*The Editor does not necessarily endorse the opinions expressed by his correspondents*

## Constant-Current Circuits

I HAVE been very fascinated by the constant-current circuits described by G. Watson in his article in the August issue, and by P. Williams in a letter published in the September issue.

The common feature of these circuits is that they are true two-terminal circuits, powered, so-to-speak, by their own constant current. They require no separate d.c. supply lines, and could, indeed, be made, using micro-miniature techniques, as very small sealed components with only two leads.

Whilst Mr. Watson's circuit looks novel and unfamiliar drawn his way, it is interesting to find that his Fig. 1 circuit can alternatively be drawn as in my Fig. A. This shows that the circuit is really a known form of stabilized power supply circuit [1] [2] except for the rather trivial difference that Tr1 collector, in a power supply, would normally be taken to Tr3 collector. When the voltage between terminals 1 and 2 is varied, the stabilizer circuit holds the voltage across points 3 and 4 nearly constant, so that the current taken by $R_1$, $R_5$ and extra load $R_6$ if added, is also nearly constant, thus requiring an almost constant current to be supplied to terminal 1.

The resistor R in Mr. Watson's Fig. 2 applies positive feedback to the "error amplifier," which is a known means of improving the performance supply circuit.

The Fig. 1 circuit in Mr. Williams's letter is most elegant—I feel this must be the simplest and most straightforward solution to the problem. It seems to me rather misleading, however, to regard it as an application of positive feedback; there would seem to be significant positive feedback only during the short time between switching on the supply and the Zener diodes catching. Once the Zener diodes are conducting, it seems to me that the circuit is best regarded simply as a combination of the simple constant-current circuit of Fig. B with a complementary version of the same circuit, the constant current of each circuit being used to energize the Zener diode of the other. The total constant current of the complete circuit is the sum of the constant currents of the individual circuits, which need not necessarily be equal.

Whilst the circuit of Fig. B is quite a good constant-current circuit, it is not perfect because of the effects of collector voltage variation on the ratio of division of emitter current between base and collector, and on the emitter-base voltage. Also, temperature variations affect the current because of their influence on current gain, emitter-base voltage and collector-base leakage current.

A circuit which is almost free from most of these defects is described in detail by E. W. Shallow and myself in a recent issue of the I.E.E. *Electronics Letters* [3], and the essentials are shown here in Fig. C. A differential output resistance of about 50 MΩ is typical when operating at 1 mA. The effect of collector-base capacitance in Tr1, which shunts the output in the Fig. B circuit, is degenerated in the Fig. C circuit, and output capacitance values of well under 1 pF are obtained.

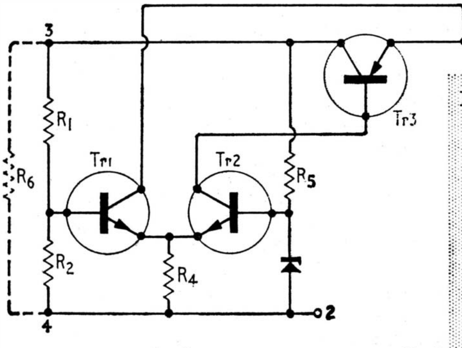


Fig. A

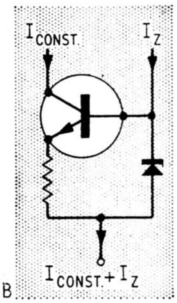


Fig. B

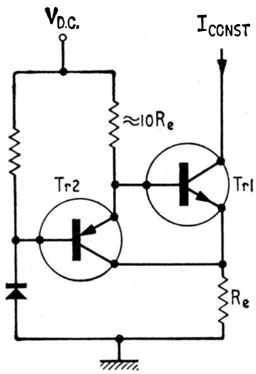


Fig. C

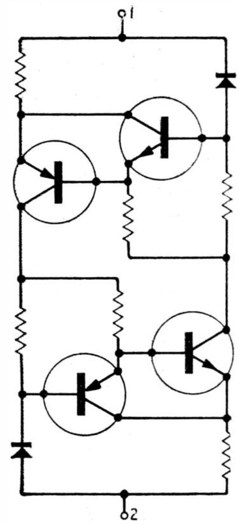


Fig. D

Two circuits of the Fig. C type could be connected together as shown in Fig. D to produce a two-terminal constant-current circuit. Whilst this would give a higher degree of current constancy than Mr. Williams's attractively simple circuit, it has the shortcoming that it would not work with such a low voltage between terminals 1 and 2.

