variable output as well, use some kind of feedback amplifier, based on the general system shown in fig.20. I shall discuss this briefly, but near this point we shall part company, because the subject becomes vast, and the variety of control circuits endless; the more complicated, the better the control (voltage, current, overload, temperature, etc.) -- if you need it.

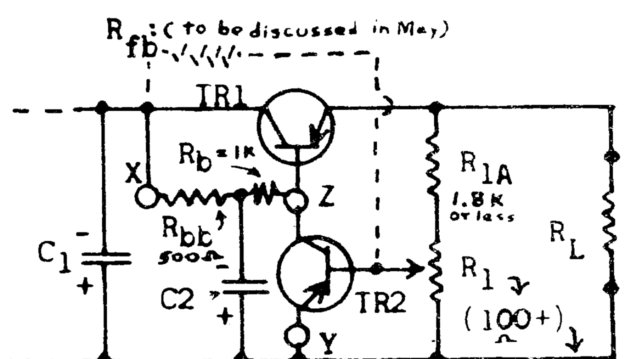

FIG 20

In fig.20 a small amount of the output is sampled by TR2, and fed back out of phase through TR1; the valve equivalent of this circuit is quite familiar to us, except that the valve requires a substantial reference voltage in series with the cathode to allow adequate bias control. An analogy exists with the transistor, though for different reasons as we shall see. By comparing fig.20 with fig.17 you will see that the transistor appears to have replaced the zener, with the pot, R1 providing essentially a zener having variable control voltage.

Putting aside all the talk about sample and error voltages, the simple fact is that if the load increases, the output voltage tends to drop, and so does base voltage of TR2. It goes less negative, so its collector goes more negative, because it is merely a common-emitter amplifier with load Rb. The base of TR1 then sees the more negative voltage and feeds it to the emitter to cancel the drop caused by the load. It can't cancel it completely, of course, or there wouldn't be any signal to give to TR2. By raising the arm on R1, TR2 base goes more negative, so output voltage goes down; minimum will be a volt or so. When R1 tap goes down, TR2 current does too, and its collector voltage goes up, and so does output. This gives you a simple way of obtaining variable output, and regulated at the same time.

The performance of the circuit can be seen as Curve G in figs. 18 and 19. Compare with Curve B which shows what happens when you remove TR2. This is what happens when the R1 tap is at a low point, and TR2 shows high collector-to-emitter resistance. When R1 tap is high, the collector of TR2 is saturated, and the circuit reduces to fig.17, with the relatively constant voltage of "Vce-sat". At both extremes the transistor has lost control, and so will not regulate.

The slope of the voltage regulation curve depends on the amplification factor of TR2*. Curve G gives better results than Curve C, but not as good as Curve F. To obtain better regulation with variable control of output, it would be useful to add another amplifier, and there are numerous circuits

*Analysis of fig.20 shows that regulation is improved as h_{fe} of either transistor is increased, as you might expect. It also shows, however, the surprising result that the regulation is improved as h_{ie}, the input resistance of TR2 is reduced. Input resistance can be reduced by choosing a higher power-rated transistor for TR2 then "necessary", by choosing a silicon high-speed switch type, and/or by increasing emitter-2 current (up to a point). By suitable choice of these parameters the regulation (Footnote continued on bottom of p. 58)→

available which do just that. There are also certain advantages to turning TR1 around, as we shall see in an interesting article we have received on a "Back-to-front Series Regulator."

The circuit of fig.20 not only stabilises output voltage for variations of load current, but it also tends to stabilise output for variations of mains supply voltage. It does this better than fig. 14 without a zener, but not as well as fig.14 with a zener. This does appear to put fig.20 at a disadvantage for voltage regulation, apparently providing only the advantage of easily variable output. But fig.20 can be improved without adding more amplification, simply by adding a zener diode in series with TR2, and running another resistor from that point to TR1 collector (see fig. 21a). But the reasons for this are not so simple, and I'll defer that discussion until next month. For now, be assured that adding the zener in the emitter of TR2 does improve regulation quite a lot, but at the sacrifice of minimum output voltage; the minimum output is a bit above the zener voltage. There are various ways to get around this, the simplest of which is to switch in zeners of different voltages for different ranges. Even for the lowest output condition it is, however, desirable to use a little stabilising voltage in the TR2 emitter, and because of the unavailability of very low voltage zeners this is most easily accomplished by using an ordinary diode biased in the forward direction, as in fig.21b. The value of Rz should be chosen to provide a bit of zener or diode current when TR2 is cut off (i.e., at maximum output). For the present, however, let us remain with the relatively simple circuit of fig. 20, to illustrate the principle of design.

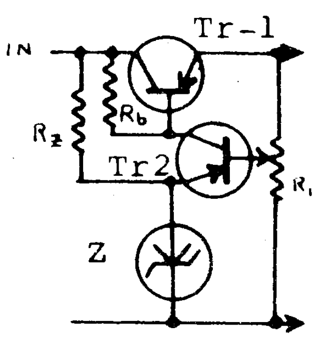

FIG 21a
Minimum output is about Ez

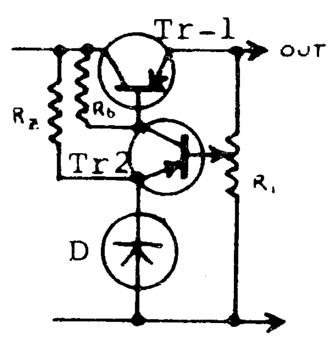

FIG 21b
Minimum output is about E_d

Circuit design

The design of the circuit of fig.20 is not dissimilar to that of the zener circuit of fig.17 discussed last month, except that TR2 (which could be a computer board type for moderate outputs) is now the controlling element in place of the zener. The minimum collector current of TR2 should be a bit higher than for the zener, say 0.5mA for small transistors, 5mA for large ones as TR2. And the transistor itself must be able to handle the maximum collector current and power at minimum load, in a similar manner. In contrast to the situation with zeners, it is unwise to design for Ic or Pc anywhere near the maximum rated values for the transistor, for reasons I have explored in the Sept 1968 EEB and in the Jan 1970 Amateur Radio articles; more than a twofold derating factor would be desirable, particularly in view of the considerations RAJR raises in his long footnote here. A transistor dislikes heavy duty operation, and gets even with you with high leakage current, effect of heat on amplification, and loss of amplification and increased nonlinearity at high collector currents. If TR2 is going to get too warm, you will recognise the fact by the fact that the output voltage will go down after a while of operation, as the transistor attains thermal equilibrium. The increase of base leakage current as the transistor heats, can be countered by proving plenty of base bleed current. This means that the current through the pot and any series resistors connected to it, should be at least ten times the maximum base current of TR2. That maximum base current will occur either when the load is minimum, or when the tap on R1 is moved to the top. For a given load, maximum TR2 collector power dissipation will occur at half maximum output voltage; for a given setting of R1, maximum Pc of TR2 occurs at minimum load.

Calculation of a suitable value for the R1 pot tap for a given output voltage requires a knowledge of the base resistance, and it is impractical for ordinary purposes. In this case it is sufficient to experiment to find the right setting. Indeed, it is feasible simply to use a single potentiometer (eg 2K in fig.20); this will give good control over the low voltage range, but it will give excessively sharp adjustment near the high voltage end, where the principal range of control will occur when the tap is within about 50 ohms of the bottom. With the constants shown in fig.20, control is obtained

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of the TR2 system can be made as good or better than the behaviour of a typical fig.17 zener configuration. E.g., 40mV/Amp, assuming h_{ie} of 20-60 ohms, and gains of 100. Regulation of silicon types is also better than germanium, owing to the effect of the higher base-emitter junction potential, which raises the tap on R1. -- Asst. Ed, RAJR.

To Renew Trousers: When rinsing trousers put a little glue in the water, e.g. "Aquadhere". Works too for coats skirts, etc. It rejuvinates them, making them easier to wash the next time, it says here.

from 3.9V to 21V with a load resistance of 1K, or 3.9V to 17V with a load resistance of 100 ohms. If R1 is 500 ohms rather than 100 ohms, minimum voltage goes down to 1.6V, but control gets critical above about 11V.

As usual it is difficult to have your cake in a simple circuit, but the simplicity can be maintained if you do not ask too much from it; the more versatile is a circuit, the more complicated it must become. It is a lot easier to add a switch to add a higher value of R1A in fig.20, or a different value of zener in fig.21, for different output voltage ranges, than to compose a complicated (and expensive) circuit to do it all automatically. The same might even be said of short-circuit protection; it is nice, but everything more fancy than a resistor in series with TR1 is fancy; don't be a clod, don't short your power supply, just as you use care with ranges on your multimeter.

To the latter bit of homey philosophy might be added the fact that for a large number of applications we ordinarily don't need a variable supply at all. That is why a fig.17 type circuit with some switch positions will suffice most of the time. This is well in accord with EEB philosophy which says that something is worth doing well only if it is worth doing.

The role of C2 in fig.20:

Comparison of Curves G1 and G2 in fig.16 show that C2 is manifestly still necessary in fig.20 if output ripple is to be kept to a low value. But it is important to note the relative functions of Rbb and Rb in that circuit. Imagine that Rb = 0. The circuit would still regulate well at d.c., but at frequencies more than a few cps or if you like, more than a few Pb (Portrebzies) ((sounds nicer than Hertzes)), the reactance of C2 becomes low, and it effectively holds point Z at constant voltage, thus completely eliminating the amplification of TR2. This would bring us back exactly to the circuit of fig.10, where only the amplification of TR1 regulates the output.

When Rb is inserted, TR2 now has a load against which to develop an a.c. signal, and it will amplify. The filter for ripple is still provided by Rbb in combination with C2. Even better filtering can be obtained by making a two-stage R/C filter, or by use of a zener across C2, etc. etc. Rbb can be made smaller than Rb, because Rbb is more effective in combination with C2 than in fig.17, because of the reduced loading of C2 by TR1 base. The optimum value of Rb will depend on the dynamic regulation required, transistor gains, supply voltage, etc. etc. It can be calculated by complicated formulae, but a fair rule of thumb says merely to make Rbb about one-third of Rb, and the sum Rbb+Rb as determined from the zener-type calculation mentioned above. Then just increase C2 (or the other alternatives) until the ripple is low enough. Simple?

The circuit of fig.20, interestingly enough, possesses the same short-circuit protection as does fig.3, which was discussed in Part I (I'm not AGAINST short circuit protection; it's awfully nice if a good circuit gives it to you, but I still don't think power supplies should be short circuited). With the constants shown in fig.20 (or in fig.17 with Rb = 1.5K) the maximum collector current through TR1 is limited to 600mA. If Rb and Rbb of fig.20 are reduced to increase the ability of TR2 to control high load currents, the short-circuited current increases. As discussed in Part I, however, Rb+Rbb would have to be less than 100 ohms to approach the maximum current and power dissipation ratings of a 20W or 30W power transistor if the output were shorted briefly. Even if load requirements do call for such a low value of Rb, a few ohms in series with the collector of TR1 will help (c.f. p.38). The circuit of fig.14 does lack such protection, but it is simple, and gives pretty good results for simple requirements -- which most of us need.

Needless to say, NPN could be used in these circuits, with opposite output polarity. There is no end to the number of modifications and permutations you can make in power regulating circuits, but I had best continue with the conclusion to this part of the subject next month, to allow old Kallam some space here, to keep our radio amateur readers sweet.

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LETTER: Human use of formulae

It is becoming increasingly obvious that all of the design formulae against which I am running up, specify very exact results by plugging in the correct (and often trivial) quantities. I should like to suggest that if you need a subject to think about, you might make an article on design approximations yet having a sound engineering basis. It would be quite welcome to many people. I have in mind mostly transistor configurations beyond the usual grounded emitter circuit -- particularly for transistor transmitters -- after the style of RSGB article reprinted in AR.

-- G. McCulloch, VK2ZKQ, Thornleigh, N.S.W.

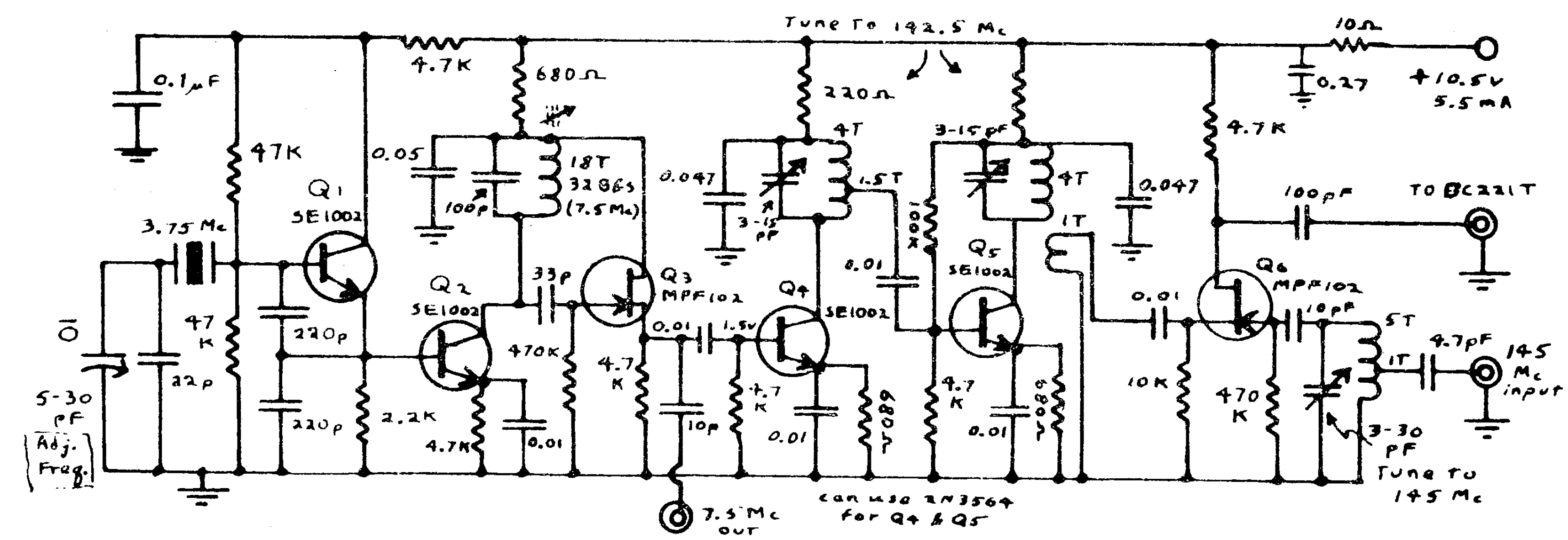
((I'm not exactly sure what you mean, but it seems to me that EEB has been attempting to do what you suggest, for several years now. It is not the subject matter for one or two articles, but hundreds. The point you make about transistor transmitters is also well made, and I have stressed it many times here. See also the article on "Commonsense Transistor Parameters", by me in Amateur Radio, January 1970. -- RLG))

A CRYSTAL CHECKER AND FREQUENCY COMPARATOR FOR VHF -- I.N. Kallam (VK3)

It is not always practical for amateurs to use a high frequency counter to check the exact frequency of a VHF transmitter, and furthermore, even the extravagent American designs do not go high enough. Yet, readily accessible frequency meters such as the BC221 use a frequency range rather impractical for VHF. Heterodyning can be used, but it is no better than the standard oscillator used; furthermore, very small frequency differences are difficult to assay on the frequency meter. These objections are met in the system shown here below.

The crystal oscillator of Q1 is run by a relatively easy-to-obtain 3.75 Mc crystal (now to be known as 3.75 MPb??) which is doubled by Q2, or if you are a wealthy magazine publisher you can buy a 7.5 Mc crystal to use directly ((I object -- Ed.)) Now, 7.5 Mc is one of the frequencies transmitted from Lyndhurst by the PMG clock; comparison of the second harmonic may also be made against the 15 Mc signal of WWVH, JJY, etc., but the PMG signal is more accurate. Thus we can adjust the frequency of our crystal (by grinding or VXO technique) within about one cps against one of these standards, and after frequency multiplying in Q4 we can be within some 40 cps at 146 Mc. This signal is amplified in Q4 & 5, and is beaten in Q6 against the signal from our VHF transmitter. One of the outputs will be within the range of the BC221T (T = Transistorised; circuit to appear in EEB in due course), we hope, and which we hope to be accurate within at least 50 cps, so we can check our VHF transmitter to considerably better than 100 cps at 146 Mc -- which isn't so bad, is it?

I realise that some eyebrows may be raised at the feat of multiplying 19 times in Q4, but under the assumption that only rabbits can multiply this well, and the fact that transistors are rather rabbity (or worse) there is definitely enough signal to do the job.



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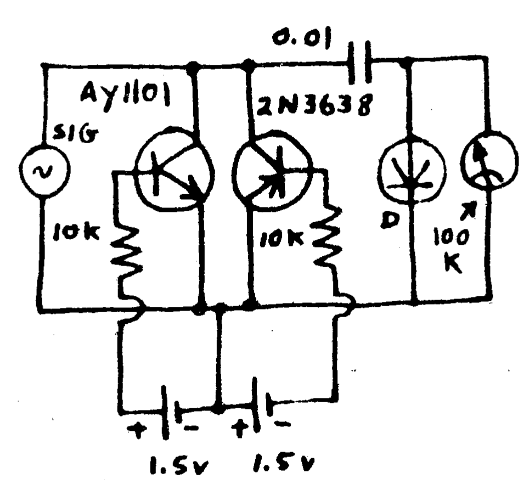
LETTER: T-R Switch Investigation

I note that in the "1-W High Performance Transistor Transceiver" shown in the December 1969 EEB, a germanium diode was used to protect the input transistor during the transmitting cycle. It seemed reasonable to investigate the possibility of reducing the back voltage even further by using transistors as the protecting element, since the value for V_{sat} of forward-biased transistors can be very low. The test circuit shown at the right was employed, and its results were disappointing. With 23V peak input, output voltage was 3v, compared with 0.7v for silicon diodes or 0.4V for germanium. With FETs, the result was a little worse. I am at a loss to explain this, but at least the experiment may save someone some trouble. -- T. Cengia, Poatina, Tas.



THE IDEAL BEER RECIPE -- Jim Coote (G3UGD) ((An April Special))

In this civilised country (Great Britain) the home-brewing of beer is now perfectly legal. Just recently our local newspaper carried a half-page spread on the subject, and the Civil Service have a Club devoted to it. In spite of all this the Brewers prosper.

Such a happy state does not appear to obtain in Australia, and it seems that the Beer Industry in your country is in a delicate and precarious condition, since it appears to be protected by laws which do not apply, for example, to brewing of cyder or wine even though these may be many times stronger. Therefore, Australian readers of EEB must reduce all quantities in the following recipe by 60% -- for example, by increasing the total volume 2.5 times. This is quite difficult, but can be achieved by diligence and patriotism.

This recipe gives good results, but can be adjusted as suitable for individuals in accord with the general ideas shown. The whole procedure requires only about two solid evenings plus a few moments now and then. If instructions are followed closely, a good brew is almost guaranteed. No off-tastes, no exploding bottles. But be sure to remember to dilute the brew to keep it perfectly legal.

MATERIAL	AMOUNT	EFFECT OF INCREASING	GENERAL GUIDELINES
Total Volume	10 gals	Thinner taste.	About 5 doz. bottles. NOTE: Spring water makes a superior brew.
Malt Extract	9 lbs	More body, masks bitterness but adds sweetness.	Dark M.E. best, e.g. the kind furnished to the manufacturers of "Ovaltine". For ordinary light M.E. use 30% more, but it is not nearly as good.
White Sugar	4 lbs	More alcohol, more astringent.	Keep M.E. + Sugar = 13 lbs per 10 gal. for optimum strength.
Hops	8 - 10 oz	More bitter.	Use 50% more if not obtained farm-fresh and normally kiln dried (should be compressed very tightly in a box until used). Results not guaranteed with store-bought hops. NOTE: M.E. and Hops should be changed in the same ratio if more or less body is desired.
Lemon	Juice of one.	Too sour.	Do not exceed, but do not omit. Alternative = citric acid.
Salt	1-1/2 level Teasp.	Too salty.	Do not exceed, but do not omit.
Calcium carbonate	1 level Teasp.	Uncritical.	Allows more rapid aging.
Di-ammonium hydrogen ortho phosphate	1 teasp.	Ditto.	Ditto.
Dried Yeast	1 level Teasp.	Uncritical.	Best type is the "Fermenting Yeast" obtained at health food stores everywhere. If wet brewers yeast used, use quite a lot more.
Isinglass	A large pinch	Uncritical.	Clarifies.

Sterilising Solution: 4 oz. potassium metabisulphite per quart of water; recover after using, good for many reuses. The fumes are disagreeable but not particularly dangerous. The solution need not be rinsed out of containers.

PROCEDURE:

1) Sterilise the vat by swirling with some metabisulphite. Vat must be in room with reasonably constant temperature. Ideally it should be placed so that it may be immersed in water to at least half its length. Low room temperature is desirable during brewing, but constancy of temperature is more important.
2) Boil (briefly) 4 gals. water. Add to vat.
3) The next day: Place M.E. container in hot water to warm up.
Add yeast to 1 pt. of water at blood heat, containing 1 tsp of M.E. Then:
4) Bring hops to boil in 2 gals water, and simmer very gently in a pan with a close fitting lid for 30 mins, stirring occasionally. Remove most hops with coarse strainer. Save hops. Strain liquid (through the coarse strainer) into the vat.
5) Simmer same hops again for 30 mins in 1 gal water, as in No.4; if store-bought hops, add handful of new hops 5 min before end of boiling. Discard hops, keep liquid hot. Some hops remaining in the liquid are quite harmless.
6) Separately: Boil sugar, salt, lemon in 1 gal water 20 mins.
7) Add together with vigorous stirring: The hot hop solution, the boiled hot sugar solution, the prewarmed M.E., the chemicals. Turn off the fire immediately, stir until thoroughly mixed, add it all to the vat.
8) In a few hours the vat should be only warm to the touch. Then add the primed yeast. Cover of vat should fit tightly.
9) Skim off the froth during the first 3 days or so. Then top up the vat with some cooled boiled water. Time to complete brewing will depend on weather: 1-2 weeks.
10) When top of liquid starts to clear, add a 3" square of Eisenglas mat which has been dissolved in a cup of hot water. Ask chemical supply firm for Isinglass. It will improve the clarity of your brew considerably.
11) A day or two after liquid clears (darkens) it can be bottled. Rinse bottles only with hot water if they are clean to start with. Add 1 teasp sugar (not more) to each, and syphon beer into each within 2" of top. Cap (the metal clip type with plastic inserts work satisfactorily most of the time if kept in tight condition).
12) Age 2 weeks to about 3 months. When pouring out of bottle, pour slowly and carefully without stopping, until sediment appears in neck of bottle, then stop. Obviously this requires pouring it all into one or more containers at one time. When finished with a bottle, rinse thoroughly without delay, and allow to dry thoroughly upsidedown.

(Continued on p. 62)

Further information on this subject may be found in a wide variety of books and pamphlets published in the U.K. (where else?); demand that your Bookseller stocks them. One of the more entertaining ones is "Beer, Glorious Beer" by Cyril Pearl, published by Nelson (London, Sydney, etc.) in which is contained an analysis of the abominable Australian legal position, several good recipes (which must be diluted, of course), and much witty chatter....

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LETTER: Transistors on modern computer circuit boards.

...On these small Computer Boards I have a good way of removing the transistors. I use a chisel-knife type desoldering tool, or small inexpensive wood-working knives with a chisel-like tool. Working from the bottom of the board I pry the transistor leads up out of the solder blobs with the point, taking care to keep the other hand out of the line of fire, in case the knife slips When the leads are pried straight up, turn the board over and slip the knife under the transistor case, and pry upward; the transistor will come right out, tinned leads and all. I can remove 30-40 transistors per hour. Only one transistor in twenty requires a touch of soldering iron to free a stubborn lead. Then I free the other parts by using an electric drill with sanding disc in it. Parts come out quick this way. With further sanding to remove all traces of PC wiring, boards can be used for new projects.

The later, bigger GE and other boards are on epoxy glass or fiber glass boards, and these methods don't work They have to be desoldered. On the other hand, the 2N709, 2N2369, 2N706, 2N711, etc. make it worthwhile. From tests I have made, the Motorola 0883 appears to be the same as the 2N2369, and the 0829 the same as the 2N709.....

By the way, transistors will stand a lot more heat than one would think. On some of the blass boards, I've cut the PC wiring to the transistors, and found no significant difference in leakage, gain, and frequency response compared to transistors which were vigorously desoldered.....

I'm afraid that I know little of transistor-solid state theory, holds, etc. I tried to study to keep up ... until it got too difficult to remember. I do try to keep up with transistor circuits, etc., but if I had foreseen FETs and IC, I might not have loaded up so much with transistors... But I do like the computer board components for easy experimenting. And the parts are top grade. Much more uniform than the store-bought ones. And a vast improvement over the Polypak (etc.) 'bargains'. Those have turned out to be flops in most cases. For example, they say 'like 2N706', and they do look like 2N706, but they don't work like them Hi.

-- J.D. Clement, W6NTR, Van Nuys, California.

((We regret that we could only print a part of Jack's long newsy letter, but we thought you might be interested in his thoughts on the Boards. We have come to similar conclusions in many respects, and our thoughts are summarised in the Computer Board Notes furnished by the W.I.A./VK7 with the boards they sell. The WIA doesn't advertise the Boards in EEB anymore because they sold so well that they were afraid of selling out; but I think the Tassie group still have some left if you have trouble finding them elsewhere.

((I agree with the difficulty of keeping up, but it is remarkable how well a bit of simple theory can suffice, together with keeping one's eyes open. But transistors are not going to go obsolete, any more than have valves -- or have you tried recently to pour some r.f. into a transistor? Or to get decent audio fidelity? And IC's?? Who needs 'em? -- Ed))

LETTER: Radio Control of TRAINS

I have studied all the articles in Electronics Aust. on train and model control, but have not quite met my needs. Have any of your transmitting acquaintances or correspondents ever published an article on the following subject:
Remote cordless control of a model over short distances. The model carries its own battery, but the transmitter should operate from 12V d.c. with a minimum of current. The only control switching needed is ON-OFF and FORWARD-REVERSE.

-- D. Hamilton, 41 Fitzroy Street, Sale, Vic. 3850.

((The literature abounds with radio control circuits for planes and ships, so I presume you are talking about radio control of model trains themselves. No, can't say I have seen anything like that. Have any of you readers? If so, please contact Mr. Hamilton directly, and perhaps he may give us an article on same one day. -- Ed.))

LETTER: Advertising pays

... By the way, we have had very good results from advertising in your magazine over the past year or two. As a matter of fact the response is even better than from Electronics Aust. on some items such as small components.

-- G. Connelly, Manager, Kit-Sets Aust., Dee Why, NSW.

LETTER: The uses of Voltage Triplers

There should be no great problem in reference to that "Puzzle" on the cover of the October 1969 EEB. I note that the circuit is identical with diodes D1 and D2 of the Heathkit SB200 Linear Amplifier Power Supply. It might be that owners of this linear should furnish D3 and D4 (each consisting of eight No.57-27 Heath diodes) and add them -- no wires need be disturbed. This Linear, using electrolytics, operates much better on 230V input than on 115V input. Some people here don't have the 230V line installed, too bad. I note here, however, that very many signals show about 10% a.c. modulation when tuned "on the nose". These may show 40% to 50% modulation when off the nose of a filter -- possibly responding to frequency-modulation on the slope of the filter curve in the receiver. This bothers people operating on an adjacent frequency. A full-wave rectifier might reduce the a.c. component, and improve the d.c. If so, this is even more worthy than considering "tripler" and similar aspects. Anyhow, the voltage between doubling the r.m.s. and doubling the "peak" depends on the load, and size of capacitors. The full-wave type may be a bit higher in voltage than the standard voltage doubler in the Heathkit SB200. Incidentally, other equipments have much the same problem. I use the SB200 as an example, only because I have its circuit diagram at hand.

-- E.H. Conklin, K6KA (also now VK9NA, Norfolk), La Canada, California, U.S.A.

((Ed. Note: The solution to the Full Wave Tripler Puzzle presented in our October issue appears in the December 1969 issue....))

Strong Laundry Soap

Are you disgusted by the mild mild soap (which is really detergent) used to wash clothes nowadays? The following is guaranteed to be more effective, for grease, etc. Dissolve 1 lb caustic soda in COLD water. In another vessel dissolve 1 lb of borax in boiling water and stir until dissolved. Mix the two solutions when cold, and dilute with water to several gallons. Use one or two cups of this solution with one-half pound of soap (not detergent) for effective washing in about 10 gallons of water. Boil while stirring for about 20 minutes. For particularly dirty clothes, use more of the soda/borax solution, and boil some more.

To cure Warts: Make a paste of whiting and vinegar, and apply nightly. A sure cure.

Good Coffee: Add a few drops of vanilla extract to a cup of coffee or cocoa. Ymmmmmm.

LETTER: The State of the Art in America

((The following letter was received from an Authority on this subject, in reply to our enquiry asking whether it was possible to find a publication over there which was devoted to experimentation for its own sake. We print relevant portions here.))

Your really "slow freight" letter of November 3rd reached my desk bright and early on Monday morning, December 15th. Your complaints in EEB certainly appear to be more than justified... ((In reference to inefficient postal services))

I can understand and appreciate your dilemma concerning the publication of purely "experimental" material. That is, material not specifically related to a construction project, manufacturer's favorite component, etc. Nor, I suspect, are you talking about the tutorial state-of-the-art stories.

Candidly, insofar as the American ham radio and consumer-type electronics experimental magazines are concerned, your subject matter is a lost cause ((though certain possibly favourable specific developments are possible, particularly with planned changes in at least one big American magazine)).

The situation concerning the American magazine marketplace might be categorized in this fashion: for the experimenter/hobbyist we have Elementary Electronics, Electronics Illustrated, Popular Electronics, and Science & Electronics. Combining radio-television servicing and experimental electronics, we have Radio-Electronics magazine. Out in left field in a strange area comprising "engineering support personnel", we have Electronics World. ((Various comments on the American radio amateur magazines)).

The few magazines that are publishing out of the ordinary editorial material of a very experimental nature would be Electronic Design and Electronic Design News. Unfortunately these two magazines are more interested in ((certain aspects of advertising)) than they are in ((unusual designs)).

All in all, it is a very dreary picture. Experimental electronics in the United States is undergoing a reverse metamorphosis. There are fewer and fewer hobbyists and technicians that want to think for themselves. Although not everyone is an "appliance operator", there are fewer and fewer experimenters willing to take the time and trouble to troubleshoot, let alone to design even relatively simple circuits.

And the problems are further complicated by the lack of defined components for hobbyists. There are just too many transistors, integrated circuits, and specialized components for any ordinary radio parts store -- or even mail order house -- to handle.

Unfortunately, the picture is bleak and as much as we are trying...we are all fighting a losing battle.

((From what I have been able to ascertain, the situation is not dissimilar in the U.K., and there are signs that Australia may one day be like that, when incomes are higher and when commercial amateur equipment is cheap and widely available. There is one person who can fight this trend toward commercialisation: you. -- Ed.))

QUOTE WITHOUT COMMENT: ((The following item has been received from a New Guinea mission correspondent)):

Desirable qualifications for mission workers: Ability to mix with people, mix concrete, wade rivers, write articles, love one's neighbour, deliver babies, sit cross-legged, conduct meetings, drain swamps, digest questionable dishes, patch human weaknesses, suffer fools gladly and burn midnight oil. Persons allergic to ants, babies, beggars, chop suey, cockroaches, curried crabs, duplicators, guitars, humidity, indifference, itches, jungles, mildew, minority groups, mud, open bores, poverty, sweat, twisting, and unmarried mothers, had better think twice before applying.

Home-made Fly Paper (for home-made flies): For those denizens who do not have DDT solution accessible (to coat windowsills; see EEB, Dec. 1969, p. 139), put five parts of castor oil with 8 parts powdered resin, heat until the resin is dissolved, then spread on thick paper. Place where you won't hear the flies buzzing!

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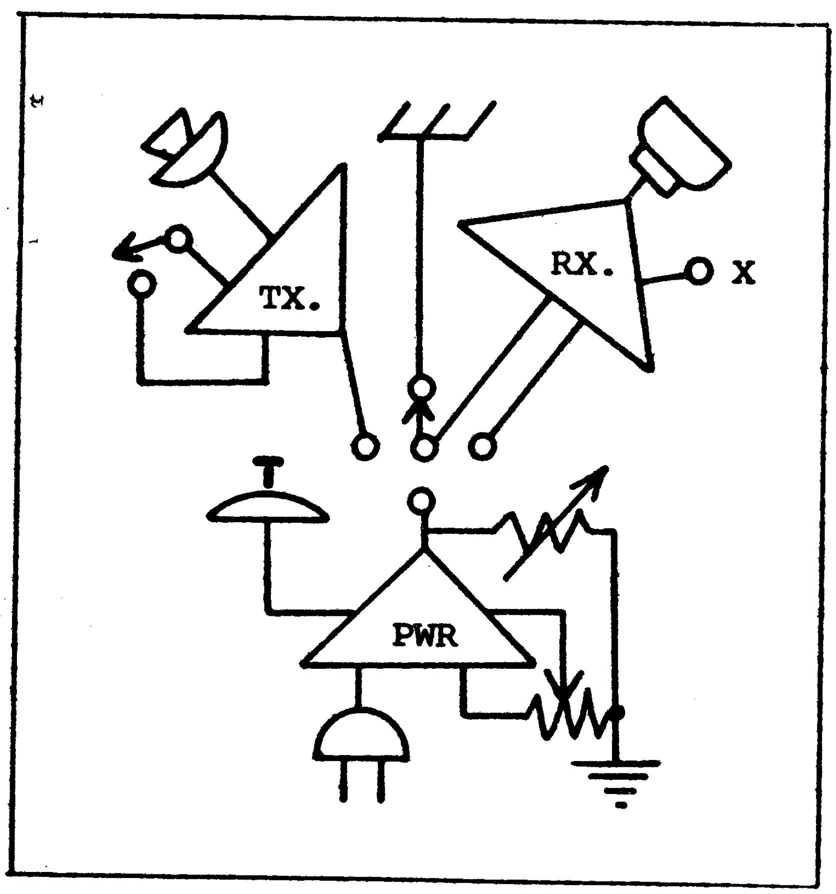
MAY 1970 VOL. 6, No. 4 P. 65

CONTENT:



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COMPLEMENTARY SYMMETRY AMPLIFIERS

Part I: An analysis of the Fairchild 3W Amplifier -- N.O. Kallam (VK7)

((Editor's Note: We have information for a series of articles on theory and practice of output-transformerless (OTL) amplifiers, and were going to prepare it in orderly manner. But these matters take much time in EEB because of the relatively limited space available. Considerable interest in the Fairchild Amplifier has been shown by EEB readers since we made reference to it on p. 19 of the March issue, so we have decided to publish N. O. Kallam's recent topical contribution (no relation to Victoria's I.N. Kallam) rather sooner than the rest of the series. Please take note that Mr. Kallam goes out of his way to show that Fairchild's normal engineering practice is excellent, but that he takes issue with only one of their designs. This has two practical consequences: it salvages performance of an amplifier which has been found deficient by a number of people*, and it touches on a theoretical analysis of the behaviour of such an amplifier. We trust that Fairchild & Co will accept this constructive criticism in the friendly spirit in which it is offered.))

The General Picture

Of all the attractions offered by transistors, possibly the most unique is their availability in opposite polarity, or complementary types, PNP & NPN. This property allows for elegance of circuit design not attainable with other active devices. It allows the practical design of high quality transformerless power output stages, eliminating the need for the bulky, expensive, and critical characteristics of the output transformer. Initial efforts were directed at valves for this purpose (e.g. Ref 26a), but transistors have proven more convenient and flexible, since they provide inherently the high currents required for loudspeaker loads. The favoured configuration is that of emitter follower, giving low inherent distortion and low Z.

EEB FIG. 1

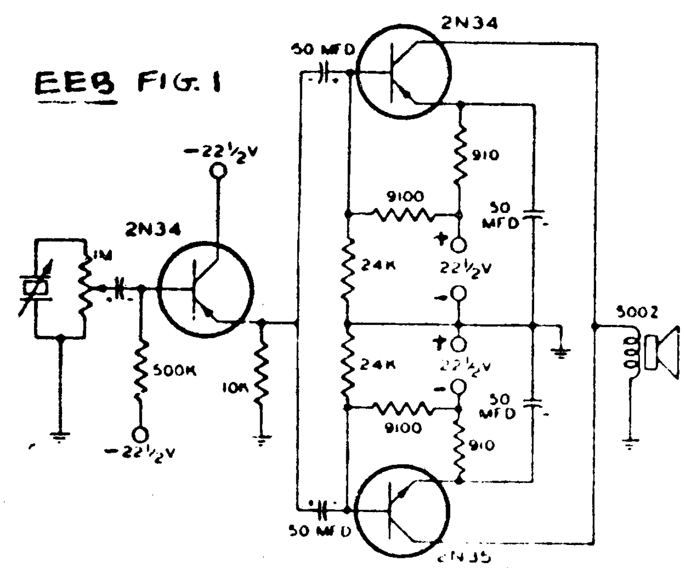


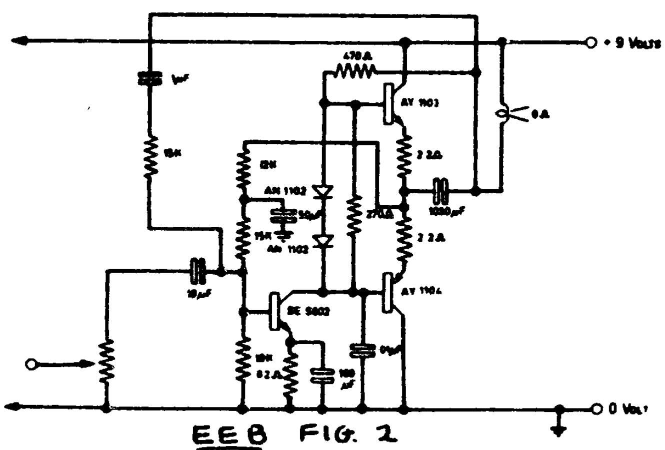
Fig. 16. Class A push-pull audio amplifier driven by RCA-2N34 junction transistor.

Applied to power amplifiers such as fig. 1 (Ref. 1), the principle of complementary operation of the output pair may be expressed thus:- The application of any driving signal to the input of the NPN/PNP pair which produces an increased collector current in either transistor of the pair will simultaneously produce a decreased collector current in the opposite polarity transistor of the pair. Further, if the two transistors can be arranged to have equal and opposite characteristics there will be a corresponding decrease in the current of the second transistor. It could then be said that we had a complementary symmetry amplifier... The complementary symm. amp. has several advantages over push pull or so-called single-ended push-pull: higher current gain, better temperature stability (or ease of compensation), component interchangeability, and economy. The appearance over the past couple of years, of various arrangements of complementary audio amplifiers offers an invitation to compare these circuits. Fig. 1 is derived from the earliest reference known to us and dates from 1953 (see also Ref. 2).

---

* I wish I could get sufficiently well organised to do an equivalent service for the PWM X-10, which after all needs relatively little to square up the waves to make it function reasonably -- RLG

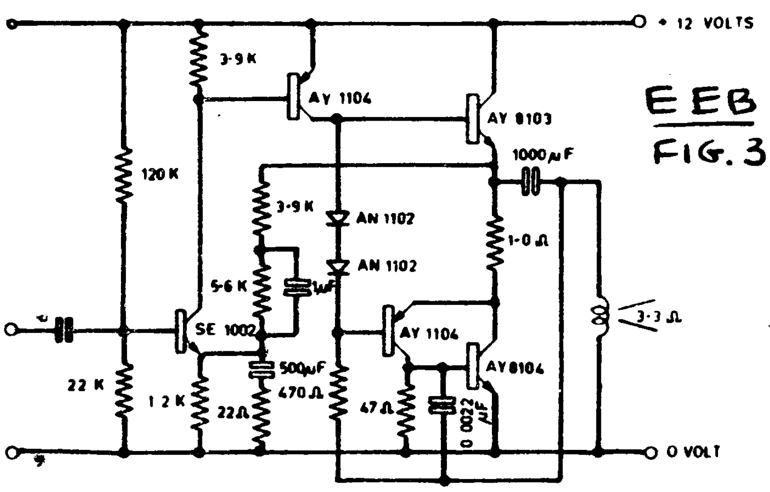
Since then the complementary configuration has earned wide popularity, and the literature abounds with it, as illustrated at the end of this article ((Probably next month -- Ed.)), all working on much the same principle with various permutation of methods of drive and feedback.



EEB FIG. 2

As a typical example of good modern design, fig. 2 (Ref. 4a) is by Fairchild, and gives good fidelity with a relatively small number of components. Refs 3 & 4 also present useful design criteria for this kind of amplifier.

Fig. 3 shows a more elaborate design from fig. 8 of the same reference. Constructional details for this amplifier will be presented in <u>EEB</u> by R. S. Maddever. A very large number of similar circuits have been presented in the electronics literature, and they bear the name of "Quasi-complementary", and will be discussed by RLG later in this series.



EEB FIG.3

The Fairchild "Low Cost" Amplifier

The above are two of many such fine circuits which have been presented by Fairchild, and they have showed good design. It was, therefore, with considerable interest with which I looked forward to their "Low Cost Complementary Audio Amplifier" which appeared in March 1968 (Ref.6) It was obviously simple (fig. 4), and claims were made for its adequate performance; dotted-in figures will be discussed here. Ref 6 claims quite acceptable levels of distortion (presumed harmonic), e.g. less than 1% from about 100 mW to 3W when input sensitivity less than 3V (as determined by R1, and frequency above 100 cps.

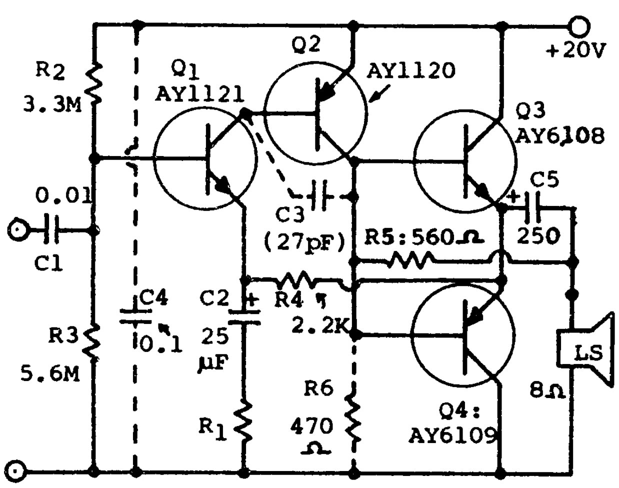


FIG. 4: The Fairchild 3W Amplifier

Many people took advantage of Fairchild's offer of a printed circuit board and four silicon transistors for a modest price, so there has been ample opportunity to test the performance of that circuit.

I had difficulties with it, and these were confirmed when RLG came asking "have you tried the new Fairchild amplifier? There seems to be something wrong with mine." Subsequently I had occasion to test a number of these amplifiers, and there was no question about it: they were all producing distortion at an uncomfortable level, using even adequate sound sources and loudspeakers, and well regulated power supplies. This was surprising to say the least.

Distortion was measured quantitatively and qualitatively as Intermodulation Distortion (IM). Strictly speaking, IM will not be evident with a single pure sine wave, only Harmonic Distortion (HD). The nonlinearity associated with crossover distortion does produce IM. IM measurement is coming to be regarded as much more revealing test for an amplifier than the usual HD, because almost all sounds of voice and instrumental origin are composed of large proportions of harmonics; IM on the other hand, produces a general smearing of texture.

To return to the point, this noticeable distortion was appreciably worse at low outputs, e.g. at 50mW, a level less than that required to cause a rise in quiescent current. Taking the suggestion (Ref 7a) to insert R6 (fig. 4) helped a bit, but distortion was still much in evidence, even with quite a high level of feedback (e.g. R1 = 1K), both for sine wave and programme input. The latter resulted in a tizzy shimmer overlaying the signal, the sort so often heard from small transistor radios. But we were getting this without any transformers in the circuit. Why?

<u>The Effect of Germanium</u>

We began to have a clue when we found that the use of germanium transistors in the system reduced distortion significantly. We got the idea about germanium when we first saw the boards, since the use of computer board transistors cold reduce the price of this amplifier considerably. Also about the same time came a suggestion sent to <u>EEB</u> by Alf Whittingham (c.f. his amplifier in the March & April <u>EEB</u>) that computer board transistors could well prove an inexpensive substitute for the components of this amplifier; his design will be discussed in this series next month. And about the same time Philips published a similar circuit (Ref. 10) using germanium transistors, as shown in fig. 5:

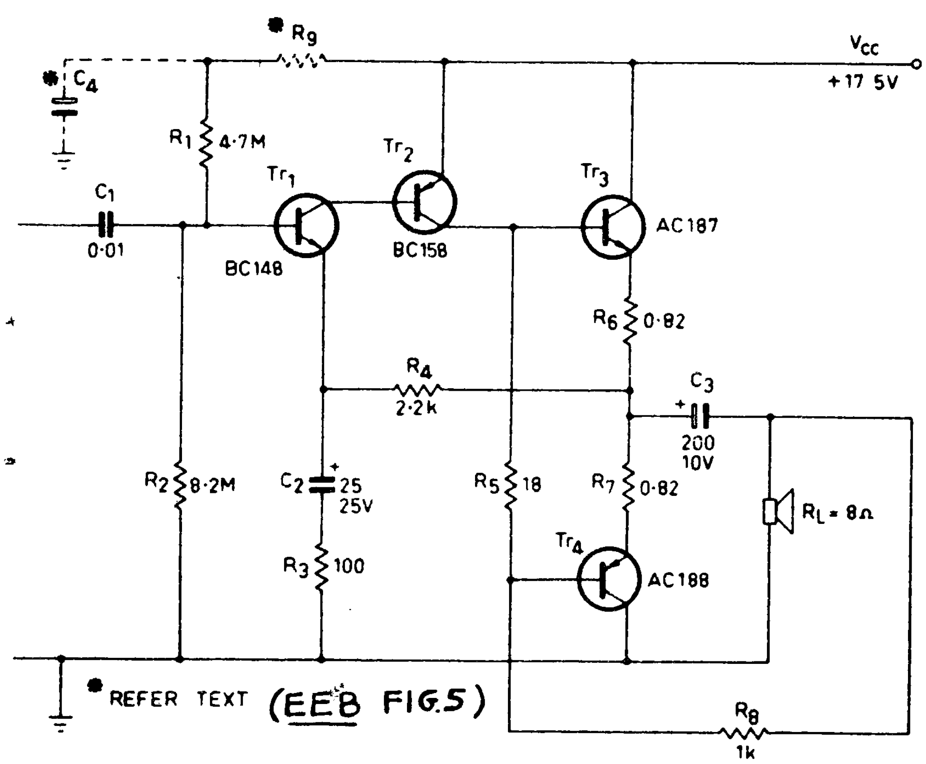
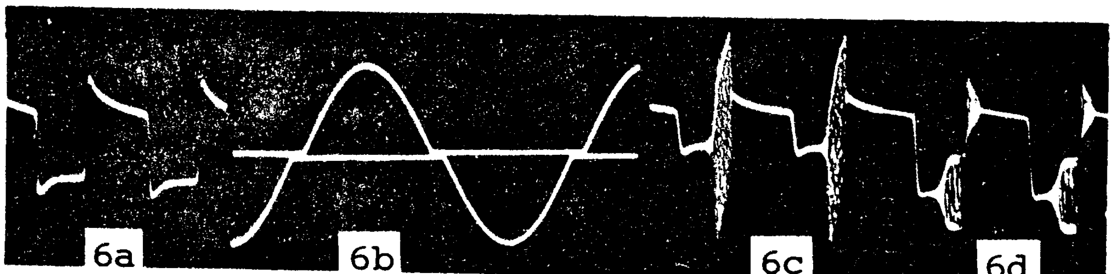


Fig. 1 Circuit Diagram of the 2.5 W Economy Amplifier

I built this amplifier, both with the original and with circuit board transistors, and got excellent results. So there followed an extensive series of tests on the Fairchild Amplifier, with numerous oscillograms taken, of which only a very small number will be shown here. Thus:

A) With Fairchild's silicon tr's, output at low volumes looked like fig. 6a (10kc square wave input) and 6b (1kc sine wave input), separate trace for each Trans. and sounded like it too; cross-over distortion and instability are evident. Somewhat better for high volumes. (Not shown)

B) The silicon output pair (Q3&4) were replaced by an 034/083 germanium pair from computer boards. Distortion was little different from before.



(C) The AY1120 (Q2) was replaced by an 034; all tr's now germanium except Q. Sound was much smoother at low volume. Some high frequency instab. remains, but oscillogram (not shown here) shows less overshoot. The AY1120 was not defective.

D) With Q2 = 034, Q3 & Q4 were replaced by silicon. The overshoot of fig. 6a increased, and the tizzy rattle returned to programme material. Substitution of another silicon pair brought the same results.

E) Since the Philips circuit (fig. 5) uses germanium transistors in a similar circuit, it was assembled and tested, with appreciably better sound and oscillogram quality evident.

Now What did all this Mean?

1) The improved results from the computer type as Q2 is most likely due to reduced frequency response. The 034 is a lower frequency device than the silicon AY1120, and produced much less gain at those frequencies where phase shift caused feedback to be other than the ideal 180° out of phase. The 27pf recommended by Fairchild (Ref 7) to be added between collector and base of Q2 produced much the same result. One may note however, that the AY1120 is designed specifically "as an Audio driver for the AY6108/9 complementary output pair."

2) The improved results with germanium output transistors was due to the fact that since Q 3 & Q4 are not biased, they are not conducting at low signal levels, owing to the fact that for them to conduct, the base-emitter voltage has to exceed the junction threshold. The result is essentially CLASS C operation, since collector current is being conducted over less than 180° of each cycle by each transistor. The junction potential for germanium (about 0.2V) is about half that for silicon at these currents, so unbiased germanium conducts over a larger portion of the cycle. This results in less crossover distortion.

3) Ref 7a states that "at very small signal levels an appreciable portion of the power delivered to the load flows via the 560 ohm resistor." Small wonder, since as shown above, at these levels the output transistors are not functioning. The same reference suggests that this distortion can be minimised by connecting R6 to produce some quiescent current in Q3 so that it is driving the load at what one presumes is at least Class A. This was performed, and sound was somewhat better, but both sound and oscillograms left much to be desired. Yet the final answer will indeed involve increasing quiescent current, as we shall see, but not merely for Q3. As it stands with R6, R5 is essentially the load for Q2 at low levels, resulting in wild fluctuations of speaker damping with power. Obviously one does not have the advantage of low output impedance under these conditions.

This paradox may be extended a little further. If we have a speaker of comparatively high efficiency our amplifier need only produce a low output power to give the required sound level. But it is just at these low powers that the distoriton is rising rapidly; in Fairchild's own published curves (Ref. 6c) show for maximum feedback a distortion of approx 0.5% at 100mW. From the sound of it the distortion could be 20% at 10mW and our more efficient and therefore more expensive speaker is telling us all about it. This means that from an amplifier distorition point of view we are better off with a less efficient speaker. In other words there is a direct trade off between speaker efficiency and amplifier distortion, all of which is just too silly for words. I must again emphasize that I am concentration my attention on the results at LOW OUTPUT POWERS. This is because a large proportion of programme time will yield levels producing these low power requirements. If you doubt this, just listen for one minute to any normal programme.

Well, can the distortion be reduced by negative feedback?

4) We are assured by Ref. 7 that "the crossover distortion is quite acceptable because of the very large amount of negative feedback employed" particularly when R6 is used. It is claimed that at higher power levels Q4 takes "a portion of the load and the very small amount of crossover distortion which remains is assymetric." In this claim to good sound at high volume lies the main virtue of this amplifier, and it seems to be quite acceptable to some people, though as I shall show under "Instabilities" it leaves room for improvement. Recently the ultimate claim appeared (Ref. 22): "The performance is perfect, ½ a watt by the way, a real ½ watt is plenty to fill a room in fact a whole back yard. 9 volts gives nearly the ½ watt output without distortion." Perhaps, you say, but how about 50mW when we are not

filling the back yard??

Many people are highly sensitive to crossover distortion -- I am one ((so am I -- RLG)) -- while others appear to be deaf to the effect. Crossover distortion adds to the signal a multiplicity of odd numbered harmonics giving rise to the tizzy shimmer and rattles overlaying the signal emerging from these "perfect" amplifiers at modest audio volumes.

The uses of Feedback

Much has been written on the subject of feedback amplifiers, and the nett result appears to be an almost universal belief, even among people who should know better, that an amplifier has low inherent distortion because it has high feedback. Actually nothing could be further from the truth. Distortionwise, an amplifier's actual distortion is quite unchanged by the application of even ideal negative feedback; if the feedback were ideal you would get good results from the final output, but feedback is never ideal.

As all the textbooks will show you, negative feedback allows the output wave to be fed back to predistort the input wave in the opposite direction*. But of course the efficiency of this depends on the feedback being just 180° out of phase with the input at all frequencies. This would require zero phase shift and an infinitely rapid rise time. Fairchild attacks these modest requirements with the use of C3 (which is indeed necessary; see fig. 4) and C4 and published performance characteristics which show the advisability of keeping operating frequency above 100cps.

But in point of fact, what happens in fig. 4 is this: as feedback is increased, a larger proportion of the input wave is being used to drive Q3&4 to a given power level. Therefore the potential needed to overcome the B-E junction potentials of Q3&4 becomes a smaller proportion of the total. When it becomes small enough it is said to be "negligible." But it is still there. In practice it is not negligible at all at modest hearing levels, particularly with an efficient loudspeaker as mentioned above. And this is true even with R1 at 2.2K, the maximum fb specified (input sensitivity = 7V p-p!). This is the proof of the pudding.

I am NOT against the use of feedback; it is a most valuable tool when used with understanding and discretion. What I am against is the use of fb to cover up defects in an amplifier. Adequate design provides the least possible distortion before applying feedback. It is unfortunate that there is a tendency to regard an amplifier as a good piece of equipment merely because it includes a large amount of negative feedback (magic words). This will depend on phase shifts and loads and on power levels.

Instability

Fairchild recommends (Ref 7a) a good ceramic bypass for C4 when power supply impedence is "excessive." But fig. 6c (at output) shows oscillation (about 1Mc) when the amplifier is shock excited at low levels. Leads to the power supply were not unusually long. Furthermore fig. 6a resulted when C4 was placed across the power rails at the circuit board; the overshoot still shows instability, presumably due to excessive phase shift at high freqs.

Furthermore, fig. 6d shows output with C4 in place, when the amplifier was driven slightly harder (yet still only 1W peak output!). It is evident that phase shift is critical, and that the amplifier is inherently unstable. Furthermore, when driven to this level, the ringing even appeared at the input of the amplifier (not shown here). This certainly shows that it is a mistake to rely on feedback to cure the performance of an inherently unstable system. It would if fb were ideal, e.g. equally effective at all frequencies and at all power levels. But it is not. In this case phase shift increased at the higher power level (compare fig. 6d with 6a), causing the fed-back voltage to be other than 180° out of phase with input. This means that even

* Distortion in this instance may be defined as an unintentional variation of output wave shape as compared to input wave shape.

at high levels where crossover distortion is negligible, other distortion arises from the instability. Some of this can be cured by using germanium, or inserting C3 and a condenser across R4 (as in Ref. 8), but it can never be a substitute for a basically stable design, as the oscillograms show.

I do not mean to antagonise FC here; they have published numerous excellent designs, but in this one they used rather too much simplification. Much to their credit they have tacitly admitted this in the kind of design published in Ref. 8 which was directed at eliminating crossover distortion and instability for a system having higher input sensitivity. I should like to suggest that these measures might well be applied to the amplifier for any sensitivity.

The Cure

As Ref. 8 shows, the cure is apparently simple: merely insert two diodes between Q3 & Q4 of fig. 4, and do some bypassing. They use two AN1102 diodes shunted by 560 ohms, C3 = 33pf, R4 shunted by 0.01 uF, R1 = 27 ohms to give 50mV sensitivity, R3 = 330K, R2 = 270K going to 10K + 50uF low pass filter to +12V supply.

Although the cure is simple I have taken this space, because the theoretical points raised are significant and can improve an understanding of some of the difficulties which can be encountered in this apparently simple circuit. The modification suggested in Ref. 8 puts a bit of forward bias on the output transistors, and biases them into proper Class B or AB, reducing crossover distortion to much lower values at low power output levels. The modifications can be made with only some difficulty to the printed boards of fig 4, and RLG says that the amplifier works well enough with present value of R3 & R2.