PETER J. BAXANDALL
Royal Radar Establishment,
Malvern, Worcs.

(1) P. J. Baxandall, "Transistor Crystal Oscillators and the Design of a 1-Mc/s Oscillator Capable of Good Frequency Stability," *Radio and Electronic Engineer*, Vol. 29, No. 4, April 1965.
(2) F. J. U. Ritson and R. C. Foss, "Transistor Power Supplies with Limited Overload Current," *Electronic Engineering*, Vol. 34, No. 414, August 1962.
(3) P. J. Baxandall and E. W. Shallow, "Constant-Current Source with Unusually High Internal Resistance and Good Temperature Stability," I.E.E. *Electronics Letters*, Vol. 2, No. 9, p. 351, Sept. 1966.

I WAS interested to read Mr. Watson's lucid account of a simple constant current circuit (August issue p. 403). It may be worth commenting on the versatility of the circuit described: with slightly different external connections, the same circuit is widely used as a voltage

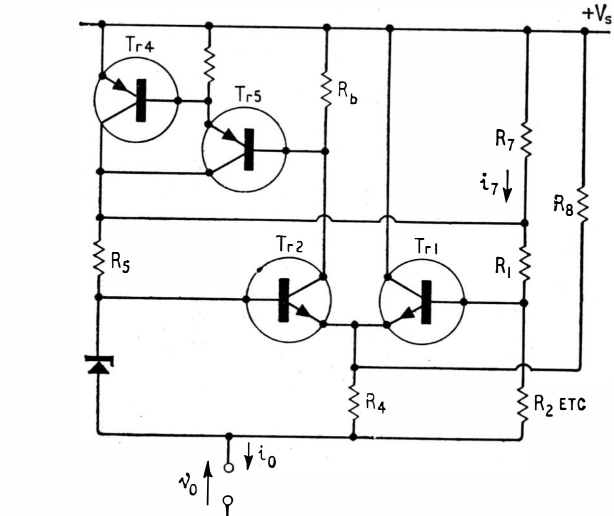


Fig. 1.

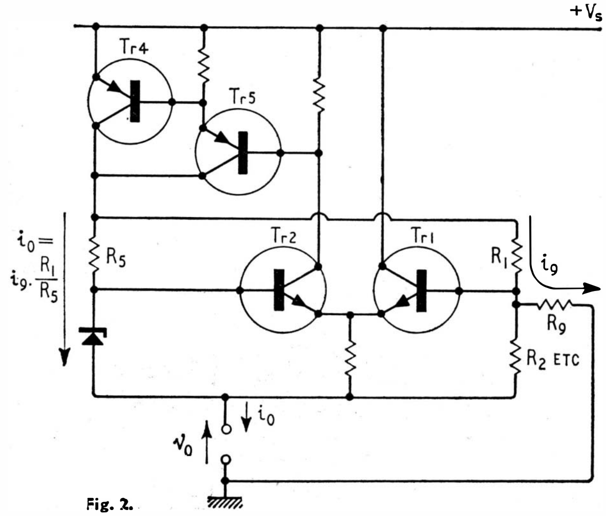


Fig. 2.

regulator, and its use as an impedance converter has also been described (e.g. *Electronics*, May 3rd, 1963; *Electronics Letters*, March, 1965).

I would like to comment briefly on some points of difference between Mr. Watson's circuit and a similar one which I developed some three years ago.