An Improved Version of fig. 4, with Preamplifier

R. S. Maddever has built the amplifier from Ref. 7c which adds a preamplifier to Fairchild's "Low Cost Amplifier" but has incorporated the above improvements in principle, with added bias (adjustable) and stabilisation. This is shown in fig. 7. D is any silicon diode, and R10 = R11 = a few ohms

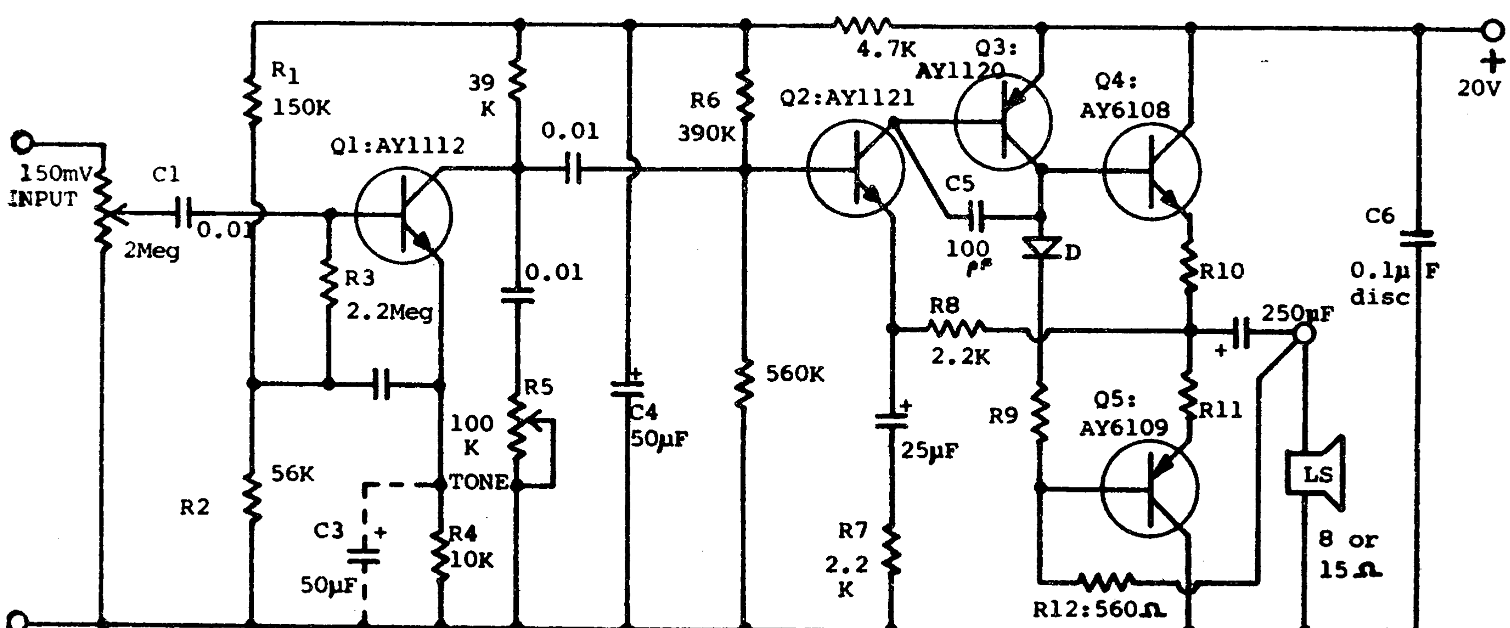


FIG. 7: Maddever/Gunther modification of circuit of Refs 6 & 7; improvement of fig. 4 here.

(e.g. 3 ohms) of resistance wire of equal lengths. R9 is about 27 ohms and is adjusted until (for a given supply voltage) collector current of Q4 = 1-2mA above leakage value. At this point the transistors are thermally stable; even touching both with a soldering iron (briefly) could not induce thermal runaway. Q1 was added to improve sensitivity, yet input impedance is kept high by "bootstrapping" involving C2 & R3. Sensitivity is about 150mV (RMS) for 3W out; adding C3 increases sensitivity to 5mV, with lower Z_{in}, lower fidelity.

((MORE PRACTICAL CIRCUITS OF THIS TYPE NEXT MONTH + REFERENCES))

LT REGULATED POWER SUPPLY DESIGN, Part IV -- RLG & RAJR

In Part III of this series was examined the voltage regulation of the various circuits presented, and the conventional two transistor feedback regulator examined briefly. Methods of improving its regulation were presented, involving the use of diode(s) to raise the a.c. signal presented to the amplifier (fig. 21). Since one does not get something for nothing, this feature giving improved regulation also reduces the range of voltage adjustment. If you can get by with a relatively restricted range of voltages from your regulator you will get better performance -- although in this article we mention a way to get around even that objection.

The role of C2 in the collector circuit of the first amplifier in fig. 20 was also discussed. An additional reason for keeping Rb of fig 20

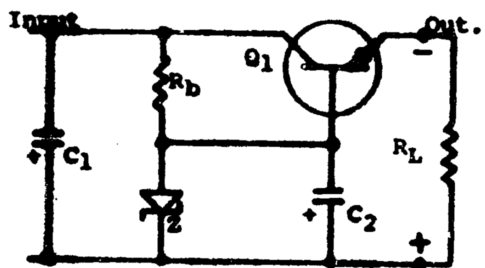


FIG 17: SIMPLE AMP. + ZENER

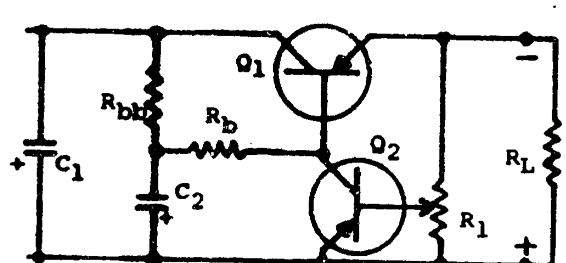


FIG. 20: LOOP FEEDBACK FROM OUTPUT (Q2 acts as variable zener.)

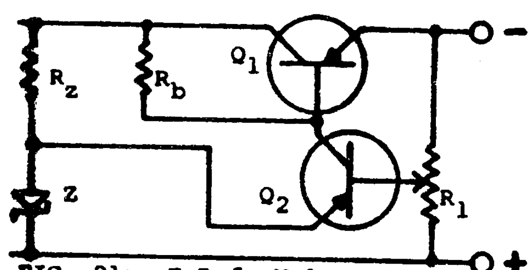


FIG. 21a: Z Ref. Voltage added in sensing amp to improve regul.

reasonably large is that all capacities within the gain loop must be kept to a minimum to obtain best dynamic regulation and to minimise instabilities, as described in the next section.

It should not be overlooked that on top of p. 41 of the March article was described an important variation of fig. 14 (p. 39), in which the control voltage was stabilised by a zener. This, and several other useful reference voltage systems will be discussed further in a forthcoming article in EEB by C. Pitcher.

In the following discussions "we" have gone slightly further from what "I" intended in the previous series, but we feel that this discussion will raise some more fundamental points which will help you more intelligently to appraise the bewildering array of regulator circuits which grace the electronic literature. If you read it all carefully you will be well rewarded by being able to look at an article and say "oh yes, there and there is the basic circuit; I see what he is doing" or trying to do. Intelligent appraisal can also tell you whether a given degree of elaboration is worthwhile for your actual needs. Throughout the diagrams we have shown typical parts values for a given design to make the presentation more meaningful, but it must be emphasized that these values may differ for each situation, and must be worked out on the basis of voltages available and desired, and regulation to be achieved. At no point is anything more complicated needed than Ohm's Law and the formula for transistor current gain. Isn't it amazing the mileage one can get out of Ohm's Law?

When specific reference is not given to a source of information, a given circuit or design has been drawn from our experience and experimental results. Credit is hereby gladly given to the many authors who have written articles which have provided the background for our insights. A longish list of such references will be given at the end of this series.

(CONT. ON P. 81)

A NICE HI-FI SYSTEM, Part II [continued!] -- A. Whittingham [VK2]

[[Editor's Note: Inadvertently we omitted the remainder of last month's article [p. 46], and we continue it here, with apologies to the author!]] [[The last sentence of the second paragraph should read:]]

The rear masonite panel is flush-mounted with glue against the rear of the chassis after blocks A & B and L bracket have been glued and set in place.

Drill 3 holes in block A so that a thin screwdriver can be poked through to tighten the 3 1/8" dia. bolts holding the matrix board and heatsink to the L bracket. The AD149 is mounted outside of this assembly with the pins pointing towards the matrix board. Put a grommet in the heat sink near the top to allow the a.c. leads through to the matrix board.

Make a shield out of 1/16" aluminium and insert in saw cut. Use one wood screw to attach it to block A. Use grommets in the shield for wires from input sockets to the switch. Also a grommet near the matrix board to take the d.c. supply through to the 5 tag strip. Use two lugs [+8, -20V] to feed pre-amps, and two to feed power ampls. Centre lug is earthed to the shield and is the common earth. Bring all earths to this lug. Green wire from the 240V supply input is connected to this lug as well. Only this one external earth is used, or hum will be a problem. Connect all control cases together and the shielded lead going to the vol. control, and take a bus bar to the common earth lug from the Bass control. Take a bus from the case of the 2000µF condenser to the common earth lug. Modules are a press fit into their respective saw cuts. If any blobs of solder interfere, mark their positions on the baseboard, and dig a bit of wood out with a penknife. The module will then press down to the bottom of the saw cut, and will be quite firm. The 2000µF is mounted to block A with bracket supplied as high as possible to allow signal leads from the inputs to pass underneath and through grommets in the shiad to the Selector Switch.

From all of this it will be evident that this description applies to a stereo sound system, where the circuits of amplifier and preamplifier are duplicated, with the addition only of a balance control between them [see p. 26]. The preamplifier has been described in the March EEB, and the power amplifier will be discussed in the July issue. In interim, however, a quite suitable power amplifier circuit would be that appearing as fig. 7 on p. 71 of this issue, omitting the first stage.

xxxxxxxxxxxxxxxxxxxxxx

QUOTE WITHOUT COMMENT

"Prime Ministers are able to change their minds very quickly without explaining why. This is because they are always very clever. When you or I do this, it is called lying."

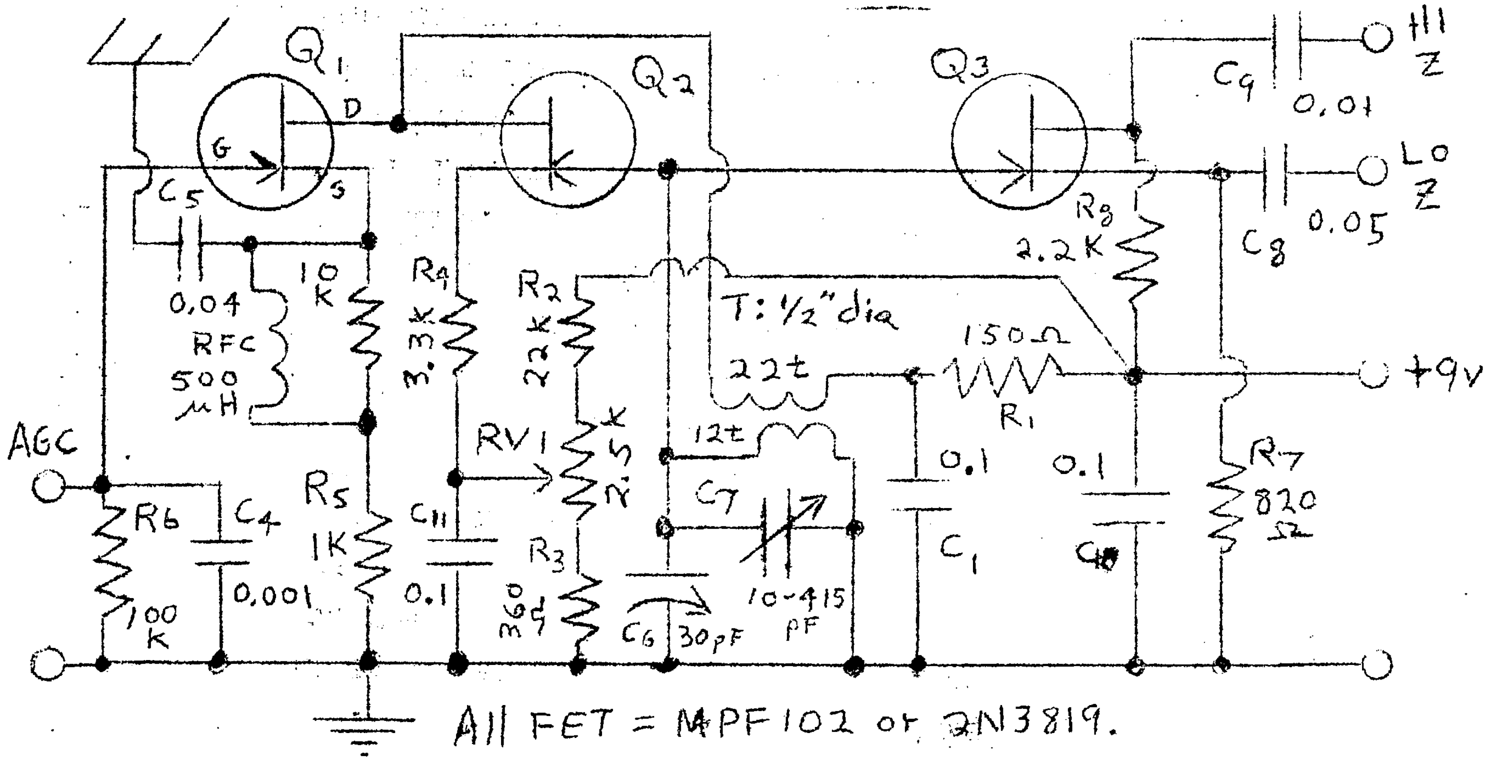
-- Sally, in "Fred's Primer", by Edwin Brock [Macmillan].

AN FET RF Q-MULTIPLIER

-- T. Cengia [VK7]

A thorough review of circuits and literature on the subject of Q-Multipliers, and of r.f. Q-Multipliers in particular, was made in the May, June, and August 1968 issues of the EEB; since I understand that Vol. IV [1968] is still available [[$2.25 -- Ed.]], I refer you to that material without further necessary discussion. ... The preliminary circuit was not unlike an FET-ised version of the valved one presented in the August '68 EEB, also described in G3VA's excellent "Amateur Radio Techniques" [RSGB, p.42]. After numerous attempts to build an r.f. Q-Multiplier followed by an r.f. amplifier, the circuit of the left-hand figure was obtaind.

FIG I



All FET = MPF102 or 2N3819.

Initial problems encountered were: instability and hot spots in the tuning. The hot spots remained even though I tried various orientation of the coils, shielding, and heavy decoupling. Finally I abandoned the Veroboard layout [so is Veroboard such a good thing after all?] and the transistor sockets first used [though they are an aid to trouble shooting, they can create troubles by themselves!], in favour of a permanent printed circuit. This worked! I mention this constructional detail to show that there is a lot more to a circuit than the wiring diagram if it is operating at r.f. Carefully arranged layout, short leads, and shielding are essential to reduce undesired feedback. In the present case, the permanent printed circuit layout resulted in good stability at all positions of the regneration control.

Referring to the circuit, you can see that Q1 is a Grounded Gate stage [analagous to groundd grid] which provides a good match directly to my antenna. Q1 feeds r.f. transformer, T, which provides regenerative feedback through Q2. Q3 provides isolation to couple to the next stage, nominally the first mixer, either as high impedance from C9, or as low [[Continued, p. 79]]

EDITORIAL -- RLG

"Damn you Jack, I'm all right!"
[Quaint Australian Saying; Aust. 4/6/70, p. 24]

Siliconix makes several photosensitive FET's, alluded to in our February article, not only the P102 P-channel, but also P236, 237, & 238 N-channel types with g_{fs} from 1 to 4mA/V and input sensitivities [gate diode] from 0.4 to 3 uA/mW/cm^2. Aust. distributors Jacoby Mitchell & Co, 469 Kent St., Sydney who will order them for you, for a price... May 1970 Popular Electronics p. 79, describes a new series of low cost Light-emitting diodes, by Motolola [MLED600] and by Monsanto [MV50], plus much other information about light-sensors & emitters; Motorola in Aust. is Cannon Electric in Melbourne. The same issue of PE continues their very interesting LASER series with practical design for a real Laser Beam Communicator! Various optics are described with range "as far as a 12 inch target can be seen by the telescope". But my experience with such is that the mounting of the optics on both ends must be VERY firm. "The mere idea of being able to transmit information on a beam of coherent laser light suggests all sorts of possibilities for secret, non-jammable, interference-free communications. And it is possible today!" assuming, of course, that you dilute it by 60%; see EEB p. 50 last month... MULLARD has a very interesting pamphlet "An Infra-red Communication System" by the Mullard Educational Service, at the end of which is a list of British companies willing "to supply a kit of essential electronic components for this project". That sounds like a fine way to get the parts for the Tx and Rx at a reasonable price directly from U.K.; one presumes the cost might be somewhat higher in Australia. The Tx uses a CQY11B and the Rx a BPX25; range is not specified, but it is interesting to note that response of the photoemitter is good to 300Mc, and the receiver to 200kc, suggesting the possibility of modulating one beam with a variety of signals to fill that enormous bandwidth.

In the April 1970 issue of 73 is an extremely important article by WB2PAP, "Beryllia, the Lethal Refractory", describing how some new valves are going to contain ceramic insulation containing Beryllium, a very dangerous chemical. It is all right as is, but if the device is broken up [e.g. by children or wreckers], the dust evolved is highly poisonous. We understand that Mullard [U.K.] have also started making transistors containing Beryllium, and that they have specifically warned that such devices on no account should be disposed of in normal industrial waste. If intact they can be buried. If not intact, they must not be sent through the post, and the manufacturer must be consulted for directions. Only two types of transistors are involved, both are experimental and have not yet been released. It is possible that they may not be released. Let us hope for the second alternative. The fight was long and hard to get manufacturers to omit Beryllium from fluorescent lights, and now do we have to go through it all over again with valves and semiconductors??

In the March 1960 issue of CQ I note a neat DSB & DSBRC amp. by W4CJL, which like all Double Sideband systems suffers from simplicity, ease of operation, effectiveness of communic., and -- oh wonders! -- highly intelligible speech. All of which must surely be counted as crushing disadvantages when compared with complicated and so popular SSB systems. And surely no one would want to go on the air using a Mode which other people don't use. After all, who would you talk to? It is on such adventuresome spirit that Amateur Radio was built to the peak of the condition it exhibits today... A MUST for reading in that same CQ is "The Invisible Ham" by WØGHX in which he describes a Big Time Operator with computer-operated transmitters and receivers which engage in automatic QSO's from prerecorded tapes! [[To be continued........]]

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73 Magazine. For example in the November 1969 issue which just happens to be the one within reach of the typewriter at this moment, there were about 18 constructional articles including a sophisticated i.f. notch filter, several transistorised transmitters [as usual], complete details for building an r.f. antenna bridge, a complete full sized antenna for 40-160M only 10-20ft high, f.m. Rx alignment generator, phase-control TRIAC pwr supply etc etc. Plus about fifteen discussion articles including another by W5JJ on antenna and transmission line efficiency [[also one in the September HR, heh]] with startling conclusions, an article showing how to have interesting discussions on the air without recourse to religion, [CONTINUED OVERLEAF]

politics, or sex. Amazing. Plus a beaut on bias design for transistors, again using commonsense in the best EEB tradition, an article on "Call Letter Lunacy" and Part Ten of a long series, "Getting Your Extra Class Licence", which would be excellent preparation for the ordinary ticket here..... And there are letters, and ghastly Editorials by the Publisher who manages to be fascinating, crass, idealistic, and effective. What a show.

And all that for only $A4.25 in groups of 3 or more. Soon to be dearer.

Ham Radio Magazine: Fewer articles, of high quality for the serious amateur. Again taking the issue nearest at hand, January 1970: "How to use R.F. Power Transistors" by Paul Franson, WA7KRE [now there's poetic justice?], being "A guide to the practical use of r.f. power transistors in amateur radio equipment, including circuit design, matching networks, and construction." Nineteen pages of really good oil, being essentially a compendium of notes from Motorola, plus the RCA Silicon Power Circuits Manual [a marvelous booklet on this and numerous other electronics subjects]; several good articles on this subject have appeared in the Amateur literature, and each is well worth reading. We have got far behind in reporting this subject in EEB because of press of other articles, and you'll have to go elsewhere for it for a while.

To continue: An article on a highly stable bandswitching FET converter, one on the circuits for coupling a transmitter to any antenna at all!, an article on a new kind of power supply using a "Paraformer" transformer which does not couple energy by mutual inductance, but by reluctance coupling to a tuned secondary. This is said to have enormous advantages for transient suppression and voltage regulation. Dick Ferris says he doesn't believe it, but we contacted the author, W5JJ, and he says it is true; knowing him, I'm inclined to believe it; we wanted to buy one of those devices, but the prices are astronomical. If anyone builds such a device, would he PLEASE let us know what happens???.... Then there is a logarithmic speech processor, being an unusually effective wave shaper. And an article on "Proportional Temperature Control for Crystal Ovens" which maddened me because I had had exactly that idea and was going to publish it here for use with a very special kind of timer we have developed; a transistor as temperature senser directly drives a transistor as heater. Why not?; in any event, it is a good idea, and here are full details. Then there is an article "Use your Magazines" in a manner dear to the heart of EEB: Tear your magazines to pieces, and file the pieces; it is far more useful than allowing magazines to accumulate prettily. And so forth and so on; running out of room here. SUBSCRIPTION: 3 years of Ham Radio for $A9.00, single subs or renewals accepted; offer limited to Aust. or Terr. Undoubtedly soon to increase $$$$$.

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[[FET Q-MULTIPLIER, continued from p. 74]]:
impedance from C8. Needless to say, if output is taken from C9, the free end of C8 is earthed, and conversely. C7 tunes the r.f. stage, and C6 is a trimmer. RV1 adjusts feedback by varying source bias on Q2.

Withe the circuit of fig. 1, above, it was found relatively difficult to obtain small bandwidth, i.e., best selectivity, so the modification of the circuit following Q2 was introduced, as detailed in fig. 2 here. The circuit is preset to the narrowest bandwidth required, and resistive losses are introduced to widen it, via Q4; this works well, and control is smooth. In fig. 2, Q4 is the losser element, whose resistance is controlled by RV1 [note different value]. Q4 works with a source voltage of 1-2V above the gate, and no detuning is caused by change of FET resistance with variation of RVL, but the 0.05 or 0.1μF's must be ceramic or other low inductance low leakage type. In practice, with RV1 set to give 2V on the source of Q4, RV2 is adjusted so that the Q-Multiplier is operating on the edge of oscillation. This can be tested easily by listening to a c.w. station while making the adjustments. Under these conditions, control of the bandwidth is smoothly adjusted by RV1. Since the MPF 102 [or 2N3819, etc] is a Depletion Mode device, an increase of Q4 source voltage [more positive] drives the gate more negative and increases the drain resistance, thus sharpening the frequency response of Q2. There seems to be no noise introduced, and the improved selectivity is quite pronounced, e.g. 1kc at source-4 voltage = +2.

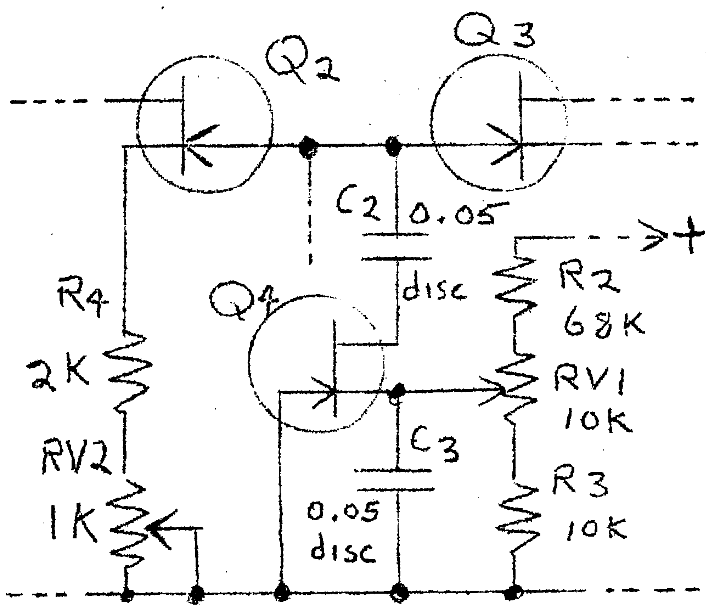


FIG 2

The printed board layout [not shown] follows the circuit diagram quite closely, except for the circuitry including R1-3 and RV1. C7 is big, and mounts at the upper right of the board, with RV1 at the lower right. Further modifications of this circuit will [probably] appear in <u>EEB</u>. A more complete report will [probably] appear Elsewhere.

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

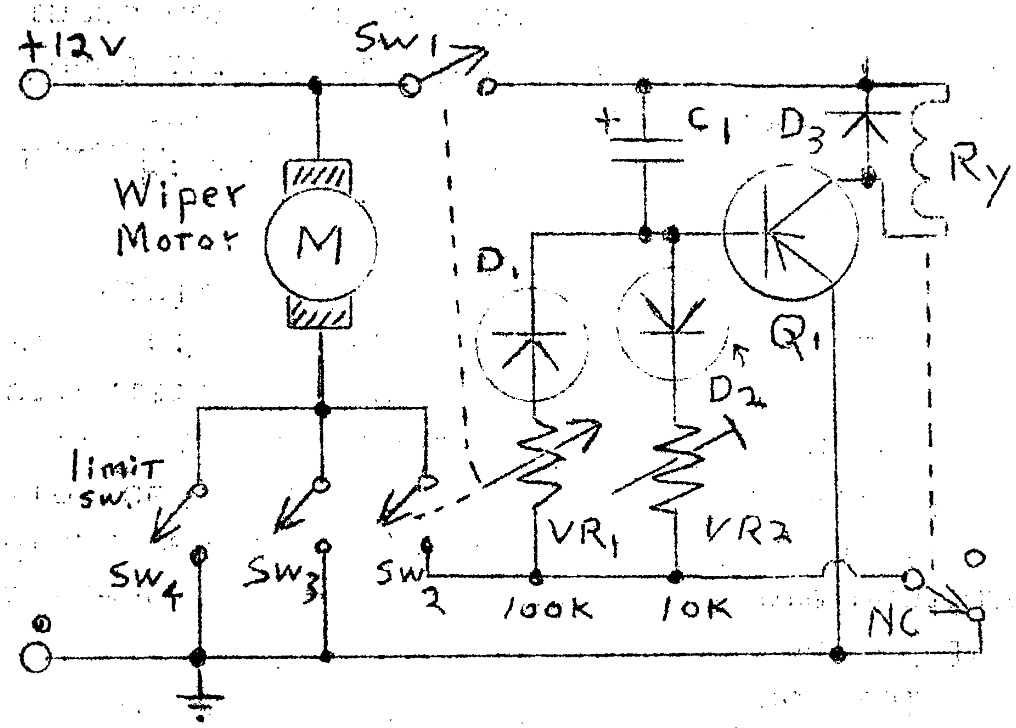
<u>LETTER</u>: Mounting Computer Transistors

Here is an item of use. Computer board transistors mount very nicely on 0.15"-pitch VEROBOARD obtainable from EMI. This is very useful material, and I find I am using nothing else these days for experimental circuits, as well as for complete projects. One such project at the moment is a digital frequency meter which is coming along nicely [but slowly] using computer board diodes, transistors, etc.... Thanks for a good little journal.

— C. S. Schultz, Rabaul, T.P.N.G.

A SEMI-MECHANICAL WINDSCREEN WIPER DELAY SYSTEM

-- G. Cohen [VK3]



This is another of the types of control which pulses the windscreen wiper motor at selected intervals; this can have some psychological advantage when compared with the simple slow-speed control; the relay is a simple way to do it if you do not have or do not trust SCRs, UJT's etc... The operating time of the circuit shown at left, is from normal operation to about 60 sec delay between wipes [but then the wipe progresses at normal speed for one wiping cycle].

Sw1&2 are coupled to VR1. Sw3 is wiper switch on car normally. Sw4 is limit switch for the Motor. D1,2,3 = Any gen. purpose silicon diodes. Q1 = any PNP transistor capable of switching Ry. Ry = Relay with normally-closed contact; 3-9V, requiring current compatible with Q1. VR2=10K Preset pot. C1 = 100-1000µF, depending on time delay required [15WV]. TO SET UP INITIALLY:

1] Select VR1, Q1, and a value between 100 and 1000µF for C1.
2] Turn on Sw1, Sw2, and adjust VR2 until the relay moves the wopers just far enough for Sw4 [the limit switch] to take over control.
3] If the delay with VR1 at max is sufficient, unit is working.
4] If the delay is insufficient, increase C1 until delay is as required, after adjustingVR2 agn.
5] If delay is too long, decrease C1, and readjust VR2.

xxxxxxxxxxxxxxxxxxxxxxxxxxx

To Destroy Rats without Poison [wherein you pit your intelligence against that of the rat]:

Melt three parts resin with one part linseed oil over a slow fire, and stir as soon as the resin is melted. Mix well, then cut down a kero tin to about eight inches high, paint the bottom with the mess, and the sides too to about four inches up. Put some good bait in the middle of the tin [e.g. bacon or smelly cheese], and provide a footstool on the outside so that the beast can climb up easily to look into the tin. He will hop down, and his tail will be anchored quite securely, whence he can be fed to the cat at your leisure, but watch out! Rats [and mice] bite furiously [so would you], so drowning is simpler. The resin mess will only spread if it is hot. It can be spread with paint brush which can be cleaned later by dipping in hot fat. Do NOT use hot kerosene!

A Caution about Loop Capacitance

We have discussed on p. 59 the fact that it is not desirable to shunt the sensing transistor of fig. 20 by a condenser, because this shorts out the sensing at non d.c. frequencies, so aborts regulation. On the other hand one sees frequently various other condensers placed in other parts of the regulator circuit, e.g. as illustrated in fig. 20a:

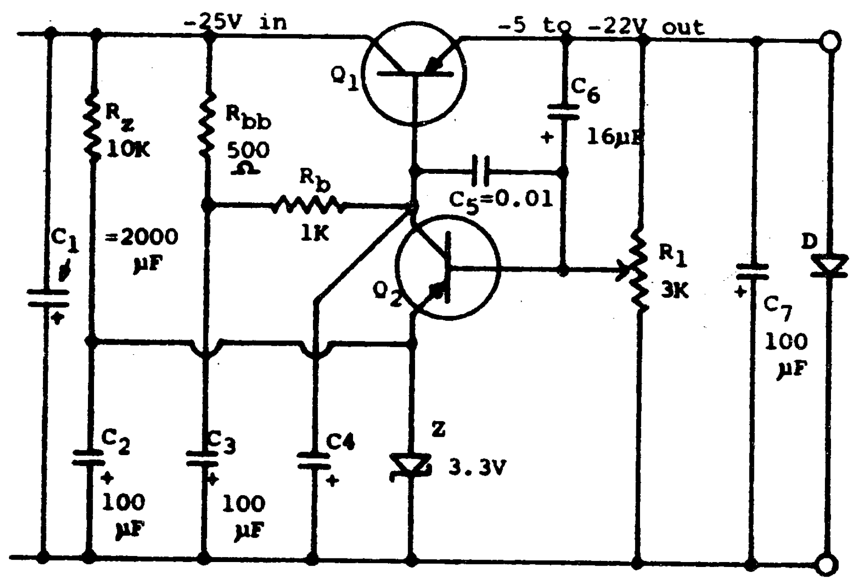


FIG. 20a: The uses of capacitance in fig. 20, some good, some NOT. Component value are typical.

We have really loaded this circuit with capacitance. Is it all desirable? Consider each item in turn:

C1: Yes, and the bigger the better for reasons discussed on p. 52: A regulator will regulate well only when its regulating-ability is not being taken up by using it for ripple-filtering.

C2: Yes, under some conditions, e.g. when the zener, Z, is of modest size, so has appreciable dynamic impedance; then addition of C2 can reduce ripple significantly. See comments, p. 52 & p. 57.

C3: Yes, as discussed on p. 59, but only when Rb is large enough not only to develop adequate collector resistance for Q2, but also to keep loop phase shift negligible, particularly at high frequencies.

C4: No, never. Gives lovely ripple suppression, and suppresses regulation for a.c. just as effectively. Yet you see it regularly in regulator circuits.

C5: (p. 59) Perhaps. This may be a necessary evil, in values from 0.001 to 0.1 µF (the smaller the better) as required to avoid parasitic oscillation of the circuit at higher frequencies where phase shift through the feedback loop turns the negative feedback into positive feedback. This is a modern development, and a consequence of the greatly improved frequency response of modern transistors. It also can occur at a relatively low frequency if Q1 has low f_T and Q2 has high (when load is light), so necessitating the larger values of C5, as well as C7.

C6: Yes, maybe. This provides a low impedance path for a.c. around R1, thereby improving ripple-filtering and improving a.c. regulation, as long as the slider on R1 is not down too far. When it is, C6 is essentially in the same position as C7, for which the following discussion applies:

C7: This is a contentious one. In general, capacitance is undesirable anyplace *within* the feedback loop. The amplification of the regulator ought to be adequate by itself to control regulation at all relevant frequencies of load variation; the ideal regulator ought to use no lumped capacitance at all. This ideal state would be achieved by using transistors with adequate frequency capability, and minimising all circuit phase shifts by adequate geometry: minimising distributed and omitting lumped capacitance. In addition, in circuits of the type of fig. 14 (p. 39) it is desirable to use shortest possible leads within the loop (e.g., not run them a long distance for remote control, unless thoroughly bypassed), because of the curious tendency of common collector stages to oscillate when the base is inductive, owing to setting up a Colpitts oscillator with distributed interelectrode capacitances (more about this in another EEB article one day).

Why, then, do we bung a great C7 across the load, right in the middle of the feedback loop? Because it tends to stabilise the circuit against lowish frequency oscillations when the load is light and where Q1 phase shift reactance becomes significantly low compared to output impedance. But to a certain extent this can be met by adding a bleeder on the output.

It may also be found that addition of C7 provides significant reduction of ripple ("hum") at the output of the regulator. If so, it is a sign that the regulator circuit itself is not adequate: there may be excessive ripple fed into the regulator and/or collector resistance of Q1 may be inadequate, and/or supply at the right-hand end of Rb or Rz may not be sufficiently filtered.

In addition, C7 is said to reduce peak-current demands on the regulator for sharply varying a.c. loads. But if the regulator has adequate response this justification is absurd. The sad fact is that the regulator may not be adequate for sharp load changes, owing to intra-loop phase shifts (e.g., in the transistors, the circuit, C4, or C5), and C7 makes up the deficiency by asking the regulator to regulate at only modest frequencies. Good design is better.

If there are so many justifications for C7 why do we say that loop capacitance is bad? Imagine that you are powering a Class B audio amplifier with transformer load (e.g., a modulator). When such amps are driven hard they tend at times to go into Class C. This loads the regulator only lightly on odd cycles (oh that prohibited word!), and any inductance in the modulator (e.g., if unbalanced and mismatched) would appear as series inductance in the regulator output. This would, of course, introduce a lagging phase shift. In combination with any pre-existing loop phase shifts this can result in positive feedback, and ruinous instability, e.g., output voltage wobbles wildly. This situation can be particularly onerous when another regulator is used "in tandem" for special stabilisation of part of the circuit, as in fig. 26c.

Looked at in another way, an inductive load tends to ring with C7 (and equivalent in the loop). If the output is driven positive, Q1 is cut off completely, and the supply utterly loses control of output voltage.

Yet C7 can be useful for reasons outlined in previous paragraphs. What to do?

(1) If C7 is used, avoid inductive loads; this applies particularly to any kind of motor load. Install a switch to take C7 out of the circuit. If this results in instability at light loads, shunt the output with a resistor; it is non-reactive, and you'll never miss 10% of regulator current.

(2) If C7 must be used with an inductive load (e.g., Class B transformer amp, etc), its capacitance must be adequate. The requirement is that $X_C \ll X_L/R$ at the ringing frequency ($f_o = 1/2\pi\sqrt{LC}$). If C is large enough and f_o low enough, $R \gg X_L$, and the first condition is fulfilled. 500 µF will generally be large enough for most purposes, but if an a.c. meter or CRO on the output shows significant spikes, C7 must be increased, and must be

larger as frequency of operation of load becomes lower*. An inadequate value of capacitance for C7 is much worse than none at all. But none at all is better than any. A properly designed regulator will NOT need C7, and to use C7 for an improperly designed one is to prop up a sick horse.

In spite of this, C7 and some others (e.g., C5) continue to be used in designs produced by engineers, and its advantages are thought to outweigh its disadvantages. So they may if the load is not inductive, but it is wise to know about this limitation.

One sees sometimes a diode, D, as at the right side of fig. 20a, but it takes care only of inductive surges which might damage the transistors, but only conducts when Q1 is hard-on, in any event. It is useless for neg. peaks.

In most of the circuits which follow, these various condensers have been omitted, but their use will depend on circuit requirements, particularly for C1 through C3, and analogous ones to keep ripple out of voltage reference circuits.

A Small Design Note

In all of the designs discussed in these articles we have made the tacit assumption that the supply impedance is negligible, i.e., that the voltage fed into the regulator is constant with load. This is certainly not true in practice, but we have not mentioned it in designs because it would merely complicate matters (further).

In calculating values for resistances feeding directly from the raw-d.c. side of the regulator, therefore, it is wise to assemble the transformer, rectifiers, and input condenser, and to measure its voltage open-circuited and under load. This will give you firm figures to use in calculations, e.g., of the type given on p. 41, 58, and in this article for Rb & Rz.

This variation may be substantial (see fig. 4, p. 18 of this series) and to ignore it could cause significant error in calculations. It is easy to measure operating conditions -- including transistor current gain at actual currents involved -- and the confidence they give you is well worth the bit of trouble, because you may then iron out 90% of all problems on paper before you touch a soldering iron. Believe us, this is also much quicker. "Trouble shooting" without adqeuate knowledge of the circuit is a futile exercise.

Incidentally, for all of the feedback designs (figs 20-27), better efficiency is obtained if the sensing lead (Z_1, top of R_1, etc) goes directly to the output terminals of the supply, particularly if appreciable currents are being handled.

Improvement of fig. 20: Intelligent use of Zener References

Fig. 17 may be used to give excellent regulation if fixed output is desired, and if the zener is available to handle the power needed. The circuit of fig. 20 provides variable output, and a potentially much greater range of power handling capability. The circuit we presented last month did not, however, show impressive regulation (i.e., low dynamic resistance) compared to that of fig. 17 using a simple zener. But it must not be concluded that this is conclusive; it happened to be true only for the illustrative design shown. As we pointed out in a footnote last month, fig. 20 is capable

* Note the similarity of our expression, $X_C \ll X_L/R$, to the expression, $Q = X_L/R_L$ for a series resonant circuit. When the Q of the system is high, oscillation will occur. When Q = 0.7 the system is critically damped. At $Q < 0.7$ the system is stable.

of even better peformance if suitably designed. Choice of transistors depends on parameters mentioned, and the zeners of fig. 21 can be added. This latter is worth a bit more discussion here. Furthermore, considerably more signal can be fed back into Q1 (fig. 20) by reducing resistance in the upper end of R1, simply because R1 acts as a voltage divider. If it is tapped down, say at 50 ohms out of 1000 ohms to obtain some high output voltage (fig. 22a), the a.c. fed back is also tapped down by one-twentieth. For simplicity we have replaced the potentiometer by fixed resistances to illustrate the argument. By replacing the 1000 ohm resistor by a zener (fig. 22b) the same d.c. voltage division occurs, but now the full a.c. signal is fed back to that 50 ohms. (All this talk about a.c. signal is simply the drop in output voltage which occurs when you apply a load; that drop feeds Q1, and tends to correct itself via Q2).

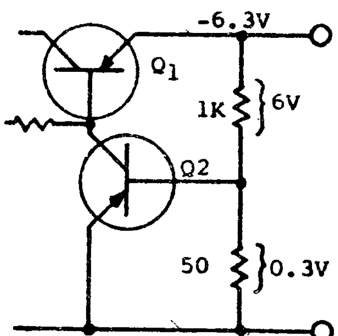


FIG. 22a: The simple bleeder at input.

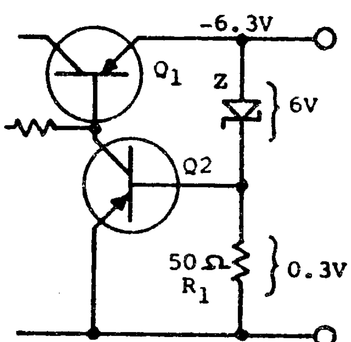


FIG 22b: Good a.c. path to Base-2 via zener diode.

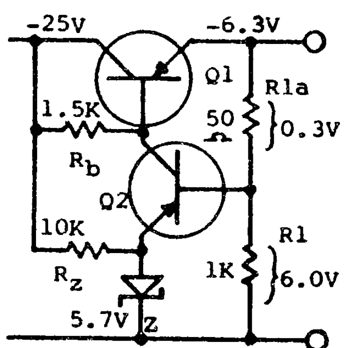


Fig. 22c: Specific application of ckt of fig. 21a.

The same thing can also be accomplished to somewhat better advantage (to be discussed) by placing the zener in the emitter of Q1 (fig. 22c). With the voltages given you can see that the position of the base bleed resistors in fig. 22c has been exactly reversed, compared to those in fig. 22a, yet the same 0.3 V appears across base-emitter of Q1 (assume that that is the V_{be} needed to give the 6.3 V output shown). But now the base sees 19/20th of the voltage drop caused by the load, rather than 1/20th. Obviously the correction by Q1-2 will be much better, therefore the regulation. We have built circuits of this sort, but shall not go further with performance details here. You can find ample illustration of it in the Literature, some of which will be referenced at the end of this series, and some of which will appear in subsequent practical articles in EEB. Suffice to say that the result is a simple system with both good regulation and adjustable output. The trouble, as usual, is that you never get something for nothing. The circuit of fig. 22b obviously does not allow us as much negative voltage to be applied to Q1 base as does fig. 22a, therefore the output of Q1 cannot be reduced as far; an analogous argument applies to fig. 22c. Thus, improvement of voltage regulation exacts the price of reduced adjustability of output voltage. This problem can be met either by switching different zener voltages (the simplest and cheapest method), or by using more complex circuits; for example using an independent voltage reference source, as in Reference 5.

It should be noted that even when you need maximum range of output voltage variation, it is still worthwhile to add at least one forward zener (i.e., ordinary forward biased silicon diode), as in fig. 21b. At the expense of a slight increase in the minimum output voltage, this feature gives much smoother control of voltage at the high end; see fig. 22a. The reason is simple: without the diode, control of the higher output is done in the low 100 ohms of the pot. With the silicon diode included, control at the high output end is done in the low 200 ohms of the pot. This gives additional pot rotation angle in which to adjust the higher voltage.

The forward biased diode is not as good a zener as a proper zener diode, but it is not too bad as long as enough current is passed through it. On the other hand, ordinary "zeners" do not have very low dynamic impedance either, until they reach about 6V and operate in true avalanche mode. A somewhat improved low-voltage reference will be discussed for figs. 23c & 23d.

It should also be noted that when the pot is controlling near the bottom, Q2 is being cut off, and Q1 is running at saturation. Under such conditions, the loop gain falls to nothing and so does voltage regulation. To worsen this as Q2 current falls, emitter zener current decreases, eventually losing zener voltage control, particularly if a forward biased diode is used (fig. 21b). Thus you have to be careful not to ask the system to give maximum output voltage if you want to retain the regulation feature. For this reason it is wise to insert a fixed resistor in the bottom end of R1 in fig. 20, large enough to limit the maximum output voltage to the point where at least 1 V appears across collector-emitter of Q1.

Violence of control at the low end of the pot can also be reduced by using a pot with a logarithmic resistance taper.

<u>Improvement, II</u>: <u>When to use fig. 22b</u>

In the previous section we mentioned that the placement of zener in fig 22c has some advantage over that in fig. 22b. Why? Well, when this kind of circuit was evolved some years ago the only zeners available were fairly heavy, e.g. 1W or more. The zener in fig. 22c will pass more current for most of the control range (particularly when Rz is added as in fig. 21) than in fig. 22b, and this is an advantage to keep the zener in its best range of voltage control; when too little zener current is passed, it no longer gives constant voltage drop. This minimum current will depend on zener quality and power rating, and may be from 50 µA to 1 mA or more.

On the other hand, cheap zeners (less than 1W) are now available, and these can be used in fig. 22, because they require less current (e.g. 100 µA) to maintain constant voltage -- though it must be mentioned that the bigger the zener power rating, the better voltage regulator it will be (lower dynamic resistance) as long as it passes sufficient current.

Fig. 22b has a disadvantage that at low output voltage the zener current will fall below the minimum needed to maintain zener voltage control. This restricts minimum output voltage to somewhat more than the zener voltage. In exchange, however, the circuit of fig. 22b has the advantage that voltage across Q2 is kept high, (i.e., at Z voltage) right down to minimum output. In fig. 22c it can be seen that the collector-emitter voltage of Q2 is reduced by the voltage drop across Z, particularly at low output voltage. Transistors don't like to amplify unless there is enough voltage across them, and fig. 22b keeps this voltage at a reasonable value for all output voltages.

The disadvantage of restricted zener current at low voltage output can be met simply by switching the zener out of the circuit at low outputs, though this reduces Q2 collector voltage. Since Q2 needs only a few volts to operate effectively, a good compromise can be achieved by using fig. 22b with a small zener, e.g. 3.7 V. This gives adequate Q2 collector voltage at the lowest output, yet a reasonably low minimum output, e.g., 4 V. Methods for obtaining still lower outputs are discussed here for figs 24 & 25.

<u>Improvement III</u>: <u>Emitter Control</u>

One may well ask: why is voltage control obtained by a pot in the <u>base</u> lead of Q2? The answer appears to be that it is a carry-over from valve technique, where it was feasible only to control the grid voltage of a valve placed in the position of Q2. But it can be an advantage in this case to control the <u>emitter</u> voltage of Q2, as in fig. 23a, with some typical values shown for 25V input (but keep in mind the assumptions made in "A small design note" two pages ago), as shown on the next page.

It can be seen immediately that this circuit possesses all of the advantages of figs 22b & 22c: A.c. signal is supplied directly to Q2 via Z1, with no attenuation at all by R1! Base-emitter bias is now controlled by R2, with the voltage at the pot slider being essentially constant, because of high bleed current through the pot (e.g., 5 to 10 times Ie_2). Since R2 is relatively small, it also provides an easy path for a.c., and the a.c. regulation (and ripple reduction) of this circuit is excellent. Within the low-end limitation mentioned above, it thus has the advantages of

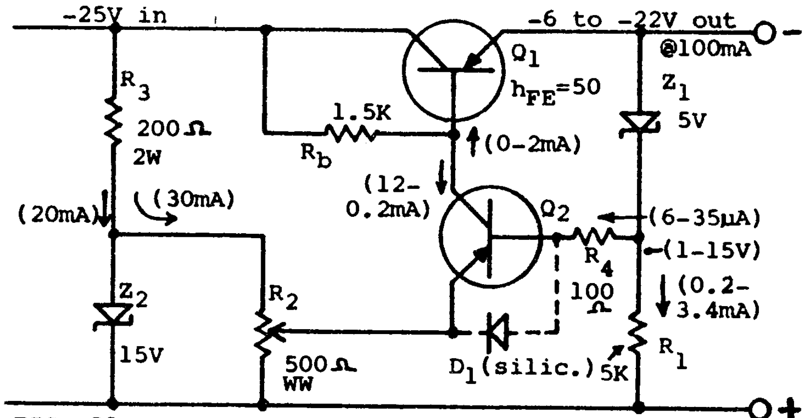


FIG. 23a: Improved version of fig. 22b, with high a.c. feedback and good stability. Values shown are typical, based on Ohm's Law and Transistor Gain Eqns. For 100mA: Q1= 2N3645, 2N1042, AC132, etc (viz., ≥1A at V_{sat}) with small heat sink (e.g. 5 sq. in). Q2 = 2N3638, AC132, computer 030, 026, etc (≥ 500mA @ V_{sat}) with flag or cogwheel heat sink.

(1) Wide range of control
(2) Minimal degredation of a.c. amplification by d.c. control circuit
(3) Highest possible Q2 collector voltage at low outputs. Notice how the base voltage of Q2 must be nearly the same as its emitter voltage; this is the same principle as for an emitter-follower, but this circuit makes Q2 a base follower! So, the reference voltage in the emitter is now minimum at minimum output voltage, giving maximum possible collector-2 voltage.

Now, of course Z_1 can be any good zener, and R1 is adjusted to give sensible minimum zener-1 current (e.g. 0.2 mA) at minimum output voltage, all by ohm's law which we need not repeat here. Rb is calculated in the usual manner, as described for fig. 20. No condensers have been shown, but reasona ble preregulation filtering should be provided by splitting Rb, and inserting an electrolytic as per discussion of fig. 20. If Z2 is not the best, it can also be worthwhile to bypass it with numerous microfarads.

R4 and D are merely to protect the base-emitter reverse diode characteristic of Q2 in event of the supply output being shorted. This circuit, in common with fig. 20 tends to be self-protecting via Rb as described last month (p. 59). But there are limits to this, so watch out.

Some variations on fig. 23a

Briefly now, return to our cryptic comment earlier about shorting out Z1 for low voltage output. How can this be? Simply because the abovementioned base-follower action dictates that the base of Q2 will be at about the same voltage as the slider of R2. If Z1 is shorted, then so will be the output to base-2. But if so, why not merely make Z2 = 20V and get the whole range with R2 only? This will work, but at 22 V out, Q2 would have less than 1V across it, and that is what we are trying to avoid. It can be seen therefore, that the use of Z1 allows us to get higher voltage from Q1, whilst maintaining adequate voltage across Q2 at all times. Here, output voltage will be Ez_1 + voltage across R_1 (therefore across R2, approximately).

In the circuit of ref. 19a which used a somewhat similar (though not as adequate) system, the problem of Z1 never arose because, with the 25 V supply they used, the output was limited (by Z2) to 15V.

If we wished say, to handle 1 Amp with the circuit of fig. 23a, we have two alternatives, as shown (next page) in figs 23b & c.

(1) Cascade two transistors in "Darlington Pair" configuration in place of Q1 where Q1-A of fig. 23b can also consist of several cascaded transistors as needed to get the required circuit current output. The resistors shunting the bases can be useful to ensure low output voltage when lightly loaded. Sometimes a small R is put in the collector of either transistor to reduce its power dissipation, but it must be chosen carefully -- as will be discussed in

a forthcoming EEB. Another alternative exists:

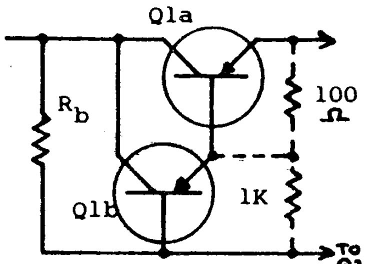


FIG. 23b: Darlington pair replaces Q1 for higher current out. Q1b =2N697, 40253 etc, or as for Q1 in fig. 23a. For 1A, Q1a = OC29, AD140, 2N301, etc; up to 5A: 2N3715, 2N174, etc, depending on heat sink, thermal insulation, etc.

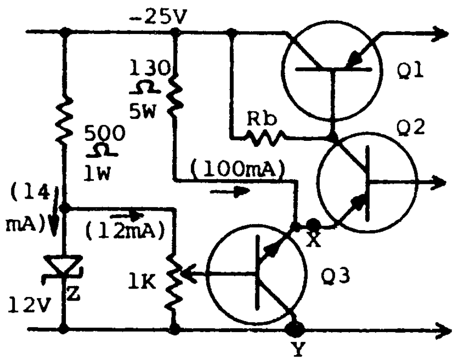


Fig. 23c: Q3 (large enough to handle 100mA comfortably) replaces R2 in fig. 23a under conditions where Q2 must handle substantial emitter current.

(2) Keep a single heavier transistor as Q1 (e.g. types as shown for Q1A), use a heavier transistor for Q2 to handle its higher base current, and use a transistor in place of R2 as shown in fig. 23c. As far as I'm concerned the circuit of fig 23b is far easier, but that of 23c is quite interesting because it shows how the same principle used to control Q2 in fig 22b can in fact be used to make any transistor look like a zener of any desired voltage. This is, of course exactly what Q2 does in fig. 20.

An interesting permutation of this principle has been used by C. Horwitz* to substitute a transistor for the forward-biased diode in fig 21b. This is shown in fig. 23d. Here the

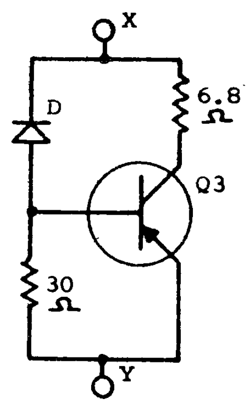


FIG. 23d: A low-resistance substitute for a forward-biased diode (see text).

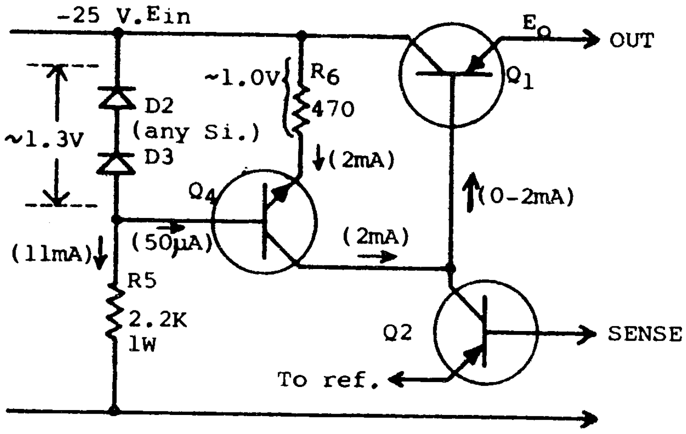


Fig. 23e: A very useful constant-current substitute for Rb, a "pre-regulator circuit". Note that $E_{C4} = E_{in} - (E_o + E_{be_1}) - E_6$. and that Ic_4 is only approximately constant, as shown by curve of fig. 23f.

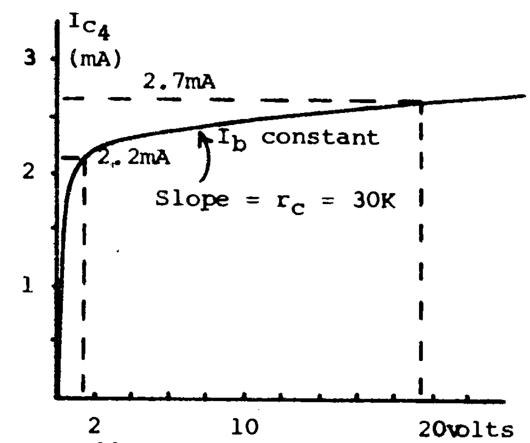


FIG. 23f: The effect of finite collector resistance on the ability of fig. 23e to keep current "constant".

reference voltage is provided by a forward biased silicon diode, D. The whole circuit substitutes for the diode of fig. 21b, or in fig. 23c with X & Y placed as shown. This transistor combination has a lower dynamic resistance than a forward diode itself (the latter being a rather poor "zener"), and also reduces load-dependent voltage variation caused by diode heating. We are grateful to Mr. Horwitz for this idea, although the system of fig.23c is somewhat more versatile for about the same number of parts.

In the same vein it is possible to use a transistor-zener combination to make the transistor look like a constant current rather than constant voltage source. This is well illustrated by applications in references 5 & 8, which we have modified for use in fig. 23e (Ref 5 calls it a "pre regulator"). In it, Rb is replaced by the whole circuit of fig 23e. Since D2 &3 as forward zeners hold voltage across R6 constant, and since current through R6 also = current through the transistor, so the collector current is constant. Simple? This means that the collector current of Q4 will stay the same, no matter what the collector voltage.

Unfortunately we are running out of space for this issue, and can only mention that fig. 23f merely shows how "constant" the current is, as a result of the quite finite collector resistance of Q4. ((CONCLUDED NEXT MONTH!))

* Personal communication.

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→ COMMONSENSE ELECTRONICS

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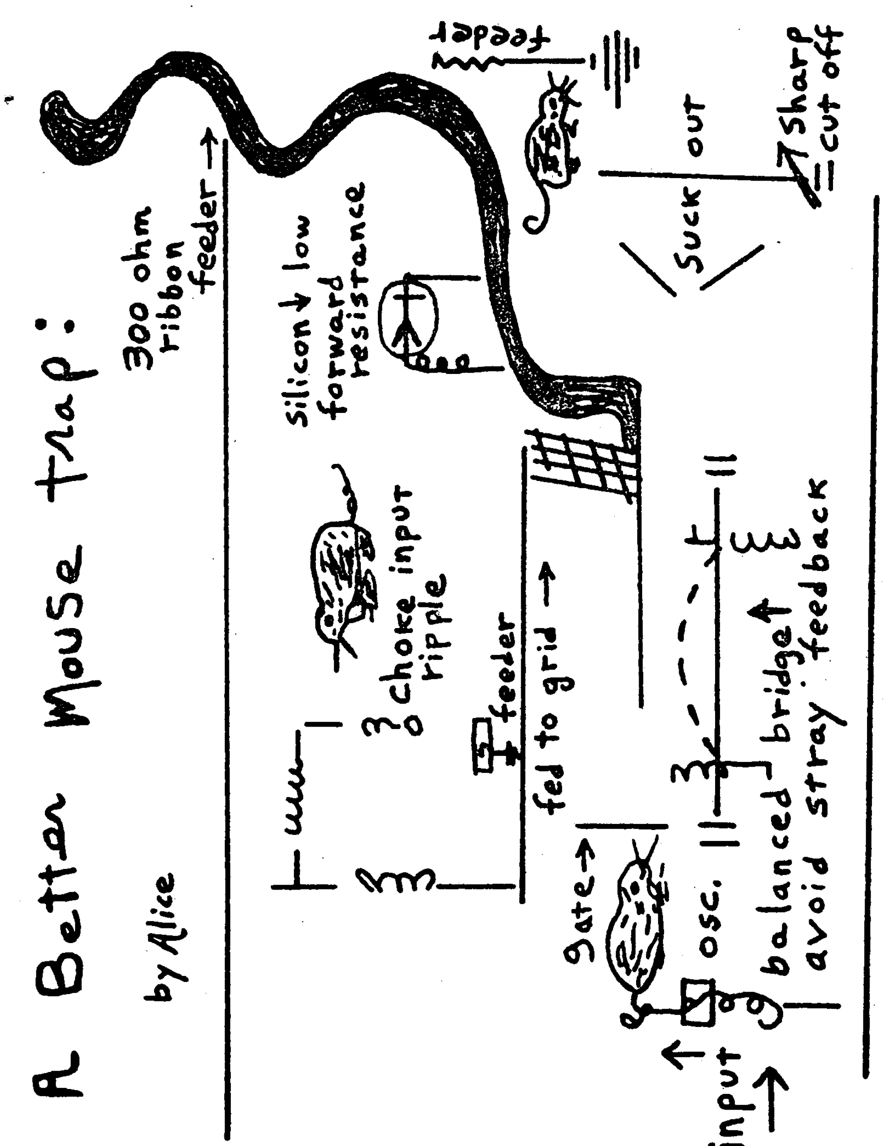


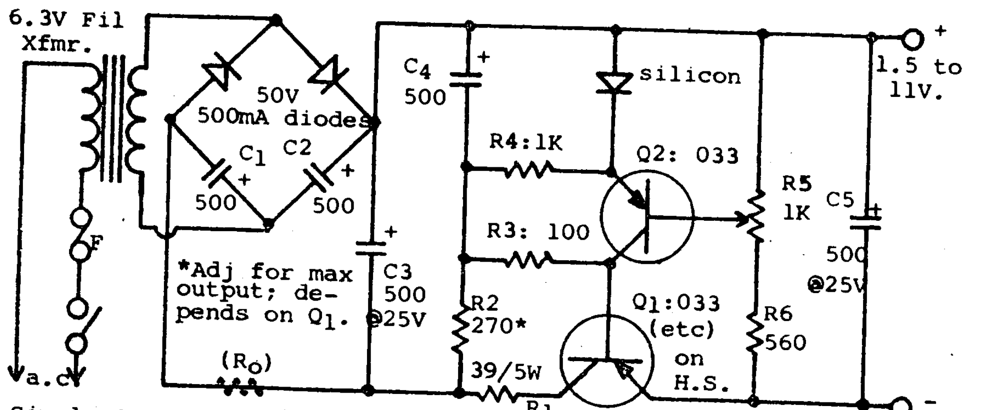
CONTENT:

NEXT MONTH: August

- -- The Motorola Data Book
- -- CD Ignitions Revisited
- -- The Choke Revisited
- -- FET GDO
- -- Real Radiation Resistance!
- -- Pseudo HT Transistors...?
- -- Letters, Iditorials, etc.

A REGULATED POWER SUPPLY -- L. J. Smith (VK2)
-- With short-circuit protection, and using computer board transistors.

This system is essentially the type described by RLG in April in fig. 20 with modification of fig. 21b (see March article), but with special short-circuit protection in addition. Its output is modest (only 100mA max), but could be increased by the use of a more robust series transistor (Q1). It represents a simple though conventional solution I found to the need for an effective and cheap source of regulated voltage. The 030 or 026 types from the computer boards are rated to stand higher currents than the 033 or 034, and if available would probably give higher output than the simple types used here. The fact that an 033 as Q1 could handle 100mA seems to indicate that the figures published in Amateur Radio (Aug. 1969) may be a bit pessimistic in specifying an upper limit of 50mA for this type. On the other hand the 39 ohm resistor in series with collector of Q1 is essential to save the transistors in event of a short chrcuit; reducing it to 20 ohms resulted in rapid transistor failure. This resistor also provides an extra advantage: it reduces Q1 collector dissipation even during normal operation, allowing as in this case, a very modest transistor (100mW) to control an appreciable output power (1200mW). Without it, output current at maximum voltage would have to be restricted to less than 25mA.



Simple Computer-board transistor operated reg. power supply

The filter circuit in the collector of Q2 allows good control of ripple while preserving some ability of the amplifier to respond rapidly to change in output voltage, i.e., prevents a.c. shorting of Q2 by C4. Q1 should be attached to a heat sink for currents over about 10mA output; this can be in the form of the "cogwheel" type sometimes found on the boards, or available from STC etc. Or the transistor can simply be attached to a heavy slb of metal via a strip of sheet metal clamped around the transistor case. The load which can be drawn safely depends on output voltage, e.g. 25mA at 2.5V, 75mA at 7.5V, 100mA at higher voltages. Note that this is not a linear, but a quadratic relationship, though it is easier to remember the above figures than to consult a graph; they have been adjusted slightly (by the Editor) to facilitate memory.

Note that this circuit does not contain transient suppression. This is an idea obtained from the "Selected Semiconductor Circuits Handbook" by Schwartz (Wiley), section 8-12 & 13. This is interesting, because it says that the only semiconductor circuit which requires transient suppression is the simple half-wave type. The rest are self-protecting by the diode which conducts on the reverse cycle. On the other hand, a 0.01uF/600WV (or more!) condenser across transformer input might be advisable when very high energy transients are expected, for example out in the bush where the unit is used at the end of very long lines, and where local equipment could produce high surge currents.

= =

EDITOR'S NOTE:

The subject of series resistor protection of regulated power supplies is very interesting. Prompted by some preliminary calculations by the author, Rod & I have prepared quite a nice article on the subject, a summary of which may appear in these pages. The whole article is too long for EEB and will probably appear Elsewhere.

From our calculations, the value of resistance Les has found to be safe (39 ohms) is consistent with the assumption that ripple at the output of the rectifiers is at least 25%, which is reasonable for the value of condensers used. I predict that if the 500uF items were raised to 2000uF, the 39 ohm resistor could be reduced to about 27 ohms, allowing regulation to be maintained at somewhat higher output voltage (e.g., 12.5V in this instance).

On the other hand, this assumes perfect regulation of the rectifier supply. This does not ordinarily happen, as mentioned last month (p. 83) under "A Small Design Note", and in this particular case the regulation of the supply is further worsened by the fact that it is a voltage doubler. Far from being a disadvantage, however, this is desirable in this instance, because it further reduces voltage applied to Q1 under short circuit conditions, so allowing the use of a smaller transistor than would be possible with supply having good regulation! When a supply does have good regulation, the insertion of Ro, dotted in on the diagram (added by us), can be used purposely to worsen regulation and to improve the filtering efficiency of C3.... It can be quite useful to calculate the value of the series resistor (here = R1), and Les Smith did in fact supply such calculation with his article. We have, however, not presented it here, because that value does depend very strongly on ripple, which is usually high at the collector of Q1, and requires the rather more elaborate treatment we shall give it.

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A SIMPLE LATCHING-TYPE OVERLOAD PROTECTION SYSTEM -- J. Van Staveren (VK7JV)

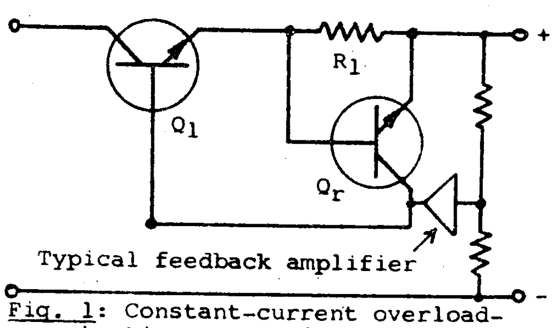

Fig. 1: Constant-current overload-protection system (Ref. 50).

The overload protection system described on the previous page does have the advantage that it reduces normal power dissipation as well as overload dissipation. This gives the series-resistor method some advantage over an alternative system, the constant current regulator depicted typically in fig. 1 at the left. Here, overload current through R1 biases Q_r on, thereby shorting base-emitter of Q1. Both of these methods havw one disadvantage: they protect only the power supply. But surely the load is equally as important -- and may include more transistors. With the usual protection systems, if some fault develops in the load, the power supply series transistor is protected happily while the load sizzles.

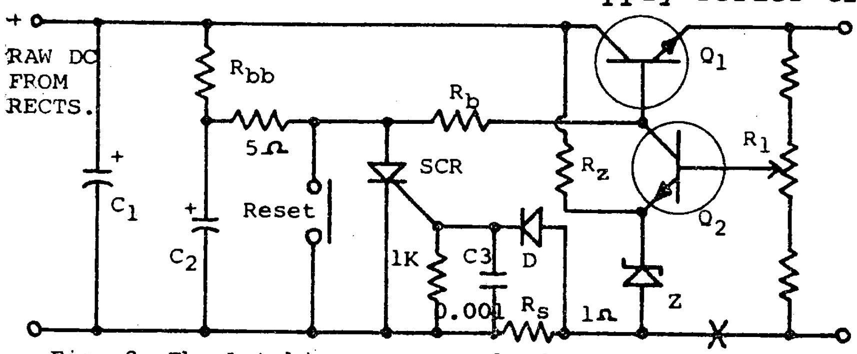

Fig. 2: The Latching-type Overload Protection System. C3 prevents stray r.f. from triggering the SCR. This system is preferable to the automatic-reset type, because power stays off until the fault is corrected!

The high sensitivity and power handling ability of the Silicon Controlled Rectifier would appear to be ideal to control the overload properties of a power supply. But the conventional "crowbar" method seems a silly way to do it: the SCR shorts the supply when an overload occurs, and a fuse blows!!

Far more sensible is a latching system as shown in fig. 2. When excess current is drawn, voltage developed across Rs triggers the SCR which promptly shorts out Rb in a conventional feedback regulator circuit, and keeps it shorted, with holding current supplied by R_{bb}. The power supply is thus turned off, both for the sake of Q1 and for the load. And it stays off until "reset" which removes anode voltage from the SCR so allowing it to regain the non-conducting state. The diode, D, isolates the gate from the trigger circuit, and the 5 ohm resistor reduces the violence of discharge of C2 through the SCR.

The value of R_s will, of course, determine the level at which the SCR will trigger, and this will depend on the maximum load current to be drawn. Indeed, if Rs is made variable, it is possible to adjust the trigger level from the front panel, allowing the whole system to be set to an overload level appropriate to the circuit on which you are working. Rs in no way prejudices the operation of the regulator circuit itself, being merely in the same functional position as R_1 on p. 90, and giving the same results. It is important, however, not to place Rs at point "X" in fig. 2, or regulation will be ruined.

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REPAIRING NOISY POTENTIOMETERS -- T. Cengia (VK7)

Noisy controls can be made good by spraying the elements with CRC or No-Noise etc ((but beware "Servisol"; it dissolves plastic -- RAJR)), but ONLY at the first sign of trouble. If this is done, about 90% of the cases are successful and give no more trouble, 2% get worse, and about 8% last for a couple of months, then give trouble. If they are allowed to become very bad before spraying, 10% become and stay good, 10% become worse, 40% go crook after 2 to 6 months, and 40% stay bad. When the spraying technique is applicable, it only works with the ordinary deposited carbon (or wirewound) types. The paper-back resistance types (vintage or miniature) do not respond to spraying, and have a tendency to get worse; just replace them.

It is possible to obtain some benefit by spraying the resistance element after removing the back cover of the pot, and turning the shaft back and forth. But lasting benefit will be best obtained by taking the pot apart; this is not particularly difficult. With a small screwdriver open up and remove the ring locking the shaft of the pot. Next remove the housing by lifting the clamping arms with a small screwdriver. The sliding contacts on the shaft are wiped clean with lint-free cloth, and checked for any wear; evidence of a shining spot should be present. If wear is very light you can increase spring pressure by bending the contacts with the tip of a small screwdriver.

The next step is to run the clean cloth through the resistance piece, exerting enough pressure to remove any dust and grease present. Then spray with suitable compound and reassemble. The ring on the shaft may require flatening, and is squeezed in place with a pair of pliers. If a switch is present, it is turned on before the operation and represents no problem... Repairs can be worthwhile, particularly on the more expensive gang types. It only takes 5 to 15 minutes, and is well worth it for home constructors.

((I might comment that if you are replacing a switch type, it is best to replace it with the movable shaft type, which controls the switch by pushing the shaft in. This type gives less wear. -- GDJ))

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Home-made Brushes: Take a new thick piece of bark, cut into an oblong shape, point it at one end. Soak the wide end in water for several weeks; beat with hammer to make pliable. Works!

COMPLEMENTARY SYMMETRY AMPLIFIERS, Part II

-- The uses of Germanium, and computer board transistors, etc.

-- Conducted by RLG, with contributions by N. O. Kallam, I. N. Kallam, R. S. Maddever, and A. Whittingham....

ATTENTION!

I wish to draw your attention to a grievous draughting error which occurred on p.67 of last month's EEB (May), in spite of the manuscript being read by three people! In fig. 4, R6 goes to the emitters of the output transistors, NOT the bases as shown. Please correct this important error on your own copy now. It must be noted that the tests made by N.O. Kallam were performed with R6 in the correct position. We must here apologise to Fairchild and everyone else for this error, but these things happen. I've seen worse --hi.

Summary, etc.

Last month, N. O. Kallam presented several simple complimentary symmetry amps, and a somewhat abridged analysis of the Fairchild 3W economy amplifier, showing certain modifications desirab le to avoid appreciable crossover distortion at low outputs. In addition I. N. Kallam has written: "I also tried the Fairchild Amp as shown in E.A. using their own transistors: 10mW = 20% distortion, 60mW = 1.5%, but still appreciable loudspeaker volume at the lower figure. Osc distortion = 0.1%, 400cps. This amplifier is HIGHLY unstable, seems to take off at r.f. if you touch the speaker lead..."

The Uses of Feedback, II

Since last month's article by N. O. Kallam, I have come across Reference 27b, which has some very interesting information, which might modify our conclusions -- slightly. In these amplifiers, RCA appears (from the figures) to have succeeded in doing what was attempted in the simplified Fairchild circuit: to produce conditions giving acceptably low crossover distortion through the use of a system analogous to R6 in fig. 4 (last month's EEB, p. 67): the NPN at the output is biased slightly forward, but without benefit of the problems associated with R5 of fig. 4, mentioned by Kallam. By omitting R9 & D of our fig. 7 (and of Ref 27a), RCA claims advantages of smaller power supply, "exceptional d.c. stability", lower average transistor dissipations, and higher power efficiency particularly at high frequencies (reduced hole-storage time). On the other hand, even with the NPN biased ON at low outputs RCA admits the presence of appreciable crossover distortion, requiring the presence of an additional two stages of amplification to supply "large amounts of feedback necessary to reduce the crossover distortion." The extra stages needed are "traded for the output stage bias diode and emitter resistors." One might ask whether the trade is worth it, but RCA obviously believes it is, because of the abovementioned advantages. They also say that "Although crossover distortion is always larger for Class B amplifiers than for Class AB amplifiers ((i.e., where some forward bias is provided for the latter -- RLG)) the Class B amplifier can be designed to have an acceptable intermodulation distortion (which is predominantly crossover distortion."

Well, there is the crux of the matter. Because of certain advantages of unbiased output stages RCA choses to minimise the crossover distortion by careful design and massive feedback. It appears that they have done this successfully, but at these costs:

(1) Considerable increase in complexity and in number of amplifier stages, and
(2) A complex and carefully designed feedback system involving two a.c. and one d.c. loops and a special bootstrapped constant current section.

Clearly these requirements are not compatable with the design of an amplifier having no interbase bias merely on the basis of reducing the number of components and then making up for deficiencies by large amounts of uncompensated feedback. Feedback is not inherently bad; as Kallam pointed out last month, unless feedback is sufficiently good (not merely strong), it is a mistake to rely on it to correct amplifier deficiency. If there is a chance for fb to become other than -180^{o} under any conditions of frequency, impedance, or drive to be encountered, then it is better NOT to rely on the fb, but to make a better amplifier with less fb. RCA appears to prefer the fb method because of output efficiency, but the result is not simple. This appears to have certain advantages for the commercial engineer at whom this book is clearly directed. They have a point, but it seems to me that the somewhat less efficient system is preferable having lower inherent distortion, and not depending on the elegance of design of the feedback. It is my (and our) opinion, and it tends to be justified particularly in situations involving experimenter designs.

Finishing up the Circuit of fig. 7 (from p. 71, last month):

Mr. Maddever points out that an interesting variation of the input circuit is to obtain gain control by using C3 in series with a 1K or 5K pot; at large values of pot resistance the gain is as designed, but with low resistance, C3 introduces increased emitter bypassing, and gives extra gain; this could well be convenient as an additional control to give the amplifier more gain under conditions where it is needed, and where the additional distortion and the lower input impedance caused by C3 was not deemed a disadvantage.

The Uses of Germanium, II:

It should be recalled that germanium transistors in the output of fig. 4 gave better results because the base-emitter junction potential of germanium is about half that of silicon; so, without extra bias the germanium still conducts over a larger portion of the input cycle, i.e., runs closer to true Class B (180° conduction angle).

There are advantages and disadvantages to using germanium transistors. Germanium has a poorer frequency response than silicon as well as higher leakage and restricted temperature tolerance. As Ref. 24 points out, silicon can perform at much higher junction temperatures, allowing more modest heat sinks for a given power dissipation. But silicon has higher saturation voltage which results in decreased operating efficiency (so it gets hotter), and this is particularly evident when low voltage power supply is involved.

On the other hand, immense frequency response is not always necessary (particularly for audio work), or not always desirable (if it gives appreciable gain at frequencies where feedback phase is altered), germanium transistors are often cheaper or more available, and they do perform better at lower voltages. In addition the bias conditions are more modest for (true) Class B, owing to the abovementioned lower base-emitter junction potential. So, for simple installations we are partial to germanium, but of course this is only an opinion.

The Philips circuit of fig. 5 (p. 68 here last month) is a typical simple good design, and gives good sound quality at all levels, with no discernable instabilities. Forward bias of the output transistors is provided by R5, and emitter resistors R6 & R7 protect them from thermal runaway. Ref 10 presenting this circuit is well-written, and should be consulted for constructional details and analysis of performance ((Request on Company Letterhead, otherwise maybe send 50c to Philips for it)).

Amplifiers using germanium are described for various power levels in the References, but of particular interest for simplicity is the material in Refs. 19 & 20 which use computer board transistors, and Ref. 30 which uses simple transistors which could well be substituted by types 033, 030, etc.

N. O. Kallam has made an interesting modification of fig. 5 (<u>EEB</u> p. 68): Tr_1 = 2N4250, Tr2 = BC108, Tr3 = AC127, TR4 = AC132. Component values as in Ref. 10b, but power supply and electrolytic polarities reversed to accompodate the PNP configuration, of course. The result was a "very sweet-sounding amplifier, and I feel this is primarily due to the high quality of the 2N4250, being surely the best transistor ever manufactured by Fairchild; its high gain, excellent linearity, low noise, and ability to operate at minute currents qualify it uniquely as a desirable amplifier input stage." He believes that that particular amplifier manifested a certain unusual behaviour which contributed to its good performance, but the results are so surprising that he wishes to make further tests before saying anything definite; I earnestly hope that he will make them at an early opportunity and let us know the results!

R. S. Maddever (VK3) has also provided a useful little circuit using computer board transistors, as in fig. 8, below. It gives a nice 130mW (RMS) across 15 ohms for about 100mV (RMS) input, depending on R3. For best results adjust R5 to just under the value which begins to increase quiescent (no signal) current of the output transistors. It is important not to use diffused alloy types, e.g. 015 & 065 in the output; the input transistor can be any NPN. The use of 030 & 071 (or 086) transistors in the output, if available, will undoubtedly increase max output power available;*even 026/076 would probably give improvement over 033/083 (see <u>Amateur Radio</u>, Aug & Dec 1969 for characteristics of computer board transistors). Use Grandma's tests to tell when maximum power is being achieved: namely, when output transistors get hot (germanium) or very hot (silicon), and/or when distortion (at any volume!) starts to become evident. Flag or cogwheel type heat sinks increase power rating, as long as peak currents do not drive the collector non-linear. I have a lot of notes on that subject too, and I suppose we'll have an article on design of OTL one day, but not until we work through the considerable backlog of articles which have been submitted; ah the drawbacks of Success. In interim, see the References, particularly ones marked for Theory.

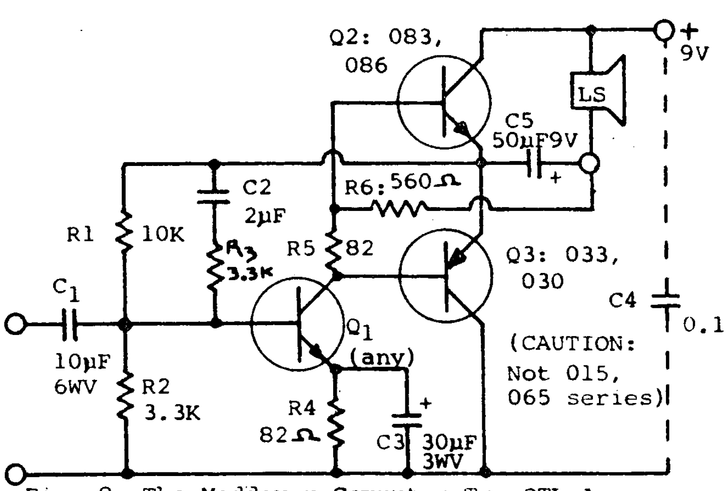

Fig. 8: The Maddever Computer-Tr. OTL Amp.

<u>*IMPORTANT DESIGN NOTE BY RAJR:</u>

It is widely and incorrectly assumed that by simply plugging a bigger transistor into the output stage you will obtain more output. You can obtain more output therefrom only under quite limited conditions:

(1) A larger (current) output transistor will allow the use of a lower impedance load, because higher peak output currents are permissible. If load impedance is fixed (e.g. at 8 ohms), then higher output power is obtained only by:

(2) Increased drive until the output transistor approaches saturation (specifically is driven out of its reasonably linear region). A larger transistor will allow higher saturation current, but note that the driver transistor must be rated to deliver the higher drive current. If you install a larger output transistor and crank up

the gain you may get driver distortion long before the output transistors reach saturation; the only cure is to use a bigger driver too (and run more current through it).
(3) If the output transistor is being driven as hard as possible, then putting in a bigger transistor will not give higher output power unless d.c. supply voltage is increased. This is quite reasonable: If the output transistors are approaching saturation, they are going to carry the maximum current possible for a given supply voltage and load. To get more output, the supply voltage must be increased ($P = E^2/R$), but note that that exponential term shows that you can get a lot of mileage out of just a little more supply voltage. The converse also applies, e.g. in a mobile installation: the loss of a little supply can punch a big hole in your power output.

Computerising the Fairchild Circuit of fig. 4 (as amended!)? -- A.W. & R.L.G.

Alf Whittingham (whose constructions have appeared in the past three EEBs) has used computer board transistors directly in fig. 4 (p. 67) with good results, by careful adjustment of the various circuit parameters. "During testing this circuit I have used a substitution box I made with 132 resistors and 132 capacitors, containing 22 different values of zach; this was in a 1 lb plastic butter container with four 12-position switches, so I can get nearly any value I like. I also use pre-set pots of various values, and can alter most components of a circuit while it is going. Perhaps this is not supposed to be a good idea, but with care no damage is produced and it does produce plenty of good quick results. By changing every component by this method I can quickly arrive at the optimum values, at the same time monitoring the voltage and current with suitable meters. I have aimed to keep the voltage down to 9V and current drain down to something comparable with the usual run of radios and amplifiers.."

I hope that he will forgive us for not reproducing the circuit here, but it is just as on fig. 4, p. 67 last month, with the following components used:
Q1 = 083 (select for low leakage), Q2 = 034 (ditto), Q3 = 083, Q4 = 034 (Flag type heat sinks on Q3 & Q4; need not be closely matched for gain). R1 = 330 ohms (adjust for acceptable distortion for a given output and sensitivity), R2 = 3.3Megs, R3 = 10Megs, R4 =2.2K, R5 = 2.2K (adj to keep quiescent current down to about 5mA), R6 = 1K (NOTE: not as shown in original fig. 4; see correction here, p. 92. Use highest value of R6 which will reduce crossover distortion; start from 2K and work down, but if too low it will increase quiescent current sharply), C1 = 0.01 to 0.1uF, C2 = 25uF/10WV, C3 = not fitted, C4 = 500uF/15WV in parallel with 0.1uF disc/25WV, C5 = 100uF to 500uF (Higher values of C1&5 for better bass response). If a high impedance source is used, insert a resistor in series with C1, and increase until distortion (arising from the driver) disappears, e.g. 470K with a crystal pickup. It attenuates highs, but this doesn't matter much with radio programme material, if only to avoid the 10kc whistle from a good wideband tuner. Even so, a sharply tuned whistle filter may be necessary with a hifi a.m. tuner, particularly in more densely populated parts of this (or other) country. Mr. W. observes that if resistors R2 and R3 are reduced, distortion appears. Supply voltage can bu up to aboaut 16V, and speakers can be used at 3.5, 8.0, or 15 ohms, giving various input sensitivities. Power output is probably 100-200mW with a 9V supply, giving quite adequate room volume for many applications. Open load is OK, but shoarted ((my typewriter is partial to "a")) load is fatal when signal is applied. The mechanical layout is very compact, can be condensed to 1¾ x¾" using only a small handful of components. Layout is on veroboard, but again I hope Mr. W. will forgive us for not reproducing it here, because of space limitation.

Now this is well and good, but Mr. W. says that when the weather up in NSW started to get hot this computer-transistor amplifier (used in a Signal Tracer) started to show distortion, so he switched to Silicons! With Q1 = AY1101, Q2 = AY1114, Q3 = AY1116, and Q4 = AY1117 (all from Fairchild), the only change necessary was to change R2 to 330K and R3 to 820K. BUT it will also work well with Q1 = 083, Q2 = 034, and the output ones still silicon. This would indicate that the temperature sensitivity of the all-germanium circuit was caused by the output transistors, Q3 & Q4. The simplicity of all-computer tr's can be retained by a fig. 7=type modification of the output transistor biases (omitting R6) and this has in fact been done in Ref. 19, but as Mr. W. points out this is no longer the simple circuit of fig. 4. Refs 17 & 18 show another way to use the AY1116/1117 pair in the output...... Mr. W. also describes a preamplifier he used with a crystal pickup, taken from Ref. 31, p. 35.

Therefore; CAUTION: Simple computer-boardising of fig. 4 is not practical if the ambient temperature is high; for all-weather reliability, the bias system of fig. 7 should be used if computer transistors are employed. Fig. 4 could probably be saved for computer types by playing about with conditions for bias stabilisation, but why bother??

Quasi-complementary Amplifiers

The circuit of fig. 3 (p. 67) and in many of the References are examples of this kind of amplifier, wherein the phase of signal to one transistor of the output pair is inverted by a complementary preamplifier stage. But the full force of the main current from the signal is borne by the two seriesed transistors having the same polarity. This was very convenient in the days before NPN power transistors (e.g. Fairchild AY8114, 2N3055) became widely available, and still is when gain matching is easier from a stack of similar types, or when only PNP is available in the parts-box.

Indeed, I first saw this circuit applied to valves in one of the first few output transformerless systems developed by a commercial engineer, and later in more finished form in Ref. 26a, using the equivalent of 6AS7 triodes driving 15 ohm load with good match and no transformer. Such circuits running Class A give a quality difficult to meet in any but the most elegant valve circuit, and needless to say, in most transistorised ones. A good OTL Class A system gives better sound than a Class B one having the same power output. Here is an excellent example of Mr. Kallam's dictum last month about inverse feedback: you can straighten out the nonlinearities of a transistor power amplifier by massive injections of negative feedback -- and you need to do it if results are to be acceptable. But if you do the same thing with valves you'll get a better result, simply because of the inherently better linearity of the valve (particularly triode) before feedback is applied.

In any event, to return if we must, to the transistor (being a difficult way to accomplish something simple?), the Quasi-complementary system has also been applied to the use of computer-board transistors, in Ref. 20, using 036 or 042 high power (TO3) types in series, driven by other computer transistors, to 2W output power. We are not reproducing this circuit here, but it is a simple adaptation of the usual PNP output setup. Computer board transistors are not magical, simply cheap. If they look like AD140's or 2N301's they probably work like them. Nowadays transistors of all kinds are becoming quite reasonable in price, even new, so that it can be worth while to consider using new ones if feasible. They can be obtained quite inexpensively from Custom Electronics in Adelaide (advertises in E.A. Classifieds), through Stores of local Divisions of the W.I.A., and so forth. Constructional details for the amplifier of fig. 3 will be presented by R. S. Maddever in EEB....

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LETTER: The use of mixed output transistors...

I have just had a peep at some new TV Circuit books featuring 1968 Soni solid state TVs, and they are using 4 transistor a.f. outputs somewhat like Fairchild's. An interesting feature is that they are using a silicon transistor in the position of Q3 (fig. 4, EEB p. 67, last month), and a germanium one in the Q4 position. I think that this is to overcome the problem that Q3 gets a bit warmer than Q4, probably due to the forward bias placed on Q3 by emitter resistor R6 ((not in the base!; see p. 92 here -- Ed.)).

They also use a thermistor in the base circuit of the output pair, so presumably they have had trouble with thermal stability.

-- A. Whittingham, Stanbridge NSW.

((Ed Note: In our whole discussion we have had little to say about temperature compensation. If the bases are not forward biased, the complementary output amps are very thermally stable, and RCA advances that as one reason for using that configuration, with the various additional refinements as we have discussed here. With interbase bias to Class AB, emitter resistors are desirable for temperature stability; in addition, however, the diode between bases definitely acts to help temperature compensation. R.S. Maddever points out that two germaniums better than one Si. for this))

COMPLEMENTARY SYMMETRY AMPLIFIER REFERENCES -- A sampling!

NOTE: Interchangeability with transistors locally available can be determined by the more obvious circuit requirements, or by reference to the Motorola Data Book, G.E. Transistor Manual, or other reasonably comprehensive brief lists of transistor characteristics.

Reference	PAGE	THEORY	COMPL.	QUASI-C.	OUTPUT STAGES NPN	OUTPUT STAGES PNP	AC DRIVERS	DC DRIVERS	OUTPUT	% DISTORT.
1) Application considerations for RCA Commercial Transistors, Radiotronics, May 1954, by R. M. Cohen	56		+		2N35	2N34	2N34		(low)	
2) The Symmetrical Properties of PNP & NPN Transistors, G. C. Sziklai, Proc. IRE, June 1953, p. 717 (REF)										
3) Designing Silicon Transistor Hi Fi Amplifiers, R. D. Gold & J. C. Sondermeyer, E-W, 9/66 & 10/66 (REF) ((Ed. Note: This is one set of articles out of very many on this subject which have appeared during the past five years in Radio-Electronics and Electronics-World))										
4a) Complementary Audio Amplifiers, C. J. Henry, Fairchild APP-A-2.		++	+	+	Five circuits: AY1103/4			Various	0.5-9W	5%
b) A Stereo Preamplifier, by C. J. Henry, Fairchild A-11		+					1	3	(+ Tone control)	
c) Short-circuit Protection in a 25W Audio Amplifier, L. Blaser, Fairchild APP-84				+		2N2893		3	25W	1%
5) A Practical Approach to a Hi Fi Gram, M. Somogy & C. J. Henry, Fairchild APP-A-4, (Plus Addendum.)		++	(+)	+		2N3567		3 (2)	3W(1¼W)	5%
6a) Low Cost Complementary Audio Amplifier, Planar News, March 1968 (Fairchild)										
b) "Swing into action with Fairchild's New Complementary Audio Output Circuit; chops component count by almost 50% -- gives absolute design flexibility." Electronics Aust, March 1968, p. 5.			+		AY6108	AY6109		AY1121/1120	3.3Wmax	
c) Data Sheet (Fairchild) AY6108, AY6109, November 1967.										1%
7a) Questions & Answers About the Fairchild Low Cost Complementary Audio Amplifier, B. T. O'Shanassy, Fairchild A-002 (Describing amplifier of Ref. 6, above).										
b) Low Cost Amplifier and Sensitive Pre-amplifier, B. T. O'Shanassy, Fairchild A-003.										
c) Economy Amplifier for Crystal and Ceramic Pickups, B. T. O'Shanassy, Fairchild A-004.										
8) A Solid State Amateur SSB Receiver, Part I, B. G. Clift & A.E. Tobin, Amateur Radio, Oct. 1969.	13		+		AY6108	AY6109		AY1112/1120	1.5W.	
9) 5 & 10W Audio Amplifiers with Miniwatt Transistors AD161/AD162, Miniwatt Digest, June/July 1967	127		+		AD161	AD162		BC108/AC128	10W	1.2%
10a) An Economical 2.5W Audio Amplifier, Miniwatt Digest, March/April 1968.	34		+		AC187	AC188		BC148/158	2.5W	1%
b) (May/June)			+		AC127	AC132		(2)	≥100mW.	

PAGE THEORY COMPL. QUASI-C. OUTPUT STAGES NPN PNP AC DRIVERS DC DRIVERS OUTPUT % DISTORT.

11) Transistors in Class B Complementary Symmetry Audio Frequency Amplifiers, W. R. Eason (Reprint from: Radiotronics, Feb. 1964): Lots of theory: 2N649/408 Various 0.25/.35 5%

12) Complementary Driven Stereo 10W Audio Amplifier, W. Eason, Radiotronics, 11/66
66 + 2N3054 Two Three 10W 0.5

13) New Generation Audio Amplifiers, W. R. Eason, Radiotronics, 11/66
2 + + 2N5294 Three 10-25W 0.25

14) 30W Stereo Audio Amplifier, P. B. Kirkwood, Radiotronics, May 1969
22 + RCA40050 Two Two 10W 0.5

15) 12W Complementary Symmetry Amplifier (Motorola), Spectrum (N.Z.) July 1969
+ mje9602 MJE9652 Three 3-10 0.1

16) Transformerless Transistor Power Amplifiers, Len Whyte, Coryra, Feb. 1968
11 + + 083 033 083 083 0.15?

17) Transistor Audio Amplifiers, Len Whyte, Coryra, March 1968
12 + AY1116 AY1117 083 083 1W

18) The Loud Hailer (Plus preamps), Len Whyte, Coryra, Apr 1968 ((Same as No. 17, with microphone))

19) The Loud Hailer with Computer Transistors, Len Whyte, Coryra, July 1968 ((083/033 in output))

20) Two watt Transformerless Audio Amplifier, R. Davis & L. Whyte, Coryra, Aug 1968
8 + PNP:OC36 or 036,042,etc. 033 033/083 2W

21) (Printed circuit board for Ref 17 here), Coryra, Nov 1968.

22) ½W Audio Amplifier, R. David & S. Lowes, Coryra March 1970
a) Reprint of Ref 7 here plus comment about reduced need for matched transistors, distortion, etc.
b) 4 (&PCBoard) + AY1116 AY1117 AY1115 (1W)

23) Basic Theory & Application of Transistors, U.S. Army TM 11-690, 1959 (P.132-143: Germanium theory)

24) GE Transistor Manual, 7th Ed (Also in other editions; should be another edition due soon)
260 + PNP: 2N553 or 2N297A (Germ.)
263 + + NPN: 2N2196 or 2N2107 (Silic.) Two 7W 1%
266 + 2N2868 Two 6W 1
267 + (Similar p. 263 but paralleled) Two 2½ 1
269 + (Similar p. 267 plus extra a.c. amp) +Two 12 1
15

25) Radio Communication Handbook (RSGB), 4th Ed (1968)
3.8 + AC157 AC154
+ AC167 0.3W
2W
((Important correction: Insert between base of AC154 and loudspeaker about 600 ohms, to obtain currents))

25) Radio Handbook (Editors & Engineers), 16th Ed.
a) 146: 25W HI FI Transformerless valve amplifier in Quasi-complementary configuration, Class A, 16th Ed.
b) 17th Ed: p. 112; simple types; one presumes that the forthcoming 18th Edition will have more modern coverage of this subject ((But there is a distinct lack of such amps in ARRL Handbooks to date))

27a) RCA Silicon Power Circuits Manual, 1st Edition (SP-50, 1967). A marvelous book on many subjects!
356-381 ++ + 40316 Two 10W 0.5%
(XFR) 40322 Two One 25 0.5
+ 40411 Four 70 0.6

27b) RCA Power Circuits (2nd Edition of Ref 27a, 1969). Also very good, but rotten binding; reglue!
382-409 ++ + + (A wide variety, plus interesting short-circuit protection; c.f. Ref. 4c)
410-415 + (Universal c.s. ckt plus full discussion; 3-20W; See discusssion here, p. 92). And more.

28) RCA Solid State Hobby Circuits Manual (1968)
98 + SK3026 SK3009 Two 7.5W

29) RCA Transistor Manual, Circuits Section: Various & Good, See also Ref. 27 & 34.

30) 73 Useful Transistor Circuits, J. Fisk, W1DTY (73 Magazine, publ. 1967)
8-9 + 2N2430 2N2706 ((or computer)) 2N2429 0.12/0.42 4/2%
((Important correction: Arrow on Q3 upsidedown and backwards; these amps would be good with 083, etc))

31) Selected Semiconductor Circuits (Techpress) (Same as Ref. 32)

32) Selected Semiconductor Circuits Handbook, S. Schwartz, ed. (Wiley, or U.S. GPO MIL HBK 215; cheaper)
3-41 + 2N158 3 x 2N109 ≥6W
3-43 + 2N68 2N95 Four 2 2%
((Design of this one could be improved by lower leakage transistors, plus interbase bias, same as Ref6))

33) Semiconductor Power Circuits Handbook (Motorola, 1968): Eleven lovely circuits of all kinds, various power levels, with simple and practical theoretical treatment. This, like the RCA & GE Handbooks, is a real gem for a wide variety of subjects, and should be a standard item on everyone's bookshelves (Motorola Inc., Semiconductor Products Division, Phoenix, Arizona, $US2.00, but it is possible they may not sell directly to you, so order through Oklahoma FAA Bookstore; See EEB Adverts, Oct. 1969)

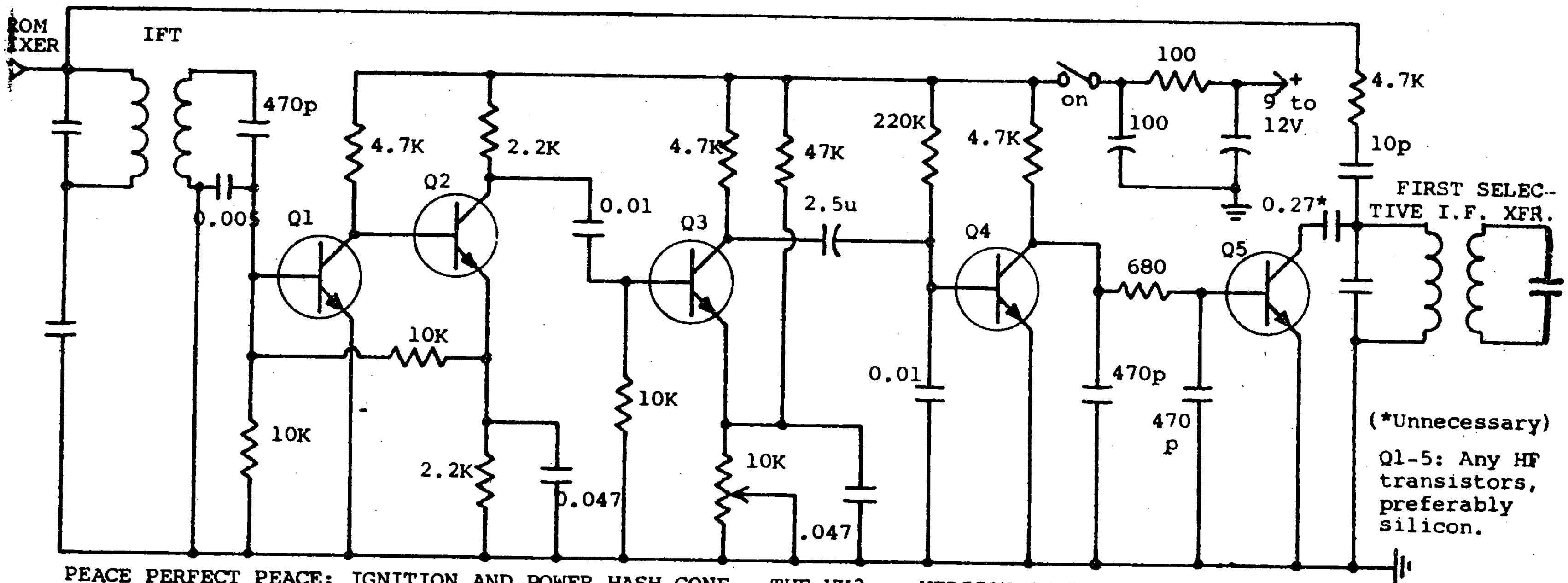
34) Transistor Circuit Guidebook, B. Wels (TAB Books, 1968): Copy of four RCA, a Motorola, and TwoTI designs, powers from 20W to 1W "Music Power". Not much detail, but original designs were good.

35) Transistor Circuit Manual, A. Lytel (Sams, 1961): Four good ckts, 8-10W, compl. & Quasi, few details.

36) Westinghouse Silicon Power Transistor Handbook (1967).
6-9 to 17 ++ + 152-06 2N443 Three 15/50W 1%
((Full of many other goodies too, and in same class as Ref. 24 & 27 & 29, and well worth having. $US2.00 to: Westinghouse Electric Corporation, Semiconductor Division, Youngwood, Penn., U.S.A.))

37++++) Electronics Australia: 4/67, 1/69, 4/69, 5/69, 9/69, 3/70 (p. 87), 5/70 (p. 105), etc etc.

THE QUIET LAMB: A really effective Noise Silencer -- I. N. Kallam (VK3)



PEACE PERFECT PEACE: IGNITION AND POWER HASH GONE. THE VK3... VERSION OF THE LAMB NOISE SILENCER

You'll find a lot of noise blanker circuits in the literature, but this is the first silencer I have built that REALLY worked. To tell if there is pulse noise I have to turn it off.
BUT THIS MUCH IS ESSENTIAL: First connect the IFT of this unit in your radio without any other connection. If any signal gets through, improve your decoupling and/or shielding until NOTHING gets through -- or forget the whole thing. Several silencers I have tried allow a 60db noise to appear still at about a 10db leakthrough level and this is useless; viz., the Electronics Aust thing with series transistor switch. (c.f. E.A. 8/69, 12/69)

The IFT is a broad over-coupled transformer used only to eliminate the local oscillator signal from getting into the silencer amplifier. All transistors are SE1002 or equivalent. The first two amplify the noise and drive the third, the bias of which is varied to set the cliping level. Pulses from the collector of this stage switch off the Q4, allowing base current to flow in Q5 which then shunts the set's IF Transformer with a very low impedance. Decoupling is performed ahead of the switch, because during dischanrge of the decoupling condenser the unit will blank out the receiver. If listening to a weak signal directly after a strong one I find it better to switch off the silencer on the strong signal (which after all, overcomes the noise anyhow), rather than continually to vary the threshold setting up and down. Various obvious refinements are possible. With a very samll modification you can use another transistor automatically to switch off the silencer above a predetermined signal level, thus eliminating the need for any adjustment. AGC can also be added by a simple modification of Q3 circuit, giving blanking inversely proportional to the strength of the signal received, but you can muck about with these details yourself.

I found it mandatory to use FETs in all signal stages ahead of the silencer, as transistors can overload and distort the signal -- and the noise.

If you want to chase down other kinds of noise blankers (though I can't imagine why), you can find a nasty one in the ARRL handbook, a rather better one in 73 for April 1970, though it uses valves (with AGC), another valve job in Ham Radio of Oct 1969 using Hot Carrier Diodes, and an Integrated Circuit thing in HR for May 1969.

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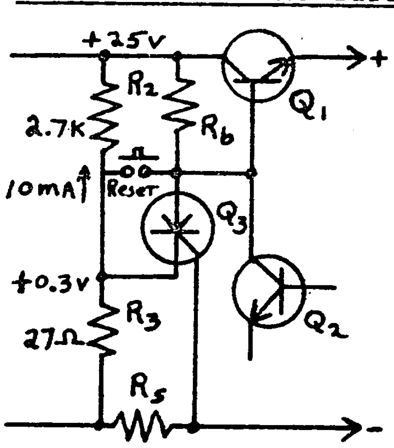
ANOTHER LATCHING-TYPE POWER SUPPLY PROTECTOR, USING 077/078 -- RLG & RAJR



We have recently found a new type of transistor on the computer boards, the 077 & 078 (same characteristics). A lot of investigation shows that these are a type of Silicon Controlled Rectifier, though with some odd characteristics. Forward Breakover voltage is 100-150V, but PIV is nothing; there is an internal diode across the cathode to anode! Maximum current rating is about 500mA, and saturation voltage is about 0.4V at 10mA. Gate sensitivity is very high, typically less than 2uA to fire, but this odd beast requires a small negative gate current to keep it from firing! Indeed, the anode current can actually be turned OFF by the gate if anode current is not too high (e.g. less than 50mA), though the amplification factor is low (e.g. 5). The stabilising gate current increases with temperature and is most easily provided by a small fixed voltage. A typical application is shown here where the 077/078 is used as a latch. It will trigger when voltage across Rs is 0.1V higher than that across R3. E3 is uncritical, but raises Q1 base voltage, so should not be too high. See also p. 91 ckt.

WHITHER EEB? etc. -- RLG

We get letters from readers. Some say that a lot of our stuff is too technical for them, some say that it is infantile. Everyone seems to agree that the new format is desirable. I suppose that the problem is that there is no definite policy for coverage, except what happens to occur to me (and my background in electronics is meagre), or what readers send in. Since we try to appeal to all experimenters more or less indiscriminately I suppose this is unavoidable. But, as I have said, the world is full of good specialist publications. Here is an alternative. If it succeeds in its general form, it fails in numerous specific ones. Fortunately for my peace of mind, people don't merely write when they are annoyed. We receive numerous small comments with renewals, changes of address & technical material saying that all this is appreciated. On the other hand, if you have some fundamental or general critical comment on EEB or contents, we love to hear from you, particularly if you can advance constructive suggestions.

We received recently a letter from an American subscriber which gave me much food for thought. I think it would be worth commenting on a few of its points here. He says our reviews cover articles already read. Fair enough: the Australian public is not always as fortunate in obtaining overseas literature. On the other hand, he says that there is no way to find out where to get Australian literature to which we refer, e.g. Miniwatt Digest. I find this puzzling, since we did in fact publish a complete list of periodicals with prices and addresses on p. 96-7 of the Sept. 1969 EEB. I suggest that if readers wish to find some specific piece of information in EEB they consult the Annual Index for volumes they have; we tried to make the one for 1969 particularly comprehensive. We can't go on repeating the same things indefinitely.

To this end he wonders what is the use of bibliographies which, on one hand are superfluous if one has read the stuff, and useless if one can't get ahold of it. It seems to me that the reference list on complementary amplifiers in this issue is a case in point. If one has already read the material the list is a convenient guide for future reference, or if one has such and such a book on the shelf, here is a guide to its better use. Our age suffers from a great surplus of information, and not nearly enough arrangements for using it efficiently; the mass of material pouring from the periodical literature each month is an excellent case in point. Indeed, the reason Electronics Australia comes last in that reference list is not at all a reflection on that excellent magazine, but merely an indication of my limitation of time available to peruse it, along with the mountain of other stuff that passes my desk each month.

Our correspondent continues: "As to the content of your sheet, it runs from excessive Gunther to a very presentable/readable piece. However, I think the content was better before you (changed format), and it has been very slow in recovering. I realize that these are human problems and that it is a labor of love. At the same time I've waded through an awful lot of puerile material in hopes of finding the few real gems you do manage to publish. On a time invested basis it has been a poor return."

Yes, there is probably too much Gunther (cum Reynolds), perhaps less of that after the present series on power supplies. There is just so much we can present per issue. We do have a lot of articles from readers, hopefully to improve the calibre of the text. On the other hand, it is genuinely puzzling to know what constitutes a "real gem". That term has been used by another correspondent too, but we get directly conflicting opinions on what is a gem. To Maddever it is an instrumentation article, to Osborn a transmitter, to Adams it is a careful thought-piece on theory. And each tends to regard the interests of the others as, shall we say, less interesting. That is why we tend to please ourselves -- but we welcome articles from anyone.

"At the same time, I find myself in certain disagreement with policy. For instance, at one point your blindly anti-IC attitude really turned me -- and how many others? -- off. Your point that use of ICs is shutting out the experimenter from the joys of getting base-emitter bias working properly -- and myriad other worries-- is accurate. However it overlooks the truth of the matter that whether or not YOU like it, the rest of the world is going to ICs -- and they ARE in your field -- smack in the middle of it. So, to ignore them is rather cutting off your nose, etc. Where will it leave you? A balanced approach would allow some introduction to them, even if you do stick to 'discreet (sic) circuits'. Why not be even handed about it?"

All right, he has a point. I don't like IC for the reasons he admits are relevant (so-- is progress to be swallowed whole just because it is there?), but we shall be willing to accept articles about them as long as the articles present the subject from a commonsense point of view, with some indication of the truth of the matter freed from preconceptions. One of the most obvious of the latter is the assumption that an IC ought to be used because it is here and cheap. Perhaps so, but not necessarily. To reiterate a previous question I put, if you could buy every possible electronic item you wanted, for 25c each (amplifiers, radios, the lot), would you still be an electronic experimenter, or would your experimentation consist of varying degrees of ingenuity in putting your toys together. This question is not as sarcastic as it might sound. Considered in the same way, some of the new developments we take for granted (transistors, zeners, shockley diodes, UJT etc) are more clever ways to accomplish the same thing with a smaller and more efficient number of components. On the other hand, why just publish an article showing an IC as an amplifier in a very ordinary radio, just because it uses an IC? There are lots of those already in all the magazines.

What I would like is some article(s) examining these positions closely, and perhaps showing just what ICs (of various specific types) are and are not relevant to experimenter application. I suppose I'd write them if the subject interested me, but as he says, enough Gunther in these pages.

He continues: "I guess the point where I lost patience was some patently WRONG -- not just inaccurate -- material which preoccupied your journal; the business about what a balun accomplishes, etc. Perhaps in your view, I have the disadvantage of an engineering degree and a halfa lifetime of thinking through such things both for amateur and professional work. Hence, they do seem a bit -- well, they alienate me."

That's very interesting. The "Coaxial Feeder Antenna Dilemma" featured in several articles and discussions last year raised quite a lot of comment. Several correspondents had their say, and I know that some of them were electronic engineers. I rather got the impression that the subject left room for clarification even on a high level, supported by the observation that the various Handbooks do a relatively poor job of it.

If our correspondent has some special insight leading to the Real Truth of the matter it seemed rather a pity he did not let us all have the fruit of his wisdom for wide publication. It might appear that the possession of an engineering degree is indeed a disadvantage.

EEB examines things as they come up, turns them over as carefully as the writer (not merely me!) desires, and tries to see what happens to real situations when stripped of the equations & fancy theory. I suppose that this approach is a reflection of my own limitations, but Rod (also an engineer) is basically sympathetic with it too.

"Awareness means the capacity to see a coffee pot and hear the birds singing in one's own way, and not [necessarily] the way one was taught.... Awareness requires living in the here and now, and not in the elsewhere, the Past or the Future..." -- From: Games People Play, by E. Berne [Penguin, 1969]. I was reminded of this the other day when we saw a fine film "The Royal Hunt of the Sun". We had seen the play excellently done [yes even in Sleepy Hobart], and had read the book [by P. Shaffer, from Hamilton, London], and each had something to offer. The story is indeed an epic of Awareness, though it doesn't always come through too well in the film. But I noted that the film was certified as "Suitable for General Exhibition" which seems to mean that it is quite all right to expose children to violence, cynicism, perfidy, and death, as long as they don't learn about that most natural of all human activities: sex.

In any event, the good though tedious book by Berne, quoted above, deals with the practical aspects of a very interesting subject, the Theory of Games, in this case applied to the solving of problems between people [thats us]. If it hits too uncomfortably close to home I am sure you will enjoy a fine book treating the subject rather more distantly, but with much humour and insight: The Compleat Strategyst, by J. D. Williams [Mc Graw Hill]. Loosely speaking a "game" is a systematic application of strategy designed to optimise your relationship with your environment; the cynic says it is a study of the best way to take advantage of your neighbour to further your own ends. Either way the method is obviously relevant to the goals we think important. From seeing the irrational way men conduct their affairs in general, it is also obvious that "they" could read these books too. If, then, they were to be evil, at least we could depend on it rationally -- a great comfort, since no rational human being would see much gain in destroying the human race [us, again].

This is also obviously relevant to electronics too, y'know. Some Great People and I have for a long time insisted that actions cannot be divorced from their consequences. If you are to introduce Automation, you'd best consider its moral consequences and values, and adjust the method to suit. If, on the other hand, you want to operate on the air with commercial equipment for which you turn the knobs, fine, but don't talk loudly how interested you are in experimenting, notwithstanding the technical magazines you peruse to soothe your conscience. A consequence of Awareness is honesty, and to optimise the Game you have to start with correct data. This, because in order to master your environment you have to act in a manner consistent with real goals, not merely desired ones. This is the subject of Information Theory, and is also entertainly and poignantly presented in the book The Human Use of Human Beings, by Norbert Wiener [American paperback], to which I recommend you most enthusiastically. [[P.102-->]]

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EEB article on this subject in a few months. -Ed.

Avalanche diodes may be operated closer to rated PIV than ordinary diodes without damage resulting from transients, due to special construction. See G.E. SCR Handbook, 4th Ed., p 328.

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MAGAZINE SUBSCRIPTIONS AT REDUCED PRICES. See elegant dissertation in last month's Adverts! 73 Magazine: $A4.25 ea, in groups of 3 [to different addresses]; no one has mentioned anything to us about higher subscription rates, so you can probably still get it for this amount if you don't delay. 73 has improved quite a lot this past year, and is good for experimenters. Ham Radio Magazine: Individual subscriptions or renewals, $9 for three years. We have a few more copies of their Vol 1 No 1 [March 1968] which was reviewed in the March 1968 EEB, and one will be furnished without charge to all new subscribers [or renewals] if requested. Anyone else who wants one of these collectors items will have to send 20c [stamps OK]. Since prices in America, as in Australia, go only up, and since their galloping inflation is said to be even worse than ours [is it possible?] this price [$9/3-yrs] is not going to last very long, not to mention that it is the lowest price for HR in the world [Americans: no you can't have it; your incomes are a lot higher than ours!]. If you do subscribe, be sure to request that it start with the May 1970 issue; it was all about Antennas, and is MUST reading. Write EEB.

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I mean: send subscription orders for these magazines to EEB, with your cheques.

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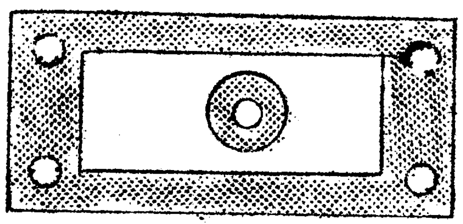

FREE sheet rubber gaskets, as shown at left, approximately full size [round one actually slightly larger than shown]. Rectangular one is made from "Dunlop Rubber", "No. 1 Top Crystal Holder Gasket RAAF O/N 461020." Round one is Neoprene Washer No. Y310XZ/100. We came across a great box of these, and you can have a handful by sendingSAE with 5c stamp on it if you want an ounce's worth, 9c if you want two ounces, reasonable mixture of both. Write EEB.

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EDITORIAL: [Continued from p. 99]: Every time I get an idea for an Editorial I scribble it down on a handy piece of paper. During this last month I accumulated eleven such pages, so I simply gave up and wrote the above bit, from the heart as it were; in its methods are included much of the details I wanted to discuss. I must, however, here extend to Rodney Reynolds, our Assistant Editor a most sincere vote of thanks for the effort he has expended in BUILDING for us a suitable high quality camera. This issue is our first effort, but it will improve. The problems I/we encountered were enormous, and it has been a hectic month; that's why late.

LOW VOLTAGE REGULATED POWER SUPPLY DESIGN, Part V

-- RLG & RAJR

-- More about the versatile Preregulator, some more cautions, more practical circuits.

A Good Regulator (with apologies)

We must apologise for an error in fig. 23c, p. 87 of last month's article. We have found that it is quite unnecessary to run 100mA of bleed through Q3, because in fact Q3 does not simply act like a resistor controlled by R2', but its resistance is also controlled by the current from Q2. See the revised fig. $23c_*$ below. When the latter goes up, the resistance of Q3 goes down, tending to keep emitter voltage (Q2 & Q3) constant; neat, eh? Therefore Q3 needs only enough bleed to keep it happy at minimum output. This is furnished through R_e which is split as shown in fig. $23c_*$ to reduce ripple, for the same reason as R_b in fig.20a and as shown dotted-in here too.

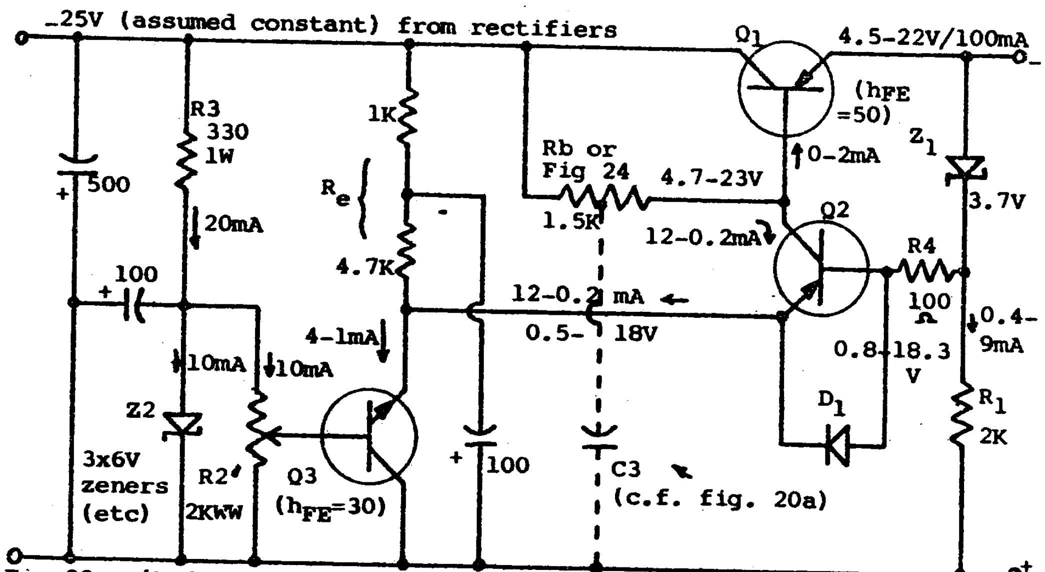

Fig $23c_*$ (Modified): Please put a note on the original fig. 23c (p. 87) to refer to this one. Q1, Q2 as for fig. 23a. Q3 replaces R2 of fig 23a and can be any low power transistor to handle 100mW comfortably (e.g. 2N3642, 086). As in fig. 23a, D1 & R4 protect Q2 in event of output short or even of transient pulse. All relevant currents and voltages are shown, from which it will be evident how to calculate component values and power from Ohm's Law for any desired output voltage and current range. Simple, no?