(1) No allowance is made in Mr. Watson's circuit for manufacturing tolerances in $h_{FE}$ of transistor Tr3. Of course Tr3 operates at constant collector current, so that its base current (supplied by Tr2 collector) will vary, from circuit to circuit, over a range which could be 4 : 1 or more. This will result in considerable unbalance between the emitter currents of Tr1 and Tr2 (unless the value of $R_4$ is adjusted individually). It is preferable to replace Tr3 by a Darlington pair Tr4-5 (my Fig. 1), arranging that the base current of Tr5 is fairly small compared with the current in $R_b$. This gives better defined working points, plus some increase in loop gain.

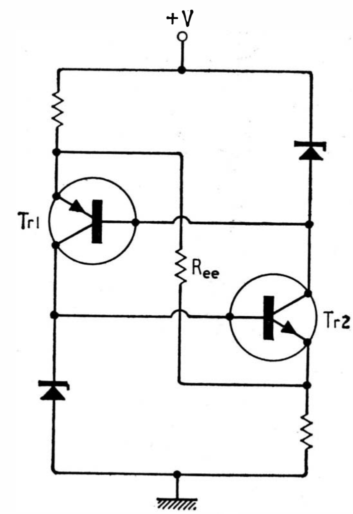
(2) Omission of the base return resistor for Tr3 is undesirable, and the reason given for its omission is not valid. Satisfactory starting of the circuit may be obtained e.g. by using a resistor $R_7$ (see my Fig. 1). This resistor can also help to reduce the dissipation in Tr3 (or Tr4) the current ($i_7$) through $R_7$ will increase as the supply voltage increases, but the output current is held virtually constant by the negative feedback loop, so that, as $i_7$ increases, Tr4 collector current falls. The small unbalance in Tr1-2 demanded by this can be minimized by the addition of $R_8$, which takes current equally from Tr1 and Tr2 as the supply voltage increases.

(3) In my application, the circuit was required to operate as a negative impedance converter, as well as providing a constant bias current. This was achieved by the addition of one resistor ($R_9$, my Fig. 2). The value of negative resistance appearing at the output terminals can be calculated very simply as follows. Application of a small increase of voltage $v$ to the output terminal will raise the potential of Tr2 base, and thus Tr1 base also, by precisely $v$ volts (assuming infinite loop gain). Therefore, a current $i_9 = v/R_9$ must flow through $R_9$, and this current must be drawn entirely from $R_1$ (because the potential across $R_2$ etc. is fixed). The resulting change across $R_1$ appears across the whole bridge, and will result in an increase in output current of $i_0 = i_9 \times \frac{R_1}{R_5}$, so the effective output resistance $-R_n = \frac{v}{i_o} = \frac{R_9 . R_5}{R_1}$. Production versions of this circuit show very satisfactory stability of both $i_o$ and $R_n$.


Farnham, Surrey. JOHN WILLIS


THE elegant complementary transistor current stabilizer which Mr. P. Williams describes in his letter in the September *Wireless World*, p. 456, has an impedance of $Z = r_{c1} || r_{c2} || R_{bb}$, where $R_{bb}$ is the value of the starting resistor between the bases of the two transistors which he states may not normally be needed.

May I offer as an improvement the introduction of a resistance $R_{ee}$ as shown here.




A change of voltage $+\Delta V$ will cause a current change of $+\Delta V/R_{ee}$ to flow through this resistor, but each transistor will then pass this amount less current.

The net effect is that the original voltage change causes a current change of $+\Delta V/R_{ee} - 2\Delta V/R_{ee}$ through the circuit.

The value of $R_{ee}$ can thus be chosen to cancel the effects of $R_{bb}$ and the two $r_c$ terms, or to exceed them and so give a two-terminal negative resistance device.


E.M.I. Ltd., JOHN C. RUDGE
Hayes, Middx.

(*Continued on page* 611)

## Receiving Stereo Broadcasts

THE article "Receiving Stereo Broadcasts" in the September issue reflects a philosophy of extreme caution if not gloom towards the pilot-tone Zenith-G.E. system.