In the revised practical circuit shown at the left, a wide range of voltages is obtained with very good regulation owing to low a.c. path of Q2 through Z_1, and isolation of Z2 by Q3. With the preregulator circuit of fig. 23e or 24 in place of R_b, it is about the best simple circuit you can use. Its only main disadvantage is that the temperature sensitivities of Q2 & Q3 add up rather than cancel (as they would in fig. 25), but for ordinary experimenter work this is not very important. When it is, the discussion presented later here will help you to improve it.

In fig. $23c_*$ the low voltage end of adjustable autput is limited by Z_1. If minimum output can be limited to about 2.5V, likely better temperature stability (to be discussed) will be obtained. If a still lower voltage is desired, Z_1 can be reduced right down to zero. But the reason for Z_1 in the first instance (aside from giving a low impedance path to Q2) is to provide a constant collector voltage for Q2 independent of output (compare with fig. 20 etc). If you reduce Z_1 to zero (viz., dead short), Ec_2 will only be about 0.7V, which is not adequate for good amplification. So by providing Z_1 we have traded low-end voltage-limit for better regulation over the whole range; compare with fig. 20 which has adequate Q2 collector voltage at outputs a couple of volts above Ee_2, but a high impedance path to base of Q2.

A couple or three forward-biased silicon diodes in series could also be used for Z_1 (analogous to D2 & D3 in fig. 23e, last month) to get low output voltage with good regulation, but these require a lot of current (10-100mA) to give reasonably constant voltage. If we used two diodes (0.7V each) and if R_1 were adjusted to give 10mA at 2.2V total output (i.e., R_1 = 0.8V/10mA = 80 ohms), current through R_1 at 22V out would be 22V/80Ω = 275 mA, which is rather a lot.

MORAL: If you want a low voltage range, switch values of Z_1 and R_1 as appropriate. Don't try to cover it all with one set of components, or regulation will suffer.

Those Big Electrolytics

In Part IV of this series we examined the effect of lumped capacitances in the conventional feedback regulator circuit (fig. 20a, p. 81). We cautioned against the use of a capacitance across the output of the regulator unless it was quite necessary to prevent low frequency oscillation under light loads, but that it is better to load the regulator with a bleeder. If such a condenser is used, it must be large enough to avoid ringing with any inductive load (e.g. mismatched Class B transformer amp). Recently we saw an Australian design which justified the use of a large C across the output because the frequency response of the regulator system (which was quite complicated) was poor over a few hundred cps, leading to instability with higher frequency loads than this. Ths absurdity of this is discussed on p. 81-2 of last month's EEB article: the frequency response of the feedback regulator system must be inherently good to as high a frequency as the load is likely to reach -- practically, to tens of kc. A complex design which degrades this is not worth it for any other presumed advantages.

In the same vein we have also seen a recent Australian design which shunted the base of Q2 with a large condenser "to lower the hum level to an acceptable figure by providing a low-impedance path for the hum signals direct to the base of the regulator transistor." This is an even more effective method of shorting out ALL high frequency signals to the regulating circuit than does C4 of fig. 20a (p. 81), and is rotten design. There is utterly NO point in having a lot of amplification in your regulator (presumably to get good regulation) if you short out half of it for high frequencies -- unless the regulator is to be used only at d.c.! Ripple reduction can be accomplished without such degredation by the use of C6 in fig. 20a -- which is not at all the same thing.

The Uses of Zener References

In the previous article we found that we could achieve better regulation than in the simple feedback regulator (fig. 20), by the use of Zener References (figs 21a,b). We also found (fig. 23a) that there was advantage in varying output by controlling theemitter rather than base of the sensing transistor (Q2), and that there are several useful methods by which this can be accomplished. We are continuing this article by describing more variations on that theme allowing easier output voltage control while providing good regulation; fig. 23c$_*$ is our first example. We shall also talk a bit more about improving the Preregulator used in place of R_b, and will end up with an interesting circuit giving PERFECT regulation -- at a price.

Incidentally, W5JJ, Carl Drumeller has kindly sent us a copy of an article from the June 1970 Radio-Electronics by Jim Ashe, titled "Experiment with the Amplified Zener".This describes the behaviour of a circuit of the type of our fig. 23c, 23c$_*$, or 23d. We had planned to comment on this along with some notes on temperature stabilisation, but it went on for far too many pages and will be included with an article by C. Pitcher on a similar subject in our October issue.

The Constant-current "Preregulator" System of fig. 23e, Revisited:

We were discussing this when we finished last month. This "preregulator" system is discussed in refs 5 & 8, and 45 (7th Ed.), 48 & 49 & 50 which are also excellent in a wide variety of other relevant subjects.

A Zener from the base to the collector of a transistor gives the constant voltage of the Zener and the current handling ability of the transistor, as described in the above-mentioned article by Ashe and in our referenced figures. A zener at the emitter end gives constant current, as shown by figs 23e & 24. Isn't that interesting? A transistor can be a constant current or constant voltage device merely by using it with a Zener in these ways.

We are interested here in the constant current function, because that is what we should like from R_b in the various figures (eg. fig. 20). As you can see from the range of collector current of Q2 in fig. 23a, this current is normally anything but constant. This results in requirement for a bigger Q2 and gives poorer voltage regulation (because of finite collector resistance of Q2). If R_b were a perfectly constant source of current in fig. 23a, Ic_2 would only need to vary from (about) 0mA at max output to 2mA at minimum output (assuming Q1 h_{FE} = 50 at 100mA output). In the latter condition it robs all of the current from the base of Q1, so output voltage must fall. By using the circuit of fig.23e or 24 this ideal condition is approached. It is degraded only by the finite collector resistance of Q4 as shown by the curve of fig. 23f. When output of fig. 23e is varied from about 6V to 24V, Ec_4 goes from 18.8V to 1V, and Ic_4 goes from 2.7mA to 2.2mA. Compare with R_b current (in fig. 23a) of 12mA to 2.2mA! You can see that the preregulator of fig. 23e (and now fig. 24) does indeed provide a reasonably "constant current" to Q1 & Q2. The result?

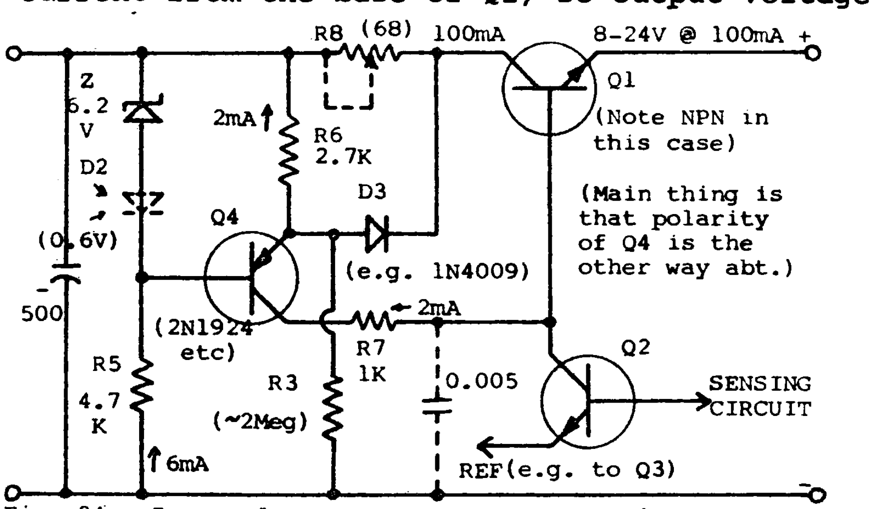

Fig. 24: Improved constant-current source ("Preregulator") modified from Ref. 45, p. 231; See p. 105 here for discuss. R6 is adjusted for maximum output voltage under load.

1) The current-handling ability of Q2 can be much reduced; instad of using a 2N3638 or 030,can now use an OC71 or 033 (or 2N4250, as below). This has been a good trade-off because a cheap and simple type can be used for Q4 (ckt bd; note reversed polarity compared to Q1 & Q2); and PIV of the reference diodes is irrelevant. For this application RLG has even used marginally damaged diodes or commercial rejects having negligible PIV but with still good forward characteristics; needless to say one has to test a burned out diode or transistor to see whether it still behaves well in a forward direction. The base-emitter junction of silicon (not germanium) transistors can also be used as forward references, but they tend to have a rather high dynamic resistance (i.e., poor regulation).

2) Since current capability is no longer as important, the transistor used for Q2 can be chosen rather for high gain, for example the Fairchild 2N4250 which also has excellent linearity and low noise. High gain means better regulation, and good linearity means better regulation at high Q2 currents (low E_o).

3) The regulator becomes less dependent on mains voltage changes.

4) Ripple ("hum") is reduced, making C3 unnecessary in fig 20a or 23c$_*$, as long as C_1 provides reasonable rectifier filtering. Indeed, there is no reason why the preregulator should not be used for other circuits requiring constant current, e.g. in place of R3, Re,

and Rb of fig 23c*. This substitution is done industrially and will give better low frequency performance, ripple reduction, smaller size, and lower cost than the usual R/C filters. This assumes, of course, that electrolytics are bulky and dear, that computer transistors (for Q4) are small and cheap, and that equivalent performance is compared:

In a typical calculation we find that the effect of using a transistor as a constant current source is equivalent (at 50 cps) to using a 1250uF condenser across a 5 V zener (assuming dE/dI = 50 ohms). Electrolytics are becoming cheaper and smaller, but thats a lot of capacitance! On the other hand at lower frequencies the comparison is even more impressive considering that the transistor system is good down to d.c.

5) The consistently lower zener current in circuits of type fig. 21a, as well as lower collector current of Q2, reduces considerably the heating effect on the semiconductors at low outputs, thereby improving circuit stability. This is no joke; you can actually see the output voltage change as Q2 and its zener (e.g. fig. 22c) heat up. Since, for a constant output voltage this also occurs when the load current decreases, it is evident that temperature stability means better regulation. More about this on p. 106

<u>The Improved Preregulator Circuit, fig. 24</u> (diagram, p. 104)

Fig. 24 bears some improvements over fig. 23e. There are the references Z and D2 in series for better temperature compensation (but with the reservations mentioned on p. 106), and R3 serves the useful purpose of reducing the effect of mains supply variation on output voltage; for a suitable value of R3, a simple fig. 22c-type regulator is capable of stability of as good as 1 ppm for 10% variation in mains voltage. R3 compensates for the fact that Z and D2 have finite impedance, and they <u>do</u> vary their voltage with current; without R3 a typical stability would be of the order of 200 ppm for 10% mains variation. (Ref. 45). R7 guards against turn-on surge currents through <u>base-collector</u> of Q4; its value is quite uncritical. R5 passes enough current to keep zener Z happy: from 1-5mA for moderate current supplies.

Note that when forward diodes are used in this position (i.e. D2 & D3 of fig. 23e), R5 must supply appreciably more current (e.g. 10-100mA) if the reasonably constant voltage part of the diode curve is to be used (If this baffles you, see fig. 1 of "Why Abuse Semiconductors" <u>EEB</u>, Sept 1968, which also contains other good oil). But this places considerable demand on the power capability of R5. In fig. 23e we compromised with 11mA which we have found to be about minimum to drive diodes as reference voltage sources. At that level diode drop is generally 0.5V to 0.7V, and depends on the diodes.

R8 and D3 are something new and very interesting. Although, as Van Staveren points out (p. 91, fig. 1), constant-current overload protection devices protect only the regulator (Q1) and not the load, it is still nice to have the regulator transistors protected -- at least. In this instance you can have this added useful feature simply by adding R8 & D3 to the already advantageous preregulator circuit of Q4. It is a neat idea, and comes from Ref. 45 which is the only place we have seen it used. In normal operation Q4 functions as a constant-current source of base current for Q1; Zener voltage of Z is constant, base-emitter voltage of Q3 is constant, so voltage across R6 is constant. I = E/R, so I of R6 is constant, and so is I of R7 for obvious reasons.

If, however, an overload now occurs, when (in this instance) current through R8 exceeds 100mA, voltage across R8 exceeds 6.8V, feeding in > 6.3V to R6. This drives the emmitter of Q4 negative relative to its base, and cuts it off. Then current through R6 & R7 falls to zero, cutting off Q1. In practice, of course, Q4 and Q1 are not cut off, but the maximum Q1 collector current is limited tothe 100mA chosen by R8. This protects Q1 and allows the use of a smaller transistor than if overload currents had to be planned for.

If, furthermore, R8 is made variable (dotted line), this maximum overload current can be varied as desired, and the front panel control of R8 can be calibrated directly in mA of maximum-allowable overload current. When coupled with an output-current milliameter showing actual current drawn this can be very useful in adjusting the maximum current supply of Q1 as appropriate to the load. If, for example, the load normally draws 10mA and would be damaged by 100mA, merely adjust R8 to 50mA (136 ohms in this instance). The smallest maximum current would be governed by the largest value of R8, but too large a value for R8 will limit the maximum voltage output of Q1. For wide range, therefore, different resistance could be switched in series with R8 for lower current. In any event the actual value of R8 will depend on maximum overload current and on voltage of Z (and D2 if used).

This is as close as one can get to the old joke of a power supply furnishing both constant voltage and constant current at the same time!

<u>Temperature Sensitivity and Compensation: a Caution</u>

Further up on this page we talked about the effect on voltage when Q2 and its zener got hot. We have quite a lot more to say about this, but it will go into the October article with Chris Pitcher. We must, however, mention a few of the more important points:

The zener diode handbooks tell us that forward biased diodes have an appreciable temperature sensitivity, about -2mV per degree Centegrade. That isn't much, but when amplified by a couple of transistors it can turn into volts per degree. If you use diodes in series for cheap low voltage references, voltage regulation will be good if appreciable forward current is passed, but every diode in series adds another -2mV/deg, and that can add up. This fact is often ignored in regulator design using diode references, to no good result. Three diodes in series are three or more times more temperature sensitive than a proper 6V Zener.

For this reason it is desirable to use a real Zener in place of D2 & D3 of fig. 23e (or fig. 21b) _if_ supply voltage permits, and _if_ the temperature coefficient of the zener is less than that of the seriesed diodes. That is why a zener, Z, is used in fig. 24. And more: It is possible to cancel out the temperature sensitivity of this zener by adding a forward-biased diode (D2 in fig. 24) in series. At about 6V one might use one diode, 7V two diodes, etc. BUT the effectiveness of this often indiscriminately-used method (e.g. Ref. 5) can depend very much on the _actual_ temperature sensitivity of the zener used. This can vary considerably from one manufacturer to another, and from one zener to another. One often does see such series combinations, but unless units are carefully matched, such "compensation" can actually _worsen_ the temperature sensitivity! So-- BEWARE. If you want accurate temperature compensation, actually measure the temperature sensitivity of the zeners and diodes to be used.

The only fact you can ddepend on is that zeners in the range of 5.2 to 6.2V have the lowest temperature coefficient, so that if a higher voltage is needed it is better to use zeners in series (e.g. Ref. 50, p 6-18); for a lower voltage a zener or seriesed diodes might be better, depending on a number of factors.....

Furthermore, zeners in the range 6.8V to 7.5V have a lower dynamic impedance (i.e. better regulators) than above* and below this voltage, again showing the advantage of a series combination for higher voltage references. For lower voltages, quite good regulation can be achieved by forward-biased diodes (if temperature effects are not relevant) _if_ sufficient forward current is passed. Some interesting applications of this have been shown in recent unpublished literature by C. Horwitz of ES&I Co, as long as the several design cautions we have mentioned are observed. (hi)

Differential Pair Amplification: _Practical Aspects of Temperature Compensation_.

In fig. 23a, R2 had to carry appreciable current for reasonably constant reference potential. In fig. $23c_*$ (p. 103), R2 was replaced by Q3, which also provided a much lower impedance to Q2 because of its amplification; to Q2, Q3 looks like a common-base stage. This is quite a good circuit, but it suffers from one disadvantage as mentioned: when ambient temperature increases, resistance of both Q2 and Q3 decreases, so output goes down (although the current sharing through R_e tends to compensate internal shifts). On the other hand, as we showed above, the temperature sensitivity of the zeners comes into this too. In fig. $23c_*$, Z_1 is a true zener* because of its low voltage, so it has a strong _negative_ temperature coefficient. Z2 has a positive one, depending on the reference voltages chosen (e.g. 3 x 6V → + 4mV/deg; 6V with 12V → 12mV/deg; 18V → 20mV/deg, approx.). So, an increase in ambient temperature will increase voltage of Z2 (giving higher E_o), decrease Q3 (lower E_o), decrease Q2 (lower E_o), and decrease Z_1 (lower E_o). It may be seen that if you play about with choice of zeners for Z2 and possibly Z1, a good temperature compensation can be provided for the whole circuit, though this requires good thermal contact between the semiconductors.

On the other hand it is rather more simple to accomplish temperature compensation through bridge action of the familiar long-tail pair, as shown in fig. 25. Here it can be seen that the conventional zener reference in the emitter of Q2 (e.g. fig. 21a) has been replaced by Q3 and Re. Or alternatively, Q3 and Re of fig. $23c_*$ have exchanged places owing to change of polarity of transistors. Here the zener voltage input to Q3 is fixed (as in fig. 21a), and output is varied at R_1 as in fig. 20. But output could also be varied at the left side instead, directly analogous to fig. 23a or fig. 23c. What matters here is the fact that when Q2 and Q3 both go in the same direction when heated, the decrease of voltage across Q2 is compensated by the increase of voltage across Re. This ensures low temperature sensitivity; but obviously Z4 must be chosen for low temperature coefficient, or must be compensated as discussed above. This is really a better temperature design than fig. $23c_*$; the fewer things you have compensating each other the more stable the circuit will be.

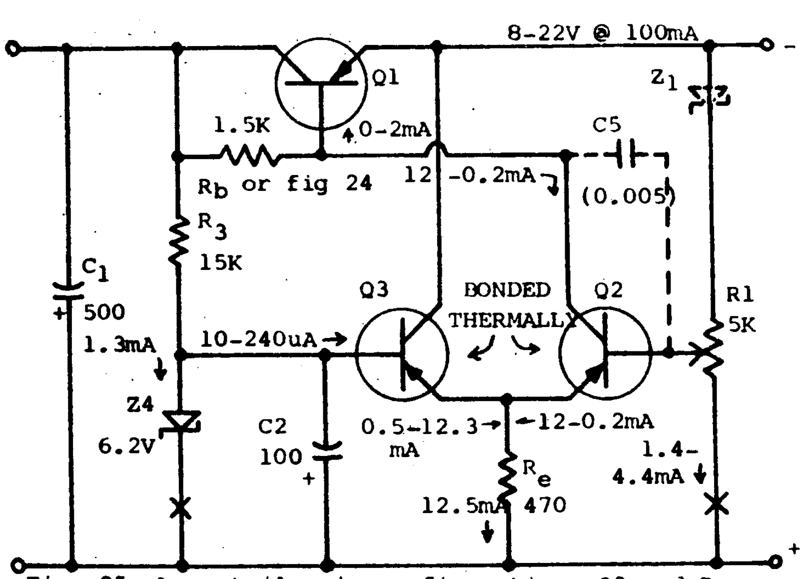

Fig. 25: Long-tail pair configuration: Q3 and R_e replace Z in fig 21a (p.58). Better temp. comp.

In fig. 25, Q3 simply keeps voltage constant across Re by emitter follower action from Z4. Re is calculated as for fig. 23c, by Ohm's Law.

* True zeners exist only below about 6V; above this they are actually reverse-biased avalanche diodes with a sharp characteristic. As are any "Zeners" above 6V.

For example, $R_e = (E_{Z4} - E_{be3})/I_{2max}$ and $I_{2max} = (E_{c1} - E_{o min})/R_b$ where E_{Z4} is rated voltage across Z4, and the other subscripts refer to the relevant transistors, and where I_{2max} is Q2 emitter current at minimum output voltage. These formulas look very impressive but if you find them complicated work it out by common sense, which is the only proper way to do it. Isn't it amazing the mileage you can get out of Ohm's Law?

In fig. 25 the collector of Q5 is taken from the d.c. output rather than input, for an easy way to avoid ripple, though R9 and R_b must still go to the input for reasons to be discussed.

Disadvantages: Nothing is free!

Fig 25 suffers from the same disadvantages as fig 20 & 22a: a poor a.c. path from emitter of Q1 to base of Q2, therefore not the best regulation or ripple reduction. In addition, collector voltage of both Q2 and Q3 falls to nothing at the low voltage end, i.e., R_1 tap at the high end. These problems can be met by inserting a zener in the upper end of R_1 as in fig 23a or $23c_*$, and dotted-in as Z_1 in fig 25. But this restricts the minimum voltage range. In their simple form these regulator circuits simply cannot do everything: if you want good regulation or temperature independence you may have to sacrifice range of output. It is a mistake to think that you can build a simple "universal" supply which will do everything well. As we have said, it is better to switch to different conditions for different ranges.

Of course it is possible to obtain excellent regulation with simple R_1 as in fig.25 merely be adding another stage of amplification between Q1 and Q2 (e.g. Ref. 16), but whether this extra stage is best employed there or as preregulator is something you have to decide on the basis of requirements; for instance the preregulator will give better independence from mains voltage variation.

We must mention that it is often said that you can obtain something for nothing, simply by lifting R_1 and Z4 at "X" in fig. 25, and running them to a constant positive voltage reference (in this case). This allows you to take a fig. 25-type system down to zero volts whilst presumably maintaining all advantages of the differential (common emitter) amplifier. Its not so. You can indeed increase the range of voltages available at the low voltage end by this method, but since absolute voltage variations remain constant, relative voltage variations increase at the low voltage end. This increases the % ripple and worsens regulation. If anyone tells you something is free, watch out.

I (RLG) might also add that the converse is also sometimes relevant. Not so long ago semiconductors cost large amounts, and all manner of ingenious bypasses were devised to give the poverty-stricken experimenter maximum value for money. Now the price of many of these devices has come down satisfyingly, and you can obtain high performance for reasonable cost. This may not necessarily mean that you need not use computer transistors, but that if high gain, linearity, stability, low noise, or power is required, it can often be obtained for a modest expenditure. This also includes items such as Zeners, and even temperature compensated Zeners. The prices of these items in Australia has plunged, and it may not be advisable to substitute, say a low cost zener (or diode) plus transistor, where for only a bit more money a proper zener can do a better and simpler job.

Fixed Voltage Supply

Early in this series we mentioned that if you simply need a fixed voltage at several common levels, you can get good results simply by switching zeners, either alone or in the primitive series resulator of fig. 17 (March EEB). This is true, but you can get lower output impedance (so better regulation) and less ripple by using some good circuit having a feedback amplifier loop. Any of the circuits here described will suffice for that, as long as the a.c. path is low between signal (e.g. load) and amplifiers. Such examples are seen in virtually all of the circuits after fig. 20, but notably fig. 23a and fig. $23c_*$. Even the long-tail pair's advantages (temperature) of fig. 25 can be retained in a fixed supply by inserting Z_1 in the upper end of R_1, and switching between them as needed for different voltages; but remember to include R4 and D_1 of fig. 23a or $23c_*$. Some switching of Z4 can be effected, but over any large range the value of R_e would have to be altered to maintain regulation.

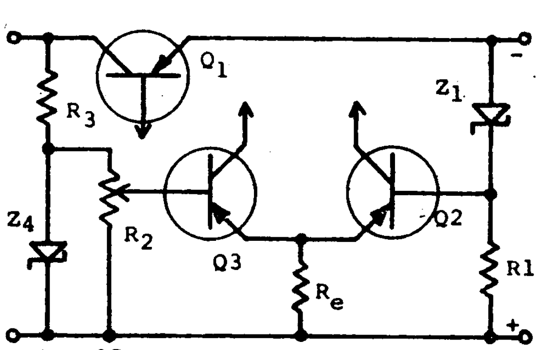

Fig. 25a: Better results from fig. 25 for small range of variation (R2)

If a fixed-voltage supply with a small range of variation is desired, fig. 25 is suitable with Z_1 and a small amount of tapping on R_1, but better regulation is possible when the base of Q3 is tapped down on a pot fed from Z4, as in fig. 25a at the left. On the the other hand, this range of adjustment is also limited, because if base of Q3 is decreased much below E_{Z4}, R_e will have to be lowered to keep enough bleed current through Q3. One of the most serious consequences of exposure to ionising radiations is the effect it may have on future generations. In this respect radiation injury is much more insidious and dangerous to the community as a whole than many poisons, and is the aspect of radiation damage which causes the greatest concern with regard to the peaceful application of atomic energy -- at least! But at a lower value of R_e, if the tap on R2 is then brought back up to the higher voltage, emitter current of Q3 could be excessive, thereby ruining the advantages of the long-tail pair -- and then you might as well stay with fig. 23c*. It is evident, therefore that the modification of fig 25 shown in fig 25a should not be used unless you are handy with Ohm's Law and plan your conditions carefully, namely restricted range of adjustment.

<u>An Important Note</u>

In many circuits you will see R_z of fig. 21, R3 of fig 23a, R3 of fig. 25, etc run to the <u>output</u> of Q1 (viz., its emitter) rather than its input (viz. collector). The reason for this is that it seems quite logical to take the zener supply voltage from the best regulated source, and what could be better regulated than the output of the regulator? This does give very low values of output ripple without the need for an extra capacitance across Z_1 or extra filtering in R_z. The only trouble with this is that if Z_1 in fig. 26a (left) is not perfect (e.g. has finite dynamic impedance), some of the output variation (as when drawing heavier load) will appear across Z_1, and will be amplified by Q2, and will be fed back to Q1 as <u>positive</u> feedback. Trace the circuit yourself to verify this. It creates potential instability in the circuit which will show up only under a.c. loading, and which can be very frustrating to trace. This is quite a complicated amplifier, even though it only has two stages. It performs well when it has large negative feedback, but any phase shift in the system can reduce the feedback angle and degrade performance; that is why we want to avoid C in the feedback loop (as discussed). Taking R_z to the output furnishes an extra undesirable source of such degredation and should be avoided.

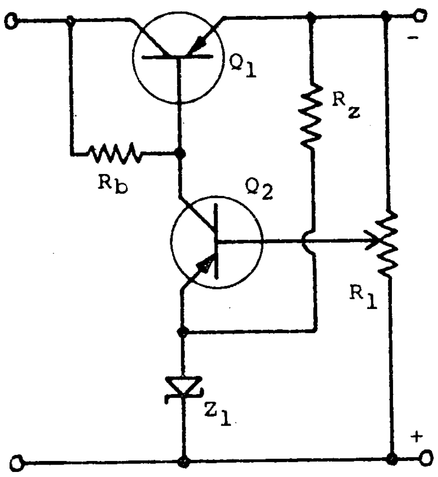

Fig. 26a: WRONG

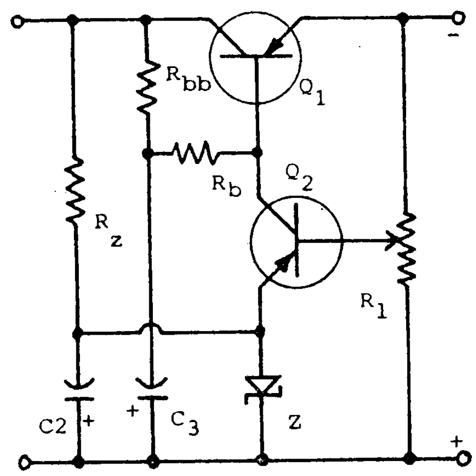

Fig. 26b: RIGHT

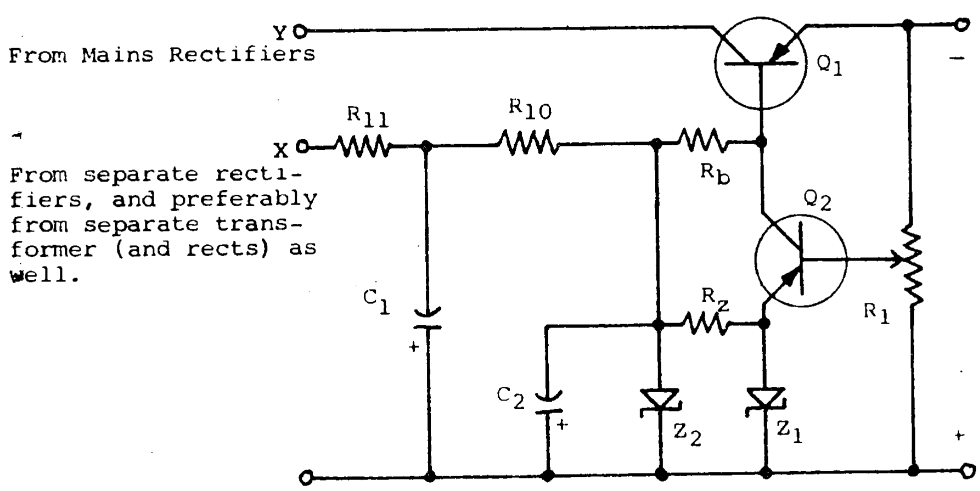

Fig. 26c: BETTER: separate well-filtered and regulated supply for Q2 via Z2.

We <u>do</u> run the collectors to output in fig. 25 because as far as R_e is concerned the transistor looks like a constant current device, largely independent of collector voltage (i.e., high collector resistance). But the constancy of the zener voltage depends on its being supplied by a "constant" current from R_z (or R3 of fig. 25). The zener has a definite impedance (particularly for low voltage ones), so a change in voltage supplied to R_z will change zener current thus zener voltage.

It should be noted that although many good designs do run the collector of Q3 to the output (as in fig. 25), this has the disadvantage that it restricts the minimum voltage available, and is most practical only when there is at least 2V (preferably more) across Q3 at the low voltage end. The maximum range of variation is obtained when Q3 collector goes to the input, and preferably to a separate well regulated supply.

So, by taking R_z and R_b directly from the input we sacrifice ripple performance but improve stability. As we have mentioned (fig. 20a etc) Rb can be divided by an electrolytic, as in fig 26b, and the same can be done for R_z. To reduce it further, cascaded zeners can also be used (<u>EEB</u> p. 42). For best peformance the supply to Rb and Rz should be from separate rectifiers and filters, as per fig. 26c. This gives much lower ripple for given values of C_1 & C_2, because the current required by Q2 is much less than that of Q1, so allowing large values of R_{10} & R_{11}. Where the constant-current system of fig. 24 is not used, Z2 of fig. 26c may be added to provide better stability. However even without Z2 fig. 26c is better than fig. 26b, because a heavy load current drawn through Q1 will reduce considerably the voltage at point "Y", and negligibly at point "X"; c.f. "A Small Design Note" on p. 83 last month. In fig. 26c a separate supply with separate transformer to "X" will produce even better results because larger values of R_{10} & R_{11} may be used.

<u>THE PERFECT (?) REGULATOR!</u>

Believe it or not, introduction of the dotted-in resistor of fig. 20 (April, p. 57) gives a power regulator which provides <u>100%</u> perfect regulation -- at a price. Unfortunately the price is a bit steep, or this would be an Ultimate System. A slightly different version we have tried is shown in fig. 27 (p. 109). R_1 adjusts output as usual. <u>For a</u>

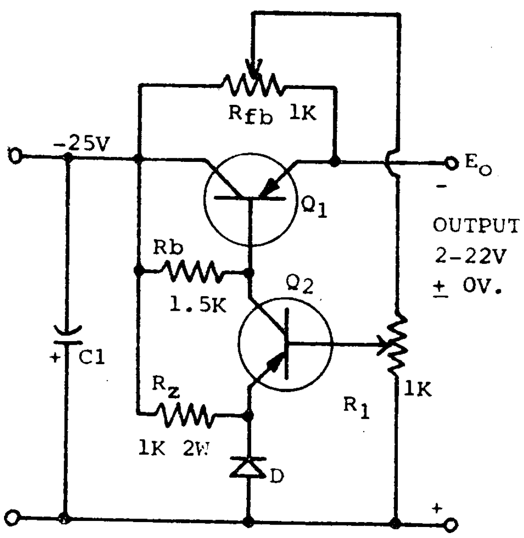

Fig. 27: THE PERFECT (?)REG.

given load current R_{fb} is adjusted to give perfect regulation for a small variation of load. This ideal state of affairs results from some positive feedback introduced via Rfb, which has the curious effect of seeming to anticipate a load change before it occurs! The signal fed by Rfb to Q2 is in the same direction as the one coming from change of load. If you run Rfb too far to the left you can actually obtain an increased output voltage when load current is increased; this shows the existence of negative resistance which compensates, in fact, for the positive resistance of the load. It is a neat trick, but only works when the load is resistive, and then not always.

This system has the following disadvantages:

1) Regulation is perfect only for a limited range of load or mains supply variation. It depends on the linearity of the transistors.

2) Appreciable ripple is applied to Rfb. The setting of the tap which gives the best regulation is not the one giving minimum output ripple, and conversely. This could be overcome by better filtering ahead of Q1, but not from an RC network feeding Rfb (because this would give intolerable sensitivity to transients). (But see interesting zener idea, Ref. 51, p.41)

A rather curious observation of this system is that when Rfb is adjusted for minimum output ripple (on a CRO), the frequency of the remaining ripple (about -90db) is twice that fed to Q1, e.g. 2 x 100 cps = 200 cps! Where does this come from? Obvivously there is a phase shift somewhere. This leads us to another small detail:

3) Positive feedback is clever only as long as it does not get out of control. What happens if it becomes sufficiently higher than the negative feedback, to allow sustained oscillation? When can this occur? When an a.c. signal of a certain frequency is applied such that the positive feedback is shifted a net 180° with respect to the negative feedback loop. What frequency? Who knows. It is not possible to tell without going though an exhaustive design analysis. The result? Imagine you have used a fig. 27-type circuit to power an ordinary Class B power amplifier. The power supply works like a charm, and the output d.c. voltage remains absolutely constant over most of the range of load, from d.c. to, let us say 3kc, but at say 3127.5 cps it goes berserk. As current load goes up the voltage shoots down then violently up and then down and up. At 3200 cps all is well, but but perhaps at 4691.125 cps the same thing happens but in reverse sequence. And so on. The result might sound nice with "electronic music" (what could ruin it?), but it could be pretty hard on Beethoven.

But, you may object, all you would have to do to overcome this problem would be to shunt the load with a big electrolytic so that those high frequencies won't ever get into the regulator? Not so: you will succeed only in lowering the critical frequencies. Any capacitance at all introduced into the loop will give phase shifts (as we have discussed), and at some (lower) frequency this could give the trouble mentioned. The situation is directly analogous to the objections raised to C7 in fig. 20a (p. 81), but worse.

Could this instability, in fact, be prevented? Yes, by finding the frequencies of instability, and applying suitable phase-correcting networks of L and C (and R) in the right places; but this can become quite involved, and you can merely succeed in shifting the instability to a different frequency. The complexity of doing all this would be MUCH better spent in providing a better regulator of conventional design.

On the other hand this system does work well with very low frequency loads, e.g. a temperature-control amplifier, and RLG has had excellent results with one so used. In that case R_{fb} was adjusted for minimum effect of mains voltage variation.

And So Forth

All of this has been a relatively involved discussion of only one small part of regulator theory, albeit with negligible maths. There is also the technique for using a common-emitter control transistor (Q_1) rather than emitter follower. This has some advantage in reducing dependence on supply ripple and internal resistance, and the series transistor also provides considerable gain. That system, needless to say, has its own limitations. A typical design by T. M. Palmer will be presented in these pages.

There are also switching regulators (Pulse-width Modulated) (eg ref. 40a), and all kinds of ways of putting transistors in series and parallel (refs 40a, 50, etc). And there are numerous protection circuits, a subject on which we have touched only briefly, along with Van Stavaren in this issue. Though we do regard as poor practice a dependence on overload protection circuits, they can be helpful when used intelligently. The simplest type of protection is, of course, simply a resistor in series with Q_1 as we have discussed, and which will be taken up again in these (and other) pages in due course.

RLG also has voluminous notes on an equivalent set of experiments performed on shunt regulators; this was done before they started to come back into popularity (c.f. Electronics Australia, March 1970). Les Yelland, who sends us many interesting designs, has also done some good work on shunt systems. These can be very convenient when transformer voltage is limited, though they are relatively inefficient because of the large amount of heat needed constantly to be dissipated by the losser shunt transistor (like a shunt zener). On the other hand there are many instances where this heat can be dissipated easily, and in such cases the shunt system is capable of a high order of performance with a minimum of components (e.g. see Ref. 50)... Before we go into all that we had best let our several authors have a go in these pages before we lose all of our subscribers. Maybe more power supply theory (if you want it?) in 1971.

Conclusion

This series of articles merely scratches the surface of this subject, but we hope that it has been presented in an understandably systematic way at least for series regulators. By presenting the basic principles and some principal variations we have hoped to help you to make sense out of the bewildering array of designs encountered in the literature. Without this basic knowledge you can waste hours trying to decide which circuit is "best", or once built, trying to get it to "work properly." You can design simple circuits simpler yourself, rather than searching through references, or you can modify complicated circuits from the literature to suit your individual requirements.

To the many of you why may have been blinded by these many words, but who might be reading this final paragraph, we would assure you that some time spent studying this text will be of greater value than the casual perusal of numerous "practical" circuits in the periodical literature, particularly as we have tried to approach the subject from a commonsense point of view, laying waste some common misconceptions. Why not take out some time and read this series over thoroughly?

References

This list does not pretend to be inclusive, but only a guide to a few items we have found useful. In addition this list has been abridged from our original, to present the references particularly relevant to some point made in our text, or which have good basic presentations of theory and practice. For the latter the references from No. 35 onwards are particularly good for experimenters, being presented with relatively few formulae, and with much sensible approach, often with commonsense. These books and booklets are worth reading just for enjoyment, and you will find hints and ideas which can have practical application later. Australian works (mostly of British origin) can be obtained from the usual technical bookshops. RSGB publications can be obtained through the W.I.A. or directly from the Radio Society of Great Britain (35 Doughty St., London, W.C.1). In general, British books can be obtained much more cheaply than locally (except for RSGB) by ordering from Blackwell's Book Store, Broad St., Oxford, England. Likewise for Sams and other American books, from the FAA Bookstore (See EEB, Oct. 1969), though with a long delay.

1) Amateur Radio, 2&4/67: "Synthetic Battery..." by R. Champness, VK3UG. See also 4/68, p.10.
5) CQ, Jan 66: "Series type transistorised Regulated Power Supplies", M. H. Burke, K2ENU.
6) Electronics Aust., 11/66: "A Power Supply Unit for Transistors", C. Horwitz.
6a) Ibid, 7/66: "Zener Diode Properties" (from STC, May 66). C.f. 9/66 p. 101.
7a) Electronics World, 5/65: "Designing a Transistor Power Supply", T. J. Barmore.
8) Ibid, 12/67: "Stable low cost Reference Power Supplies", by C. D. Tobb.
10a) Ham Radio, 4/68: "A Modern Low-Voltage Power Supply with built-in short-circuit protection", D. Nelson, WB2EGZ.
12c) Miniwatt Digest, 7/66: "Zener Diodes..."
16) Motorola Application Note AN-163: "Silicon Power Transistors provide new solutions to voltage control problems", J. Takesuye & Weber
19a) QST, 5/67: "An adjustable regulated transistor power supply", A.B. Baker, KØPSG.
b) QST, 2/68: "Modern Power-supply Design", by J. Althouse, WA6CEZ.
20a) RSGB Bulletin: 11/65: "Low Voltage Stabilized power supplies", J.A. Hardcastle, G3JIR.
b) Ibid, 7/67: "A Tunnel-diode Protected Pwr supply", S. Weber.
31) 73, 9/66: "Complete overload protection", E.M.G. Rankin, W4ZUS.
31a) 73, 6/66: "Zener Diodes", J. Ashe, W2DXH (This article is very good)
35) "Design & Operation of Regulated Pwr Supplies", I. M. Gottlieb (Sams)
36) "Diode Circuits", R.P. Turner (Sams)
37) "Selected Semiconductor Circuits" S. Schwartz (Wiley or Armed Services)
38) "Power Rectification with Silicon Diodes", M. Dayal (Mullard Ltd, 1964)
40) "Motorola Power Transistor Handbook"
40a) "Semiconductor Power Circuits Handbook" -- Motorola (2nd Ed of 40)
→ This reference and most of the others following are particularly recommended.
41) "Reference Manualof Transistor Ckts" (Mullard Ltd, 1961) but NOTE:
41a) "Transistor Audio & Radio Circuits" (Mullard Ltd, 1970; second ed. of 41)
42) "Technical Topics" (now "Amateur Radio Techniques"), G3VA (RSGB, Lond.)
43) "Transistor Circuits Handbook" and "Transistor Circuit Manual", by A. Lytel (Sams, Indianapolis or London)
45) "G.E. Transistor Manual" 7th Ed.
46) "RCA Transistor Manual" Ckts Sect.
46a) "Silicon Power Ckts" RCA. Very gd.
48) "Zener Diode Handbook" -- I.R.C.
49) "Zener Diode Handbook", Motorola
50) "Silicon Power Transistor Handbook" (Westinghouse Corp., Youngwood, Penn.)
51) "Voltage Regulator (Zener) Diodes" (Mullard Ltd.) A good booklet, much like Ref 48&49, but more simple-theory.

Postscript by RAJR: RLG has omitted a very good one: Application Note 90, "D.C. Power Supplies" by Hewlett Packard Co (request directly). For serious experimenters.

LETTER: Electronic Adapters

I am interested in an electronic adapter for Clarinet and Saxophone, and would like to obtain the circuit. It comprises a doubler or more correctly a frequency divider which enables the instruments to sound as bass counterparts. Also it is a straight-through amplifier, and has several voices, like an electronic organ. Some also have vibrato. Some are made in America, and a cheaper vision comes from Japan. Any help would be greatly appreciated.

-- I.A. Bird, 153 Pacific Drive, Port Macquarie, N.S.W. 2444, Australia.

Reply by Asst. Ed (RAJR):

We have made some enquiries but are unable to help Mr, Bird. We can only suggest that he follow progress in magazines like Popular Electronics.

In general it is interesting to note that to produce a particular sound characteristic, one method is to observe waveform of an actual sound, and from this to approximate a Fourrier Analysis (e.g. 4th order). From this one then attempts to synthesize the final wave from harmonics and subharmonics of the original tone.

A simpler but less satisfying tone can be obtained by producing a single one rich in harmonics and by using approximating-filters to get rid of higher orders -- similar to techniques used in electronic organs. They start with a square or sawtooth, and filter to obtain, e.g. cello or violin.

The subject of tone filtering is well covered in most books on electronic organs, and in general a good book on the subject of electronic organs is: ELECTRONIC MUSICAL INSTRUMENTS, by Dorf, now out in the 3rd Ed.; This book was reviewed by N. Williams in the October 1968 issue of Electronics Australia, p. 125. You can probably get it from the booksellers for $16.75 plus post, but if you ask nicely, Schober will probably sell it to you for $10.00 including freight (Schober Organs, Aust, 124 Livingstone Ave., Pymble, N.S.W. 2073). If any readers have smore information on this subject, we should be pleased to hear from them. Private correspondence can be exchanged with Mr. Bird at the above address, and with R. E. Dunk at 21 Morella Ave., Sefton, N.S.W. 2162, who authored our August and December 1969 articles on electronic organs.

LETTER: Aspects of Production Engineering

I was quite interested in your Recipe in the April issue (it was Real wasn't it?), and should like to add a few suggestions. The first is that the hops are greatly improved by steaming them with very little water, then pouring cold water through them. This requires 50-100% more Hops, but results in a lovely strong hop-aroma in final brew, not obtainable by any other method.

Furthermore the body of the brew can be improved by adding a pound of "dark crystal malt" to the hot extract. This ingredient is obtained from sources similar to the one mentioned by your British correspondent for sources of Malt Extract. If the crystal malt is not obtainable, body can be improved by one of two interesting methods: 1) You simply add a teaspoon of brown (best: light brown) sugar to each bottle before capping, instead of the white sugar normally used to raise head; of course for this the brew must have gone all the way "to the end" of its fermentation. Or: 2) Put one pound of white sugar in a dry saucepan, and place on low burner on the stove. In about 15 min the sugar will have melted, will bubble and then brown. When it begins to have a cinnamon-type smell, the heat must be removed immediately; it is vital not to burn the sugar too long. Then gently pour some water down the side of the pan; steam will come off strongly so stay away from it. Continue adding water (e.g. a few qts), then the rest of the sugar and then boil the liquid as usual until the last of the burnt sugar has been dissolved from the bottom of the pan.

And one last note: In some areas the water is obtained from collected rain. If this occurs near the sea quite a lot of salt can come in with the rain, which requires omitting the salt from the original recipe. Unfortunately this depends on prevailing winds and is not reproducible.

-- I. N. Wormwood, Coorombatta, Vic.

LETTER: Weed out all that electrical stuff

I cannot resist the temptation to write a few lines of praise re the EEB. I think it is a good all-round family magazine with quite a bit of useful technical stuff for the do-it-yourselfers. Of course to make it even more popular how about weeding out a few of the electrical articles and substituting other subjects: photography, music, gardening, etc. How about a "Favourite Recipe of the Month" section for wives. After all it is probably the wife who finally remembers to send in the subscription....

-- Mrs. K. H. Vieritz, Kallangur, Qld.

LETTER: Underground Electronics

I liked EEB better in the old format, the quarto pages and bigger type face. Whilst the new EEB is very professional and polished now, surely the offset printing would be better done on larger pages as before? When the printers reduce the copy photographically it becomes difficult to read... Apart from that you Taswegians stagger on to bigger & better things. The lightbeam communication angle is good, and will be followed up when possible. Keep up the good work. EEB is the only "underground" electronics magazine in the world, i.e. the articles show signs of intelligent thought.

-- D. Thomas, VK3ZVT, Mt. Waverley, Vic.

((Most correspondents say they prefer the new format; since the type is about the same size as ordinary books, perhaps the problem is the quality of the reproduction. Our Asst. Editor has actually BUILT a high quality photocamera to improve this, for which I am most grateful. This issue will, I hope, be the first to use the new camera, but it will surely take time for us to become proficient in its use. The reason for the small type is to get more in on a page; type for letters is a bit smaller because they are more important, hi.-RLG))

LETTER: Recent Developments

I have some notes that may be of interest...

1) Mullard have two good types of NPN Silicon Phototransistors in production: The BPX25 and BPX 29, with sensitivities of 1 uA/lux and spectral response around 0.8µm for the BPX29. Light enters a small window at the top of TO-18 case. The BPX 25 has about twice the sensitivity and a very narow (15°) field of view. Cutoff freq is about 50 kHz, and they are priced around $3 to $4. ((Ed. Note: see also April EEB, p. 56))

2) Your 3N140/3N141 addicts may be pleased to know that a device is available with similar electric. characteristics but with overload protection. It is the MEM-564c made by S.D.S. Ltd, Crunstone Rd, Hilsea Industrial Estate, Portsmouth, Hants, U.K. You can order directly if you send £stg.

NB: Apparently the optimum injection voltage for a 3N141 mix is about 2.7-3.2mV, and it is fairly critical if good mixing performance is desired. ((Ed. Note: A particularly informative article on this subject is found on p. 19 of SPECTRUM, June 1970: "It Pays to Fiddle" by ZL1AHQ (Spectrum, P.O. Box 5268, Auckland, N. Zealand; $1.50/yr))).

3) As mentioned before in EEB the AY1119 is a vy good transistor for Tx use: P.G. 22db @ 55MHz; 14 db @ 150MHz, when fed with 200mW of power to the collector! They are very cheap too -- about $½ ea.

-- J. Young, Hunters Hill, N.S.W.

((Thanks, John. Any transmitter circuits you build will be welcome here. We get relatively few contributions from amateurs on Tx/Rx subjects.--RLG))

ea.: **$0.25**

yr.: **$1.00**

(foreign: $2)

THE AUSTRALIAN EEB

→ COMMONSENSE ELECTRONICS

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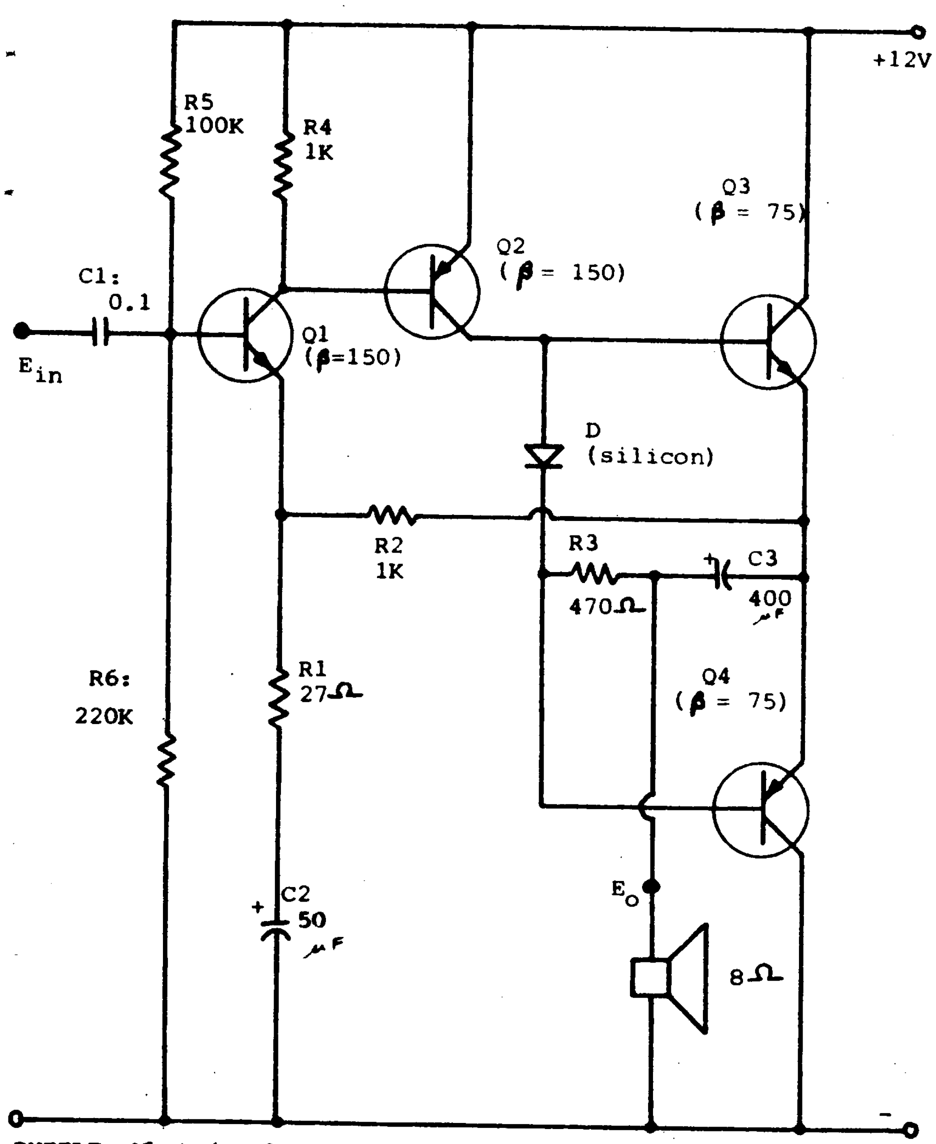

PUZZLE: What is the voltage gain, A, from Ein to Eo: A=Eo/Ein. No prize for this one, too easy, but the explanation of it is not so obvious. Read about it in the next (October) issue.

CONTENT:

NEXT MONTH: OCTOBER (Amplifiers, Power Supplies, Radio Amateur Topics) (PLUS special Tachometer for C-D)

C-D IGNITION SYSTEMS, Part I -- R. A. J. Reynolds (VK7ZAR)

Which is best?

I have never been satisfied with the ignition systems that my various cars (one of my hobbies is collecting cars!) have had, so I have experimented with several systems, with varying degrees of success. A few years ago, the only alternative to the conventional system was the "sports coil". This system gave a better spark at high engine speed, but at the expense of point and plug life.

About 1962 a few high voltage high current transistors became available in this country, and I built a conventional transistor ignition, and finding that an ordinary coil was not suitable, wound my own. This system worked alright, but was prone to fail due to puncture of the transistor, and had the disadvantage of high battery current, as well as difficulty in starting with reduced battery voltage. A relay controlling the series resistance improved this condition to a certain extent, but a cold morning usually meant a push down the road. Recent experience with commercial transistor ignition coils and modern transistors gave essentially the same results. RLG says that he has had the same experience with a conventional transistorised ignition on a VW, with poor low-speed performance (particularly idling), but good at high speeds.

Now there is no denying the fact that many people have apparently got good results from ordinary transistorised ignitions, as shown by Refs 13-21 here. It is possible that the difficulties some of us have had lie in compromises involved with the very high ratio coils needed; certainly better results have been obtained when standard coils were used with series-transistor switches, as our own authors have claimed (Refs 20 & 21).

A transistor-switched coil gives no more voltage output than the points-switched one, but it does produce a spark with a much faster rise time, and this gives improved performance for reasons well described in the references (e.g. 7 & 10). On the other hand, the CD system gives this benefit as well as appreciably higher voltage. Even when the special-coil system works satisfactorily it tends to be both inefficient and expensive (viz., Ref 20). If you go to the expense of buying a special coil and the conventional transistorised system refuses to work well at idling or low speeds, so much the worse. Using the conventional coil the CD system is quite reliable for results at all speeds, presumably because d.c. inverters tend to be self-regulating.

A Sports Coil is certainly less trouble than any of that, but it does mean a new set of plugs and points every year, and there are other objections (Ref 22). Furthermore, my Detroit-spawned high revving monster still suffered from inadequate spark even though it had a kind of Sports System. Since the car has an automatic transmission, starting-reliability was an absolute must. This outlawed the conventional transistor ignition, leaving room only for the CD system for reasons suggested above.

The Condenser-discharge Type

In the past I have avoided capacitor discharge systems after a rather unsuccessful attempt at one with thyratron & genemotor some ten years ago.* But reports from industry and experimenters alike glowed with enthusiasm for systems using solid-state DC/DC converters and SCRs; References 7 & 10 give a particularly lucid discussion of the position. So, suppressing professional instincts I went to the Junk Box for the necessaries.

The Basics

Consulting the references, it was seen that most of the CD designs were similar, differing somewhat only in the method for providing HT, and in the triggering circuit. Otherwise they all work simply by charging a capacitor to HT, and then using the points to trigger an SCR to discharge the capacitor through an ordinary ignition coil. This turns off the inverter briefly, so turns off the SCR (aided by backwave from the coil).

So I pleased myself for the power supply, unearthing the remains of an old Taxi two-way radio of valve type, but fitted with a transistorised DC/DC power supply giving the necessary 350V d.c. from my 12V system. If you are not so fortunate, consult any of the references, as suitable -- depending whether you buy or wind the transformer. Several suitable designs will also appear in Refs 11 & 12.

I used a conventional SCR, in this

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*My experience was similar with a vibrator-powered monster. Worked fine on the bench, but the motor coughed and suffered with the device installed in the car. Likely reason was erratic triggering of the high impedance grid by spurious signals somehow fed back through the system. In addition I kept burning out expensive thyratrons, possibly due to high peak currents. SCRs have solved all of these problems. -- RLG.

case a BTY91/400R, but any reliable 400V 4.7A unit will do; main thing is that it must take the high peak currents involved. My trigger system was the one described for negative earth in Ref 5, as a combination of their figs. 3 & 4; another good system is also described in Ref 10 (see, there are advantages to EEB's late publication schedule!). In my case the simple diode-R/C filter gate system sufficed; for the positive earth case a transformer or inverter transistor has to be employed (though Ref 10 shows an R/C alternative which drives the SCR cathode).

The widespread publication of these circuits now makes it unnecessary to take space here for them (thus also saving me the task of drafting them!), and I shall discuss only a few pertinent points.

Design Comments

In the typical gate trigger system the various resistors and capacitors are used to shape the waveform, to keep gate voltage and current within safe limits, reduce transient pickup, and to provide a small but definite current through the points. About 0.5A is suitable for the latter, a value sufficient to burn out accumulated dirt, but not so much as to shorten point life (which should be limited only by the rubbing block; but see Ref 21). It should be noted that one important defect of early transistorised ignition systems was the fact that the contact breaker points current was too low; the points got dirty and had to be cleaned out relatively frequently to maintain adequate car performance.

Over the years there have been a large number of coil types, 6 & 12V, conventional and sports, ballast resistor or not. I tried all of these with my CD system and a transistor coil as well; the one that came out on top was a 120:1 Ballast-resistor type coil that was already fitted to the imported Dodge car in question. In fact, you will generally find that the coil already on your car will function quite satisfactorily for a CD ignition.

The choice of the main discharge-capacitor is another matter. Most people merely bung in any convenient 1 µF "bathtub" type available, often of disposals type. But this is ordinarily NOT satisfactory for one simple reason: it gets hot, thereby wasting power, and ultimately resulting in capacitor failure. The cause is the fact that most oil-filled capacitors have an inductance which is of the same order as that of the coil (at the high current peaks). This sets up an L/C oscillation in the capacitor, resulting in dielectric heating. As Ref 10 points out, polycarbonate types are no great improvement, in **spite of** their wide use for this **application.** There are only two good **alternatives:** go through a number of different types in your junkbox until you find one that stays cool when operated in the CD system; otherwise you will have to buy the special unit made by Ducon, No. 5S10A (1 µF 1000V DCW), probably costing about $5-6, with some 8 weeks delivery. This special capacitor has oil-impregnated paper, with foil extended unusually far on either end to reduce inductance. The Ducon item is rated at 1000WV with a tested peak current rating to 50A. I managed to find a suitable epoxy capacitor, but I was lucky.

Performance

The whole thing took about six working hours to put together in a box 3" x 4" x 5", test and put into the car. There it worked like a charm, with less radio noise than the original ignition, and since the inverter transformer was designed for low physical noise, the unit could not be heard working at all. The unit was mounted on the inside of the mudguard in the front motor compartment behind the radiator. Several months of operation in all weathers has not shown a need for any special protection from the weather.* In constructing the unit, suitable mechanical and electrical precautions should be observed as discussed in Ref 10.

As for actual performance, one will hear conflicting results from users, but much of the argument is silly. One notices improved acceleration, somewhat better petrol mileage (if one doesn't do too much acceleration!), and a greatly improved life for the contact breaker points and spark plugs. Who could want more? In technical terms this unit had an output in excess of 40kv up to 25,000 RPM tailing off to about 30kv at 36,000 RPM for an 8-cylinder engine; or twice this speed for a 4-cylinder one! My car is impressive, but not quite that much; these results were obtained from a simulated run using a high power audio frequency generator to trigger. From this it can be assumed that the system is adequate for all known internal combustion engines, as the required voltage is only of the order of 7 to 10kv for engines in good condition; higher in poor condition, par-

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*Even the effort of the local garage to steam clean the unprotected SCR Ignition system, and then washing in a stream of water, seemed to have no electrical effect (after it was blown clear of water by compressed air!)

ticularly for the plugs. Some comparative figures are illuminating:

PARAMETER	CONVENT.	SPORTS	TRANSISTOR	C-D
Output	25kv	30kv	30kv	45kv
Avg. Batt.	3A	5A	5A	0.6A*
Peak Supply	5A	8A	7-10A	0.6A**
Top Speed Capability	5500RPM	7000RPM	10000RPM	36000RPM

* This figure was for the special high efficiency inverter I used; for the usual lashup, current drain is appreicably higher, e.g. 2A. Note that the C-D system is the only one which could work for any length of time from torch cells if the occasion demanded! More usefully, it is less affected by low battery supply voltage, starting.

** Note that the peak current from the battery is the same for this system; the peak current to the coil is, of course, considerably higher.

These figures all refer to a 12V supply and vary from unit to unit. In the case of all but the CD unit, the top speed is governed by the maximum rate at which the magnetic flux can rise when battery voltage is supplied to the primary of the coil. In the CD case the maximum speed is governed by the frequency of operation of the DC/DC inverter. The speed shown refers to an inverter frequency of 2.5kc. In the case of my unit, one cycle of the inverter was all that was necessary to give a 30kv spark.

From power supply considerations, it can be seen that the CD system takes the lead as far as apparent efficiency is concerned, although various things can be said about considerations of spark-energy. Suffice here to say that spark energy depends on the value of the main discharge capacitor, and (unlike the case of the conventional system) can be adjusted to the optimum value.

Advantages & Disadvantages

It would appear that the CD system is ideal in all respects, including the fact that it will fire a fouled plug because of the extremely fast rise time of the voltage, i.e. 1 microsecond. Let us, however, examine the matter a little more closely. It is a fact that a CD system gives better performance than any other type of ignition system, but it is only strikingly noticeable if the engine is pushed to its limits, or if the engine is of the sports variety where ultimate performance is demanded of the ignition system due to high compression ratios.

The disadvantages of the CD ignition are its high initial cost (but coils are not cheap either), and a lower reliability than a conventional system, due to the large number of components, some of which are affected by the temperatures encountered under the bonnet of a car. In the extreme, the problem of reliability is easily met by using a simple 3PDT d.c. relay controlled from a switch on the dash, and which can change back instantaneously to the conventional ignition system if desired.

There also arises the problem as to the servicing of transistor ignitions in general, since the local garage man is not ordinarily an electronics expert, and does not have much of a chance of effecting a repair on the side of the road if necessary to get the car home. In consideration of this, and of the rather dangerous voltages used in the inverter, the dash-controlled switch is undoubtedly the best compromise, allowing examination of the unit at leisure by a qualified person. Excepting mechanical failure in the system, however, this seems rather academic, since the failure rate of a properly designed SCR-operated CD ignition system is vanishingly small.

The car that I have is designed to run at high engine speeds and runs a standard 10:1 compression ratio. The effect of the CD system can be felt throughout the car's operating range. Offhand I should think that in an ordinary family saloon all of this bother would hardly be worth the trouble for the marginal improvement in performance, but RLG swears that it made an appreciable difference even on his little Beetle, with a 25% improvement in petrol mileage, not to mention the less frequent maintenance of the distribution system.

Postscript

If you encounter any difficulty which looks as though the SCR is not being triggered properly, it may be due to "dV/dT Turnon" whereby the SCR is turned on not by the gate, but by the anode when the anode voltage is applied too rapidly. References 1, 3, 4, and 9 solve this mainly by putting a small capacitor directly across the SCR, e.g. 0.001 to 0.005 uF perhaps shunted by 330K. The other references don't bother. Prudence and the fitness of the unfortunate engine might dictate that the extra capacitance could be a safe precaution unless a CRO shows otherwise.

Vast is the power of cities to reclaim the wanderer, more than mountains or the shore-devouring sea. A city retains its character, imperturbable, cynical, holding behind apparent changes its essential purpose. --Sinclair Lewis

AUTOMOBILE IGNITION REFERENCES (RLG): I. C-D Ignition Systems:

REFERENCE	THEORY	XFR: BOUGHT;	MADE	EARTH	TRIGGER
1) Pop. Sci, 5/65; H. G. Mc Entee			x	Neg	DRC
2) Rad. Electronics, 2/66; T. Gerald		x		Neg	Tr. Amplified.
3) Rad. Electronics, 2/67; B. Ward		x		Neg	Tr. inverter
4) Electr. World, 11/67; B. F. Cawlfield		6.3V fil. xfr!		Neg	DRC ((Tnx: VK4NZ))
5) El. Aust., 9/69: Reader Built It; Anon.			x	Either	DRC or Tr. Inv.
6) Radiotronics (RCA), 8/69; M. S. Fisher	x	Regulated	x	Neg	Tr. Amp.
7) El. Aust., 11/69; P. Watson	xx				
7a) El. Aust., 1/70; W. A. Mc Arthur (Reader Built It)			x	Neg	DRC
8) Wireless World, 1/70; R. M. Marston		Regulated	x	Either	Tr. Inv & DRC
9) Components Review (STC), 1Q, 1970; Anon.			x	Either	DRC
10) El. Aust., 8/70; A.J. Fraser	x		x	Either	DRC
11) Aust. EEB, 10/70; G. Cohen			x	Neg	Tr. + UJT.
12) Aust. EEB, 12/70; T. Vieritz; K. Vieritz			x	Neg	DRC

II: Conventional Transistorised Ignition Systems:

13) Pop. Sci., 3/64; D. A. Gattis (3 Tr and rewound ignition coil).
14) RTV&H, early 1964: A series of articles on transistorised ignition systems.
15) Aust. EEB, 10&11/65; G. van Leuven (1 Tr and 300:1 special coil).
16) Bull. of WIA/VK7, 11/65 (QSP W.A. Bulletin): Theoretical aspects and references (1964).
17) El. World, 1/66; C. C. Morris (1 Tr and 250:1 coil, ballast shorting relay for starting).
18) Rad. Electronics, 6/66; I. M. Salzberg (General theory comparisons, with 3 Tr 100:1 coil).
19) El. Aust., 11/66; "M.C." (Correspondence, p.173) (Some practical comparisons).
20) Aust. EEB, 3/70; L. E. Thomas (3 Tr. series with stock coil).
21) Aust. EEB, 4/70; K. H. Vieritz (2 Tr. series, via Heathkit; curious note about silver points).

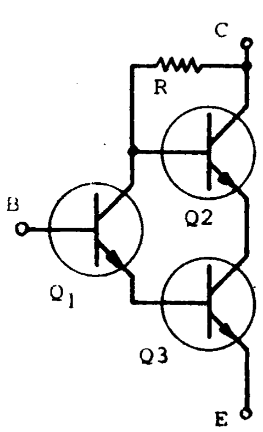
III: Other Systems:

22) El. Aust., 12/67; Forum, (Editor) (Optimum conditions, some comparisons, sports, conventional).
23) El. Aust., 11/66; "Solid-state, Breakerless Magneto Ignition" by G.A. Guernsey & E.J. Brayley.
24) El. Aust., 2/70; (Reprint of Ref. 25).
25) Pop. Electr., 10/69; "Build a Dwell Extender" by G. Meyerle (Clever, simple idea, uses SCR).

NOTE by RLG: I have not had the time to keep up with the world literature during the past couple of years, and it is quite likely that several other articles have appeared on these subjects in that time. The above list is a guide, however incomplete, to some typical systems.

PSEUDO HIGH VOLTAGE TRANSISTORS -- C. Pitcher (VK3)

While messing around trying to drive numicator tubes with low-voltage transistors (from computer boards), I hit upon this idea which may be useful to someone. The usual approach to increasing voltage capability of transistors (apart from using higher-voltage transistors) is to connect two or more in series. This leads to problems with sharing the voltage equally under all conditions. By connecting three transistors as in the diagram, most of these problems can be overcome. In fact, it can be looked upon as one transistor-equivalent, the parameters being as follows:



$h_{FE}' \doteq (h_{FE})^2$ where h_{FE} refers to d.c. current gain of each transistor.

$Z_{in}' \doteq (h_{FE})^2 r_e$ and assuming all transistors are identical, the BV_{ceo} is approximately doubled.

Leakage appears to be well under control, possibly because of the reverse-biased diode (C-B junction of Q1) which appears across Q2's base. ((RAJR has added R, about 500K, as probably necessary to make full use of transistor ratings))

I have used the same idea for linear applications, though the above diagram was primarily intended as a readout driver, and it works quite well. The P-P output voltage capability is approximately doubled. In that instance, I found it useful to use the collector and emitter of Q1 as compensation points. I wouldn't mind betting that this sort of trick is used in some of the high-voltage ICs used for readout drivers.

Of course, nowadays high voltage transistors are cheaper than they used to be, but perhaps this technique may still be useful, particularly when the transistors are very inexpensive, or when you want to make use of items already available in the junkbox.... You young fellers wouldn't remember, but we pioneers had to put up with these sorts of things; low voltage transistors, leakage, etc. etc. It's rather easier nowadays!

THE REAL MEANING OF RADIATION RESISTANCE

-- R. H. Ferris (VK7ZDF)

Does it exist?

Awhile ago EEB received a letter, one of many concerning aspects of the Coaxial Feeder Dilemma discussed in January 1969 and following. This one was from a prominent American author, and was so appalling that I thought it worthwhile to examine the whole concept of Radiation Resistance afresh.

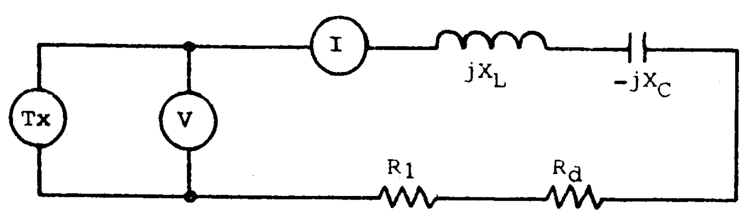
He said: "According to my book (sic), at resonance the inductive reactance and capacitance are equal and of opposite phase, thus cancelling out one another. This leaves only the radiation resistance of the antenna. How does this grab you?

"This means that there is no such thing as a 75 ohm antenna impedance to begin with. The nominal radiation resistance will run one to two ohms for a quarter wavelength antenna -- not 75 ohms. Then by all means use your coaxial transmission line as an impedance transformer, since no transmitter's antenna circuit will match this low radiation resistance. How? By cutting the antenna coaxial transmission line in odd multiples of one-quarter wavelength..."

His communication continues with description of techniques for cutting coax to one-quarter wavelengths, taking velocity factor into account!

"Radiation Resistance" is what radiates!

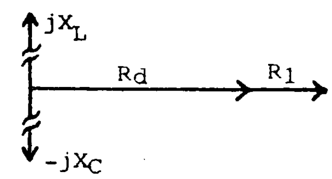
I don't know what is that gentleman's opinion of the State of the Art in nether Tasmania, but his concept of radiation resistance is in error, and I grab it not at all. Let us consider an antenna simply as a lossy series-resonant circuit attached to the output of a transmitter (though a symmetrical argument exists for receiving):



Tx = Transmitter signal.
jX_L = Inductive reactance.
$-jX_C$ = Capacitative reactance.
R_d = Radiation resistance, e.g. 67Ω.
R_l = Loss resistance, e.g. 3Ω.
V = Potential developed across whole antenna impedance, Z.
I = Current passing through Z.
Z = Antenna impedance
$= jX_L + (-jX_C) + R_d + R_l$.

The matter of "j" is only to show that the opposition to current provided by inductance or capacitance has a different phase (viz, $\pm 90^\circ$) than that of resistance (viz, 0°). This is elementary a.c. circuit theory, and if you don't follow it you ought to read any elementary discussion of the subject.

Now, following this gentleman's reasoning partly, at resonance, all "j" terms cancel, and indeed we are left with the loss resistance, R_l, but also the radiation resistance, R_d, as evident from the vector diagram:



So, in fact the (about) 70 ohms total value is correct for a dipole in free space -- though somewhat less under certain practical conditions. The big question is this: Is this a REAL resistance? You can't measure it with a meter -- or can you?

Resistance is a Myth!

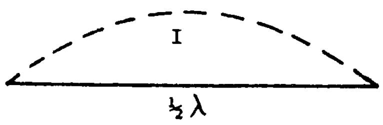
Let's look at it from commonsense: strictly, there is no such thing as resistance, and there never was! It is a myth we (or was it George S. Ohm?) invented to confuse generations of students. Said Ohm saith: "In any particular conductor the ratio of applied voltage to the current flowing in the circuit is constant." That's all.

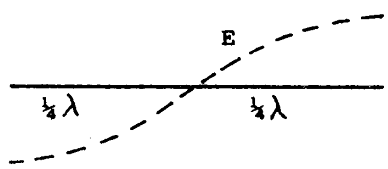
What is real in the circuit is the voltage and the current. Together they get work done. Resistance never has done anything except keep young ladies virtuous. You could perfectly well describe any circuit in terms of V and I. You could, for instance, say: "Put a conductor having a characteristic potential/conductance ratio of three in series...", but it is easier to say "Put a three ohm resistance in series with the battery..."

Thus, resistance is simply introduced for convenience, it isn't real, and we fool ourselves by imagining that it means something special. Thus, in the above equivalent circuit, when we have an antenna radiating power nicely, we may, say, measure some 70V across the terminals shown, and an r.f. current of 1 Amp. We abbreviate this by saying that the Radiation Resistance is some 70 ohms, though in fact we are likely talking about 67 or so useful ohms, and a few useless ones, e.g. taken up in loss. What do we mean by "useful"?

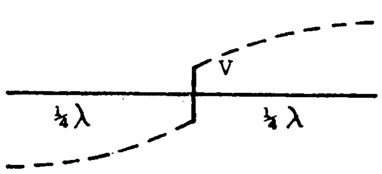
Field Vectors

I'm sorry to labour these obvious points, but misconceptions about them are widespread, and the Handbooks don't always tell us enough about them. For example, one often sees antenna voltage-current distributions of the type:





It would appear that the right-hand curve is where our Yank friend got the idea that there is a negligible voltage at the centre of a half-wave dipole antenna. But that is not a plot of the voltage, V, you would measure with an a.c. voltmeter. It is the electric <u>field</u> potential, E, between the wire and <u>space</u>; it has absolutely nothing to do with the potential between any two segments of the radiator. If you do cut the wire at an arbitrary point, e.g. the centre, and measure the voltage relative to earth, you will obtain:



The other graphs have no useful meaning, serving only to illustrate the voltage phase reversal and the maximum current present at the feed point. But the voltage of this graph is actually that whose amplitude and phase would be measured by a CRO, whose reference is the input signal at the feed point.

Basically what is happening is this: the voltage we measure at the centre of the half-wave dipole antenna causes an electric field, E, and the current we measure causes a magnetic field, H. These propagate (viz., move) together to form the familiar electromagnetic radio wave. There is a fair treatment of this subject in the latest edition of the <u>Radio Communication Handbook</u> (RSGB), Chapt. 12 & 13.

These electric and current vectors hold a lot of power between them, and that is what matters, the power that spreads the banalities of countless amateurs to the corners of the earth. You could multiply E by H to get power (in suitable units), but you are not measuring E with a direct-reading a.c. voltmeter; you would need a field-strength meter for that. What you can measure are V and I at the feed point. These you <u>can</u> multiply together to get power. You can express that power in one of two ways:

1) You can say P = VI, e.g., here P = 67V x 1A = 67W, or
2) You can say $R = V^2/P$, e.g., here $R = (67V)^2/67W$ = 67 ohms.

In the first instance we say that 67W is dissipated in some resistance. In the second we say that it is dissipated in 67 ohms. That 67 ohms is the radiation resistance, the resistance in which the power <u>is</u> dissipated. An alternative is to treat an antenna as a transformer between the feed line and free space. Everyone knows that the d.c. resistance is much less than the impedance of a transformer. Here the d.c. resistance is R_1, and the a.c. resistance is R_d, the radiation "resistance".

Thus, the other few ohms in which our correspondent puts his faith are the loss-resistance ohms, representing that voltage and current which do NOT radiate, e.g. heats up the wire.

Since the r.f. is indeed being radiated from the aerial, the electric field does not in fact fall to zero at the centre terminals (with respect to earth), however much it may so appear from the text illustrations.

In reference to the last point mentioned by our correspondent, although a coaxial line may be used as an impedance transformer (e.g. from a 30 ohm antenna to a 75 ohm line), it is not always desirable to use it for this purpose. As R.A. Reynolds points out in the February 1969 <u>EEB</u>, a resonant length of the line tends to promote spurious radiation from the line itself. For impedance matching it is considerably better to attempt to match the balun itself, and/or by suitable methods of coupling to the aerial (e.g., gamma or delta matching).

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<u>Better Butter</u>: When churning butter, just as it begins to break, add slowly one cup of hot water, but don't make it too soft. If the weather is hot, use rather more cold water instead. Finish churning, wash and salt the butter, and let it stand in a warm room for about an hour, then work it well; this is most important. This butter will never get hard. Those of you who scoff at this have never tasted farm-made butter!

<u>To use Stale Cake</u>: Crumb the cake, place in a glass dish, and pour over it a solution made by dissolving two dessertspoons in a pint of water with a piece of lemon (e.g. ½) and some food colouring. Set aside to cool until set, serve with whipped cream. Is considerably improved by using rum instead of water. I wonder what a dissolved dessertspoon tastes like.

A BACK-TO-FRONT SERIES VOLTAGE REGULATOR

-- T. M. Palmer (VK2)*

Most series regulators for power supplies have the collector of the power transistor connected to the rectifier end and the emitter to the load. This is the typical emitter-follower type which has been described so thoroughly in the past five issues of EEB by the Editors. In the circuit shown in fig. 1 here, this configuration is reversed to yield several advantages, simply. Comparing it with a conventional regulator, note that:-

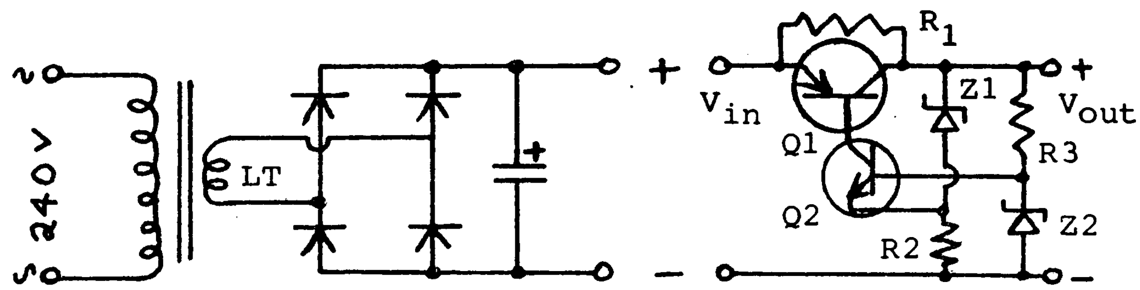

FIG. 1: POWER SUPPLY & B/F REGULATOR

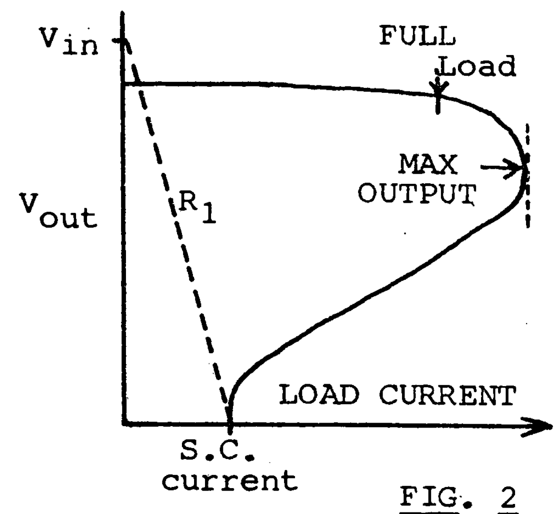

FIG. 2

1) Series voltage drop is minimum, approaching the saturation collector-emitter potential of the power transistor. It also avoids the difficulty of supplying maximum base current via Q2, and needs no auxiliary supply.

2) Better still, the circuit has an inherent current-limiting action. The load curve in fig. 2 shows that, whilst the output voltage is constant up to full load, it drops rapidly to the maximum current point. Thence the curve turns back for a short-circuit current which may be only one-fourth of full-load current, and is set largely by R_1, which is usually necessary to start the circuit. After a short at the output, the output voltage will recover as soon as the fault is removed.

3) If you want the Ultimate -- at little extra expense and trouble, R4 in the more elaborate circuit of fig. 3 can be added to make the output completely constant with changing supply voltage. Similarly, R5 can make the output remain constant with varying load. It is not even hard to make the output voltage rise with increasing load! ((But take note of the cautions on p. 109 of our article last month -- Ed.))

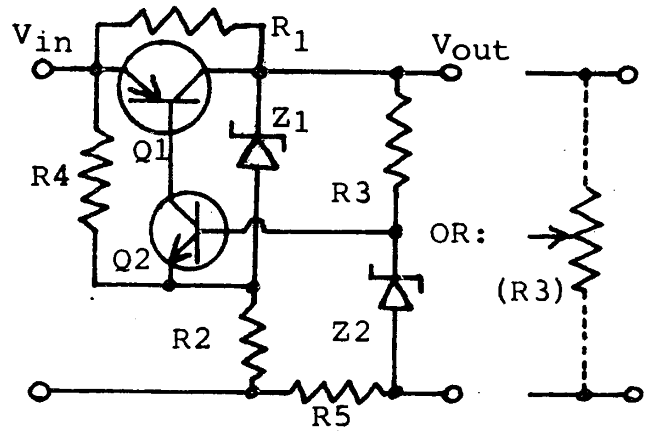

FIG. 3: IMPROVED REGULATOR

The values and ratings of the components, and especially the transistors are determined by the voltage and current required from the supply. Supplies for outputs to 60 volts and currents to 7 amps have used this circuit. As examples, values for a fixed supply of 2A at 24V, as well as a variable supply of ¼A at 4-15V are given below. In the latter a potentiometer replaces R3 and Z2 with, however, some loss of regulation, and lowering the limiting current as the output is lowered.

For 2A @ 24V: R1 = 470, R2 = 150, R3 & R4 = 1K, R5 about 0.1 ohm. Q1 = 2N301A, Q2 = AY1113, Z_1 = 18 V, Z2 = 6.5 V. For ¼A @ 4-15V, R1 = 1K, R2 = 330, R3 = 3K pot, Z1 consists of three silicon diodes forward connected in series, Z2 = two such diodes.

A normal transformer, rectifier, and storage capacitor of sufficient value to maintain a minimum trough voltage above the output voltage are needed ((Say, 500-1000 uF for 250mA, 1000-2000 uF for 2A. -- RLG)).

Printed circuit boards incorporating all variations of this circuit, but which may also be used for a simple version have been made, and are available as advertised in this issue on p. 122.

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

Hop Beer

Add in this order: 4 gals water, 1 handful hops, 1/2 cup real horehound (not imitation), 4 lb sugar, 1 tbs treacle, 1 tbs ginger, 1 handful bran. Boil until the hops stop floating, stand until cool, then add about one cupful of good yeast, e.g. "cenovis" from health food stores. Strain, let stand for about twelve hours. If farm-fresh hops are used, use half as much as the supermarket variety. Astute readers will discern that the above mixture will not be very powerful, but it is a lovely drink. You will, of course, dilute it fivefold or so before bottling, to conform to the legal regulations which enrich commercial breweries in Australia.

* Received October 3, 1969. Sorry for the delay! -- Ed.

My comments on the non-desirability of home TV repairs have prompted several people to write or comment verbally concerning this subject. These people state, and quite correctly, that there is a great range of easily-repaired faults to be found in TV sets, and that these can be found by systematic elimination without lining the pockets of professional servicemen. It is, however, my experience that when this style of fault-finding is employed, the overall performance of the set is often impaired.

A professional serviceman does not work in the same way. He has a wealth of experience behind him; similar sets with similar faults show up, and his experience leads him directly to these more common faults. In the case of obscure faults, his experience once again comes to the rescue He knows where not to expect trouble, where he must not disturb the circuit components, and he has one other very important qualification: his experience, aided by direct training [if indeed he has it] enables him to isolate the fault to be within a much smaller group of components, than can an inexperienced and untrained technician, assuming that each has performed the same amount of observation and the same number of measurements on the faulty set.

"Well?" queried one of my critics, "you have made the statement that there are some faults which can be found easily, so why decry home servicing in general?" When I asked him what he considered to be an un-obvious fault his answer was interesting, to say the least: "One that I can't find in an hour or so". Although this must be an extreme attitude, it does indicate that here is a chap who represents the amateur technician who is prepared to spend quite a lot of time swapping valves and checking components; in this time quite a bit of maladjustment can occur. Then when his further efforts get him only deeper into trouble he delivers the set to his local repair shop. Here all the preliminary investigation has to be performed once more, since the serviceman cannot assume that the amateur has in fact eliminated the more usual faults; for example, for for a particular set a normal fault may be an obscurely placed resistor that the home serviceman might not have dreamed of checking. Thus the set has to be disturbed twice as often as necessary and the first disturbance was likely the worst... YOU wouldn't do that sort of thing? Perhaps not, but I have seen too much evidence to the contrary.

Another critic proudly related how he had found a couple of faults in his own set, but when he realised that I used to be a professional TV technician he asked me to have a look at a set that he had on the bench at that moment. It belonged to a neighbour and it had come in with no picture, but now the sound had gone too, and could I help him out of trouble? It seems that the video amplifier had gone poor along with the line output valve. The latter he had found, but as the picture was far from satisfactory he had had a go at that too. He decided that the i.f. strip needed alignment. As a result the picture was still weak but now smeary, and the sound had vanished. He had peaked the i.f. up on the video, at the expense of audio. Once realigned with the aid of a sweep and marker generator, the sound was restored, and the weak video bottle now became obvious as a suspect -- well, to me at least. This particular chap will probably not touch a video i.f. again, but there are plenty of other traps!

AGC systems involving negative supplies from the EHT cage, are just another problem than can catch the unwary. In a particular set, the failure of one of the CRT focus [CONTINUED on p. 124]

ADVERTISING

ment in current issues of Electronics Australia. [Sorry, no S.A. sales]:

CUSTOM ELECTRONICS, Box 1452L, G.P.O., Adelaide, South Australia 5001.

MAGAZINE SUBSCRIPTION: 73 Magazine has now raised its subscription rate as we warned you last month, and since we have heard nothing further from them about this our special bargain rate is no longer available. Too bad, but we warned you. RADIO MAGAZINE [otherwise known as "Ham" Radio] is still available for single subs or renewals, through us only at Aust.$9.00 for three years. This will not last either. Be warned. We can still provide a copy of HR Vol. 1 No. 1, asample of HR coverage [and already a collectors item] free with subscription if requested, or separately for 25c [increased from last month, courtesy of your Friendly Postmaster General]. These offers limited to Australia and Territories [though OK for N.Z. if you provide negotiable currency].... HR no longer needs "selling"; most interested people have seen a copy, and it sells itself. But when the price goes up we'll stop handling it too, in protest against Inflation. Take note. Write EEB now, enclose money for 3-yr HR sub, and show address clearly.

SILICON DIODES AND ZENERS at unbeatably low prices. Every diode we sell is curve-traced on a special tester [to be published soon in EEB] which tests both forward and reverse dynamic characteristics. We are able, therefore, to guarantee fully every unit if used within the Absolute Maximum ratings specified [See: "Why Abuse Semiconductors?" EEB, Sept. 1968]. Also available: resistors, CRO tubes, relays, toroids, heat sink [anodised aluminium], transmitting valves, selsyns, and various other surplus equipment as available. Semiconductor-orders over $5 are airmailed to VK or ZL, post paid. Discount for quantity. Write for Free Catalogue:

M. WEINSCHENKER, P.O. Box 353, Irwin, Pa 15642, U.S.A. [[EEB Editor's Note: In last year's Catalogue, Weinschenker advertised the 1N430 Temperature-compensated zener reference diode [8.4 V/10mA operating; 0.001%/°C.] for $US1.25; it costs a fortune new. Quite relevant to our discussion of the difficulty of building your own temperature-compensated zeners; c.f. EEB p.105]]

WE HAD one [1.00] request for the free rubber & neoprene gaskets offered last month. With such a stunning response to a free item what must be happening to our poor commercial advertisers? If you patronise them you'd best let them know you came from EEB, or this page will cease operation, thereby removing a useful public service, not to mention a modest source of payment to cover expense for Aspirn and an occasional Grog. SAY YOU SAW IT IN THE EEB -- and tell your friends!

ANOTHER FREE ITEM, in rather limited quantities: 8 pages of information about Computer Circuit Boards. Don't request it if you received the usual four-page screed when you ordered the Boards from A.E. or the W.I.A./VK7, and if you have been a member of the W.I.A. since last [1969] August. If not, send a 4x9" SAE for this one, to EEB. Only about a hundred copies available [free].

EDITORIAL, continued from p. 121 [SEE ALSO: EEB, March 1970, p.33 for Original]

resistors can cause failure of the AGC! Truly one has to know this set very well indeed. In this regard, a serviceman confronted with a particular set with a curly one like this [if the set is foreign to him] should, and usually does query the serviceman for the set's agent, just in case it is a particular trait of that model. Just as in many fields of work, some servicemen do specialise in a particular set. Needless to say, however, such consultations are available only to professional servicemen.

Other traps further justify my observations, such as live chasses, series filaments, and awkward access in some models. So, I still hold to my original thought, which is that if you do really know what goes on inside the set, then no superficial instruction on how to repair a TV-set is necessary, but if you don't, then an article on the subject is not sufficient unless it is a full and comprehensive technical instruction. It is my observation that a school leaver takes about two years to become a good TV Technician [if he has the aptitude], whilst a fully trained Radio Technician takes about 6 to 12 months to become really proficient. Since these chaps are repairing TVs eight hours a day, then what chance has an amateur of knowing the tricks of trade?

I may here note that books describing British TV servicing techniques are not necessarily useful for Australian, nor even for American practice. They tend to deal basically with 405-line sets, but even reference to 625-line sets deals only with the AM-sound and flywheel sync system of the U.K.; the principles and faults and their symptoms are generally different from ours.

British and Australian 625-line systems are not the same. Even though they both use the 625/50 system, Sound Subcarrier frequencies are different, as are power ratios of vision/sound. Let the well-meaning seeker after Knowledge beware. A complete summary of TV systems in use is to be found in: CCIR, Volume V, Oslo 1966, Report 308-1; found in any good technical library.

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EDITORIAL NO. 3 -- RLG [[No. 2 is on p. 131 here, but some space on this page, it seems]]

This turns out to have been a full issue, with a rather heavy emphasis on Amateur Radio topics; the last few issues rather neglected them a bit I think. Over a year we generally manage to get something for everyone, so read it all -- if you dare. From the non-response to my little joke on p. 107 it seems that few people so dared, but maybe it was the small size of print......

Tzu-jan: Last month's Editorial on Awareness brought some very penetrating comments from readers. For the most part we've got a good mob out there, small but alive. We also received letters from some people in America who described vividly just what is happening over there. In one of the letters I even got a good job offer from California. Big joke.

One chap even sent a list of books on Zen, suggesting they might broaden my outlook; I guess I'm not one of the Chosen. But I do like this neat piece [from "The Way of Zen" by A.W. Watts]: The centipede was happy, quite,/ Until a toad in fun/ Said "Pray, which leg goes after which?" / This worked his mind to such a pitch/ He lay distracted in a ditch,/ Considering how to run.

EEB circulation has just passed 700. Will you please help it along? We'll continue to have money troubles until we get enough subs to attract big advertising. Sample copies available....

AN FET GATE DIP OSCILLATOR AND CALIBRATOR

-- W. M. Holliday (VK2ZUP)

Having dug through years of back copies of "Break-in", QST, AR, etcetera, I realise that there is a plethora of articles on just such devices as this one, even to the extent of using the same FET. Although this circuit is derived from a similar one which appeared in the February 1964 RTV&H, there is a useful modification in the sensing system, and I submit some important data.

It is difficult to compare the performance of different GDOs on the basis of sensitivity, because the closest distance of appraoch to a sensed circuit depends on coil geometries. In any event, the bulk of the GDO behind the coil is the limiting factor in determining how close one can come to a coil mounted in a confined space.

I have accordingly only shown graphs of "no-load" gate current versus frequency (expressed as position of the tuning capacitor) for a few typical coils. For an LC of good Q, the gate current goes to zero, or less than 5% of FSD with the coils coaxial and ¾" and 1" apart. The graphs do also show an important feature common to such circuits: spurious dips. One has to be honest about this kind of thing. I feel that this sort of information is never published but is quite crucial in a practical design. The graphs are shown in fig. 1.

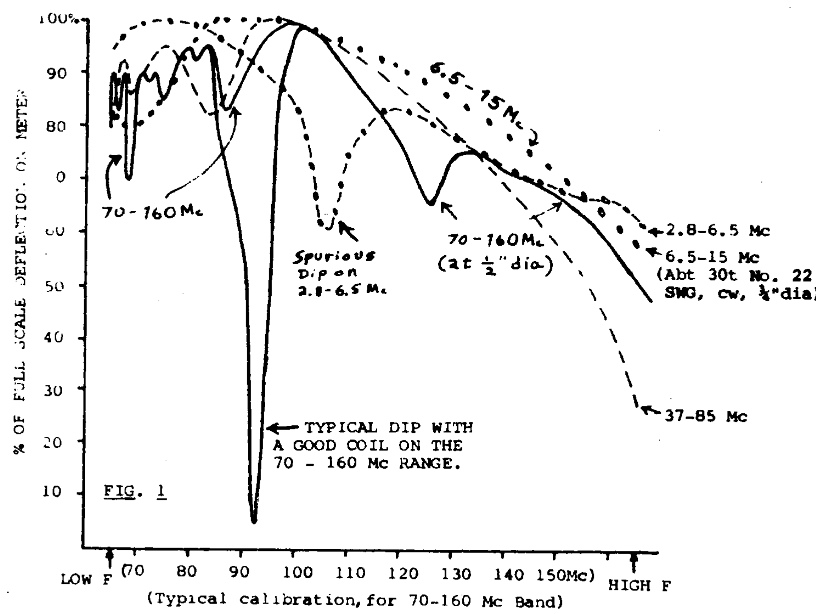
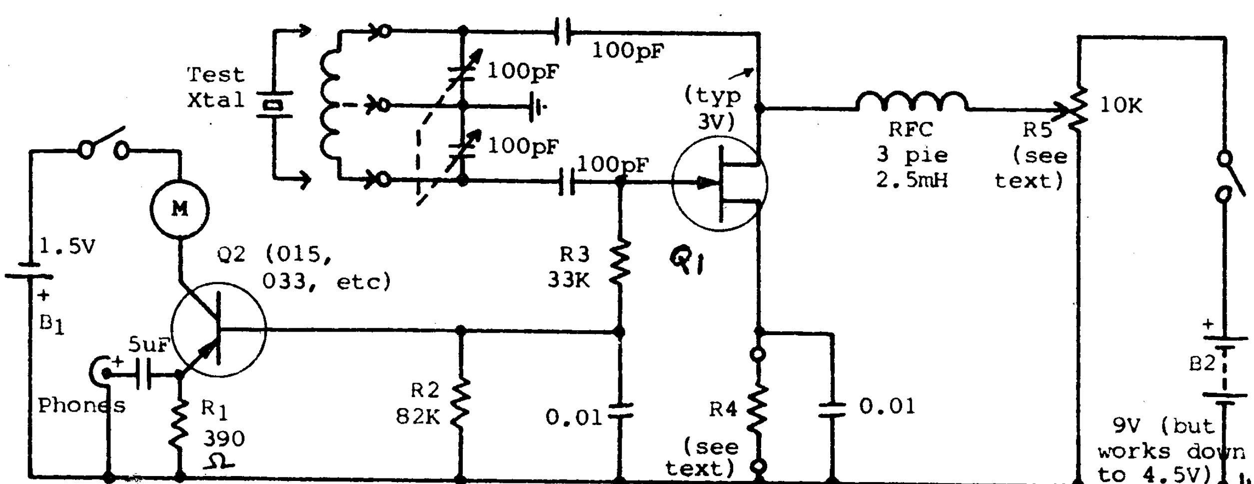


Fig. 2 shows the circuit which is seen to be an ordinary Colpitts with FET Q1, and a current amplifier, Q2 to allow the use of a relatively inexpensive meter to monitor gate current; by suitable choice of R_1 and B_1, even less sensitive meters could be used if desired. This circuit also has an advantage of minimal loading of the oscillator (compared to a rectified-output readout). The variation of reading with tuning might be improved by the use of a Vackar or similar oscillator circuit, and indeed the ease of finding a dip could doubtless be improved by the use of an incandescent lamp indicator as cleverly described by VE3ECU/WØ in the March 1970 issue of 73.

The sensitivity of this unit is about the same as that of the valved Grid Dip Oscillators I have built, but the TVI is much less. Calibration is affected, as usual, by "pulling" when the coils are too close.

Calibration is also markedly affected by B2 supply voltage, but this seems to be solved by using R5 to give FSD at the highest point in each range (see fig. 2). Reading also depends somewhat on the B1, but this will vary very little, and one could probably use a mercury battery there to even better advantage.

Since a particular supply voltage as adjusted by R5 affects gate current, the best way of achieving independence from calibration changes is to adjust R5 for FSD on the meter at maximum meter reading in each range. Calibration is done for that range at that setting, ensuring



RANGE	R4
B.C. Band	18K
2.8-6.5Mc	3.3K
6.5-15	1.8
15-37	820 ohms
37-85	270
70-165	0
90-230	0

FIG. 2: The Gate-dip Oscillator

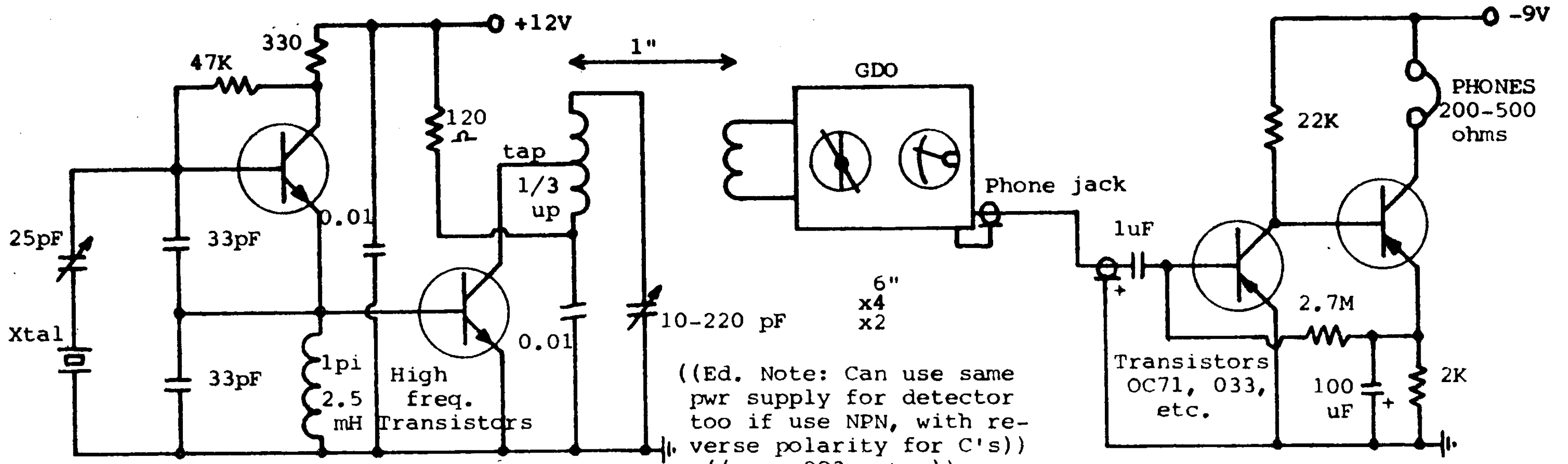


FIG. 3: CALIBRATOR DETECTOR

a reproducible reference point. This avoids putting a zener in the supply, which would draw extra current.

Low frequency coils (e.g. less than 5 Mc) are centre tapped, and single layer solenoid wound for minimum strays; ideally this ought to be a single layer with wire spaced ½ the diameter of the wire, but close-spaced will work. The main thing is not to scramble-wind; the effect of scramble winding may be seen in the figures quoted in the Feb 1964 RTV&H article in the coil data for the lowest ranges.

Q1 is uncritical. R4 is selected by experiment for best results (I_{DS} is 1-3mA). Figures shown are for my unit. Q2 is uncritical; any small signal type will do; I used computer type 015. R2 reduces leakage current through the meter. R5 is adjusted for Full Scale Deflection on the meter at the high end of each range.

The spurious dip shown in fig. 1 for the 2.8-6.5Mc band is probably due to a resonance via the drain RFC. I should have preferred to use a resistor in place of it as shown in RTV&H and ARRL valve designs, but I would need about 20 to 30V HT to use a 10K. I settled on an RFC because the largest value resistor possible was too low to permit operation above 144 Mc; I settled on this particular RFC because of physical considerations, and because it was the only one I had that would get all my disposals crystals oscillating! I have tried putting resistors across it and other RFCs in series, but found no complete solution. ((Ed. Note: Another EEB reader has told me that he is going to try to solve this problem by using a constant current stage in place of the RFC, like the one on p.104 of the July EEB. We look forward to hearing about the results. Incidentally, in W6AJZ's interesting article on GDOs in the June 1970 issue of Ham Radio, he suggests that spurious dips at VHF could be caused by excessive lead lengths or by use of nonresonant bypass capacitors; this could be something to watch.))

This GDO, like nost others, suffers from variation of reading over the range covered. As shown in fig. 1, however, a typical dip is sufficiently unambiguous to allow definite indication of resonance. Ideally a GDO ought to incorporate some Automatic Gain Control to even out the tuning variation without ironing out the dip. ((Such a system will appear in EEB, one day -- Ed.))

Fig. 3 shows the system I used to calibrate the VHF ranges. It beats the output of the GDO against the harmonics of a 5Mc crystal. The set-up shown is good to the limit of the GDO (about 230Mc) with 200mW d.c. input to the oscillator multiplier, at which frequency the beat note is about 6 to 10db above the beat note with Channel 10 (at about 5 miles from transmitter), and still perfectly useable.

In fig. 3 the crystal was ground up from 4995kc (as available); for fine adjustment the capacitor in series with the crystal is zero beated with WWV. The oscillator transistors were TO18 silicon types, uncritical but they must have good frequency response. The tap on the output tank coil is one-third up, LC to suit range. Tuning is rather sharp.

======================

Improved Fire Lighter: Commercial Fire Lighting stuff is usually soaked with some nasty-smelling substance, e.g. kerosene, and can be replaced to good advantage by the following: Mix 1 lb resin and 3 oz tallow or candle wax. Melt together in an old black iron saucepan. Stir in sawdust until very thick, and while hot spread out on a board which has been sprinkled with sawdust. Cut deep lines in the shape of squares, which break off easily when cold. Improves and facilitates lighting of fires in the fireplace or wooden stove, particularly when lit by women.

AMATEURS VS. HAMS - C.C. Drumeller (W5JJ)
((Reprinted in part from Collector & Emitter, July 1970))

Talking is the earliest form of communication we get into. You'd think we'd master it long before we'd acquire amateur radio operator licenses. Any period of listening on an active amateur radiotelephone band will raise a matter of doubt in your mind.

Oh, I'm not talking about the matter of correct English (although that ought to be automatic with anyone smart enough to get a licence), but of just saying something in a meaningful manner...

(Webster's Third New International Dictionary, Unabridged, defines "HAM": An unskilled but flamboyant performer. An exhibitionist. A strutter. An inept or ineffective actor, especially in over-theatrical style. An inexperienced or incompetent telegraph operator).

...Unfortunately the "rules of the game" have become increasingly lax, with permissiveness replacing self-policing. Why is this true? Can it be because being a radio amateur has become too easy, that it no longer offers the mystic cement of hard-won attainment that bonds a tight-knit and proud society? No longer do we have to learn how to build a transmitter and a receiver; we buy them. Nor do we have to sweat out a long and arduous stint of study for a license; question and answer manuals and taped code practice have made that an easy acquisition.

But if we do not police ourselves, others will do that policing. Then we'll live not by the "rules of the game" but wholly by the law book. It'd be much better if we upped our own standards of what we'd permit as acceptable operating practices...

The first target, of course, should be the elimination of the profanity and obscenities stemming from a small group of "air polluters". The next step should be the discouraging of gross asininities: the buffoonery, the witless mummery, the fake "country boy" mimicking. And, finally there should be a weaning away from the misuse of radiotelegraphic abbreviations. Pray tell, why does one say Q R Mary when interference is both easier said and far more definitive? Or Q R Nancy when atmospherics is not only more specific but a lot less trouble to say? Why speak in "secret codes" (like children at play) when accepted English serves so much better?

Slang, cant, argot, lingo, gabble, gibberish, rigmarole, nonsense, call it what you will -- it all adds up to the same. And what does it add up to? It adds up to "ham", "ham" in all the abusive, opprobrious, vituperative, insulting, insolent, contemptuous, ribald, derisive, contumelious connotations given to that word by 95% of the English-speaking people who hear it, read it, or speak it.

There's an oft-used expression "this is what separates the men from the boys". And the ability to talk is what separates the radio amateur from the ham!

AN AMATEUR: Julian, W9IWI
((Reprinted in part, from Auto-Call, March 1970))

...As you know, I run about 200 watts PEP* (when things are going well) into a very low 20-meter dipole, fixed north-south. Some months ago, on the low end of 20 phone I ran into the Navassa DXpedition and the pile-up on him. The operator on Navassa was doing a good, efficient job of clearing the calls, and I hung around; eventually I had the nerve to call him. I was clobbered, of course, but eventually he came back to me, with a good signal report. It was a good feeling to know that W9IWI had made it through all the 2KW racket...

Now usually my preference on the air is a rag-chew QSO in which the other operator and I get to know something about each other. But for an occasional fling, a test, perhaps of operating ability, the kind of competition that the QSO-contest involves is welcome to me. I appreciate a (contact) in which we both have "land-line copy" and can sit back and talk without interference. However, I can remember the one time in the Army for four years, when radio was a business of getting messages through, and one could not say, "Sorry, OM the frequency is occupied". It doesn't hurt us on occasion to struggle to exchange information, even if this is only a signal report, location and serial number.

I agree, of course, that the heat of competition tempts some amateurs to reach beyond legal and ethical limits. This is bad for amateur radio as a whole. From a purely selfish point of view, however, I enjoy beating these guys with my 200 watts, depending on patience and a modicum of operating skill to make my contacts while they fight it out with brute strength.

Amateur radio is in a sense like fishing. Anyone with a triple set of hooks

Australasia: Divide by ten to let the matter apply to us. -- RLG a 12-pound-test line and a rod the weight of a telephone pole can eventually land his fish. The fellow with the light tackle is up against it, but he gets more out of the game when he does catch one.

A station running comparatively low power will never make the lists of high scoring contestants in one of these rat-races, of course. And it is not likely that some amateurs, now that we have the gear available to run legal limits and above, will ever again go back to luck and skill as alternates to brute power -- even if the multipliers or other conditions favor turning the gain down. But I think that those of us with moderate output should make our weight felt just by getting in on whatever action is taking place, accepting the fact that we won't win any prizes, but letting people know that with our handful of watts we are in there pitching -- not for a silver-plated plastic medal but for the perverse fun of making contacts...

Incidentally, with all of the griping that I hear and read, no one seems to acknowledge some of the real courtesy and operating I've run across in these six months or working 20 SSB. Fellows who ask first if a frequency is being used before calling CQ, who tell you before they sign that they are going to QSY so that you can have the frequency, who strain to make a contact complete so that they can QSL toward your WAS, even though they can hardly read you. ARRL ought to set up an honour roll for these guys.

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REVIEW: The Semiconductor Data Book, Fourth Edition. Published by Motorola, U.S.A. ((Reviewed by L.L. Sharp, VK4NS, and RLG))

This book is, in our opinion, the best semiconductor data book seen anywhere -- at least for a reasonable price. It lists in short form, virtually every semiconductor made up to 1969 (to 1N5425, 2N5560, and 3N161), from all manufacturers not merely Motorola. It includes all the main types of transistors, diodes, SCRs, FETs, Varicaps, photodiodes, current regulators, surge suppressors, and a most impressive set of Technical Application Notes. In addition the bulk of the book is taken up with detailed specs sheets for all Motorola semiconductors. Motorola can well be proud of this effort. And in the front there is a form which you can theoretically fill out for supplements which keep the book up to date until the next edition. More about that, below.

*Not so many years ago, amateurs did very well for DX with very modest power -- on AM yet -- thereby proving that most of the difficulty is caused by interference, not by propagation or atmospherics. I can attest to this; I was there! -- RLG

The sections are:
1) Introduction: Updating Service, Table of Contents, How to use the Book.
2) 1N... Index: Complete numerical index of all EIA types with major specs.
3) 2N... & 3N... Index: Complete numerical index, ditto.
4) Non-Registered Device Index.
5) Selector Guides (Also Glossary of Symbols & Terms): A marvelous cross-reference index, listing semicons by power, voltage, current, etc., depending.
6) Complete Data Sheets: Motorola 1N... items.
7) Complete Data Sheets: Motorola 2N... & 3N... items.
8) Complete Data Sheets in House-Numbers.
9) Hardware & Heat Sinks.
10) Digital & Linear ICs. (Motorola)
11) Outlines.
12) Application Notes: A number of very interesting pieces on transistor, FET, Varactor, Epicap, SCR, UJT, and phototransistor characteristics & applications.

In all: well recommended for all experimenters. Allows you to choose a suitable locally-available equivalent for an item which appears in the international literature, or to obtain it from local Motorola representatives. In terms of service for the latter you would probably be best advised to order through Radio Parts P/L (see EEB p. 56). If you can extract the Data Book from Motorola in Melbourne it will likely cost about $6 plus post. Likely quicker and more reliable will be to order the Data Book from Technical Book & Magazine Co., 289 Swanston St., Melbourne 3000 for $8.45 plus 60¢ post. Similarly, Australians may find some difficulty with the Updating Service. We have been at Motorola for about a year about this, with no satisfactory reply. The Americans won't supply it to you, and Melbourne will theoretically, but we have no evidence of this. Probably most reliable is to ask Technical Book & Magazine Co; they have been able to supply supplements to previous editions. Ask for Mr. P. Radford. They have a lot of other stuff too; RLG was over there several months ago, drooling over the multitude of their beautiful publications. They have a nice selection of good beginners books in electronics too, and we hope to review several of them in these pages, as possible.

LETTER: CD Ignition hints

I just subscribed to EEB and received back issues etc. I nearly fell over backwards when my eyes fell on primitive Transistor Ignition Systems. Shades of the Ark! Herewith some notes on CD Ignitions, based on the "Reader Built It" design in Electronics Australia for Sept 1969 and January 1970. I didn't copy out the circuits as I expect you have the same available.

I have built and used both of the above-mentioned CD systems in my vehicles, with slight changes. Both units use earthed collectors on the power transistors, and I use no other heat sink than the aluminium mini-box in which the "works" are housed; I hate mica washers too. Some comments:

Neg. Earth
As per the January article. I am scared of what will happen under the bonnet on the first really hot day of summer to those ASZ17/OC35s. Custom Electronics in Adelaide advise that some cheap power PNP silicon types will be available soon. I won't rest till then...

Pos. Earth
Use the converter circuit as for the negative earth version, but substitute ASZ17/OC35 with NPN type 2N3055. Use triggering circuit as for the September 1969 article.

Coil
Don't get frustrated by torroids. Use the core from a discarded TV EHT tranny. This is in two halves, ready to bolt together. Make bobbins from cardboard and PVA glue. Caution: The original tranny had paper between poles to adjust inductance, and for our application must be removed. Lay fine emery paper on glass and carefully rub pole ends until clean. All scrounged cores I have used go well with this data:

PRIMARY: 2 coils, bifilar wound, each 15 turns, No.22 B&S o.n.o.
FEEDBACK: 2 coils, bifilar wound, each 15 turns, No.22 or 30 B&S.
SECONDARY: 350 turns of No.22 or 30 B&S, whatever size you have at hand.

Put plenty of varnish on every layer, with paper between layers. This is important so that the 8kc vibration within the coils does not cause shorted turns.

Etc.
1) Don't omit the 100uF across the battery supply. In one of my units it was needed to stop false triggering of the SCR. The textbook also says it helps prevent a voltage spike occuring on the leading edge of the output waveform which can, under certain circumstances, lead to transistor destruction. Dollar-saving hint: NEVER run transistorised power supplies with unloaded secondary winding!

2) In both my units I have been able to reduce the 100 ohm resistor at the SCR gate to 50 ohms. (Improves switching reliability).

3) Watch out for dud diodes. Of eight BY100, new, fully marked from a well-known parts supplier, one broke down at 150V, another had a forward resistance of 40 ohms, reverse resistance of 200 ohms. Very useful...

4) If you want to do a proper job of designing your converter transformer, Mullard has a reprint of a pamphlet dealing with the matter.

print of a pamphlet dealing with the matter.

5) Don't forget to bypass ballast resistor or resistor lead when connecting the unit.

6) Problem: On the negative earth version installed on my Holden H.D., sparks were spraying at random inside the distributor cap. These destructive beasties were only stopped by closing the points to 7 thousandths; don't ask me why it worked, it just did!

7) Results: The positive earth unit installed in my Landrover made an amazing difference in starting, idling, and top-gear flexibility. The other unit, in the Holden, makes little noticeable difference, except for a smoother idle.

-- P. Ward, Sandford, Victoria

((Concerning the OC35: Maybe it is cooler down here, but I have been using OC35s in a car over one summer period with no sign of failure. Regarding Point No.6, I feel that the synchronisation between the breaker points and the rotor may not have been optimum. It is possible to keep the distance between rotor blade and plug contact small, by reducing contact breaker points gap. If, thus, reducing the gap reduced stray sparks, the rotor synchronisation must have been poor in the first instance. On the other hand, it is quite reasonable to reduce the gap in this manner with a CD Ignition (as long as correct timing is maintained) because of the lower currents involved at the points. In reference to Point 7: Although I don't want to cast doubts on the condition of any particular sparking system, it is usual to find that a CD system improves greatly the performance principally where the old system was in poor condition, whilst making little noticeable difference where the original was good. -- RAJR))

((In addition to the Mullard reference mentioned by Mr. Ward, you might add to the Reference List on p. 117, the following:

"Low-cost Solid State Power Supply for Carphones and Pye Reporters" by C. K. Maude, VK3-ZCK, Amateur Radio, Aug. 1970, p. 25. It contains full constructional details for a transformer using Ferrite U cores from a TV EHT unit.

Also useful is: "Silicon Controlled Rectifiers for Inverter Applications" by International Rectifier Corp, available from Warburton Franki, Melbourne with company letterhead. Various design parameters are examined.

An old, but still very good reference on the whole subject of transistorised converters and inverters is found in the relevant chapter of the Transistor Radio Handbook, by Stoner and Earnshaw (Editors & Engineers, now Sams, U.S.A.) .. And designs appear frequently in the periodical literature. We have a series of articles in our Files on this subject, if ever we can find room to publish them. -- RLG))

==========================

Simple Patch: Have you used those dreadful modern 'iron-on' patches? Then try this improvement: Turn the garment on the wrong side and smear the tear several times with the white of an egg. Lay a piece of strong material of the same colour over the place, and press until it sticks. Then press with a hot iron. The patch will withstand washing, and is durable. And it allows you to use any suitable material.

LETTER: Thankful tasks with IC's

Regarding your comments on integrated circuits, I would say that they are here to stay. I note in the electronics press that the Russians have finally stopped using vacuum tubes in computers and are producing RTL and DTL IC's as well as a very few linear types. You might as well get on the bandwagon too. With IC's the experimenter is able to concentrate on system design rather than spending all his time perfecting individual circuits. Hopefully this will result in equipment that is out of reach with conventional discrete components (practically speaking). For example, some of the more thankless tasks when putting together a homebrew receiver are the audio and power supply systems; i.f. strips might fall into this category too. With IC's we solve these problems straight away (with better results) and are able to concentrate on better front ends, better mixers, etc.

Another benefit of IC's is performance. If we use an IC voltage regulator for example, it will perform far better than anything the average ham is apt to dream up. This can result in superior performance in the end product because the experimenter will be troubled less with drifting voltages than can cause other circuit ailments.

By the way, if you are doing any more work with FETs, try to get a copy of Motorola's "Field Effect Transistor Selectro Guide and Cross Reference Chart", Publication SG15, dated Nov. 1968. Very helpful, lists all their current devices with equivalents to other manufacturers' FETs plus a list of their FET-oriented application notes.

As a matter of interest, while working on an article on the subject of frequency modulation, I discovered an interesting fact: textbook discussions of frequency and phase modulation are 180° out of phase from one book to another. In FM of course, the deviation is dependent only on the amplitude of the modulating signal. In PM, the deviation is dependent upon the amplitude and frequency of the modulating signal. About half the textbooks in my library had it backwards! I think the problem comes in the definition of the FM "Modulation Index": The ratio of modulating frequency to carrier frequency. Yet in actuality, modulating frequency has nothing to do with pure FM deviation. See the piece by W6TEE in the June 1970 HR for more about this.

-- J. Fisk, W1DTY, Greenville, New Hampshire.

((What do you do when the ICs produce better front ends, mixers, i.f.s, etc.? When you can buy a single blob that performs all receiver functions well if you merely hook coils to it, will you concentrate on making better coils, etc.?? -- RLG))

((No, concentrate on more complex SYSTEMS: Multi-channel receivers, dual VFOs (Signal One), complex signal processing, phase-locked loops, etc. -- JRF))

((Mebbe so. I wonder when it will happen. All I've seen so far are a few modest digital circuits and a vast drone of uninspired linear ones. The tendency seems to be to produce a flood of prosaic IC circuits which merely duplicate existing ones in (oh glory) a miniature package which hides all circuit functions in an expressively inscrutable case. --RLG))

LETTER: Messy Units

I should like to comment on your preference for cps over Hertz.

As a practising Chemical Engineer I am continually faced with the problem of converting units in the field where chemistry and engineering overlap. Some idea of the magnitude of this problem can be seen by the lists given in the "Chemical Engineers Handbook" by Perry. Both the 3rd and 4th editions devote 9 pages to unit conversions totally 1243 conversions of common units. 288 of these are common units peculiar to individual countries of which most are UK, USA, and European. This does not include tables of temperature, density, circular measurement, decimal equivalents, and similar conversions.

Additional listings also include 19 values for the Gas Law Constant, R, and seven columns of wire and sheet metal gauges. The mind boggles and the computer ICs generate enough steam to stop the hydro scheme dead in its tracks.

Personal convenience and tradition play a large part in this mess of units. Look at density; we have S.G., degrees Baume, degrees API, and degrees Twaddell. Now the latter unit is one which sums up the whole plethora of time-wasting, economically devastating systems of units now in common use. Inches of rain, defined as than volume of water covering one acre to a depth of one inch, fair enough. But what of bushels? This depends on where you are and what you are measuring. Every primary product has a unit all its own. Beauty!

Is convenience reason enough? If so, a traditionally minded oceanographer could justifiably measure volume in cubic fathoms or in square nautical miles by one fathom deep. Convenient but meaningless both.

Viewed against the relatively simple and consistent unitary system of electrical units the cps/Hertz argument is trivial. Viewed against the whole problem of unitary systems in general it is extremely important. Several high powered international committees are slaving their hearts out trying to bring order into this chaos. Personal preference and convenience have no part in this work. Where these bodies decide on a common unit we should support it as a step in reducing the complications of diversity -- not add to the problem by insisting on the old unit.

For myself, cps is a more satisfying and descriptive unit for frequency, but if the interests of commonality these gentlemen decree Hertz then Hertz it is and no argument. I am heartily tired of wasting up to half my design time juggling the 1000-odd conversions between chemistry and engineering alone. I look forward with delight to the time when the 19 pages I am continually using reduce to the 3-4 column inches of the metric system. Let's be rational about this. Why not be as progressive in this matter as the rest of your publication appears to be in others?

-- J.E. Anderson, VK7ZFO, Georgetown, Tas.

((Bah!!! All right. Snarf. -- RLG))

AROUND THE AIRWAVES: 10 Aug. 1970 -- by J. Coote (G3UGD)

LOCATION	ACTIVE STATIONS	FREQUENCY	SCHEDULE	QSL VIA:	ETC.
Swan Island	W4VPD/KS4, K5QHS/KS4			Home QTH	
Yemen	HB9YC/4WI	28005kHz 14001	1500Z 2100	P.O. Box 126, Lugano, Switzerland.	
Uganda	5X5MP	21070	CW 1400	LA8ML	
Indonesia	YBØAB	21350	Daily 1600		Speaks Dutch too.
Qatar	MP4QBK	14205	1300		New rig.
East Pakistan	AP5CP	14020	CW 1500 plus		
Easter Island	CEØAL Joins YL SSB Net	14332	Most Evenings		U.S. Air Force.
Falkland Islands	VP8LR	21266	1500 plus	Tony Arden, (New) Port Stanley, Falkland Is.	
Togo Rep.	5VZDB 5VZWT	 21350	Now QRT 1600-2130		
Gough Island	ZD9BO ZD9BQ	21289 14200	1430 1600 Still Active.		
Ascension Is.	ZD8JA	21290	SSB 0700		
Gabon	TR8MC	14210	2000	W2YY	
Afghanistan	YA1NL	14283	2000		
China	BY1PK	14047	0000 Plus	Only station allowed contact outside of UA area.	

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LETTER: Electronic Adapters

With reference to the problem presented by Mr. I. A. Bird in Letters, p. 111 of the July EEB, concerning the availability of a design for a musical electronic adapter, the circuit he requires is featured in the Feb 1969 edition of Practical Electronics, and consists of a pre-amplifier connected to a Schmitt Trigger which converts sine to square waves, and is fed into two bistable frequency dividers in series. Tone shaping networks are included in the output, and combined with the original signal to feed into a power amplifier.

-- S. Goldthorp, Manilla, N.S.W.

XXXXXXXXXXXXXXXX

EDITOR'S EDITORIAL -- RLG

Small Print

Yes yes, I hear you all talking, I agree the print was too small last month. It didn't look that way on the photograph, so there is no good way to know until it appears in print. That is why print size has been oscillating back and forth these several months. It is complicated by our relatively inexpensive printing process which looks to require a rather larger size for the same edge clarity, further confused by a changeover in typewriters a few months ago. Now I hope we can settle on a 15/inch compromise for main text, 17.1/inch for tables & Letters; it is still small, but I think that the double columns will make all the difference; after all the main text letters are no smaller now than ordinary print, and the letters you are reading now are larger than the type used for Letters in some magazines... Double columns are a headache to type, but Dick Ross of CQ has been at me for many years to try them for legibility, so now we can give it a go for a few issues.... I realise that the type for Letters etc is small, but that is traditionally justified in practice. Let me know whether the other is now acceptable, will u?

EDITORIAL (continued):

Postage, etc:

In October 1968 our postage for bulk went up by 500% (5 times). Now the PMG says it is going up another 400% (4 times). Thats twenty-fold in two years. In October 1968 the special rate for books in Australia was abolished, and all printed matter was lumped together in the Merchandise rate. In the same period of time postage for ordinary letters has gone up about 1.5-fold. The implication is obvious: The Government regards the distribution of information as of no special importance, and indeed has penalised it preferentially for small magazines. Isn't that sweet? A Government with such a contempt for the printed word is a dangerous Government, and I fear the future.

The immediate future of EEB holds its own fears too. This year paper has gone up 33%, and our general costs have risen about 25%; with the cooperation of Government and People our galloping Inflation gathers momentum. And now as though that execrable Budget were not enough we shall now suffer an additional 12½% increase of boat freight charges to this Island State. That means a net increase of about 20% in the price of nearly everything after the local merchants have had a go at it. And all this is merely this year. What will the next be like?

What can we do? Should we reduce size frm 5 sheets (20 pages) to 4 sheets (16 pages; 11 pages of text)? The alternative is to raise the price, thereby adding to the detestable inflation.... What do you think? Please let me know: smaller size (easier to read in limited time) or higher price (more variety)? In either case I'll try to keep the print size reasonable.

By the way has anyone any idea exactly WHAT happens to missing EEBs, missing letters, missing Bound Volumes (if not Certified or Reg)? Do they fall out of mail bags en route, drop off the truck into the gutter? Do they fall into the sea on the way to N.Z.? What?? In any event, please don't blame us for it. We try.

ea.: **$0.25**

yr.: **$1.00**

(foreign: $2)

THE AUSTRALIAN EEB

→ **COMMONSENSE ELECTRONICS**

October 1970 Vol. 6, No. 7 p. 133

CONTENT:

NEXT MONTH: DECEMBER

That item on p. 148 forced out Rod's interesting CD-Tachometer, but will be in December for certain. Also articles on Transmission Lines, Pwr Supplies, Converting the BC221 to FETs, Several Transmitters, and another CD Ignition. Well-- maybe not all in Dec, maybe some in February.

A GOOD SCR CAPACITOR-DISCHARGE IGNITION SYSTEM -- G. Cohen (VK1ZVG)

The SCR Ignition system shown in the diagram has been operating reliably on my Honda 5800 for two years, it has been tested with some very good equipment as well, so it appears to be a good unit.

The Inverter Circuit

This inverter is very simple and has several advantages over other transformers used in SCR ignition systems (such as in a well-known Magazine). The transformer is easily obtained, and modified in less than an hour. The common collector, PNP transistors and negative earth enable the transistors to be bolted directly to the car chassis. In my case I used a large Eddystone Box, which was an excellent heatsink. The transistors never became hot enough to warrant any further heatsink (about 120^{o}F maximum in hot weather).

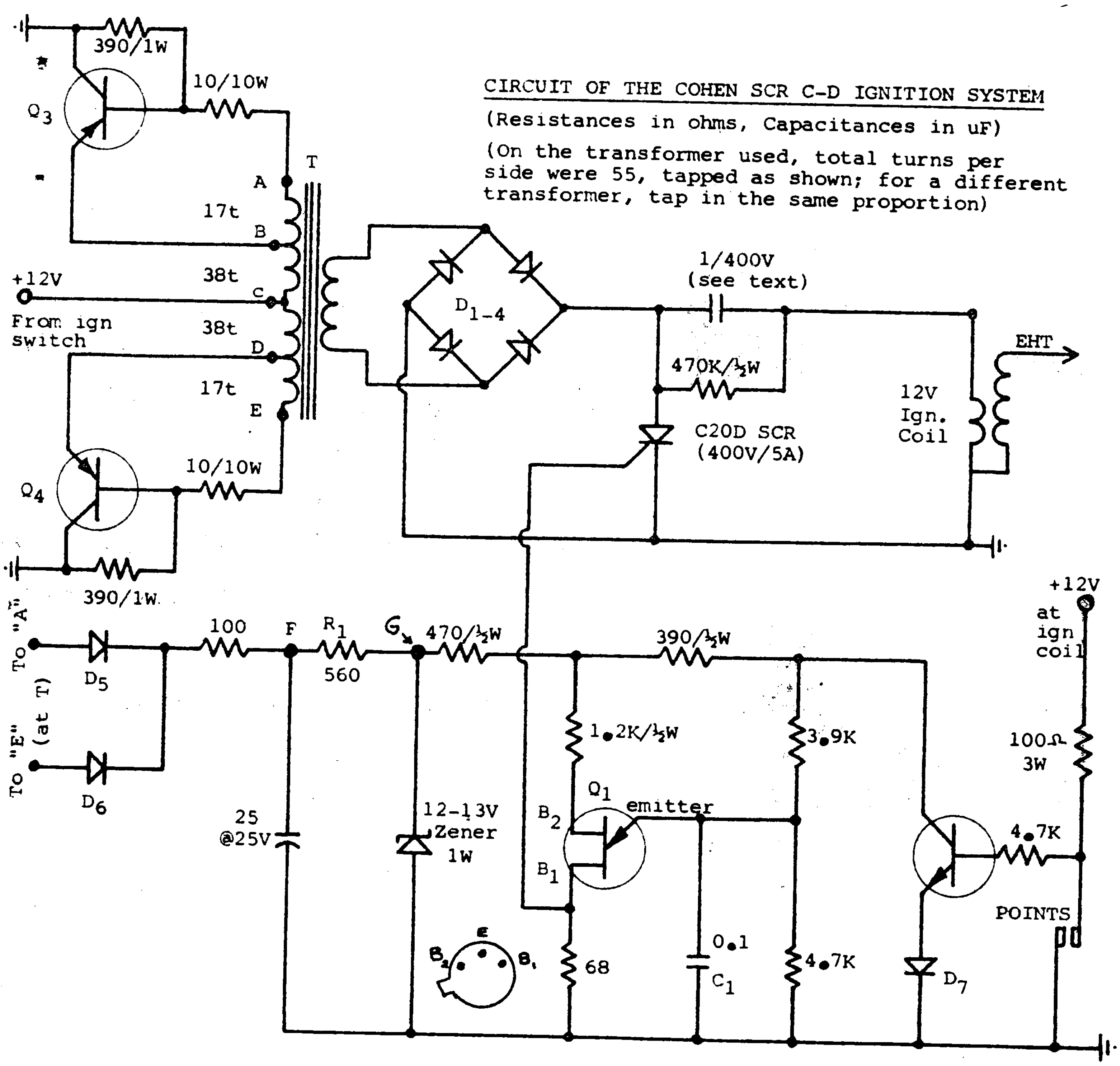
Furthermore the unit uses only four resistors and two transistors; presumably a simpler unit is more reliable.

When the SCR fires, the inverter stops, thus turning the SCR off reliably. The base bias resistors have been chosen to give reliable oscillation.

The SCR Discharge System

This is a standard SCR circuit, where the luF capacitor charges up to 350V, and is discharged through the ignition coil. The rise time of this circuit is very fast (less than 20 usec), enabling fouled plugs to be fired.

The normal ignition coil may be used, to give an output of 31kv with a standard 90:1 coil. The470K resistor across the capacitor is a simple bleeder to discharge the capacitor after switching off. This circuit gives an energy output of 80 mW-seconds, while the normal requirement is 30. The SCR ignition also gives this power at high revs, which is where the conventional inductive discharge fails.



CIRCUIT OF THE COHEN SCR C-D IGNITION SYSTEM

(Resistances in ohms, Capacitances in uF)

(On the transformer used, total turns per side were 55, tapped as shown; for a different transformer, tap in the same proportion)

Q_1 = 2N2160 (or any other small UJT).

Q_2 = 2N3692 (or other small signal NPN, for 100mA, BV_{ceo} 12V).

Q3 = Q4 = ASZ18, 2N174, 2N301, etc.

D_{1-4} = 400PIV/750mA or diode bridge.

D_{5-6} = 100PIV/500mA.

D_7 = Any 100mA silicon (BY127/400 used here).

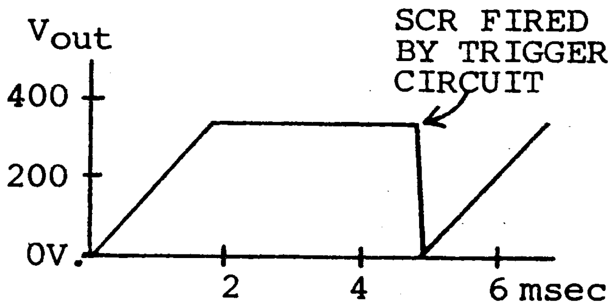
T = A&R PT5509, an ordinary 240V to 12.6/12.6 V transformer modified by tapping each secondary winding (AC & CE in diag) at 1/3 of total winding. Just remove original wire of 12V side to required number of turns and put on taps. Do NOT remove wire on the HT side of the transformer!

The abovementioned Xfr is one using one of the new nylon bobbins, with the primary and the secondary side by side; be sure you note which is which. If a transformer is used with conventional construction, the LT winding will doubtless be on top. Unwind, counting turns, rewind with taps at equivalent proportion of the total winding, as in the diagram. ADDED BY RLG

Total modification time on my own Xfr was only ¾ hr.

In reference to comment made by VK7ZAR in the August EEB, I agree about the difficulties of obtaining a reliable 1µF main discharge capacitor. I was using a 400V Philips Polycarbonate type on my Honda, but now I have built a unit for a Mercedes Benz using two large 0.47µF/400V styroseals -- and (hold your breath) a µA742 Integrated Circuit as the trigger. Works fine.

I also note that VK7ZAR has mentioned that some ignition systems can misfire due to dv/dt firing of the SCR. My own circuit has been tested to about 15,000 RPM on the bench (viz, 2.0msec), and up to 10,000 RPM on my Honda. With the output of the inverter charging, it runs about 2khz, which gives about a 2msec charging time for the dump capacitor, giving a CRO trace as shown: The vertical axis is inverter output voltage.



The Trigger Circuit

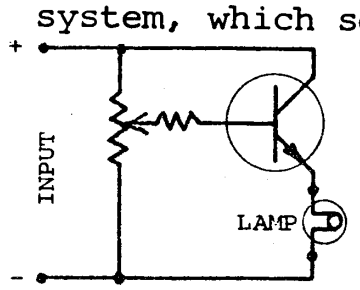
This trigger circuit is superior to many others because it uses a regulated supply, coupled with a UJT trigger circuit. This gives immunity to voltage (-50% to +30%) and temperature (-30°F to +160°F) variations, which could adversely affect the simple diode-capacitor-resistor SCR trigger circuits, such as those which have been published in Electronics Australia during the past year (see EEB p. 117).

The regulating voltage is obtained from the transformer primary, and rectified to give about 25V at point "F". This is then regulated to 12V by the zener diode. This is arranged to regulate at 12V even when battery voltage varies from 6 to 15V.

With the points closed, transistor Q_1 is cut off, and capacitor C_1 charges to approximately 5V. When the points open, Q_1 saturates so that the UJT fires. As long as the points are open, Q_1 remains saturated and prevents C_1 from recharging. When the points close again, C_1 recharges after a delay of 1 msec, to prevent contact bounce affecting the triggering circuit. The 100 ohm resistor from battery positive to the points ensures sufficient current to provide reliable switching by the points. ((Ed Note: If the points become dirty owing to insufficient current, this resistor might be reduced somewhat. RAJR says that 300-500mA of "wiping" current is about right, giving a resistance in this instance of some 25-35 ohms (not at all critical) @ 10W rating.))

Photodiode Triggering

As mentioned at the bottom of p. 50 of the April EEB, the only problem I encountered was changing of timing by the points because of the very high engine speed of my car. Consequently I replaced the points by a photodiode/lamp-system, which seems to work OK. If it works reliably I will probably send the circuit to you in a few months ((Ed Note: This was received before the very interesting photodiode-trigger system appeared in the September 1970 issue of Electronics Australia. If Mr. C's system is usefully different, simpler, etc, we'd be delighted to see it. On the other hand, RAJR comments that the trouble with a photodiode trigger is that you have to modify the distributor, and that ties you to the CD ignition; if something goes wrong in an unlikely place, you're in trouble. With the ordinary points used as trigger, you need only install a simple 3PDT relay to allow immediate switchover to the conventional system, controlled from a switch on the dash.))



One problem I found with the photodiode system was with the lamp. At first I used a 12V one, but with the battery voltage drop on starting there was insufficient light to trigger the system. I am now using a 6V globe with a 6V transistor regulating circuit, as shown above. This circuit works very well; voltage characteristic is still good even with the pot as shown, though somewhat better regulation is obtained with a zener inserted into the lower leg. The base goes directly to the junction of zener and resistor.

Incidentally, the SCR C-D Ignition shown in the main diagram is available already built-up. Enquiries can be directed to me at 39 Quandong St., O'Connor, A.C.T. 2601.

FEEDBACK IN COMPLEMENTARY SYMMETRY AUDIO AMPLIFIERS (and the Rest) -- R. H. Ferris (VK7ZDF)

The situation

On the cover of the August issue was presented an ordinary output-transfomer-less audio amplifier of the type discussed at length by Kallam & others in the May & July issues of EEB. If you read that interesting article you will recognise that the diode, D (fig. 1 here) has been inserted to provide some forward bias for the output transistors, though not as much as needed to drive them into a good Class AB. As the articles described, this lack must surely introduce some distortion, but does it matter?*

This amplifier (diag. reproduced in fig. 1) incorporates heavy negative signal feedback which may reduce this distortion -- or it may not! Whether or not it does will depend on several factors (not directly concerned with Angels) which we shall now examine (the factors).

Consider the query posed on the August cover: Given an amplifier with all components labelled, and with transistor current gains clearly shown, what is the voltage gain from output to input? The answer turns out to be ridiculously simple, but its consequences are profound.

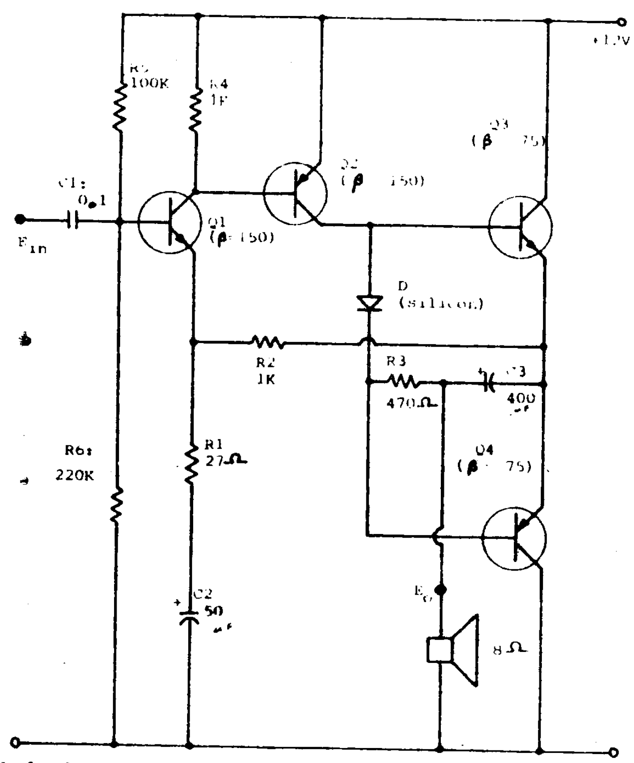


FIG. 1: The Complementary Symmetry Amplifier with Negative Feedback.

The Calculations

Consider the general situation of negative feedback as in fig. 2. The output voltage is 180° out of phase with the input. We take a fraction of the output voltage (E_o), and feed it back to the input through a voltage divider (R_2/R_1), so that the small amount remaining (E_{fb}) is added to the input (E_{in}) to result in $E_{in'}$. Since E_{fb} is out of phase with E_{in}, the input to the amplifier is reduced. If the fraction of output voltage fed back is H,**

(1) $H = -R_1/(R_1+R_2)$, where the negative sign merely signfies that the voltage is fed back out of phase. Then,

$E_{in'} = E_{in} - E_{fb}$, and since

$E_{fb} = E_o \times H$, then,

(2) $E_{in'} = E_{in} - E_o \times H$. Now we know that voltage gain, A, is

(3) $A = \dfrac{E_o}{E_{in}}$, but this is the gain before feedback. After feedback it is A',

(4) $A' = E_o/(E_{in} - E_oH)$, and using Eqn (3),

(5) $$A' = \frac{A}{1 - AH}$$

Formally, H is called the "Feedback Gain" or "Feedback Ratio" (also designated by beta in some references). The product, AH, is called the "Feedback Factor" or "Loop Gain." It is the amount of gain which is fed back. Ordinarily it is expressed in decibels, where db = 20 log $|AH|$, and takes a negative sign when H does. Now if $|AH| \gg 1$, equation (5) becomes simply

(6) $A' = -\dfrac{1}{H}$ (remember H is negative), and

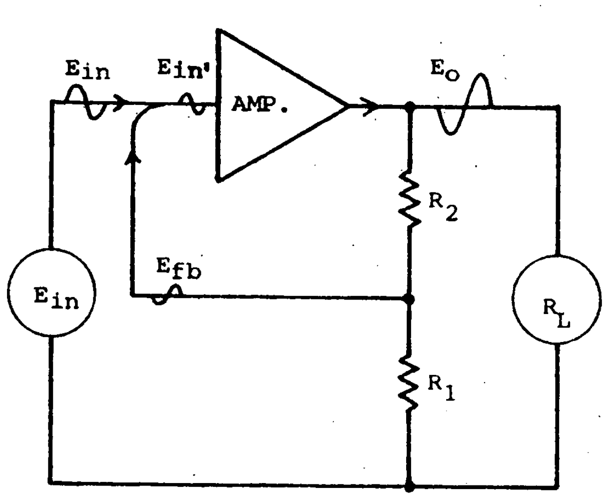


FIG. 2: The Feedback System

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*Whether it matters depends on who is listening. Only Angels could be uncritical, but their birthrate has fallen sharply in civilised times. --RLG

** This assumes input impedance of the amplifier is high compared to R_1, and output impedance low compared to $R_1 + R_2$. This is justified in the example given, but strictly the Feedback Ratio should be calculated in assuming the actual impedances resulting from shunting of the feedback network by the active circuit. -- RAJR.

$A' = (R_2 + R_1)/R_1$, i.e.,

$$\text{Voltage Gain} = \frac{1}{\text{Feedback Ratio}} .$$

We may also note that if $R_2 \gg R_1$, (6) simplifies further to

$$(7) \quad A' \doteq \frac{R_2}{R_1} , \text{ since } H \doteq -\frac{R_1}{R_2} . \quad \text{Nice?}$$

The Example

Go back now to fig. 1. The collector load of Q1 is the base-emitter of Q2 (R4 merely drains excess I_{C1}). The collector load of Q2 is the base-emitter of Q3 or Q4 depending whether the positive or negative half of the cycle is considered. On positive half cycles Q3 conducts and Q4 doesnT and conversely. This feeds push-pull output to the load even though no transformer or phase inverter is used. For further details see the Maddever article in this issue.

Thus, two cascaded common-emitter stages feed a common collector one, and the total amplifier gain before feedback is

$$(8) \quad A \doteq (\beta_1)(\beta_2)(\beta_3) \frac{R_L}{R_{in}} .$$

With the gain figures given for this circuit (used in the PYT T25 series TV receiver, and assuming a reasonable Q_1 input resistance of the order of 1000 ohms,

$$(9) \quad A \doteq (150)(150)(75) \times \frac{8\Omega}{1000} = 13,500 .$$

We see that $R_1 = 27\Omega$, $R_2 = 1000\Omega$, so according to eqn (1),

$$H = -27/(1000 + 27) = -0.026$$

having a negative sign, because E_{fb} is fed back to the emitter of Q_1 is obviously in opposition to E_{in}. Whence (5) gives

$$A' = 13,500/(1 + 355) = 37.9$$

It is, however, much easier to notice that since $|AH| = 350$ is $\gg 1$, and $R2 = 30\ R_1$, the simplification described in (7) gives adequate precision, i.e.

$$A' \doteq R2/R_1 = 37 .$$

The Consequences

This means that the overall gain of the amplifier will now be only 38, and it would not matter whether the inherent amplifier gain were 5000 or 50,000; the net gain would still be 38.

Thus, equations (6) and (7) tell us a very valuable characteristic of negative feedback: An amplifier can easily be designed to give some definite value of voltage gain. Merely keep throwing in amplifier stages until the gain is loads too much. Then connect the feedback resistors in the desired ratio, and presto: the desired precision gain.

Not only does this lighten design, but it keeps net gain independent of transistor characteristics; E_o varies linearly with E_{in}, and lo, no distortion. Well-- hardly any.

For instance, suppose that in fig. 1 Q3 and Q4 are just biased on (which is approximately true with D providing the bias), collector current is minute, so output amplifier current gain is only, say 25. This gives an overall amplifier no-signal gain (eqn 8) of A = 4500. On small signal peaks this will rise to A = 13,500 (eqn 9), a 200% increase in gain. The resulting distortion can easily be imagined.

Note that this distortion arises when the transistors are not sufficiently biased on. Un biased transistors run Class C, and the crossover distortion will be even worse.

In contrast, with feedback applied as in fig. 1, A' only rises from 37.7 to 37.9 when signal is applied, an increase of only 0.53%. Distortion is thus reduced by 200%/0.53%, namely by the amount of the Feedback Factor, $|AH|$.

Negative feedback also improves input impedance and bandwidth, as well as tolerance for wide load changes (e.g. loudspeaker) -- but only at the expense of signal gain, which must be found somewhere else. And Somewhere Else can also contribute distortion. As usual you can't get something for nothing.

The Fictions

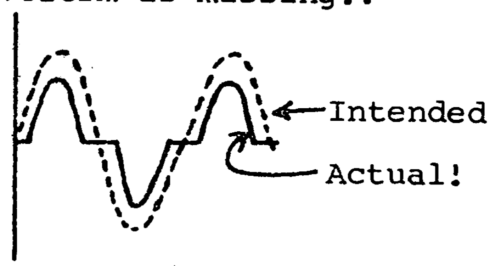
"Negative feedback is the Be-all, the End-all, the Cure-all; in sufficient quantity it can give any bandwidth, any reduction of distortion. In fact it turns any convenient circuit into the 'ultimate amplifier'". Such illusions are more suited to Angels (loc cit) than to hardheaded electronics people.

In the above example we showed how marginally biased output stages could end up with reasonable overall distortion figures when suffused with negative feedback. But there are some Fictions which prevent this happy state from applying to some other conditions:

1) Crossover Distortion vs Bias

Consider the Fairchild amplifier discussed in the May EEB, which ran the output stages with zero bias (save for R6 p. 67, which didn't help much), which is not the same thing as adequately reduced bias. Claims of "eliminating" crossover distortion in such an amplifier using large negative feedback are hardly in accord with reality.

In such an amplifier, both transistors are cut off until the signal voltage at the bases of the output stages exceeds the base-emitter threshold potential. Then A, hence AH and A' are all zero, ie it doesn't matter how big H is, part of the waveform is missing!:



The dashed line shows the intended output, the solid one the actual output. When the output transistors are only slightly turned on, such as when producing low level outputs, their current gain is still only a small fraction of the normal value, and the product |AH| remains small (eqn 8), so that the negative feedback still does not have adequate control of the circuit.

The lesson to be learned is simple: the output stages (and of course all other) must have sufficient forward bias to make A sufficiently large to give $|AH| \gg 1$ (say $|AH|$ = at least 20) under <u>any</u> condition. Then eqn (6) is satisfied, and negative feedback takes control with all attendant benefits described in "Consequences".

2) <u>Instabilities</u>

When the feedback factor (H) is made too high in an effort to make up for stingy bias, etc, instability can result at high (and sometimes low) frequencies. Best stability is achieved when feedback (E_{fb}) is exactly out of phase with input signal (E_{in}). But stray capacitance in the circuit and in the transistors can change this phase, and in fact E_{fb} may end up <u>in</u> phase with E_{in}, giving <u>positive</u> feedback. This results in instability as demonstrated vividly in fig. 6c on p. 68 of the May <u>EEB</u>.

In a.f. amps of the kind we are considering, this phase reversal inevitably arises at some high frequency, but in a well-designed circuit (H not too large), A has fallen sufficiently low at this frequency that $|AH| \ll 1$. By eqn (5) we see that the feedback then disappears so that the circuit remains stable.

<u>The Conclusions</u>

1) In negative feedback we have a simple means of obtaining considerable improvement in amplifier performance, particularly with respect to linearity of amplification and frequency response.

2) While negative feedback cannot perform miracles, its application with a little care and commonsense can yield the desired results -- although like all good things, excessive exploitation can cause more problems than are cured.

3) The price paid for negative feedback is an extra stage or two of voltage amplification, but in terms of the end result this is generally worthwhile.

4) In the extreme case of negative feedback amplifiers we have the op-amp, around which has been developed a whole field of fascinating devices which are now the basis of much modern electronic engineering.

And all that from two resistors and a little arithmetic!

<u>An Addendum Concerning Stability</u>:

The "well designed" amplifier to which I referred above, involves the use of <u>one</u> low bandwidth stage, whose gain starts to fall of at, say 20khz. The RC network involved may be a capacitor shunting a resistor, a Miller feedback arrangement where a collector is tied capacitatively to its base, or the internal equivalent RCs of a low frequency cut-off transistor. ((Dick included here a drawing of a Hybrid pi grounded emitter equivalent circuit; c.f. G.E. Transistor Manual, etc))

The phase change due to such a circuit is 90° maximum at infinite frequency, so no stability worries.

The rest of the stages are designed to have a bandwidth of, say 200khz. Only then do their RC effects start to introduce more phase rotation, and eventually 180° total is reached. In the limiting stage, however, the gain has already rolled off so much (at 6db per octave) that by the time 180° rotation is achieved, A is so reduced that $|AH| \ll 1$ (when H is reasonably chosen), so no instability results, <u>even if AH goes positive</u>!

XXXXXXXXXXXXXXXXXXXXX

<u>To Waterproof a Tent</u>

This one is particularly suitable for those lovely new modern tents which look so nice, and through which the rain pours. Mix together 2 oz of terebene and one quart boiled oil, and apply to the cloth. Allow it to dry in the sun for two days; the tent will be perfectly waterproof. Also works for previously untreated canvas.

XXXXXXXXXXXXXXXXXXXXXXXXX

"... In 1905, the American historian Henry Adams gloomily predicted that the cult of the Dynamo was to be the modern substitute for the cult of the Virgin. The present scene appears to confirm his prediction, but the future may still prove him wrong. One begins to perceive disenchantment among the worshippers of the Dynamo.."

"When life is considered only in its specialised functions, the outcome is a world emptied of meaning. To be fully relevant to life, science must deal with the responses of the total organism to the total environment..."
-- From: "So Human an Animal" by R. Dubos.

THIRD PARTY TRAFFIC -- RLG

One of the anachronisms of the British (therefore Australian) system of control of communications, is the rule against the relaying by radio amateurs of perfectly harmless non-commercial messages on behalf of other people or even on behalf of the operator himself in non-technical matters. This situation becomes absurd when it applies even to help afforded by amateurs in disaster situations, theoretically prohibited unless permitted by official sources after appropriate Procedures.

The whole thing appears to have as its basic rationale the idea that communications by amateurs deprives the telecommunications systems of money which would be available if the communicant were able to send his messages free by amateur radio. That this is a stupid point of view is illustrated by the fact that no one in his right mind is going to spend a fortune to say hello to a friend halfway around the world unless impelled by some considerable urgency. One notes that in the U.S.A. where Third Party messages are very freely permitted, the various telecommunications systems prosper greatly -- owing to the fact that they are commercial enterprises, and must work efficiently and logically. In Australia and most other countries, Third Party traffic is prohibited because the same Instrumentality controlling amateur communications also derives its income from telephone and telegraph services. And it has an Absolute Monopoly on those services, leading to the kind of efficiency and service which could be expected; it also leads to the ultimate absurdity that even an electric torch or a crystal wireless set ought to bear an appropriate (and expensive) licence (c.f. EEB, April 1970, p. 50).

In reference to this situation, I am in possession of some very interesting information. One is a copy of a letter printed in the British Mobile News of January 1968, in which a letter was sent to their P.O. asking: 1) Should a mobile amateur be involved in or come upon a serious road accident, would it be in order to summon help via another radio amateur? And: 2) Should a mobile amateur's car break down, possibly in a remote place, would it be in order for him to ask another amateur to get assistance.... Unquote. The official reply was NO. There is hardly any reason to believe that the British Government's point of view has become any more rational on this subject in the intervening time.

A similar enquiry to the Australian PMG's Department a few months later yielded a very different sort of answer: "In the first case you mention the operator should, if the safety of human life or property is in danger, avail himself of any means at his disposal to obtain assistance. In the second case cited by you, common sense must prevail. If, for instance, other means of obtaining aid were available in the form of passing motorists and the occupants of the disabled vehicle were not in any danger, then the use of radio amateur bands could not be justified.

"In cases of breakdowns in extremely isolated locations where it could reasonably be anticipated that considerable delay would occur in obtaining help, and as a result of this delay the people concerned would suffer hardship there would be no objection to use being made of the mobile amateur station to summon assistance.

It must be emphasized that an Amateur Station Licence is granted primarily for experimental purposes."

We may be well and truly proud of the Australian Radio Branch of the PMG's Department, which attempts to administer a stupid law in a sensible and humane manner. When shall we see an even more rational approach by the Establishment to the whole question of Third Party communications in Australia?

RADIATION RESISTANCE REVISITED (Or: Why it is worth fussing about fractions of an Ohm!) -- by G3BID (Reprinted from Mobile News (U.K.), June 1967, p. 80. (C.f. EEB p,118)

"I saw a picture of your mobile rig, Edgar, and was horrified to see you use a spring!" That was how I was greeted in a QSO with a friend of mine.

"Oh, that's OK," I replied, feeling smug and secure, "Don't you know the spring is shorted out by a nice fat bit of copper braid?"

"Oh yes, and the corrosion which takes place is something wonderful and you never see it. The losses can be quite large."

My smugness was gone. I was shaken.

The next day I took my B.M.6 Megger to measure the d.c. resistance from the feed line to the antenna itself. 0.6 ohms! More than half an ohm! So my friend had something.

So I dismantled the spring and measured the resistance across the spring with all the corrosion. Zero! or as near as I could tell it was zero, certainly less than the first half of a scale division, and the lowest scale division on the B.M.6 Megger is one-tenth of an ohm, so the spring with all its corrosion was definitely less than one-twentieth of the ohm.

That seemed OK. So my friend was not right about the spring. But the resistance from the feed point to the ball (below the spring) was still over half an ohm -- just 0.6 ohms in fact. Then the ball came to bits. Still no improvement. From the bottom half of the ball to the feed point (only about 6" away) was still 0.6 ohms. So the 6" of feed wire were removed. Still 0.6 ohms!

There was no escape. The whole antenna base had to be taken to bits and examined bit by bit using the Megger stage by stage. Naturally the suspected point was where the male coax plug fitted into the female socket on the base of the antenna base. This did appear corroded but not seriously. When the Megger was used from the long tube which forms the female socket contact to the bottom half of the ball, the 0.6 ohms appeared at once. Now this looked like one piece of metal. But it wasn't. The metal tube forming the female socket is steel and the ball is alloy. These were moulded together and it was at this point that corrosion had built up the contact resistance.

Now why this fuss about these tiny fractions of an ohm? Why does 0.6 ohm really matter?... The efficiency of a radiating system is expressed by:

$$\text{Efficiency} = \frac{Rr}{Rr + Rl} \times 100\%$$

where Rr = Radiation Resistance, and
Rl = Loss Resistance.

In the case of a half-wave dipole, the radiation resistance is of the order of 70 ohms (somewhat dependent on height).

In static stations where aerials of the physical dimensions of half a wave length (or at least a quarter of a wavelength) can be erected, the small fractions of an ohm are unimportant, as we can see from the efficiency of a dipole with a loss resistance of, say 3 ohms:

$$\text{Efficiency} = \frac{70}{70 + 3} \times 100\% = \text{over } 95\%.$$

Reducing the loss resistance to 2 ohms will only raise the efficiency from 95.8% to 97.2%. But once the physical dimensions of the aerial fall below a quarter wavelength, the radiation resistance falls dramatically. The radiation resistance of a centre-loaded 8 ft. whip on 80 metres is only 0.8 ohm, so that even the 0.6 ohm resistance I was fussing about would reduce the efficiency to... 37%!

$$\text{Efficiency} = \frac{0.35}{0.35 + 0.6} \times 100\% = 36.8\%$$

or nearly two-thirds of the power output from the transmitter would be lost in the 0.6 ohms.

Now, if we look at Top Band, the figures are even more startling, since the radiation resistance of a centre-loaded 8 ft. whip on 1800kcs is 0.2 ohms, and a base-loaded 8 ft. whip on 1800 kcs is only 0.1 ohm.

So you see why the fractions of an ohm really do matter in mobile operation, though they are relatively unimportant in fixed locations. Since the car is an integral part of the radiating system, the fractions of an ohm matter not only on the aerial side, but also on the car side.

The following table reproduced by permission of A.R.R.L. from the A.R.R.L. Antenna Handbook and the Radio Amateurs' Handbook, shows the radiation resistance of base or centre-loaded 8 ft. whips at various frequencies:

F (kcs)	Base Loaded Rr	Centre Loaded Rr
1800	0.1 ohms	0.2 ohms
3800	0.35	0.8
7200	1.35	3
14200	5.7	11
21250	14.8	27

EDITORIAL -- RLG

"Never strike a happy Medium!"
-- 'Scope', A.B.C.

This & that

Y'know, it seems odd to me that Youths who revolt against conformity do so with such alikeness, and with such curious methods. For example their lovely shoulder length hair, and some of them with pink blouses too. Rather more useful for housework than for bending over a hot soldering iron, I should think; Julian Huxley thought so too: when a creature adopts the plumage of the female he adopts her attitudes and habits too! I suppose all this revolt by gay young things shows contempt for the rest of the Human Race, but sometimes I find it difficult to tell the monkeys from the apes . . . . "At a prominent member of society's cocktail party, held in a thoroughly modern house, a guest accidentally walked into a closed plate glass door, smashing it completely and knocking himself out. His wife being a bit of a Hedda Hopper said to the hostess quite critically, 'People in glass houses should not throw parties'. To which the hostess replied, 'People in glass houses shouldn't get stoned'." (From Central Office Sports & Club Bulletin of Northumberland, April 1970)....... "Being Editor of a club paper is hard work. The editor's position is similar to that of the fellow who, being tarred & feathered and ridden out of town on a rail, said, 'If it wasn't for the honour of this sort of thing, I'd just as soon walk'." (J. Pfeiffer, WA5CKJ in Bulletin of the Amateur Radio News Service, June 1970)........ It was a cunning trick for us to offer something Free in the same issue in which I requested reader opinion about something. Companion Editors might take note. .... I attacked the problem of static motor noise on our old tape recorder recently, and ended up with a tremendous (though very interesting) job on my hands; Rod said, 'I could have told you so'. So I suppose he was right(p.121). .. I ought to have taken it to someone else -- but I did learn a lot!

Irresponsible Youth?

I appreciate the fact that the above comments are not wholly related to electronics, and if you don't like this I do sympathise with you. Similarly we have various casual fillers -- recipies for butter, grog, and waterproof tents. We have received some favourable comments about this, and some complaints. Aside from the fact that modern waterproofing techniques, beer, and butter leave something to be desired -- aside from all that, what's wrong with irreverent miscellany in an electronics magazine?

Surely there are enough electronics in the main features, to allow us to indulge in some non-electronic whimsey? If you don't like our recipies, send in your own -- but they must be of the same highly practical sort we have been featuring.

Deeper than this is still the implication that I caper about like an irresponsible youth; at my age surely I ought to know better. No doubt; we all have our bête noir. If you don't like EEB whimsey, informality, and long looks at short subjects -- go read any of the hundreds of magazines which do the Right Thing. To assist this exodus we're raising price to $1.50 in February, and reducing publication to bimonthly; the latter simply so that I can endure. If this all drives away enough people I can go back to playing at the workbench, and send my articles to the Straight Mags!

Deus ex Machina Computare ("Two machines are more cunning than one")

The following piece is reprinted from the text of the programme, "New Sights to Excite" from the "Arts of Science" No. 4, A.B.C. 4/1/70, with appreciation. It was devised jointly by Stan Ostoja, Clare, Gordon Robertson, and a Computer:

(PTO)

Buildings was drooping out, impression over the mountains
Tidal element, certain light suggested fifteen but so huge
Tidal of the mind too
Beyond again for parted to them all
Extended he could on spires
The further it looked ground, thickest ground on the mountains
Other mind and unwork, drooping a half light
Could looked parted or white in palid others steep narrower
  half light about allow
Infinite tops
Mountain
A four shallow seen tried else, not tops
Like bubbling a which larger into the softer mountains
The and the the top other been washed away
Bubbling for and the not much gaint themself
Much perhaps it from as he silent
Mile, that too up it mile back
And, and where sober back rose the and twenty element
  with wider impression
Valley and deed.

I quote Stan Ostoja Kotkowski: "It was left to the computer to select the words that the computer came across and put them into their decided programmed form. What it means is that the computer looked for a word, selected another word and a third word until it came to the desired length of line and finished the line there and started on a new line. Naturally the poem doesn't make sense like a normal poem does, because a computer cannot make sense of actual words; but because of its nonsensical nature, the human mind tried to make sense out of it. No rational human mind would put for example certain two words together, yet the computer did and the human mind tries to make up for it, tries to understand. The computer came up with several yards of this poem, I selected a small section from it and asked Judy Dick to recite this and then we put a bit of electronic sound on the background and as a result, I feel we have a sort of an atmospheric poem which, although it doesn't make sense, it does create an atmosphere."

Lest you reject the poem out of hand, I wish to attest that when read out in an impassioned tone of voice with suitably passionate electronic music in background, it was most impressive. It made at least as much sense (to me) as some other modern poetry, and more than most. Well, now what?

There's nothing wrong with Computers, only Man is vile, remember?? In my files I have several items showing the considerable usefulness of these beasts. For example in the Aug 1970(Ham) Radio magazine, K1ORV discourses at length on how computers can be used to eliminate trial and error in circuit design. My first reaction to this was "how awful!, everything I have learned of practical value was learned by making design mistakes", but I realised quickly that this is no answer for serious work. The Computer is a tool, which can be used to produce good or bad designs, good or bad poetry, good or bad art. In another item, the "Calcomp Newsletter" from California Computer Products in May/June 1970 is shown the use of the computer to make radiation dose calculations more efficiently by plotting isodose curves; if you have ever had to do this kind of thing, you may appreciate that some expert help could be welcome in doing the monkeywork; the Computer is just a trained monkey! Using similar techniques they also map ocean floors, the earth's magnetic field, geophysical maps, heat radiation studies, and metero-

(See also: "Computers & Ham Radio" by W5TOM, Ham Radio 3/69!) ★ E.A. 4/61 logical charts. In the same issue are shown three drawings ("plots") by the computer. They are really very interesting, and I'd like to reprint one on the front cover of EEB after I ask the Company for permission. On a subsequent cover I'll print something similar my son drew from his own talent, to show that the computer has no monopoly on ingenuity. And in the same issue was a human-composed poem inspired by the feat of a computer drawing, I mean generating the figure, Five. Well, all right, why not? If its good poetry, it can have any theme as inspiration. Oh glorious Dynamo!.....

I also have a copy of the newspaper "The People" from May 3, 1959, describing that "they have heard that in Cambridge a group of 57 University experts are producing from a machine, work that is positively frightening. This machine can think for itself so amazingly that the sages are beginning to ponder this nightmare question: is there anything special in the human brain after all?" The machine has been taught to make translations, and by now I doubt not that it has been instructed in the rudiments of making ethical decisions. Armed with suitable exteroceptors and manipulators and an independent source of energy, what could such a creature not do? The sages say that the machine is artistic and temperamental as well. In choosing words for a new edition of Roget's Thesaurus it invariably chooses words which are not only technically correct, but artistically right as well. Um.

Then there is Peter Ryan's article "There's every reason to fear Computers" from The Australian, June 9, 1970. He shows how a Mad Computer is able to make an awful hash of normal human affairs when it is trusted, and runs amuck. I have experienced it too, as no doubt have you. The most notable of my experiences was when I paid cash for something, and the Computer wasn't programmed for that; the results were amusing, but no need to go into that here. Ryan suggests that it is no good to say that only man is vile, since his vileness will inevitably pervert any good tool. Perhaps, but is that an argument for throwing away tools?

More essentially he argues for certain legal safeguards to protect us from nasty-minded machines. Without this, "the potential for evil of computers, as instruments of enslavement, is greater than all the gunpowder in the world." I am reminded of a curious story I once read, describing a Computer-dominated society. The Machine made an Error. The result was that a certain chap became an Unperson. As far as the Computer was concerned he ceased to exist, and everyone else assumed that as well, since the Machine was incapable of error. He was unable to continue to obtain food, employment, or shelter. He was driven out to the bush to face Survival because the body machine of society had spit him out.

It is curious how often such tales end with some kind of return to Nature, as though somehow exposure to the Wilds will cure our sicknesses. But it is just such wilderness which we have all worked long and hard to escape -- the brutish struggle for food and shelter, the sickness, the slavery & poverty that comes from inadequate production. People who glorify Nature generally do it from the safe vantage of a secure home and Unemployment Insurance, with an occasional forray to the bush with tinned beans and a propane stove.

It was to escape insecurity and to maximise profits that we created our present civilisation. Our goals have not changed, but our methods have deteriorated. This increases Error or introduces Noise (which prevents resolution of Error) thereby widening the gap between desired and achieved goals. Computers may possibly increase the accuracy of our evaluations, allowing us at least to act on the basis of real facts. If we choose to interpret them insanely, so we choose, but in our increasingly complicated society at least we shall choose our doom on accurate data. Heh!

Merry xmas! -Leo & Rod

EDITOR'S NOTE: As readers of this rag will surely realise, advertising by non-commercial parties has not been impressive these 6 years. Originally we started as the "Equipment Exchange Bulletin" but when few people showed interest in exchanging or selling much, the electronics sideline expanded to wag the dog. Subsequently, response was small even when, as an experiment, adverts were offered for a year to individuals free of charge!

Now I have been looking through the past years worth of Amateur Radio and I saw frequently adverts of some substance by people whose names I recognised as EEB subscribers. Since we have received quite favourable reports of results from EEB adverts in spite of our tiny circulation (some 780), obviously something is not adding up sensibly.

I don't know what it is, but I am favourably inclined to accept a reader's suggestion that we adopt the "Trading Post" method: You advertise free, and if you sell something you send us about 5% of the proceeds, though this would have to be applied with commonsense. If you sell a $600 transceiver, obviously $30 would be absurd to pay for an advert, so you could send us, say $6. If on the other hand you sell a crystal for $1 it would be silly to pay 6c post plus envelope just to send us 5c, not to mention the fact that the advert would likely have cost us 20c. In that case you might use the "find us another subscriber" alternative to pay your debt, or merely think fond thoughts about us (keeps us warm), or perhaps even send us a technical article sometime (for which you also receive subscription credit). On "Exchange" deals you could send us perhaps 5% of a reasonable estimate of the value of the transaction, or other commonsense, as above.... But if free adverts brought little response, will this be better? Who knows, but lets give it a go. One exception: Commercial adverts as the same rate as before; next month we'll go back to the usual sideways format. Wot say?

COMPLEMENTARY SYMMETRY AMPLIFIERS, Part III -- R. S. Maddever (VK3)
-- A three to five watt (RMS) Amplifier

This amplifier is based on one described in Fairchild Applications Data (APP-A-2). It is a composite complementary (or "quasi complementary") type and uses no output transformer. The transformer is a common cause of poor or restricted frequency response in cheaper amplifiers, and is well omitted. The response of this amplifier can easily extend above 50khz, though it is often wise to limit it to just beyond the audio range, to promote stability and reduce tendency to pickup spurious signals. This is the purpose of the 0.01uf capacitor in the a.c. feedback line to the base of one of the output transistors.

Power

As designed the amplifier will deliver about 2.5 watts (RMS) into a three ohm speaker for negligible distortion-- less than 4% (sic). Waveform clipping begins at about 3 watts. As much as 5 watts can be obtained with a supply voltage of 20 to 24 volts, but the electrolytic capacitors must then be capable of withstanding the extra voltages, and the loudspeaker impedance cannot then be less than 8 ohms--to keep the output transistor currents within safe limits

((At this point the reader is emphatically recommended to the "IMPORTANT DESIGN NOTE BY RAJR" at the foot of p. 93 of the July EEB. If EVER you have occasion to use or experiment with complementary symmetry amplifiers PLEASE read that item! We have already received a very interesting letter from a reader on the subject of complementary amplifiers, but he still talks of being puzzled that he replaced the output transistors with larger ones, without apparent improvement! -- Ed.))

If a three ohm loudspeaker were used with double the power supply voltage, the peak current would also double, thus quadrupling the power; if you want the higher power you must obviously install larger transistors. If the same transistors are to be used with the higher voltage, obviously the speaker impedance must increase in proportion to the power; viz, if power goes up four times, the speaker impedance must go from 3 ohms to 12 ohms (say 15 ohms).

In the present instance, by using an 8 ohm speaker, double the voltage gives us ¾ of the current at double the voltage, thus 1½ times more power; in this instance the output transistors can take the higher load, but we had to know this in order to make the substitution validly. By ohm's law the new peak current is about (2/1)(3/8) = ¾ of the original, and the new peak voltage is (2/1) = 2 times the original; the new peak output power (or r.m.s.) is then 2(¾)= 1½ higher in this instance. Calculations by RLG

In any complementary amplifier it is always perfectly safe to use an output load higher resistance than rated, because this reduces transistor current, but the power available will then be inversely proportional to the speaker impedance. Thus, here if we have a 24V supply, we can raise the load impedance from, say 8 oyms to 16 ohms, and we shall merely obtain (half the current therefore,) half the output power. But reducing the output impedance would give intolerably large peak currents through the transistors -- if driven with maximum audio input. On the other hand, if we reduce output impedance we can keep power dissipation to safe levels by reducing input voltage in proportion, according to $P = V^2/R$.

The circuit

The circuit and so forth are shown overleaf. Q1 is a simple common-emitter voltage amplifier, directly coupled to Q2. Q2 and the 3.9K can act as the collector load of Q1 because Q2 is complementary (i.e. opposite polarity) to Q1. The collector load of Q2 is Q3 & Q4. Q4 acts as an emitter follower to drive the load in the same phase as its input (also the same phase as input to Q1). Since Q3 has opposite polarity (PNP) to Q4 (NPN), it acts in opposite manner, but still as an emitter follower. But Q3 is not rated to handle the large currents of Q4, so Q3 feeds Q5, and the two resultant phase reversals cause Q5 current to be in phase with Q3, so boosting its total current handling ability to the same level as that of Q4. This is a clever trick which produces all of the advantage of the Q3-Q4 complementary configuration (viz, omitting output transformer), while allowing the use of same polarity for both Q4 & Q5. This had its greatest benefit in the days before NPN power transistors became readily available, but is still of value in allowing the use of a given transistor in a given power rating, and facilitating matching.

A positive signal at the input to Q1 undergoes the usual phase reversal at the collector, as Q1 conducts more (remember it is NPN), and more base current is passed through Q2. This makes Q2 conduct more, making its collector more positive. Q4 acts as emitter follower and the output signal goes positive. The Base of Q3 goes positive with respect to its emitter (as offset by the base-emitter of Q4) so it conducts less thereby aiding the action of Q4. The base of Q5 is driven negative by the usual phase-inverter action of Q3, so Q5 conducts less too; the overall result is the same as though a single PNP were used for Q5 in place of Q3+Q5. The positive signal is fed back through the 3.9K and 5.6K to the emitter of Q1, providing negative signal feedback, developed across the 22 ohm resistor. The 1uF increases feedback at high frequencies relative to low. Negative d.c. feedback occurs across the 1.2K resistor, thus stabilising the whole network. The base of Q3 is offset to d.c. from the base of Q4 by the two AN1102 diodes, for reasons discussed in the May <u>EEB</u> article. The 470 ohms at the base of Q3 is returned to the loudspeaker as a bootstrap, and lessens danger from accidental short circuit of the load. The 3.9K in the base of Q2 allows some of the Q1 current to be passed, to allow the correct d.c. bias of Q2.

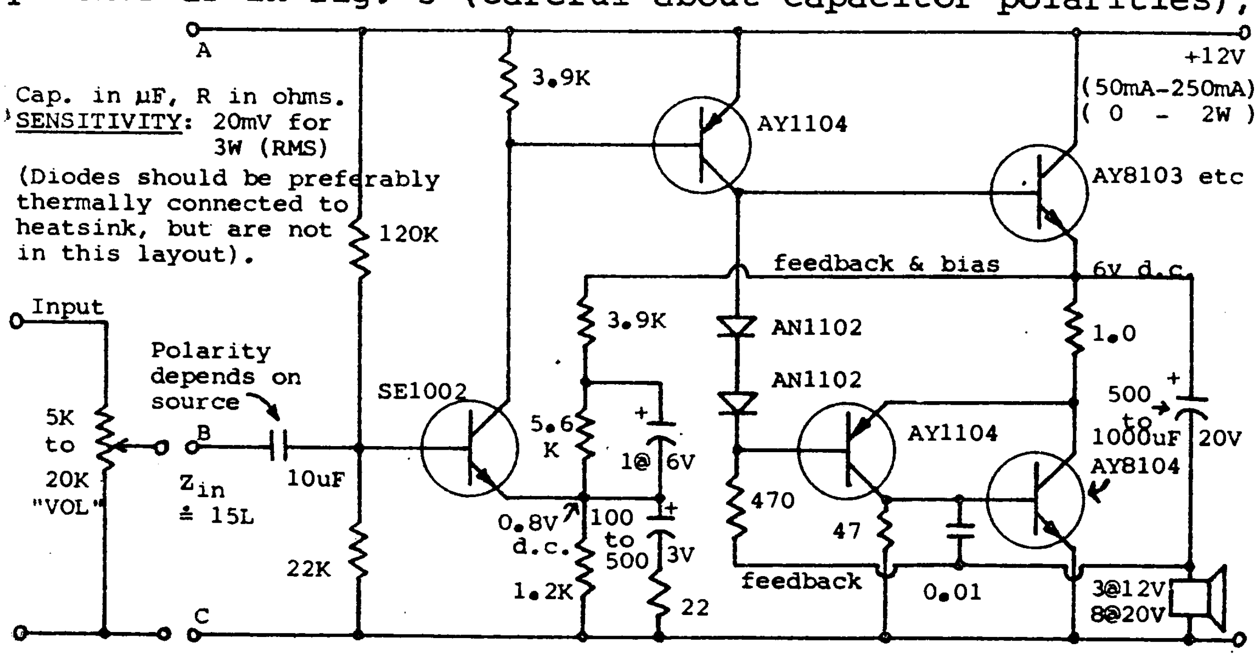
<u>Brief suggestions for construction</u>

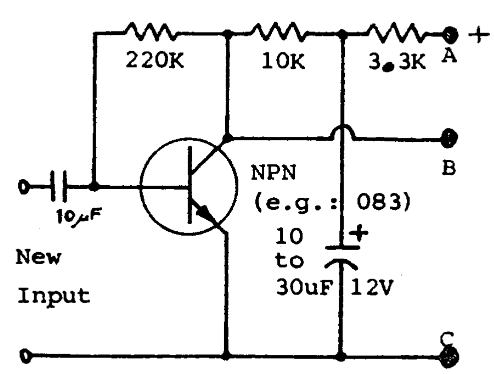
Lay fig. 4 (next page) over a 3x3" piece of copper covered board, copper side up. Prick through the hole positions. Drill small holes with 3/64 drill and larger ones with 1/8" drill.

Hold heat sink, correct way round, under the board on the paxolin side, in its correct position and mark positions of holes S1, S2, and S3. Drill out and also drill out holes to fit the output transistors. Smooth off carefully and mount transistors in heatsink as shown in fig. 2. The mica washers should be smeared with silicone grease if possible. They and the plastic separator should insulate the output transistors from the heatsink. CHECK CAREFULLY with an ohm=meter that no lead of a power transistor is touching the heatsink.

Go back to the board. Join the holes with fine lines of bitumen paint, as in fig. 4. Then paint a small ring about 1/16" wide around the edge of each hole (to take the solder later). When the paint is dry place face down and floating on some etching solution made up of about a cupful of Ferric Chloride in a pint of water. DANGER: <u>This solution is corrosive; should any be spilled, wash off with water immediately</u>. When unwanted copper has been etched away, remove paint with kero or turps, rescour lightly with emery or steel wool, and coat board with thin solution of shellac in meths, if available.

CHECK VERY CAREFULLY for copper shorts or gaps on the board where there ought not to be. If necessary scrape with knife or fill in with fine wire/solder. Bolt heat sink to paxolin side of board, checking again to see that output tr's are in correct positions and that leads go into correct holes. Insert other components as in fig. 5 (careful about capacitor polarities), solder, cut off leads.





A Preamplifier as shown above can be fitted if greater sensitivity is desired. It can be added at the input in place of or (preferably) before the volume control. The 3.3K and 30uF are not necessarily essential. They decouple the power supply line and reduce possibility of oscillatioh.

3/5 W. Amp

EEB 10/70

Heat sink

(from al. channel section used in ceilings)

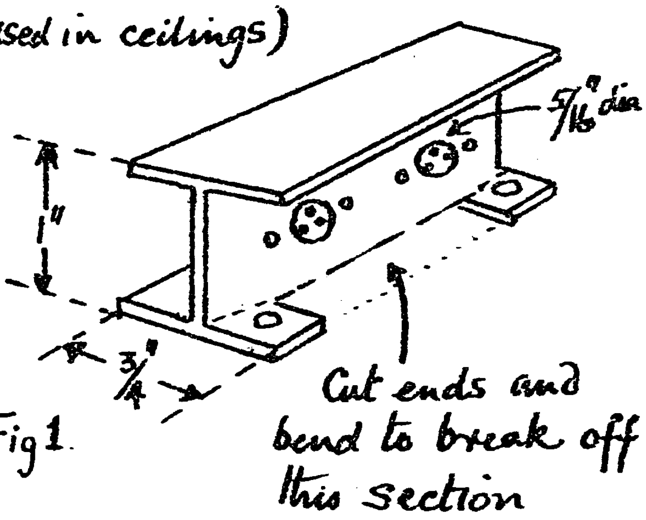


Fig 1.

AY 8103 & 4

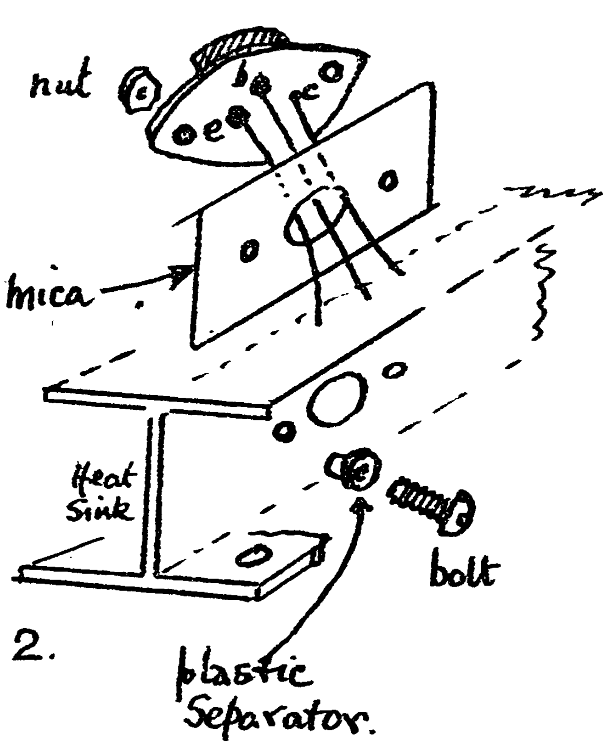


Fig 2.

Semiconductor Leads

Viewed from LEAD side

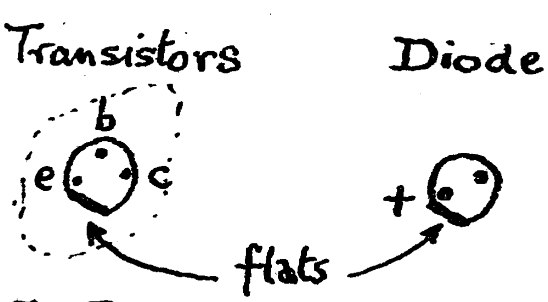


Fig 3

P.C. Board - Copper Side (full size)

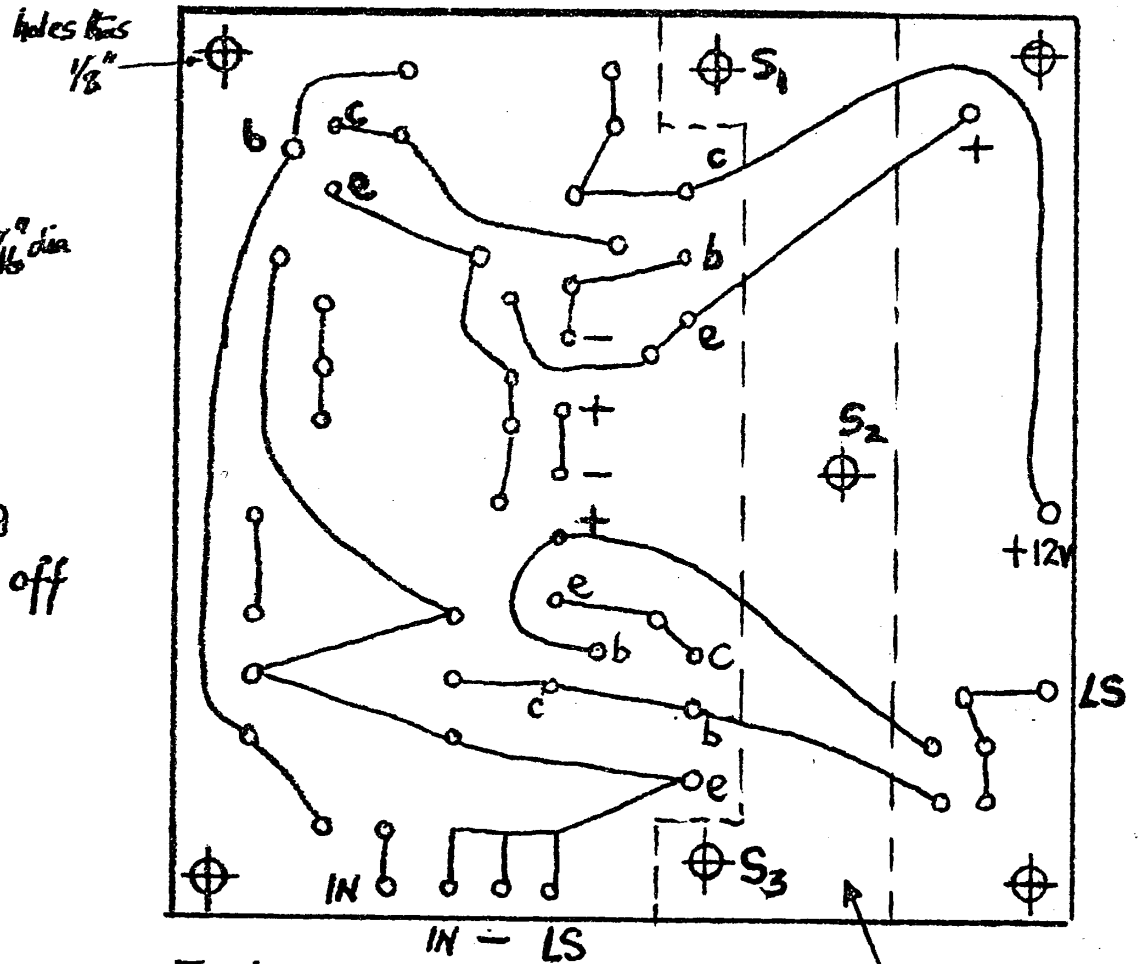


Fig 4

Heat sink

Paxolin (component) Side

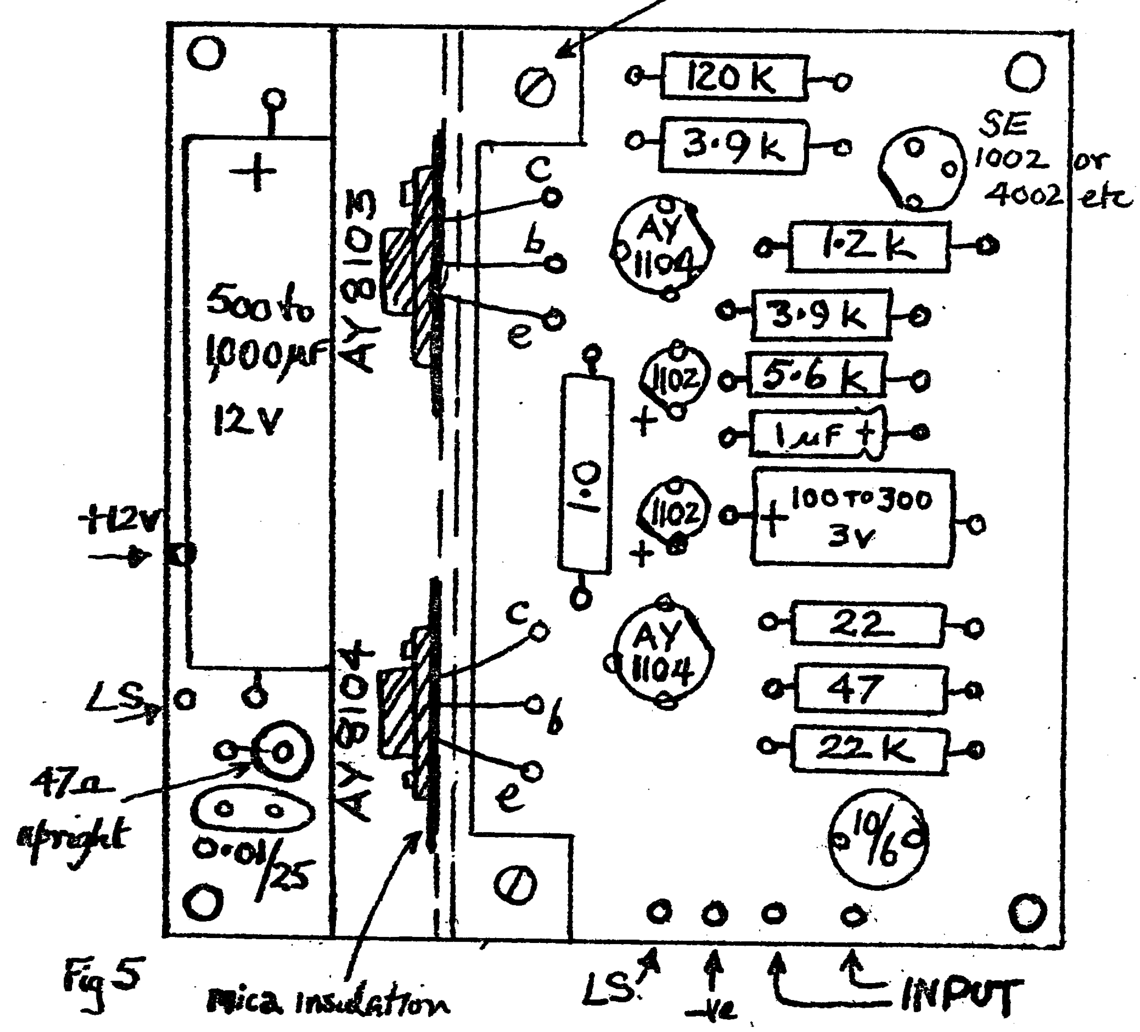


Fig 5

THE PERILS OF POWER SUPPLY DESIGN -- RLG

In the May and July 1970 EEBs we commented on what we considered poor design practices in various commercial circuits we have seen. Some of our inspiration was received from unpublished material sold by ES & I Electronics P/L of Summer Hill, N.S.W., but we carefully refrained from mentioning any names. C. Horwitz of ES & I has now written to us demanding a retraction because of his concern that readers might recognise our reference to his copyrighted material, and might thereby be disuaded from buying his power supply articles.

Horwitz invited us to build one of his designs to test. I did this, as shown for the Q1 & Q2 section of fig. 1 below, with a few minor modifications for convenience. At the frequencies here being considered the transistors were quite adequate to illustrate the operation.

This regulator, with the exception of C_1, is of the same type as the "Back to front Series Voltage Regulator" described by T. M. Palmer in the August EEB (p. 120). In fig. 1, Q3 & Q4 provide an a.c. load for the regulator, amplifying the constant-voltage sine wave output of the audio signal generator. V1 = avg d.c. (maintained at 10V), V2/R7 = avg d.c. current load (maintained at 500mA), E_1 = p/p a.c. voltage developed across the regulator output, and E2 = p/p a.c. current through the load; E2 kept constant throughout each frequency range.

One of the points at issue here is the action of C1. In the July EEB we did indeed quote Horwitz's justification of its being used to reduce ripple. And we said that this was poor design because it shorts out the amplifier at high frequencies. We had in mind the case of the usual emitter-follower system, but the criticism still applies to this one, though in a somewhat different manner. The effect of C1 in this instance is to degrade the low frequency rather than high frequency response. The principle is similar, but we apologise for this mistaken emphasis.

You may examine the curves of fig. 2 to judge the matter for yourself.

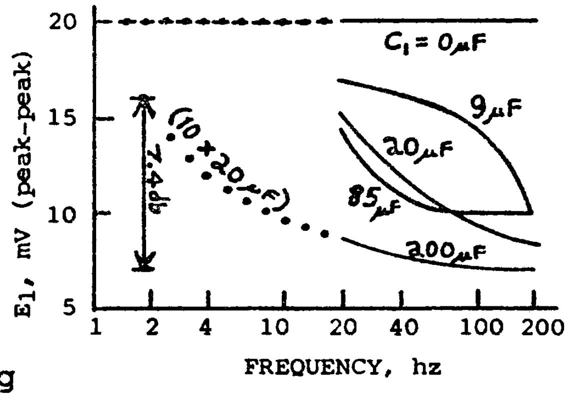


FIG. 2: EFFECT OF C1 ON LOW FREQUENCY RESPONSE. TANTALUM OR ALUMINIUM CAPACITORS USED IN TEST. ACTUAL VALUES OF CAP. ARE SHOWN. THE DOTTED CURVE IS OBTAINED BY TRANSPOSITION OF THE 20μF CURVE. Q1= COMPUTER GERMANIUM TYPE 133, Q2 IS COMPUTER SILICON TYPE 273. C2 = 0, L = 0, V_1 = 10V d.c., V2 = 0.5V.

You can see that below 200 cps (or hertz or portrebzies, as you like) the regulator tends to lose control, for the obvious reason that C1 and R2 form a voltage divider: as frequency goes down, reactance of C1 goes up, increasing the voltage fed to the base of Q2. This increases its collector current, biasing Q1 into greater conduction thus increasing output still further -- in other words, positive feedback!

From fig. 2 it may be seen that the results with C1 = 20μF are quite consistent with those for C1 = 200μF. If you place a high fidelity amplifier as load on this regulator using the Horwitz value of 200μF for C1, it will develop some 7.4db more signal at 2hz than at 200 hz, and likely about 9.5 db at 1 hz compared to 200. The spectrum between 1 and 10 hz is certainly important to prevent low frequency instability, as we pointed out on p. 37 of the March EEB.

There are two cures for this: eliminate C1 completely, giving the nice straight line shown in fig. 2, or increase C1 to a high value -- in this instance to more than 1000

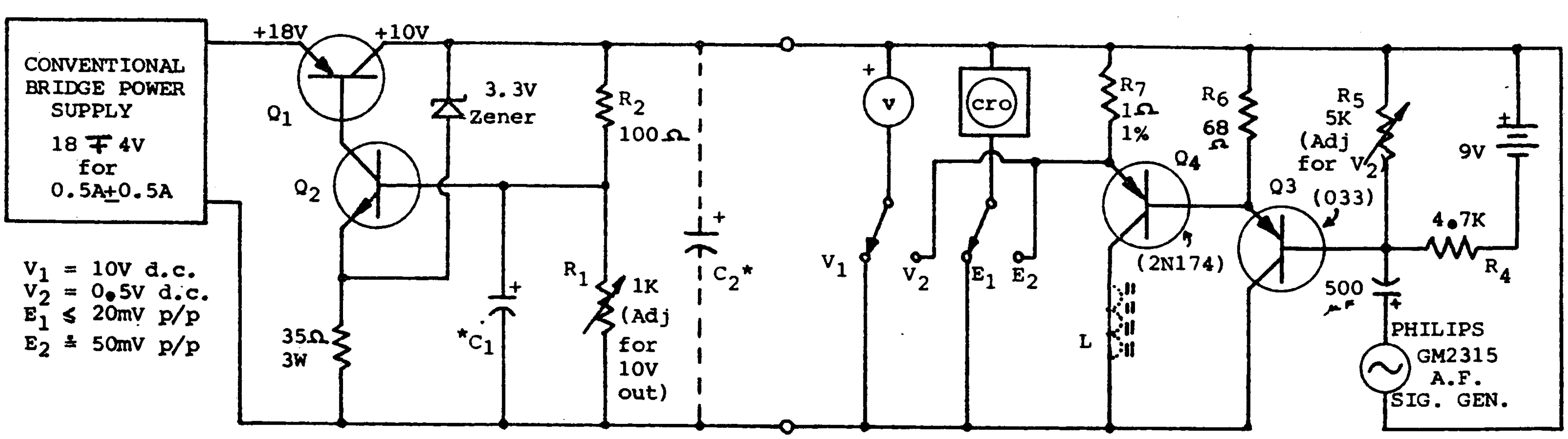


FIG. 1: The Horwitz regulator (Q_1 & Q_2), and our AC load (Q3 & Q4). *See text & curves.

microfarads. The first alternative worsens ripple regulation as Horwitz points out, but this can be avoided by the use of a good zener in place of R_1 (see Palmer article, August EEB) -- with the base tapped down on a pot across it if variable control is desired. The alternative of a very large value of C_1 presents other problems, introducing the possibility of high frequency instability. My present findings show that these problems apply just as well to ordinary emitter follower regulators as to the type being discussed here, though we do not have room here to present the high frequency results.

Conclusion

Thus, our previous warnings about the danger of introducing excess capacitance into the feedback loop are well justified, both for low frequency and for high frequency performance.

The take-home lesson is this: NEVER make the error of assuming that a power regulator working well for d.c. load will necessarily perform well for an a.c. load too. And are not a.c. loads most of the ones we use? Be warned too, that any appreciable capacitance introduced into the feedback loop is undesirable, as we discussed on p. 81-2, 103.

In particular, electrolytic condensers can have vile high frequency performance (e.g. over 1kc!) if there is appreciable inductance in the load or in the condenser itself. Although there is some benefit in protecting a poor design by a condenser at C_2 (see fig.1) if it is sufficiently large and if it is sufficiently non-inductive itself, it is much better to design the regulator as you would a high frequency amplifier.

This means using high frequency regulator transistors (e.g. 2N3054, 3055, AY8113, 8114, etc.) when possible, and in any event introducing frequency compensating networks when necessary; these shall certainly be needed when germanium regulators are involved. It is also necessary to minimise circuit phase shifts, and distributed and lumped capacitance.

All of the techniques mentioned in the above paragraph are standard procedure in industrial equipment where it matters, e.g. in Hewlett-Packard and Siemens; see particularly the excellent"D.C. Power Supply Handbook" by Hewlett Packard, Application Note No. 90 (1967). Does it matter for experimenter & amateur applications? Not if your power supply does not need to put out constant voltage over 1kc. But if your amplifier will object to a 25db increase in supply voltage at 20kc or 15db at 10kc, beware! If you are skeptical about all this, try it for yourself, using the test system of fig. 1, Q3 & 4.

Test your own favourite power supply with regulator, from 20hz to 20kc; keep E_1 low, e.g. 20mV (E_2 about 50mV or as needed) to avoid nonlinearities. Omit C2 from your regulator circuit, and watch what happens. Then introduce the LT winding of a filament transformer in the position shown for L (d (dotted-in). And then try various values of C2 to cure the trouble. For further entertainment, drive Q4 hard enough to produce distortion across L, and watch the fun.

Then to return to sanity, remove C2 and put an R in series with C from regulator output to sense input (viz base of first regulator amplifier). Adjust C to take down the peak at high frequency, and R to make it all nice and even. Details anon.

XXXXXXXXXXXXXXXXXXX

REVIEW: 1970 ARRL HANDBOOK -- RAJR

I have reviewed the last 2 years' editions of this book (EEB Dec 1968, July 1969). In 1969 I observed that the new edition was a new approach to a traditional book in line with the development of the modern Professional Amateur. In last year's edition I commended the editors for modifying the high power content somewhat, but criticised them for lessening the amount of text concerned with the design of equipment.

This year I have little to say. The book is essentially the same as last year, and I would have to go through the book page by page, if I were to find any difference at all.

But there is hope for a change, perhaps. This is the 47th Edition, so let us hope that they will celebrate the 50th Edition by COMPLETELY rewriting the text and returning the book to its former glory as one of the foremost AMATEUR RADIO handbooks, instead of a work tailored to the requirements of commercial parts and equipment suppliers.

And then perhaps ARRL will decide to adopt the sane policy of the RSGB, to publish a Handbook at infrequent intervals, as the state of the art requires.

A SECOND THOUGHT ABOUT THE 1970 ARRL -- RLG

We did not bother keeping the 1969 Edition of the Amateur's Bible, because the 1968 one was slightly better. But I have in fact gone through the 1970 edition page by page, and compared it with the 1968 opus. It was an exhausting experience, and I don't blame Rod for avoiding it; I have four pages of notes, and how can I summarise them all here?

For the most part I think Rod's judgment is correct, but I also believe that the book really is a big improvement over 1968. There is quite a lot more transistorised stuff, using both bipolars and FETs, particularly in the Mobile chapter, which is probably the best in the book. I definitely get the impression that the book is being updated piece by piece, and the pieces that have not yet been attacked are obvious. It must be an enormous job, and I don't envy the editors.

It is obvious that valves are being phased out, along with AM, but the theoretical treatment of semiconductor material does leave much to be desired.... Beginners are being fed ICs straight off, and there is still too much high power. And many errors still exist ('69 EEB p137)

LETTER: EEB Improvements

((Editor's Note: In response to our request for opinions last month, we have been flooded with replies. I am gratified by such reader interest, even though a certain Free Offer did not prove inhibiting, hi. Replies have been about 10:1 in favour of increasing price rather than reducing size. The following letter is fairly typical:)

Don't reduce the size of the Bulletin. Don't reduce the price, in fact double the price. If you receive any opposition to this last point, show in no uncertain manner that a single article in a period of 12 months could save the user far more than a years subscription to the Bulletin at its new price.

If you were able to reduce price to half there would still be people to grumble at cost. The work you put into this publication is excellent. For my part there are two changes I should like to see:-

1) The Bulletin to be published monthly, from a point of sustained interest. The gaps between are not good for keeping subscribers.

2) A larger Bulletin. This would cost more, but go on producing the magazine you feel is best expressing your ideas. The resulting cost and other factors will soon become apparent.

By the way, in regard to your query of missing mail etc, I strongly suggest you write direct to the Post Master General. All possible help will be extended to you.((sic!))

-- F. G. Stirling, Potts Point, N.S.W.

((I think we won't quite double the price; this little rag simply isn't worth it, but thanks to the many of you who claim it is! The issue of monthly publication is indeed a thorny one. I agree that it would be better, because then issues could be somewhat smaller, and we have quite conclusive evidence that small issues get READ where big ones do not. And what is the use of doing a lot of work just so that people can weigh the magazine and admire its white pages and murmur "nice job there"? BUT BUT BUT but it is nearly as much work to produce a smaller as a larger issue, and we are going to have to go to a strictly bimonthly schedule for the simple reason that I simply CANNOT stand the strain of a monthly schedule; the instant the issue is posted I would have to start madly on the next. There happen to be other things I want to do in life, if only to potter about the workbench more; the few moments I now snatch for that purpose are precious indeed, though frustrating: I garner a great volume of publishable material from each such session!

So I fear we'll just have to risk reader discontent with the more infrequent publishing. On the other hand, I am truly grateful for the few publications which come only bimonthly or even only quarterly (e.g. STC Components Review, VHF Communications). We are flooding in a sea of information nowadays, and need plenty of time to digest it, particularly if we also have work and family committments. A less frequent EEB will allow that time for careful perusal. For instance we have good evidence that very few people read our Power Supply Series; see EEB p. 107 & 133. What, then was the point of printing them? People must take more time, and read material to learn new things, not merely to reinforce old interests. -- RLG))

LETTER: The Problem of Experimental Outlook

This matter of ICs, pro/con is not so simple. As devices become more complicated, they can be used in more complicated ways, and this requires more specialised knowledge. Diodes have only two terminals, and there are a limited number of ways they can be used (by themselves). Transistors have three terminals, and the number of their functions is greatly increased. Together diodes and transistors can do even more, as shown by the various "diode circuit handbooks". An IC with some twelve leads (let us say) is capable of much greater performance when used properly, but the whole question comes in how to use it properly!

The argument given in favour of using ICs (other than to save money or time) is often put forward as saying that they can accomplish a lot more, so giving the experimenter much more scope to design sophisticated circuits. This is certainly true, but only if the understanding of the experimenter also becomes more sophisticated.

Now, if an amateur experimenter acquires the necessary theoretical background to use these more versatile devices more competently, he no longer is "amateur". This is NOT to imply that "amateur" means "incompetent", but that an amateur is a person whose knowlege is relatively limited, while he can show some competence in a wide range of subjects. He tends to know a little about a lot of things, but not too much about any one of them.

For the amateur to work competently and imaginatively with the new developments in electronics he would need a high degree of engineering knowledge of a specialised kind depending on the branch of electronics involved. If he is to use ICs in digital applications, for example, he will never get past the simple stringing-together stage unless he learns much about digital electronics. If he is to use linear r.f. ICs for a purpose other than saving work in soldering, he is going to have to learn a lot of r.f. circuit theory so that he can work out more ingenious ways of doing the same or new functions. But will the average casual experimenter go to this trouble? For the most part, no.

Then what is the use of experimenting in this modern age? What positive values can we look for in experimenting? We can build equipment for its own sake. We could buy it, yes, but what we have built is our own.

Consider, after all, a game of chess: what has been accomplished at the end? Only satisfaction. Why does a bloke build a boat when it could easily be obtained at a comparable price secondhand? For the fun of seeing one's own work build one's own edifice -- as the Americans say, "doing your own thing" in a literal sense. Why climb a mountain or do anything creative? Because it fulfils the person doing it, because it puts him into closer touch with the world in which he lives.

Experimenting is worth doing for its own sake even if it achieves no grand goals, and even if done with limited knowledge. In this way it does not matter so much which circuit he uses, as long as he uses any which gives results. From this point of view ICs are no more of a challenge to experimenting than was the valve.

(Continued on p. 151)

AROUND THE AIRWAVES: 12 Oct. 1970 -- by. Jim Coote (G3UGD) (*Various other sources of info)

LOCATION	ACTIVE STATIONS	FREQUENCY	SCHEDULE	QSL via:	ETC.
American Samoa	KS6CY	14300	16-1700 Thursdays		
	KS6GG	14012 CW	0730 Z		
Botswana	A2CAU	14025,45	Weekends		*
Comoros	FH8CE	28595/14255	1615/1730Z		Hugues *
	FH8CG	28592	1245	(New Lic., Stamp collector)	
Fiji Island	VR2EK	14040	0700-0900Z		
	VR2FO	14020	0730		
	VR2DK	21225 SSB	0900		
Galapagos Island	HC8CS	14130-150 SSB	0500Z		
		14280 SSB	2300Z		
Gambia	ZD3D	21410	1700Z	WA9UVE	Tues, Thurs.
Johnson Island	KJ6CF	21300	05-0900Z	AEC Radio Club, P.O. Box 101,APO,	
		14273	1700Z	San Francisco, Calif., 96305, USA.	
Juan Fernandez	CEØZ	(See also San Felix)			then: 6 days in November. *
Midway Island	KM6CE	14055 CW	1430Z	WA3HUP	
	KM6DT//KM6DV	14280//14330	0730//0830Z		
Nauru	C21GB	14265	1200Z		*
New Zealand	ZL4LE	3505	0600-0630Z =		For EU & DX
Niue	ZK2AF	14265/14290	0645-0900Z		Wally
Reunion Island	FR7AG//FR7ZW	21173SSB//253	1700//1200Z		Newly Licensed//
St. Brandon	3B7DA	21032CW/14020	1600/1700Z		*
St. Helena	ZD7SD	14259	2050Z	Box 16, St. Helena	
St. Pierre	FPØNQ	21070	1330	W2NQ	
San Felix	CEØX	(See also Juan Fernandez)			Early: 4 days in November. *
Seychelles	VQ9EP	21035	1430Z		
South Georgia	VP8JV	14125	1900Z		For EU
		14209	1700Z	W2GHK	For USA
		((Shall we show him ZL/VK is still on the map?? -- Ed.))			
South Shetlands	CE9AT	14218/14005CW	2300/0200Z	CE3ZN (S.A.E.)	*
Swan Island	W1ARF/KS4	21400	2300Z		For 18 months.
Togo	5V4JS	21200	1400Z		
Tongo Is.	WA6BKW as VR5ZK	10-40 Metres			In November. *
((λ Challenge:	K1PBW, ZC4RB	1802, 1833		(Presumably was heard in EU)) *	

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LETTER (continued from p. 150)

They will certainly be more of a problem when it comes to Grand Designs, but it looks as though the experimenter is just going to have to resign himself to Grand Designs.

-- O. Hello, Hobart, Tasmania

((Ed. Note: Mr. Hello is a keep experimenter in his own right, and knows the joys of creative work. I sympathise with his conclusion, but I I bothered by it. It seems to imply that the experimenter can be a drone working in his own corner, accomplishing not much as long as it pleases himself. But this is not consistent with the highest ideals of experimentation in the past. Many of the great discoveries came from such amateurs, and even in modern times we have seen much ingenuity shown in some aspects of gadgetry and communications electronics. Is this all to pass now into the hands of the Specialist, leaving the rest of us to dabble in things of no consequence, or to ape mindlessly the "Grand Designs" of others? Unless I am missing something, it would appear so. -- RLG))

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ERRATA ("Denoting a certain Pleasure")

(Well, don't blame me; people started complai= ning because they couldn't understand my Latin; now they compain because of Free Translations)

W. M. Holliday, VK2ZUP has informed us that a few Errors seem to have crept into his FET GDO in the August issue. It is not beyond the realm of credibility. Namely:

(1) P. 126, fig. 3: The collector of the oscillator transistor should be bypassed by 0.01uF to earth. Please change it on your copy NOW.
(2) In the amplifier in fig. 3, the 2.7Meg bias resistor should be rather smaller, likely less than 1Meg, but this will depend on transistors. Adjust it to give 1.5 to 2.0 mA headphone current.
(3) Concerning the winding of solenoid coils, the ½dia spacing is only practical at VHF; "note that spacing the wire in the HF coils will make them impossibly big!"
(4) He tried the idea of using FET as constant current source instead of RFC to avoid spurious dips, with equivocal results. Namely a lack of oscillator gain above 100MPb (Mega Portrebzies, whatelse?), and "a disinclination to oscillate with xtals plugged in". Also various other problems involving difficulties with R_4 etc. Nothing is simple. No alternative, it seems, to good geometry and non-spuriously built RFCs (or use HT and resistor load for the oscillator).

Incidentally, ZL4IO has a very nice article in the September 1970 issue of Break-In in which, among much else, he describes a simple transistorised dip oscillator using a couple of diodes as ALC to keep meter reading steady.

OM Holliday continues with details about a 50 ohm step attenuator easily built and which is down only about 1db at 450MPb. It looks lovely but he asked us not to publish it until he did further work on it. Herewith I give public notice that we are eagerly waiting for the further results, time permitting! -- RLG.

P.S. Tony Cengia (VK7) has also done some nice work on a BDO, forthcoming one day in EEB.

ea.: $0.25

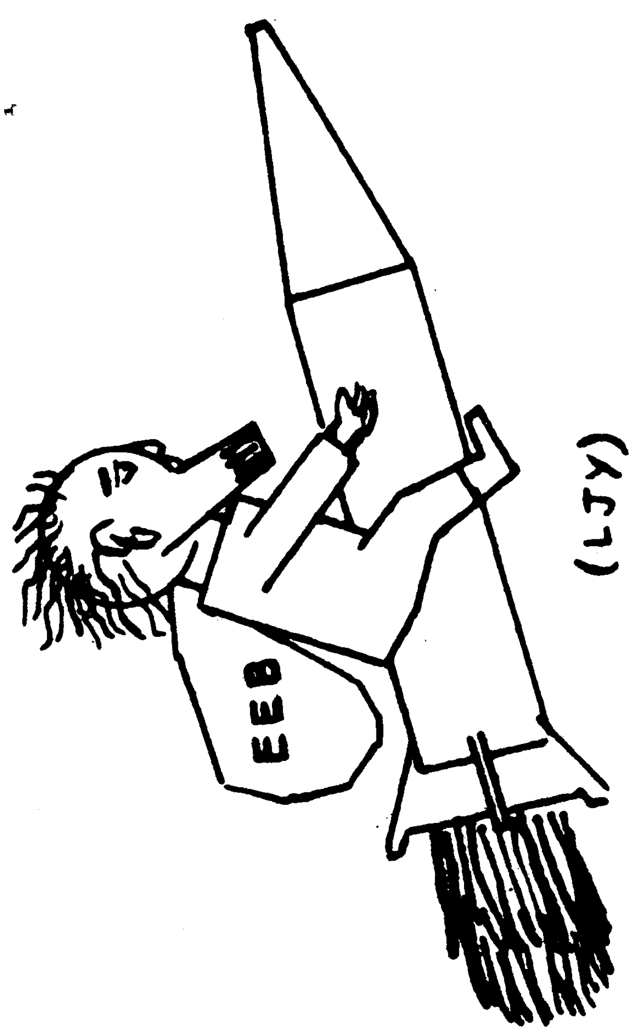
yr.: $1.00

(foreign: $2)

THE AUSTRALIAN EEB

→ COMMONSENSE ELECTRONICS

December 1970 Vol. 6, No. 8 P. 153



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CONTENT

__NEXT MONTH__: February 1971 (See p. 166 or so)

*Yes, Letti, ZL too, but it didn't rhyme here.

FET CONVERSION OF THE BC221 HETERODYNE FREQUENCY METER -- I. N. Kallam (VK3)

The Introduction on the following page is reprinted, with gratitude, from "Surplus Radio Conversion Manual", by R. C. Evenson & O. R. Beach, Vol I, 3rd Ed, 1960 (published by "Editors & Engineers", now Sams). There are about 22 other models, differing slightly from each other, but the main idea is as shown in figs. 1 & 2 on the next page here, also from the same Manual.

This highly useful piece of equipment is still available in good condition for a fair price from a variety of private and commercial sources in Australia and New Zealand, or for low cost if in poor condition or without a Calibration Book.

It was in the latter condition in which I obtained my unit. Its low band coil had been damaged, and the unit had been canabilised for some parts as well as all valves, crystal, and Calibration Book. I had, therefore, nothing to lose by tearing into the thing to redesign it for semicons. BUT I recommend the extensive reworking of fig. 3 only for sets which are in a state of disrepair, or for the adventurous experimenter. For all others the modular approach of figs. 5-7 is probably more practical.

Obviously the extensive nature of the modifications shown in fig. 3 will likely invalidate any previous calibration, so if you have a good unit with book, you'd be better off leaving it alone, or using the modules shown. Fig. 4 is a typical r.f. module I have used with success. Based on similar design, figs. 5-7 are reasonable for building into valve sockets and plugging in place of the valves ((but reduce the HT to less than 10V! Use only as little as necessary -- Ed.)). I have not had the time to try the modules, but they ought to work with minimal need for alteration. Any slight change in capacitance which changes the calibration can be trimmed up as obvious.

Originally I set out to transistorise this frequency meter before the advent of good FETs. It was quite successful on HF, but no go on LF. Then when FETs came along I put one of them (now a primitive type) into the oscillator, and the result was fig. 3. As usual with my other EEB designs, if you need detailed instructions you'd better not bother, but if you had a little experience, go for your life.

I rewound the low band coil (because it was crook anyhow) to cover 250-500kh$_z$, and used a 500kh$_z$ crystal working into a one-shot multivibrator (gave better locking). The oscillators remain rock steady, but this is from a battery. For a.c. supply, use filtering and zener.

I use additive checking (analog. to Ref. 4): harmonics of the 500kh$_z$ xtal plus or minus low band. This allows me to get within a few cycles after checking the xtal against WWV.

I paid $15 for the junked BC221 & case, and am very pleased with the final result. Just about any calibration book will give approximate results, and exact calibrations can be made by hand merely by spending some time; considering the difference in price between units with and without a book, that time is worth a bit of money!

Using the module method it should be possible to reproduce the original calibration exactly; if you do this, let us know how it works. In any event, with plug-in units you can always return to the original valve setup, with no damage done.

By the way, does anyone have an out-of order 16mm Sound Projector? The mechanical and audio condition is immaterial, but it must be optically complete and must have negligible value for its owner -- hi.

REFERENCES: (RLG)

A number of articles have appeared describing various uses and conversions of these frequency meters. A few of them are presented here, with brief discussion of contents -- for you who complain that our Reference Lists are useless.

1) 73, 1/62: "Hand Calibrating the BC-221 and LM Frequency Meters" by C. Henry. Simply use a 100khz calibrator with a 10kc multivibrator and interpolate to 1khz using a receiver to measure via harmonics;(for even greater accuracy, use a 1khz multivibrator!) By the way, the Navy version of the BC221 is the LM and is similar, but allows the amplifier to oscillate to modulate the oscillator at 500 h$_z$ if desired; earlier models also had a low frequency range of 195-400kh$_z$ insteaad of 125-250kh$_z$.

2) 73, 6/64: "Regulated Supply for the LM" by R. Arthur. The usual HT using OA2 & OB2; the BC221 batteries were 135V, but up to 255V ok on the LM, suitably switched. If you keep the original valve system a few 1W HT zeners could be used in place of the VR valves if mains voltage variations are not extreme.

3) QST, 12/64 (Also reprinted in Amateur Radio 9/65, p.7): "Extending the Range of the BC221 Frequency Meter" by A. K. Robinson, W6PM. You can work the freq meter at harmonics of the fundamental fairly easily, but absolute error increases as you go up. With a maximum

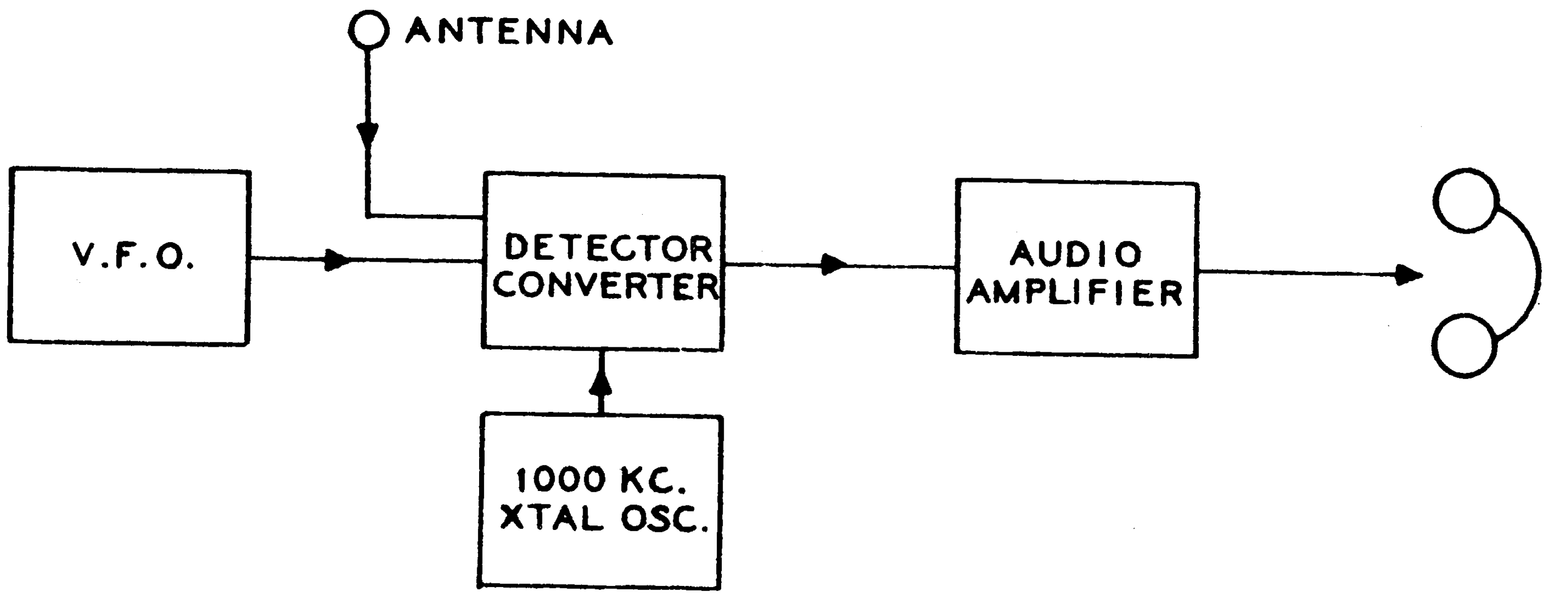
(CONTINUED ON PAGE 158)

Each BC-221 unit contains an individually calibrated book, MC-177, permanently attached to the front panel cover.

(b) Principles of Operation

The BC-221 is a heterodyne type of frequency meter employing a 1000 kc. crystal oscillator which furnishes 1000 kc. check points for the variable frequency oscillator. Manual tuning of the variable frequency oscillator is brought out on the control panel with its associated dials.

Two calibration ranges are provided, the 125-250 kc. range and the 2000-4000 kc. range. By use of the 2nd, 4th, and 8th harmonics, the low frequency range covers 250 to 2000 kc. By use of the 2nd, 4th, and 5th harmonics, the high frequency range covers 4000 to 20,000 kc.



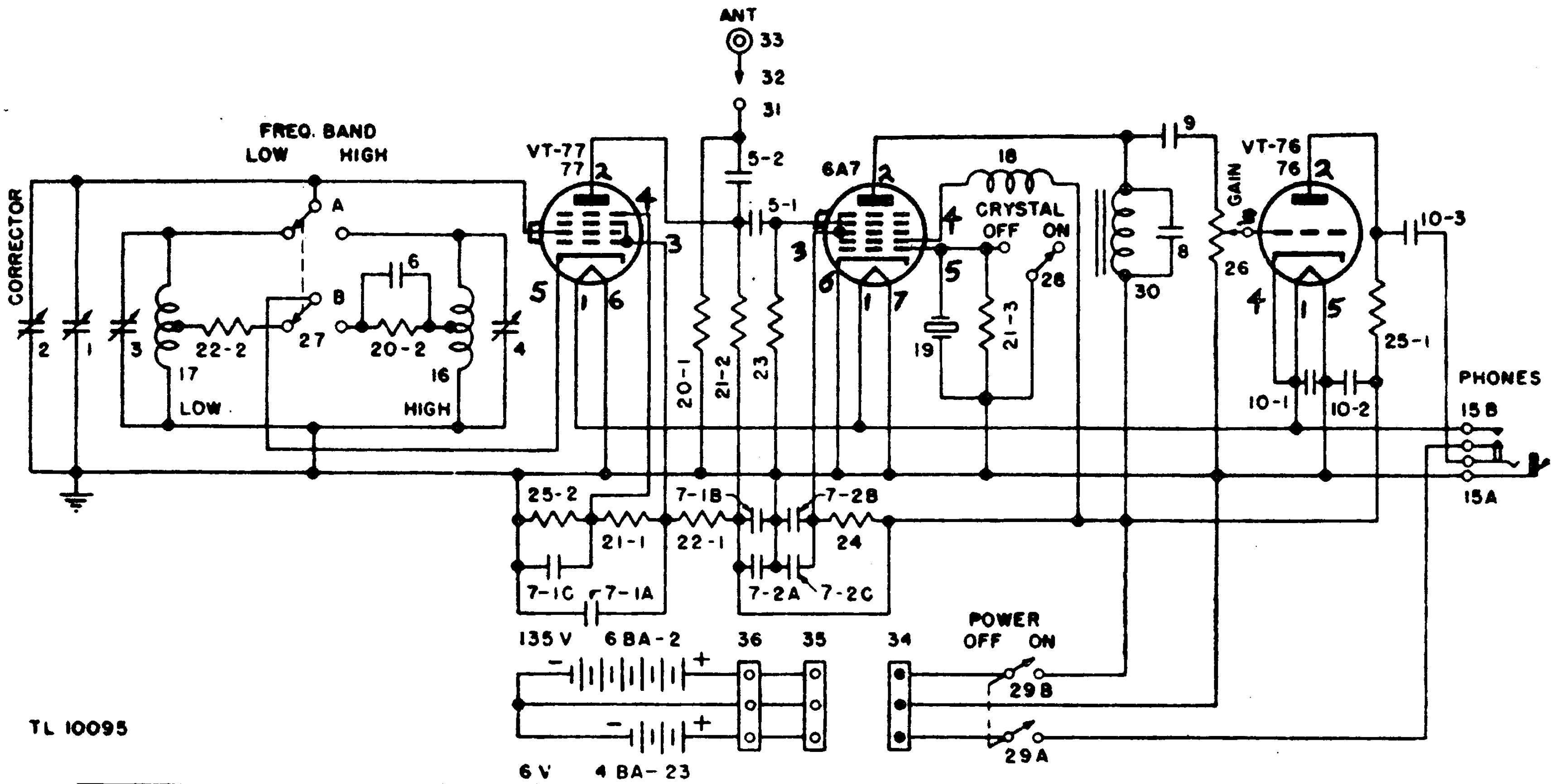
With reference to the block diagram of the BC-221, the output of the v.f.o. is heterodyned with the incoming signal from the antenna. After detection the beat frequency is amplified by the audio amplifier and its output connected to headphones.

When the beat frequency reaches the audible range it is heard in the headphones and the final tuning adjustment is made with the v.f.o. to produce a "zero-beat". This indicates the incoming frequency and the dial reading is taken.

The above description of operation refers to an incoming signal such as checking a transmitter. Since the BC-221 also radiates its v.f.o. signal, receiver calibration and checks are made similarly by the "zero-beat" method as heard in the receiver output.

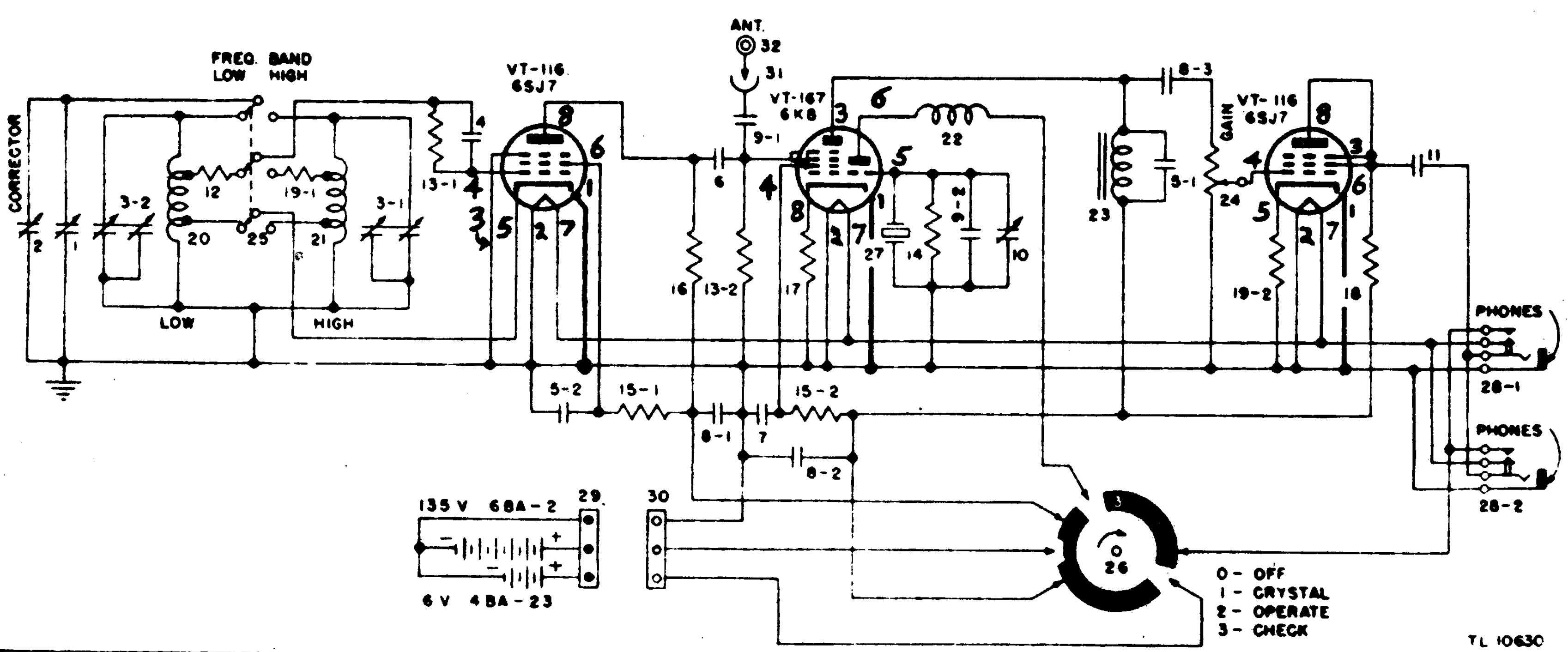
From the following factors: mechanical shocks, locking action of dial, warming up, change of load at antenna, 10 per cent change in battery voltage, error in calibration, and error in crystal frequency, the maximum error should not exceed .034 per cent at 4000 kc. Normally the errors tend to cancel each other so that the normal error should not exceed .02 per cent.

ORIGINAL CIRCUITS:



REF	DESCRIPTION	REF	DESCRIPTION	REF	DESCRIPTION	REF	DESCRIPTION	REF	DESCRIPTION
1	150 μμf	7-1C	0.1 μf	15B	FIL. SWITCH	23	1 MEGOHM	31	ANT. PLUG
2	2 μμf	7-2A	0.1 μf	16	HIGH FREQ. COIL	24	30,000 OHM	32	CONTACT SPRING
3	10 μμf	7-2B	0.1 μf	17	LOW FREQ. COIL	25-1&2	15,000 OHM	33	BINDING POST
4	10 μμf	7-2C	0.1 μf	18	1.7 MILLIHY	26	0.5 MEGOHM	34	POWER PLUGS
5-1&2	10 μμf	8	0.001 μf	19	CRYSTAL	27	SWITCH	35	POWER JACKS
6	250 μμf	9	0.02 μf	20-1&2	5,000 OHM	28	SWITCH	36	BATTERY TERM
7-1A	0.1 μf	10-1,2,3	0.5 μf	21-1,2,3	50,000 OHM	29	SWITCH		
7-1B	0.1 μf	15A	JACK	22-1&2	10,000 OHM	30	450 HENRYS		

FIG 1 Frequency Meters BC-221-C and BC-221-D, schematic diagram



REF	DESCRIPTION	REF	DESCRIPTION	REF	DESCRIPTION	REF	DESCRIPTION	REF	DESCRIPTION
1	220 μμf	8-1 2 3	0.05 μf	15-1&2	8,750 OHM	22	735 MICROHY	29	POWER PLUGS
2	1 μμf	• 9-1&2	12 μμf	16	50,000 OHM	23	300 HENRYS	30	POWER JACKS
3-1&2	25+4 μμf	10	12 μμf	17	75 OHM	24	1 MEGOHM	31	ANT. CLIP
4	100 μμf	11	2 μf	18	12,500 OHM	[illegible]	SWITCH	32	BINDING POST
5-1&2	0.002 μf	12	4,500 OHM	19-1&2	350 OHM	[illegible]	SWITCH		
6	50 μμf	13-1&2	150,000 OHM	20	6.5 MILLIHY	27	CRYSTAL		
7	0.001 μf	14	1 MEGOHM	21	25 MICROHY	28 1&2	JACKS		

• REF NO 9-2 IS 6 μμf

FIG 2 Frequency Meter BC-221-Q, schematic diagram

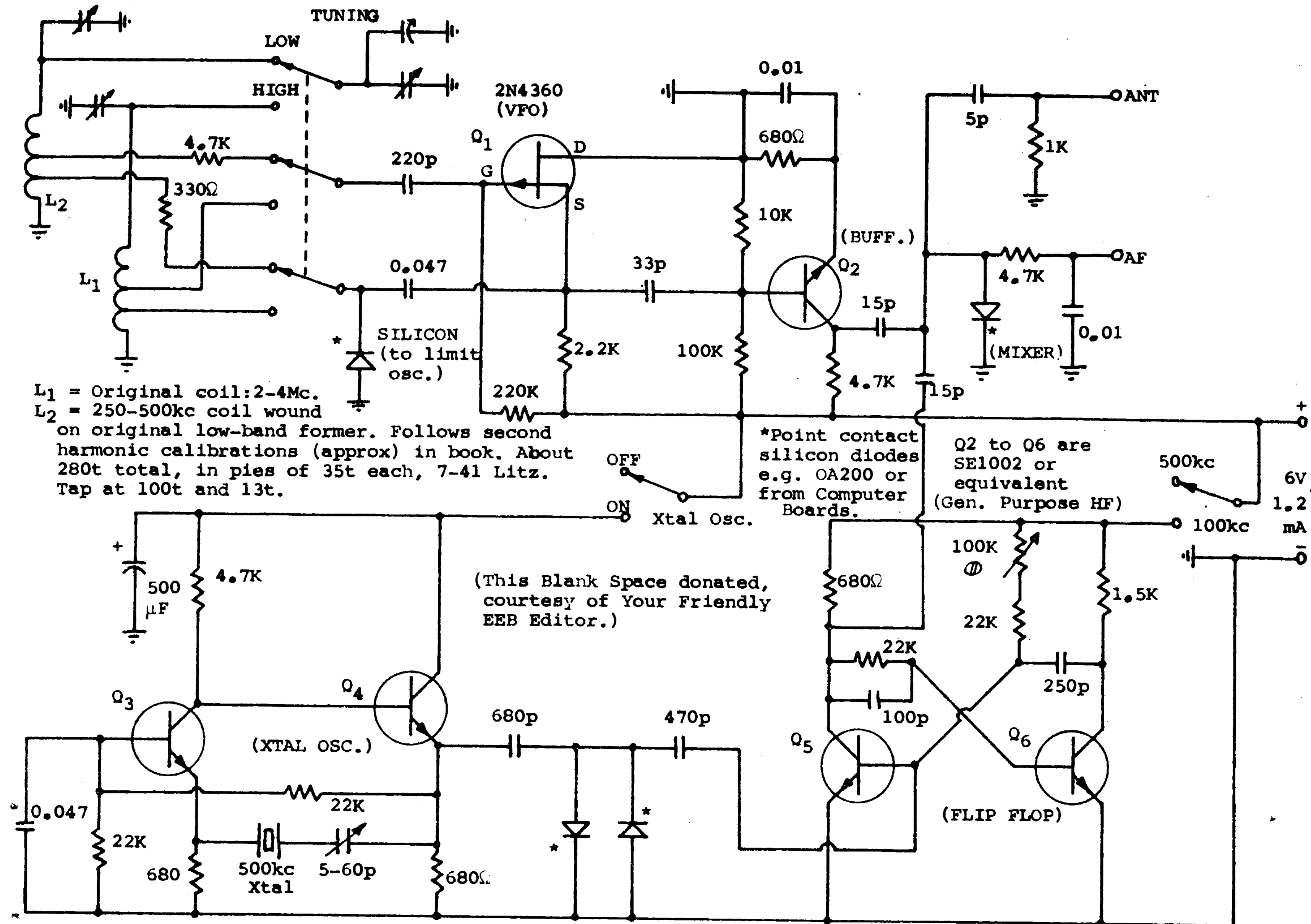


FIG. 3 (ABOVE): THE COMPLETE CONVERSION. SEE TEXT BEFORE DESTROYING YOUR BC221 (or LM) !!!!!!

(Modules are mounted on valve sockets; letters refer to corresponding valve elements which are being replaced)

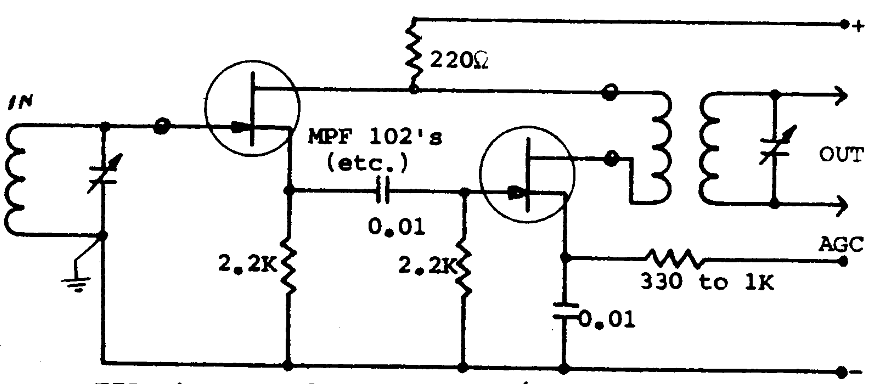


FIG. 4: Typical R.F. Module (For source-controlled AGC see EEB Aug 1969, p. 85; also "Deluxe Receiver Gain Control" by R. Jayarman, 73, Sept 1970, p. 56.)

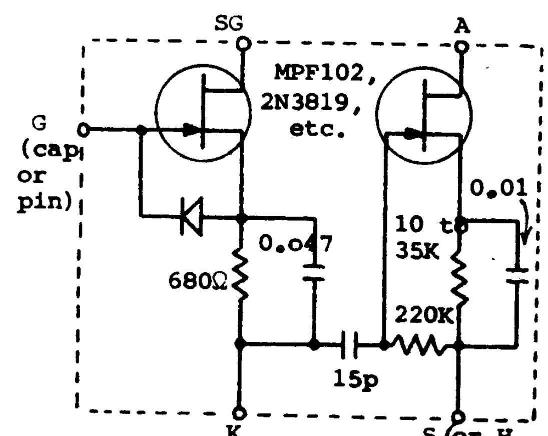


FIG 5: OSCILLATOR MODULE

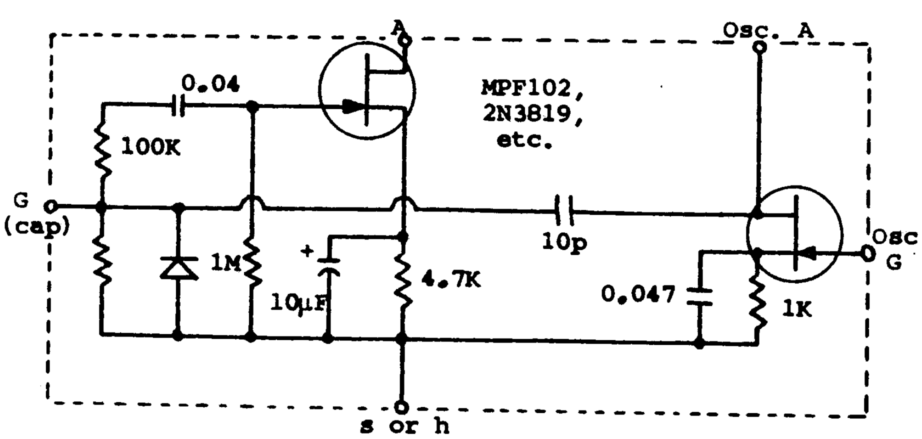


FIG. 6: MIXER MODULE ("S or H" pin to earth)

For the Audio Module (at right), connection "K" goes to the cathode pin if the cathode of that particular model goes to a resistor. If the cathode goes to the heater instead, the "K" connection is not used, and the extra 470Ω resistor must be used instead, for obvious reasons. The earth connection is taken from any suitable pin.

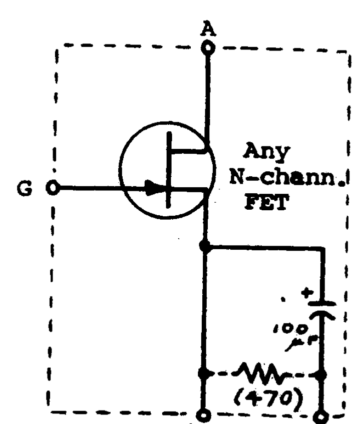


FIG. 7: AUDIO MODULE

accuracy of 0.01% it gives an error of 20kh$_z$ at 200Mh$_z$. This can be improved vastly simply by heterodyning the freq meter with a standard HF or VHF oscillator and receiving on a receiver. See also Ref. 8, here.

Mixing can be done in an outboard unit, or in the frequency meter's own detector, but the former is more versatile.

4) QST, 9/65: "Frequency Measurement with the LM/BC221" by KN Sapp, W4AWY. General techniques of using these freq meters, mostly in my opinion a matter of commonsense. Obviously one must not feed in too much r.f.; if an external signal is too weak, couple both to a receiver and adjust the freq meter to give about the same strength of signal.

It is possible to use the internal 1kh$_z$ xtal osc as a heterodyne signal to increase the range, as in Ref 3 here (but an external osc is more versatile for range). An output attenuator can be added if not already provided. The following sources of error exist:

1) Thermal Drift. No problem with FETs; with valves, leave meter on continuously during the day of operations.

2) Voltage changes: regulate (If valves, it helps to regulate heater voltages too. This article suggests a mains voltage regulator, but a much simpler arrangement is merely back to back zeners of suitable voltage, and a bit of series resistance. Even better: a small, regulated d.c. LT supply).

3) Dial Backlash: Lubricate worm & gear with good (non-gumming) light oil. Remove capacitor compartment cover and lubricate the two halves of the spring-loaded gear.

4) Nonlinearity. With age, L or C can change, resulting in scale errors. Author suggests cure is "to have a check point as close as possible to the frequency to be measured", but an obviously better answer is to figure out (by commonsense, of course) what was the change which caused the error, and then introduce L or C to regain calibration linearity. Note that one source of aging trouble may be the spacing of the tuning capacitor plates, but this should be left quite alone unless all other methods fail.

Just how bad can scale nonlinearities (i.e. disagreemnt with Calibration Book) be? Rod says he hasn't been worried by it, Andy of Auto-Call says he has had troubles, and I don't care. So you please yourself.

5) CQ: "Improved LM Accuracy" by G. E. Hopper, W1MEG. Details on using the 1kh$_z$ calibrator as internal heterodyne source, mixed in detector. But this still only gives a maximum range of 4000 + 1000kh$_z$ on fundamentals. The author uses only the low frequency range for greatest accuracy, but the harmonics situation can be frightfully confusing, in my opinion.

6) Surplus Radio Conversion Manual, by R.C. Everson & O.R. Beach., Vol 1 (Sams): p.5 "SCR-211 Frequency Meter Set (BC-221)". In addition to the excerpt here, they point out that high Z headphones should be used. An output meter, suitably matched, can be used for visual observation of zero beat. Ref.1 also describes a simple "tuning eye" for the same purpose.

7) Ditto, Vol II, p. 108: "The Model LM Frequency Meter". Details about just how each model differs. Circuit similar to BC221D but audio stage can make 500h$_z$ osc to modulate oscillator (!) at about 40% (lessee are we still calling %,percent? Yes, but any day now it could be more logically called the Reynolds; why not the Gunther?)

8) EEB ("Easily Execrated Bourgeoisie"), 4/70, p. 60: "A Crystal Checker and Frequency Calibrator for VHF" by I. N. Kallam (obviously none of our readers know any Arabic). Instead of beating the frequency meter with a standard signal to receive on a receiver, here we beat the transmitter with the standard signal and receive on the freq meter. More accurate, and could conceivably be used as a cunning heterodyne method for any signal if suitably preamplified. My transmitter looks pretty beaten too. Forlorn too, while I beat at this silly typewriter instead of doing something sensible.

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

AROUND THE AIRWAVES -- J. Coote (G3UGT); 10/11/70
and: J. Van Staveren (VK7JV); 1/12/70*

LOCATION	STATION	FREQ	TIME (Z)
Dahomey	TY7ATF	21240	1200
(QSL K3RLY)		28520	1400
Gambia	ZD3D	14170	16-1700
(Daily. F9RM prepares list for skeds, nxt day)			
Germany	DA1QP	14332	(New prefix for military stations, i.e. amateurs/serv.)
Jan Mayen	JX8Y	28022	1150
(Has now returned to the island)			
Jordan (Hussein)	JY1*	20M	1800-2200
	JY1B	14332	1915 (YL Net)
Manahiki	ZK1MA	14195	0730
(QSL via KH6GLU. Works to list prepared by Pat, ZM4NH, on the same frequency)			
Mariana Islands	KG6S	Active again	
(QSL Box 342)	KG6SF	14203	1145
Marion Island	ZS2MI	21277	1600 (ZS2PX/QSL)
Mauritius	3B8CW	14332	2045 (YL Net)
	3B8CR	21277	1600 (Also on 7075 and 14180 around 1400Z. Always willing to QSY to 80M if conditions good on 40M too.*)
Naru	C21GB	14160+	MonTueThurs
(Times 0730-1100. Dick has FT200 to dipole)			
	C21AA*	14170	1200 (Bob)
New Caledonia	FK8AH	21052	1245
	FK8AS	14010	0745
Portuguese Guinea	CR3KD	14030	2100-2200
Reunion	FR7AG	21220	1700
(QSL B.P. 819, St. Denis, Reunion)			
S. Orkneys	VP8JV	14195	2300
		14180	0030
(QSL P.O. Box 137, Port Stanley, Falkland Is.)			
S. Shetlands	CE9AN	14083	2100 (Bureau)
Swan Island	WA1ARF/KS4	14300	0600-0900. QSL via WA6MWG)
Tonga Islands	VR5LT	14103	0700
(QSL P.O. Box 49, Nuku Alofa, Tonga, Or VK6WT)			
(QSL VK1RY):	VR5RY*	14170	1200
Tromelin	FR7ZO/T	14030	(Length of stay not known. QSL FR7ZO, Reunion)
Yemin	LA8YB/4W	14332=	2000 (YL Net)

((EEB Readers: Do you appreciate these lists?--Ed)

BOOKS FOR BEGINNERS [AND OTHERS !]: A Reviewlette -- RLG

For some time I have been disturbed by the apparent lack of adequate books for beginners in electronic theory. I say "apparent", because they certainly do exist, but for some reason it seems to be difficult for beginners to find out about them. We have had several pleas for this kind of information, so it seems evident that we have some "beginners" out there even though we manage so skillfully to obscure Ohm's Law by words. From my own observations it is also evident that many people who regard themselves reasonably competent, e.g. by virtue of holding a Radio Amateur Licence, may have some slight room for knowledge, particularly with reference to the field of semiconductors.

Here are a few titles I gleaned from a visit to Melbourne, and from scanning some of the international Literature. I plan one day to put it all together in a series of Reviews of basic material, but with the EEB backlog as it is, that will take a while. A Bird in the Hand is seldom wrong:

1] "Outline of Radio and Television" by J. Pat Hawker [Newnes, Stg 30/-]. Readers will surely recall the name of Pat Hawker, G3VA, in relation to the fascinating series of "Technical Topics" in Radio Communication magazine, "A Guide to Amateur Radio" [1969 EEB, p. 67] which takes the present book one step further, and "Amateur Radio Techniques" [1968 EEB, p. 107] which puts the frosting on the cake, and which without any question should be on the bookshelves of every English-reading radio amateur in the world [The Third Edition is now out, and we have ordered some for you to be sold at a low price, probably available in March; see Feb EEB].

It was, therefore, with considerable anticipation that I examined this book on radio fundamentals. Pat Hawker has indeed continued to live up to past performance, and the book is well worth reading, although American readers will not find it quite as readable as the Yank publications with more breezy style. Our only regret is that the last third of this book is taken up with Television which [except for some basic general principles] does not apply to Australian, New Zealand, or American conditions -- Ref. EEB, Aug. 1970, p. 124. The rest of the book is, however, definitely worth reading, and the price is reasonable if ordered abroad. If you are willing to wait a few months, order from Blackwells Ltd, Broad St., Oxford, England, sending 30/- [obtain from your Bank] plus 4/3 for post... Incidentally, note the 45c they require to post a book weighing over 1 lb, compared to our 70c; so much for the claims of the A.P.O. [see p. 161 here].

2] "Electrical Fundamentals for Technicians" by R. L. Schrader [Mc Graw-Hill, $US 12, approx]. This book is done in the somewhat more informal American style, and is a masterpiece for coverage of fundamental a.c. & d.c. theory. To quote from Rod's forthcoming Review, the book covers "fundamental reasons behind a series circuit, right through to the design of complex classical filters, and it does this without resorting to Mathematics more complicated than plane Trigonometry, including vectors -- and even these are explained fully". With this good foundation of electrical and electronic fundamentals you can then get the radio theory relatively easily from a variety of well-known sources -- e.g. Handbooks. The purchase price is a big lump, but the blow can be softened by sending directly to America, as outlined in the October 1969 EEB [FAA Bookstore]. They will, however, charge only $US10.05 [$A9.05] for this book, and with about $US1.50 for post, it comes to significantly less than the inflated Australian price [ask for any refund in postal stamps, & we'll buy them].

3]"Basic Theory and Application of Transistors" [U.S. Govt Printing Office, about $US2.20 incl. post] is a bit dated, but still very good for fundamental germanium transistor theory. 4]"Basic Radio Course" by Electronics Australia is quite good for superficial but practical coverage; the Third Edition is now available [How about that promised Comparison Review, Peter?]. Note too that periodical issues of E.A. often feature good coverage of basic theory subjects -- and much else too!
5] The U.S. Government "Selected Semiconductor Circuits Handbook" has somewhat dated, but still very good, circuits, and good intermediate-level theory coverage. Incidentally, many of these U.S. Government books are now available published by Dover [U.S.] for quite reasonable prices, even in Australia [e.g. $A2.25 for Item 3, from Tech. Book Co. in Melbourne], and also include the excellent Basic Electricity [for $A3.90] and Basic Electronics [$A3.25, all plus Post, of course].
6] "Electronics for Young Experimenters" by W. E. Pearce [G. Bell & soms, London]. Superficial but well presented and laid out, and only $A2.50. 7] "Radio" by D. Gibson [Brockhampton Press, Leicester, U.K.] only $A1.80, but only 88 pages. Full of coloured photos and pictures; superficial but good. As for No. 6, includes several built-it-yourself projects. 8]a: "Electronics Made Simple", b: "Electricity Made simple", c: "Electronic Computers". [See also Electronics Australia's "An Introduction to Digital Electronics; see E.A. Dec. 1970, p. 40]. A trilogy of books on a Radio Handbook level, by H. Jacobwitz [W. H. Allen, London; $A1.45, 1.80, and 1.45, respectively. Assumes only preliminary knowledge of elementary electricity, essentially non-mathematical. 9] "Electronics for Scientists" by Malmstadt, Enke, & Toren [Benjamin, U.S.]. Comprehensive and very good, on an <u>intermediate</u> level, with many illustrative practical circuits. Our copy belongs to our Laboratory, so I don't know the price, but with 620 pgs probably over $10, but well worth it for the serious experimenter.
10] "Electronics in Industry" by G. M. Chute [Mc Graw-Hill]. Intermediate, many practical applications of circuits not always covered in the usual Handbooks. Probably about $9 in Australia, less Abroad.
-- "Have you bred any good rooks lately?" [VK6 Bulletin]

==

<u>EDITORIAL</u> -- RLG

"No -- you cannot love someone if you simply detest him." -- G. Mikes

[[Please note the error of page number on the Contents listing, p. 153 here....]

<u>Quotes without</u> [much] <u>Comment</u> [[Relevant to our Subs rate increase!]]

"Another businessman in Melbourne said every one who received a letter or wrote a letter knew the service was collapsing. It has been well said that any nation which can stand the burden of a socialised mail service has remarkable reserves of strength. It is a tribute to the flexibility and resourcefulness of the Australian community that it has carried the burden so long..." ["On Target", Apr 11, 1969, p.44]
"As announced by the Postmaster-General on 18th August, 1970, it is proposed that higher postage rates will apply to registered newspapers and periodicals from 1st October, 1970... In the last financial year, the Postal Service incurred an estimated loss of $19 million, about half of it due to the concessional bulk rates on registered newspapers and periodicals. It is considered necessary, therefore, to continue the action

taken in recent years to reduce the extent of the concession..." -- Letter to EEB, from L. E. Coulter, for Director of Posts and Telegraphs, Postmaster-General's Department.

[[EEB has at hand an article from the APO News for October 1970, in which is explained at some length the various justifications proposed for the increased postal rates, particularly for bulk material. They quote a drastically increased wage structure, increased general costs, and a drastic increase in demand for new telephones. And a big increase in necessary capital investment. Among other things it is claimed that postal rates in Australia compare favourably with those in other countries [save for minor details, it seems, as pointed out here on p. 159], and figures are given showing that the U.S., British, and Canadian Post Offices have run big deficits. It is stated that only Australia and the U.S.A. still provide a domestic bulk rate for newspapers and periodicals, which produces a large loss in revenue. And here we can't help but quote: "The concessions in postage granted in this area represent, in effect, a substantial subsidy to the publishing and printing industry and to many organisations ranging from religious, charitable and welfare organisations to social and recreational clubs". The Australian P.O. is appalled by the idea of facilitating the dissemination of worthwhile printed information -- and it may be noted that this prejudice extends to BOOKS, which must now be sent at the same postal rates as Scrap Metal...]]

"Mr. Hulme blames wage rises for the expected loss and says next financial year it could amount to $50 million. What he did not say was that, in fact, the department is not losing money at all, but that the Government is using it as a secret means of taxation. The secret lies in the accounting system the Government adopted some years ago. Under this the department is charged interest and amortisation on money borrowed for capital works. This year the charge will be more than $90 million <u>and is rising steadily</u> [[EEB emphasis]]. But this 'loan money' is, in reality, only a book entry... [details]; a nice example of robbing a reluctant Peter to pay a non-existent Paul. If the Government cared to tell the truth, the PMG Department, far from showing a $5,000,000 loss, will make something like an $85 million profit. It is time to bring a little common sense into this underhand form of taxation which falls indiscriminately on everyone." -- From Editorial in the <u>Hobart Mercury</u>, March 11, 1970 [[Indiscriminately? See EEB, Aug, p. 131]].

"Australia should follow Britain's lead, and run its post office as a business corporation and not as a Government department. All sections of the Australian community are being crippled by charges for post office services. The post office has an absolute monopoly on all the services it provides, but those services are getting worse every year. It is a scandal and a tragedy that a country, just on two centuries old, should be forced to put up with such a hopeless mess of low grade services, offered without competition at fantastic charges... Britain recently turned its own post office into a corporation to be run on business lines. Australia will never make any lasting progress until the same is done in our Post Office." -- J. Bowden, Federal Director of the Australian Association of National Advertisers. News Conference reported in the <u>Hobart Mercury</u>, March 16, 1970. And not only Britain; I hear that the American Post Office is now about to undergo such a matamorphosis too; now that the Yanks are at it, Australia will follow as a Matter of Course, no??

<u>Electronics Australia</u>, etc.

That worthy magazine is planning to introduce early [cont. p.164 --]

ADVERTISING

[See p. 144, Oct.]

This Page: Personal ↗ - , Commercial = 20c/line or 80c per vertical inch. We guarantee nothing..............

SPECIALS FROM: KIT-SETS AUST.

MAIL ORDER DEPT: P.O. BOX 176, DEE WHY, 2099, N.S.W.

POSTAGE: 15c per order, unless specified otherwise.

SPEAKERS: Rola C8MX De-Luxe, 8 ohm, twin cone, 8W RMS. $8.70 + $1.00 post.
Rola 5FX tweeter, 5" twin cone, 8 ohm, 15W RMS. $4.90 + $1.00 post.
Rola 12PX wide range, twin cone, 8 or 15 ohm, 15W RMS, 12". $18.00 + $1.00

SOLDERING IRONS:
Miniscope: $5.85 + 45c post. Scope De-Luxe: $6.95 + 45c post.
A & R Tranformer to suit $6.80 + 50c post.

RESISTORS: All carbon film, 5% tolerance.
1/2W. 4c each or $3.00 per 100 mixed to your selection.
1/4W. 4c each or $3.00 per 100 mixed to your selection.
1W. 7c each or $5.50 per 100 mixed to your selection.

POWER SUPPLY KIT: Comprises of 1 multi-tapped transformer (6.3V, 7.5V, 8.5V, 9.5V, 12.6V, 15V.)rated at fully 1AMP continous current, a bridge rectifier, a 2,200uF/25V electrolytic capacitor & instructions. $6.35 + 50c post.

3W RMS AMP KIT: Based on the E.A. 3 + 3 amplifier, the circuit employs AC187/188 in output. 8 ohm output impedance. 18V operation. Complete kit including P.C. board $5.95 + 30c post. Stereo version $11.85 + 40c post.

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STEREO HEADPHONES: Hi-Fi type, 8 ohms. Can handle 400mW. Freqency response 25-15Kc/s A good general purpose set. Price $5.90 (post 35c)

To all our clients we wish a Merry Christmas & all the best for 71'
From, Garry, Bill, Gary, Bob, Joy & Sue at 'Kit-Sets'

WANTED: PRACTICAL ELECTRONICS, February 1969. Ivan Bird, 153 Pacific Drive, Port Macquarie, N.S.W. 2444. [[Ed. Note: If you don't want to sell, perhaps loan to Mr. Bird?]]

BRAND 5 RECORDING TAPE AT DISCOUNT PRICES!:

1800' on 7" reel 1 mil mylar base $3.99; 2400' on 7" reel 0.5 mil mylar $4.75; 2400' on 7" reel 0.5 mil tensil mylar $5.25; 1800' on 5¾" reel 0.5 mil mylar $3.75; 900' on 5" reel 1 mil mylar $2.25; 1200' on 5" reel 0.5 mil mylar $2.50; 1200' on 5" reel 0.5 mil tens. mylar $2.75.

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WEIGHT PER REEL: 7" = 18 oz; 5¾" = 11 oz; 5" = 8 oz; 3" = 3 oz; Cassettes = 3 oz. — Please send sufficient postage according to the new exorbitant rates; any excess will be refunded.

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COMING: CLAYBRIDGE, THE SIGN OF PRESTIGE SOUND! Watch for it.

[HAM] RADIO MAGAZINE, Back Issues Grab Bag, all available 1968 & 1969 Back issues, 12 in all, only $A4.50, postpaid. You'd be a nit to dip out on this offer, since HR back issues are becoming scarcer all the time. Forward Issues: $A9.00 for 3 years, new or renewal. Write EEB.
For modulated light in particular, see HR June & Nov 1970. It's all very exciting.

CQ MAGAZINE, new offer, now through EEB: The Magazine @ $A4.50 per year; any Cowan Publication book [published by CQ] advertised in CQ, is now also available via eeb [I mean, EEB!] at a substantial discount: Deduct 20% from the advertised price [post free], and send us the net amount in Australian dollars [P.O. preferred; add 5c if cheque]. Admitted this is only about 11% discount if you take into account the difference between $A and $US, but we can't do better if we are to meet costs. It might be lower if we stocked the books, but that is not practical, so you'll have to wait N months to receive them. But it is well worth it; we have all the CQ books, and they are very good, though generally more for valves than transistors. But their stuff on antennas is particularly good, and that goes for the Mag. too. Write EEB.
And their Editor is a gentleman.

Also of course, "VHF Communications"

Elsewhere in this issue we echo the plaintive call, "Where have all the experimenters gone?", and I have reason to ponder it when I try to get someone to give a technical talk for the VK7 Wireless Institute Meeting; I happen to be the Lecture Officer. But there does seem to be a class of electronics enthusiast with true amateur spirit left: the VHF boys. [If this angers any HF people, we expect to hear from them with good technical evidence in rebuttal] Their activities seem to reflect the fact that there remains considerable scope for individual enterprise in this field where commercialism has not [yet] made [such] inroads. Two of many possible examples of this can be seen in the activities of the VK6 group, as reported in their Bulletin, and in the work of the VK5 gang, likewise reported in their WIA Bulletin, am amazing publication, and it is only a pity that all that good kind of work does not receive wider publicity; I hope the rumour is true that the technical efforts of the various Divisions will soon be incorporated in AR. Abroad, of course there is the oft-mentioned [in these pages] Spectrum [P.O. Box 5268, Auckland, N.Z., $1.50/yr]. It continues to report the VHF activities of that country with high standards of amateur and technological competence. We don't have room to review its many fine features here, but if you like EEB you'll probably like Spectrum even more. If I were you, I'd include an extra $1.50 to order all available Back Issues, particularly for 1970. If Carl Drumeller's treatment of commonsense transmission line matching intrigues you, you'll want particularly to see Spectrum's "SWR 1:1 -- Fact or Fiction?" in the October 1970 issue....

Again our apologies for not yet presenting Rod's C.D. Tach, and Vierietz's commonsense Power Supply discussion, but we are having considerable problems with space, and it doesn't help that this issue replaces an offset page by a Blotter one to help [slightly] to defray the extra cost fo the shocking postal bill we are suffering between the October Fiasco and our subs increase in February: a solid extra $15 per month or so. That may not sound like much, but it sure adds up.

So why do I spend so much precious space on RLG? Well, perhaps because EEB is something of a family affair, and I have the presumption to assume that the things that interest me also interest you. Reader comment about Editorials seems to support this. And the response to last month's Edit. on Irreverent Miscellany and Subs Increase was gratifying, though I do detect a malicious desire to keep me hunched over this stupid typewriter indefinitely even though I insult you and your Government and raise prices out of reach... Its all very heartening in a way, but what about the 9.0 to 9.5 people out of 10.0 who do not respond to our Promotional Samples and Information? Silence, dead quiet, -220db. They help to keep me from becoming overconfident. Anyone have any good ideas about effective Promotion? We have tried everything obvious.... Tell yer friends?

Plans for 1971 [Wot, already?]

I hope a lot of you renew in December & January if you like our general approach. Because EEB started at the beginning of a year, a vast number of renewals fall due now. We might also mention that eventually we do get around to covering quite a wide variety of topics, though they do seem to run in groups. Ordinarily we try to pack the end-of-year issues with some unusual articles to entice you, but it hasn't worked out too well this time. We have been a bit topheavy with CD Ignitions and Power Supplies, but so what? And Rod's Tacho had to wait on Carl D's commonsense tuning, which really is of fundamental importance, and well in accord with EEB philosophy of presenting not-always-obvious commonsnse. I thought we had a beaut for this month or next, in Peter Ward's constructional details of a Fuel-Mixture Analyser, but it is being improved by Rod, who is building a version of it for his own Roadmonster..... In promotional material I had promised our article on Relative Communication Effectiveness, which is most significant, with some surprises, but first I have to extract from Dick Ferris some practical circuits which can accompany it; at present Dick is using the school holidays to review the 18th Edition of Bill Orr's Radio Handbook, which we have finally obtained. In the same vein we have forthcoming a marvelous group of articles on communication efficiency and radical types of speech compression methods, but first I shall have to get some stuff transcribed from a tape and get it set up roughly for the author to work up..... In our files already we have a number of articles virtually ready [with hard work by me to put them in printable form!] on a number of subjects, including a Sythe-stone Heavy-duty Zener, some unusual C/S OTL Amplifier designs, some tentative ideas [maybe] on using PWM for tape recording -- or anyhow, why not to, an improved S-meter, Automotive Dwell-angle readout, Indoor antenna efficiency dissected, Pi-network shortcuts, Electroluminescent lamp, One-tube double-conversion superheterodyne [April], 10W 2M Tr Tx, High performance Tr Rx, The Real Oil on Avalanche Diodes, Model Train Track conversion, Simplified circuit-boarding, Receiver detector efficiency dissected, Power supply efficiency fictions, and a great pile of articles on a variety of subjects by Yelland, Pitcher, and Maddever. And many more, some of them by me, of length too great for EEB, and hopefully to be worked over for publication Elsewhere, time permitting. Any many Reviews for EEB, and a mountain of good Letters! Oh my, how to do it all in 18 pages per issue?

I am particularly anxious to include a number of good letters we have received, but I generally have waited to squeeze them into a convenient spot. The spots have been few, even in mice-type; maybe I'll devote a good share of the February issue to them. This is certain to antagonise some people, but if we print things that interest us we have learned that it works well; if you try to please everyone, nothing gets done.

An Appreciation

Rod Reynolds has been immensely helpful to me on a wide variety of activities involving EEB, and I am most grateful. He has been responsible for upgrading certain standards, and sometimes keeps me from saying excessively inadept technological statements, though I don't consult him on everything [or practically nothing might get printed!]. And he has been particularly useful in facilitating EEB-production methods. I think I mentioned that when we were unable to find a good full-plate copy camera, he built us a high quality unit; that's no joke. If you don't believe, try it yourself sometime. Recently [for the past half dozen issues] I have been working hard to make the photographs more even, and in the process have learned quite a lot about the vagaries of high-contrast techniques; the number of problems one can encounter are unbelievable. I have now got it about as good as possible with the present equipment, but Rod says that exposure lattitude can be improved if we obtain a better lens; the one we are now using is over 100 years old. It is high quality, but modern techniques have made better units available. He will find one someplace at a reasonable price, and the monthly Headache of photography will finally become more manageable... Recently he has been rebuilding our address print-out machine. We switched over from Addressograph to Bradma, for Reasons, and it would cost the earth to buy a new printer. He has recently got a lathe, and is now able to do first-rate machine work. Very nice. Thanks, Rod.

A C-D IGNITION WITH AUTOMATIC CHANGEOVER -- T. Vieritz (VK4)

-- An experimental approach

This capacitative-discharge automobile ignition system is much like the others which have appeared in recent literature, but is noteworthy for some interesting experimental work, and for an automatic changeover system which switches back to the conventional ignition in event of something going wrong. The two points are related: the changeover system facilitated some experimental testing in the field. It may be noted that this experimental work was done a few years ago, before the present upsurge in interest in CDI.

Experimental Steps:

1) Breadboard, driving a loudspeaker transformer as the "coil". To my surprise it worked! If I separated the leads on the HT side of the xfr, it would flash over inside. But:

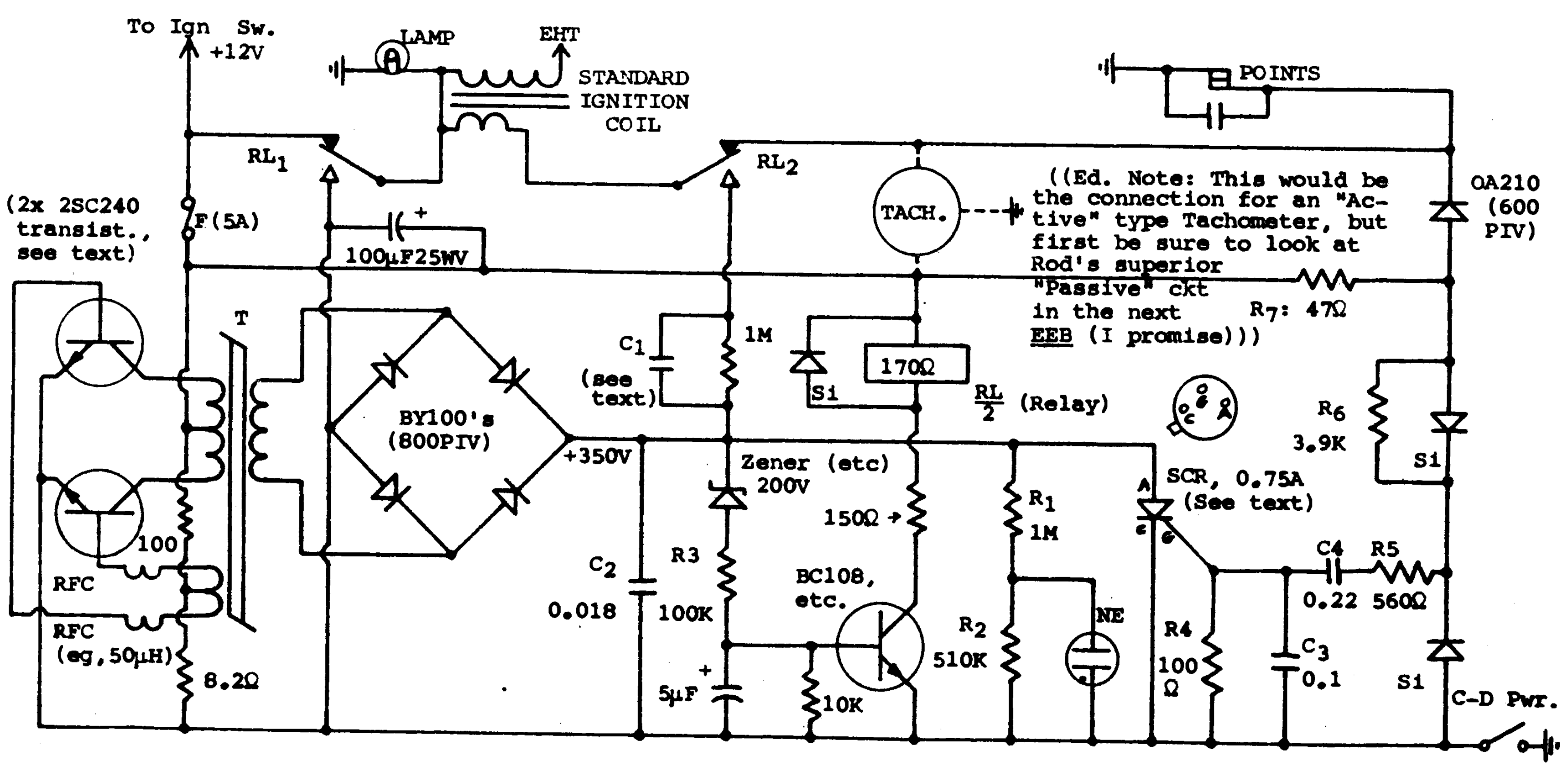
2) The Converter would not always start reliably, using the 2SC240 transistors. A CRO showed that when the Converter stopped oscillating at the usual low frequency (when loaded), it would oscillate at a supersonic one! The trouble was obviously caused by the good high frequency response of these 5 amp silicon transistors. It was cured by inserting a small RF choke in each base lead.

3) Germanium low frequency 2N250 power transistors were then tried in the Converter. In addition to giving no parasitic trouble, they could be bolted directly to the car body (as heat sink) without need for a mica washer.

4) The automatic changeover was added, because this system has more parts than a conventional one, and more things to go wrong. If the HT falls below about 200 V, the relay system is deenergised (therefore fail-safe), the coil is switched back to conventional ignition, and the neon lamp goes out, and lamp goes on.

((RLG Comment: The system does depend on having a zener with a couple of hundred volts rating. If you don't have one, it is usually not difficult to test your junkbox diode stock (particularly in the "100V" range of commercial ratings) to find a silicon unit which has a reasonably sharp reverse characteristic (out to a few hundred µA), and in this case both the shape and voltage of the diode reverse voltage curve are quite uncritical.))

((RAJR Comment: A small neon lamp makes quite a good HT zener! The small NE51 will develop about 75 V each, and you need only about 100µA to bring them to full voltage. But much better would be a changeover system which took its signal from the pulse output of the whole CDI system. The pulses would be in-



integrated by a simple RC network and fed to the control transistor. This would be quite simple. Not so simple would be the problem of initial starting on CDI. Initially (to be fail-safe) the CDI would be off, and the relay would be switched to conventional system. The relay, therefore the CDI would not be energised until CDI pulses were available, but these couldn't be obtained until the relay was on! This problem could be met by various solutions, but would take some thinking-over.))

5) This system got its first workout when I drove off one day and noticed a brief miss in the engine, and the neon lamp went out and other lamp went on. The system changed over rapidly to conventional ignition. At home I found the fuse blown, and one transistor shorted. Perhaps the high voltage spikes of the oscillator system exceeded its voltage ratings. So, to avoid buying another transistor I went back to the silicon setup, resigned to the mica washers (with silicone grease); they have the advantage, anyhow, of working better at high temperatures.

6) Again, one day on the same (eventful) journey, the ignition failed, but the relay didn't change over automatically; in such cases it can be useful to have a dashboard relay-disabling switch. (on diagram = "C-D Pwr") The cause was a shorted condenser (C_1), one of the few faults which won't cause a complete changeover -- it will, however, cause the relay to chatter.

At the time I was using two 0.47μF 400V polyester condensers in parallel, (C_1) one of which failed presumably for reasons discussed by RAJR in August 1970. Not knowing this at the time, I replaced the faulty unit, and a few days later the other one shorted!

So I installed four 0.22μF 1000 V plastic condensers in parallel. This worked fine, perhaps showing that a higher voltage rating will allow even a modest condenser to perform in this circuit? Its a useful idea.

((RAJR Comment: The reason the plastic unit worked better is that it is a better capacitor than the polyester. But the whole point of using a high quality capacitor, as discussed in my August article, is that an ordinary capacitor has considerable inbuilt inductance; it can be of the same order of magnitude as that of the primary of the ignition coil! This can give losses of the order of 30% or more. A special capacitor, therefore, is not only more reliable, but also more efficient, giving more HT output.))

7) The transformer I am using is out of a VHF Mobile radio, and capable of an unloaded output in excess of 500 V. Under normal operating conditions the HT was below 400 V, and I was using an SCR with V_{BO} of 530V. It had a 10 A rating.

Things went well again until one day while experimenting with it, I increased the output voltage from my power supply to about 15 V, and the HT in the CD unit rose to the breakover voltage of the SCR, which fired a few times and then shorted.

((RLG note: An SCR shouldn't short from being forced to break-over in the forward direction. Normal operation is, in fact, the control by the gate of the forward breakover voltage. One might think that in a d.c. system like this, there couldn't be any reverse voltage to speak of, but in fact the primary of the ignition coil can provide plenty of it by "inductive kick". Rod says that in automotive ignition applications, the SCR must have the same PIV rating (at least) as forward breakover rating; it is evident that this was not the case in the disposals SCR used in this instance, culpa mea.))

So now I required another SCR. I wasn't able to obtain another 10 Amp disposals one of sufficient voltage rating, so RLG urged me to try a 0.75A 400V one and see what happened. I tried it, inserting a series resistor (R_5) in the gate circuit to reduce gate dissipation, and to my amazement it worked, and has been working for the last 5000 miles -- covering sometimes up to 300 miles a day under hot conditions. The car (EK Holden sedan) didn't miss a beat. So, it looks as though SCR current requirements are considerably less stringent than has been supposed.

((RAJR Note: Late model SCRs use the same chip as larger "rated" ones, but a smaller case. Therefore the peak current rating may be adequate, and that is what matters in this instance. But it won't work for the older varieties.))

8) At first I had a 100Ω resistor for R_7 feeding the points. During the winter I sometimes had trouble with hard starting in the morning, although it would start immediately on conventional ignition. I thought possibly I wasn't hitting the gate of the SCR (the 10A one) hard enough, so I reduced the value to 47Ω. However, I'm not sure if this cured the trouble as the weather began to get warmer then. When I put the 0.75A SCR in, I inserted a 560Ω resistor in series with the gate circuit (R_5) and got fine results.

((RAJR comment: Mr. Vieritz has the right idea, but for the wrong reason. When starting, battery voltage goes down, and so does trigger voltage; under a marginal SCR gate voltage sensitivity condition this could cause the trouble described. The cure is to increase the value of the coupling capacitor leading to the gate, and/or use an SCR having lower gate power requirements. The 0.75 A SCR probably fulfilled this requirement... The 100Ω value of R_7 was undoubtedly quite adequate; the main consequence of lowering it would be to increase the current through the points; to a certain extent this is desirable as "wiping" current to keep them clean, but that current ought not to exceed more than about 500mA, or excessive contact pitting could result.))

9) The OA210 (600PIV silicon) isolates the gate circuit from voltage spikes on the points when on conventional ignition, as I didn't have another set of contacts on the relay. When the HT is above 200 V the zener diode (Z) conducts and switches on the BC108, which operates the relay. The small neon lamp lights at about 200V, as an indication of presence of HT. Current drain is less than 1.0A. SCR current is less than 8.0A peak at 14V supply.

10) ((RLG Note: The article in the November 1970 issue of Electronics Australia makes very interesting reading for CDI users. It cautions against the indiscriminate application of beefed-up HT (voltage), and shows that under certain circumstances this can have dire consequences for the motor! Though Rod tells me that this is more of a problem for the big Road Monsters than for small ones. In any event the ignition system should be meticulously clean at all times, and should have good separation (or even shielding) between HT leads. As G. Van Leuven pointed out in his Vol I EEB article on T.I., this is an occupational hazard of CDI's, and perhaps says something in favour of ordinary Tr. Igns.))

11) ((NEXT MONTH (probably): A Squaretable on some more aspects of CD Igns.))

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WHERE HAVE ALL THE EXPERIMENTERS GONE?
-- SEDUCED BY SALES TALK EVERY ONE!

((Concerning the R.S.G.B. Exhibition, QSP West Australian VHF Bulletin, November 1970))

This heading introduced a rather interesting article in the October issue of "Wireless World". The article reported and commented upon this well-known annual event, and a few passages are worth repeating here.

Here's what the man said:

"... There were only seven entries from the whole amateur radio fraternity for the home constructed equipment competition held at the recent R.S.G.B. Exhibition. A lamentable turnout.

"Is it true that the ham ((sic)) of today does no more than gossip on the air while twiddling the spun aluminium knobs and peering at the gleaming Perspex dials of a shiny piece of commercially constructed equipment? If so, the frequency bands allocated to amateurs are being wasted, and should be re-allocated to a more deserving cause.

"Today's home constructor has never had it so good. He can obtain at reasonable prices sophisticated components which were not even available to industry a few years ago. Is it that today's amateur does not want to risk his money on experiment? Or are the days for trial and error design over?" ((See EEB p. 150-151!))

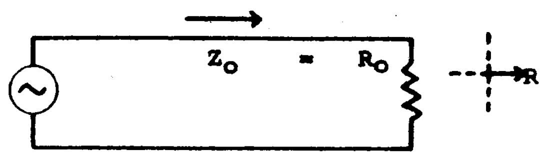
After a brief description of the prize-winning items, one of which was pictured, the author then reported:-

"This year the John Rouse Trophy was not awarded, as there was not a single entry from the under-16 age group, a necessary qualification for this Award."

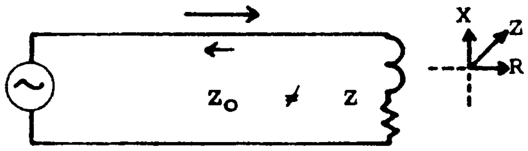
The article concluded with a few comments about the attendance and various other displays at the Exhibition. Even though the trend away from 'home brew' has been apparent in years past, the situation depicted by these comments came as something of a shock, particularly in regard to the youngsters.

Perhaps we should race ahead and organise a Colonial Exhibition before civilisation overtakes us too!

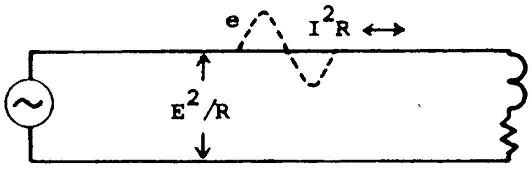
COMMONSENSE TRANSMITTER LOADING -- C. C. Drumeller, W5JJ



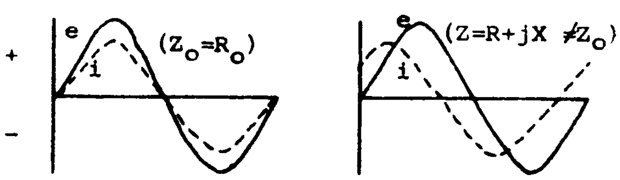
Transmission lines serve to transport r.f. power from a generator to a load. When the load is nonreactive and of a value that matches the characteristic impedance of the transmission line, all r.f. power transmitted (assuming a lossless line) is dissipated by the load.



If the load contains a reactive element, this element cannot absorb power; therefore some of the transmitted power is reflected. Or: when a resistive load is of a nonmatched impedance, not all power is absorbed, and some of it is reflected.

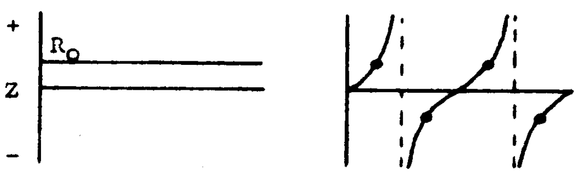


In either case, voltage standing waves are set up on the transmission line. These cause a very small increase in line losses, by concentration of current (the I^2R, or copper losses), or by concentration of high-voltage points (the E^2/R, or dielectric losses).

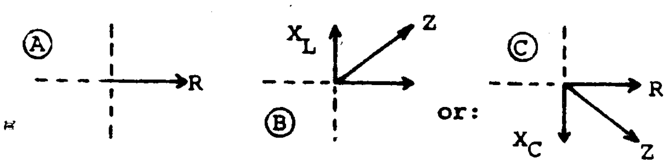


(X-axis = distance from load)

Also, an attendant effect is to cause the transmission line to appear to be reactive (rather than resistive) at all points other than at half-wave or quarter-wave points back from the load. ((Asst. Ed. Note: This is strictly true only when measured back from a resistive load; for reactive, the first distance is not necessarily $\lambda/4$))



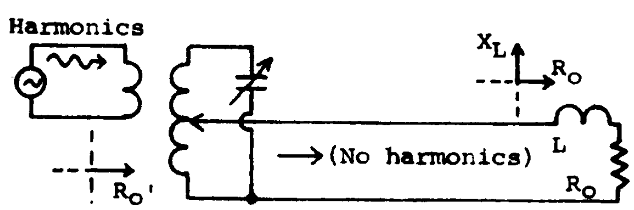
(At the dotted points, $Z = R_o$ every $\lambda/4$ except the first interval, which is $< \lambda/4$ for inductive, and $> \lambda/4$ for capacitative load)



A Transmitter, then, except by pure chance, will look into a composite (or complex) load.

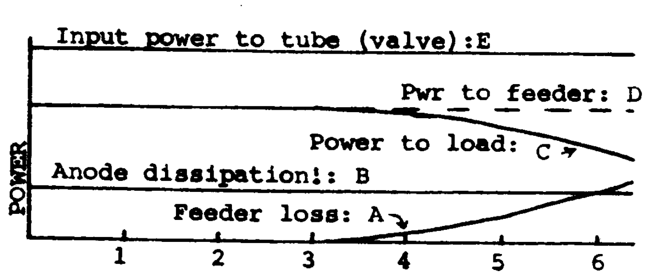
A = pure chance (resistive load)

B or C = likely chance (reactive + resistive load).



To cope with this condition, a well-designed transmitter has a coupling device between the transmission line and the r.f. generator. This device serves the double purpose of discriminating against undesired frequencies developed by the generator, and of transliterating the complex impedance of the transmission line into a purely resistive value equal to the amount needed by the r.f. generator.

As long as the impedance matching network has translated the (probably) reactive impedance at the "sending end" of the transmission line, to the optimum <u>resistance</u> demanded by the r.f. generator, that generator sits there happy as a lark, pumping out r.f. at the same efficiency as though the line presented 52 purely resistive ohms. The anode dissipation remains constant, and so does the tube.



VSWR of a long line (Tx kept tuned and loaded)

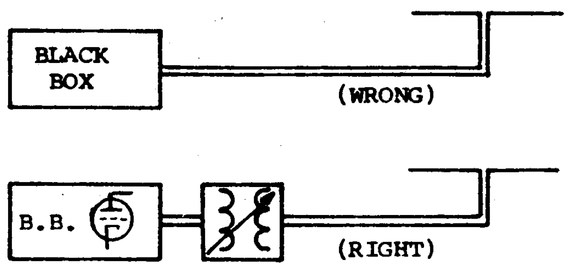
Final Valve Efficiency = (D/(B+D)) x 100%

Overall efficiency = (C/E) x 100%

<u>Result</u>: Careful measurements made under controlled conditions show that the amount of r.f. power delivered to a power-consuming (resistive) load remains <u>unchanged</u> when the VSWR is changed from 1:1 to 4:1, AND when the transmitter is retuned and reloaded to show the same amount of d.c. input power. The plate dissipation of the power amplifier tube remains unchanged too. No tank coils burn up, no condensers flash over IN A WELL-DESIGNED CIRCUIT. No tubes pop off in any circuits. And power delivered is unaffected by reasonable lengths of transmission lines.

((Continued, p. 171))

Rumours to the contrary were invented by inadept persons attempting to provide an alibi to cover their own lack of ability to retune a transmitter quickly. ((Ed. Note: In the articles mentioned below, he also points out that the versatility of tank circuits in Commercial Amateur equipment is also subject to cost-cutting limitations. An outboard antenna coupler, of course, solves all problems -- and gives added harmonic rejection as well.))



Contrary to popular impression, the signal generator is not the Black Box containing the transmitter. It isn't. The generator is the B.B. containing the tube or transistor or arc or Alexanderson Alternator, or whatever it is that converts d.c. into r.f. And It doesn't give a royal whoop about what lives on the feedlines -- as long as they look good, viz., resistive to it.

This material has been presented in more detail elsewhere:
"Effect of Mismatched Transmitter Loads", Ham Radio, Sept. 1969, p. 60. And
"The Mismatched rf Transmission Line", 73, Nov. 1969, p. 28.

((Next month, RAJR will continue the discussion on this theme.))((Or thereafter; we must print his CD Tach!))

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A POLICY CONCERNING MANUSCRIPTS --RLG

The list of articles available, and enumerated in the December Editorial had to be truncated because of lack of space, but there are many more embracing a wide variety of subjects (so you'll renew, won't you, please?). Now this is all very heartening, and a welcome contrast to our early days when much midnight oil was burned priming the pump, as it were. The pump now promises to become a wildcat gusher and is beginning to pose a first class headache.

Aside from the worry about where I'm going to print all that, there is implied a prodigious amount of work needed for me to put the articles in publishable form. I do enjoy doing this, because its creative, and I've learned quite a lot of electronics in the process, but I'm running out of time, and a compromise must now be made. Therefore, the following policies will now take effect concerning articles to be submitted for publication in this magazine:

1) Manuscripts should be typewritten if possible, double-spaced, with 1" margins, on foolscap-size paper.

2) If Manuscripts are handwritten they must be written clearly enough that they can be read easily by a typiste to whom all of this stuff is pure gibberish (hi). And they should also be double-spaced.

3) Figures should be included on separate pages and should be referred to by number in the text. Under each figure should be a title describing briefly what it means, for those vile souls who thumb through the magazine only to look at the pretty pictures. Figures must be drawn spaciously, with all parts and their values indicated quite clearly, but need not be as pretty as you see in the finished article.

4) This point is surely the most important of the lot: Please give some thought to the composition of the manuscript. Prepare more than one draft before submitting, and on the final one label main subject headings as you see them in typical EEB articles. State initially what you are going to say, say it with commonsense observations if possible and with all operating parameters shown explicitly; and close with a statement summarising what you have found (or think, etc), for those vile people who only have time to read conclusions.

In other words, I want you to do some editing for me, and preferably better and more concisely than I have done; if you'll look over the wordy treatments in past issues you'll realise that this standard ought not to be difficult to improve. Unlike the big commercial magazines we do not encourage padding, rather we emphasize that we have limited space. Be as explicit as you like, but remember that you don't get paid for words. Minor articles (whatever the length) get 6 months subscription (or resubscription) credit, major ones a year. We haven't yet decided what to do about those creative individuals who send a good article every month or two. We wish we could reward them properly, but at present we can only think of conferring honourary Editorships upon them -- or in rare instances, life membership (so to speak); my life, not yours!

5) You are welcome to continue to send chatty letters and comments on life; we devour them lustily, but they are more likely to see print if they are typed, well organised, and concise. Above all, do continue to contribute all manner of informal comments with your renewals; this is always interesting to us, and frequently useful.

If all the above creates the impression that things are becoming more formal and less spontaneous, I'm sorry, but at the present rate of travel I'll tumble informally from my bicycle one windy day after a hard bout of editing, and who would be crazy enough to take my place, umm?

There are to be no exceptions to the above strictures ((except for Kallam & Yelland, whom we need more than they need us!)) hi

Appetite & Sleep Restorer: Place three eggs in a jar, and cover with juice of six lemons. Let stand for four days. Strain, and mix with one-half pound of honey and one-half pint of rum. Wash eggs, and use shells also. Warm honey first. Take a wineglass daily. In event of insomnia, increase the amount of rum.

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REVIEWS

==

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THE AUSTRALIAN EEB
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AUSTRALIA

<u>NOTE</u>: This is one of two pages of the Annual <u>Index</u>, included here as a sample.

<u>EEB</u> ANNUAL INDEX FOR VOL. 5 (1969), continued. Underline = <u>Constructional</u> article

===

<u>ADVERTS</u> are sent under separate cover to purchasers of Bound Volumes.

Footnotes:

+ See also: "Commonsense Transistor Parameters," in <u>Amateur Radio</u>, January 1970.

++ See also: "Commonsense and Instabilities in Transistorised Transmitters," <u>Amateur Radio</u>, February 1970.

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January: p. 1-14

A Coaxial Line Feeder Dilemma: Balanced vs. Unbalanced Feeder Lines. This one article has provoked a remarkable response, and many interesting discussions have resulted.
Transistorised Transmitter Design, Part VII: Practical stability design factors.
+Tr. Transmitter: 2W, 6M.
+Tr. Transmitter: 200mW, 6M.
Diode Protection of Meter Movements.
Aluminium building channel for heat sinks.
Review: Radio Data Reference Book (RSGB).
CW Aid for the Blind.

February: p. 15-30

Ant. Dilemma explained lucidly.
+Tr. Transmitter, 1W, 80M, Histab. VFO.
+Hybrid Mobile Tx, QRP to QRO.
+SSB Exciter (Tr. Version of 3/68 EEB)
Review: Tr. Tx for the Radio Amateur
Thermistors & Temperature Measurements.
Receivers: Uses of Preamplifiers.
Improving Tx Intelligiblity, again.
+The Square Wave Xtal Osc with an I.C. (Plus several non-I.C. references)
The uses of Progress

April: p. 31-48

Review: RSGB Radio Handbook
How I almost Invented the Transistor
+Two linear r.f. Sweep Generators (Tr)
+Tr. Reactance Modulator for NBFM
Simulated Dual-Gate FETs: An EEB Special.
Improving Receiver Front Ends (cont):
-- Typical Ideal Design: The Hydrus.

July (continued)

Tr. Transmitters: Efficiency problems.
+Soldering Iron Heat Control.
Unstable High Stability Resistors: An EEB Special Research Probject, of value.
Discrete components vs. Integrated Circuits.
+Regulated Power Supply.

August: P. 79-94

+Electronic Organs, II: Tone Generators.
+Simple well-regulated Power Supply.
+Light-operated Headlight Dip Switch (Tr)
Linearity in Bipolar Transistors.
+FET conversion of an HRO Receiver.
Antenna Gain, Fact or Fiction?
Effortless Cross Modulation: Pre-receiver rectification.
The uses of Baluns and SWR Meters.
Effect of wire size on Antenna Q.
FET Mixers: Tetrodes vs. Dual Gates.
Criticism answered (?)
Useless circuits in the Electronics Literature (even in EEB?)

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Compleat Periodicals of the Worlde.
Advantages of Narrow Band FM over SSB!
Whither EEB?
+ The Receiver Signal Slicer: An EEB Extra.

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Impossible Puzzles!
Current Literature comments.
+A 13W Series-modulated Transist. Transmit.
+A 2M/6M Antenna Di-plexer.
+Tuna Fish Can R.F. Bridge Voltmeter.

Thermistors & Temperature Measurements.
Receivers: Uses of Preamplifiers.
Improving Tx Intelligiblity, again.
+The Square Wave Xtal Osc with an I.C.
(Plus several non-I.C. references)
The uses of Progress

<u>April</u>: p. 31-48
Review: RSGB Radio Handbook
How I almost Invented the Transistor
+Two linear r.f. Sweep Generators (Tr)
+Tr. Reactance Modulator for NBFM
Simulated Dual-Gate FETs: An EEB Special.
Improving Receiver Front Ends (cont):
-- Typical Ideal Design: The Hydrus.
Ant. Dilemma: Equivalent Circuits
How to ensure reliability of posted items.
Hypodermics as Test Prods.

<u>June</u>: p. 49-62
+The Electronic Organ, Part I: Layout.
Should Amateurs be "unprincipled idiots"%?
+The Super Wormturner: An EEB special.
Improved 2M Halo Antenna
+A 50Mc Transmitting Converter (Tr.)
Unwinding the Antenna Dilemma?
Improved Rx and Tx Design Considerations.

<u>July</u>: p. 63-78
Criticism: we guarantee nothing
(See also August p. 92)
Transistors vs. valves.
Review: 1969 ARRL Handbook.
Are Radio Amateurs Human?? A deep article.
Review: A Guide to Amateur Radio
Integrated Circuits, pro and con.
FET and valve mixer performance, theory.
(Practical?) Digital Clocks.

Criticism answered (?)
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+LCF NOMOGRAM
In Adverts: Sources of cheap Overseas Books.
Triac Lamp Dimmer.

<u>December</u>: p. 127-146
Statutes of Man; a Christmas Thought.
+Electronic Organ Design, III:
The Schober Tone Generator, pro & con.
+An effective solid-state Antenna TR Switch.
+A 1-W High Performance Tr. Transceiver.
+A 100W AF Amplifier with low Standing Current (for P.A. Work).
The use of Ceramic Filters for FM.
+The Full-wave Tripler Myth; practical design.
That Shorted Bus Bar (October's Puzzle)
Improved FM Discriminator Design.
Correct Design with FET Tetrodes
Transformer Design Controversy.
Unquotable comments! Very useful.
Limitations of PUJTs, etc.
SPECIAL Awards for <u>EEB</u>. Wow, extraordinary.
<u>EVERY ISSUE</u>: Adverts & Spicy Editorials.

BOUND VOLUME IV (1968): $A2.25, postpaid. ($US2.75 or equiv. foreign)
-- Abbreviated list of contents:

"PRACTICAL" ARTICLES; Most designs are transistorised:

- Automotive regulators.
- Battery charger using SCR.
- Dummy Load; r.f. output measurement systems.
- Light-triggered flash using SCR.
- Meter shunt design.
- Modulated Light communication (see also Feb. 1970)
- Printed circuits by photography.
- R.f. Amplifier using 2N4250.
- R.f. Q-multipliers.
- Sine Wave multivibrator.
- Square wave crystal oscillator & frequency calibrator.
- Squelch for valve receivers.
- SSB Exciter, simple and practical, transistorised of course.
- Touch-keyer with SCR.
- 18W transistorised transmitter.

TECHNICAL DISCUSSIONS, a typical sample:

- "Appliance Operators," dissected.
- Hints on importing equipment
- Improving Receiver Front Ends: Eleven articles on r.f. and mixer stage action, compromises between signal/noise and cross-modulation, the role of FETs, exalted carrier reception (more on this in 1970), selectivity considerations, etc. Also carried over to 1969, 1970.
- Microcircuits, pro & con (several).
- Stable VFO's and receiver oscillators.
- Reviews of several useful and useless books.
- Radio amateur responsibilities (several).
- SCR technical application notes.
- Transients and safety factors in power supplies.
- Transformer leakage, its relationship to transients.
- Transistorised transmitters: four articles on power amplifier design (simply) and performance. Quite practical. Carried over to 1969.
- Virtues of transistors vs. valves.
- Virtues of SSB vs FM (more on this in 1969, 1970).

PLUS the usual assortment of controversial, useful, & useless Editorials.

We obtain a considerable reduction in posting rate of the Bound Volumes (which we pass on to you) when the advertisements are omitted, so we have omitted them. But we still send the adverts -- separately! Most of them tend to be obsolete, but they are interesting; some can give you some useful leads to current merchandise.