It is noteworthy that a rather similar attitude of near despondency heralded the start of the v.h.f.-f.m. service, when much was written about the "severe" problems of oscillator drift, reliability of v.h.f. receivers, problems of discriminators and so forth.
term "phase linearity" cropped up, being guaranteed to invoke an awesome silence in any argument, since many people don't quite understand what it means.

An academic analysis of the effects of poor a.m. suppression, multipath propagation, and all forms of non-linearity known to man can quickly convince one that the pilot-tone stereo system is quite unworkable. Such an analysis is valuable in promoting a fuller understanding of the system, but can become a liability if it leads to the design of unduly complex decoders designed to accommodate deficiencies in a tuner, which may well not exist in practice.

If a tuner is found to cause signal distortion surely it is more appropriate to correct its design than to employ elaborate circuitry in the decoder.

The waveforms of Fig. 2, which show the pilot carrier at a level of 50% rather than the actual figure of 9%, in context with statements like "the necessity of filtering the 38 kc/s subcarrier by twin-T filters," tend to imply that the simple switching decoders described by G. D. Browne in *Wireless World* are unworkable. Such a conclusion would be totally unjust.

In my own experience, using a tuner some 13 years old, and a loft-mounted dipole aerial, a very simple decoder (See Fig. 3 "Transistor Decoder from FM Stereo Broadcasting" G. D. Browne, *Mullard Technical Communications* Vol. 7, No. 67, December 1963) gives quite adequate results. The cross-talk figure is better than 20 dB, and no background noise is apparent. How about keeping our feet on the ground?

Oxted, Surrey. D. R. BIRT

[Mr. Birt would perhaps have preferred reference to constant time delay to avoid what he considers to be "magic."

We agree with the writer's fourth paragraph.

In connection with his comments on Fig. 2, we would point out that it was stressed in the caption that the vertical axes were not to scale.
have said ". . . *any* necessity. . . ."

It might be emphasized that it does not follow from his last paragraph that all or the majority of tuners will be suitable. Hence the peroration in our reply to Mr. Browne's letter last month.—ED.]

## "High-Performance Transistor Amplifier"

JUDGING from its published performance the amplifier described by Dr. A. R. Bailey in the November issue is quite outstanding and it is of special interest that it should incorporate an interstage transformer, the use of which is rigorously eschewed these days by so many designers.

Dr. Bailey's article, however, does less than justice to many earlier writers who have covered much of the same ground and reached some of the same conclusions. There are no references to such work in the text and one is left to speculate whether he has been influenced by it or not. In an attempt to set the record straight and give credit where it is due, this lette
reference to earlier original work, from which the impartial reader may well conclude that Dr. Bailey's circuit is only one of many which are capable of reaching the desired standard of performance. At the same time I shall comment on a number of design features and principles which may stimulate further discussion.

One of the first people to describe a really high-grade transistor amplifier was A. B. Bereskin[1], using a circuit basically similar to Dr. Bailey's.
sistors available today, the performance might well be indistinguishable.

More recently, R. C. Bowes[2] and P. J. Baxandall[3] have evolved designs which in my view have not been surpassed in excellence and which incorporate features of great technical interest. Though of lower output power than Bailey's design these amplifiers could readily be scaled up to give any desired output.

In 1961 I described a 50-W amplifier[4] which was virtually a doubled-up version of Bailey's model, with four transistors (Texas 2N458) in the output stage and with four secondary windings on the driver transformer. Although the measured distortion figure at full output was 1.3%, the use of high-frequency power transistors would divide this figure by 10.

Soon after publication of this article I received a private communication from C. F. Wheatley and H. M. Kleinman of R.C.A., describing their version of a high-power high-quality amplifier, and a paper on this has since been published.[5]

Coming now to some specific design features of Bailey's amplifier, I am by no means convinced that constant-voltage drive to the output transistors is the best idea. Some work[6] carried out at the General Radio Company, U.S.A., made out a compelling case for constant-current drive. Crossover distortion virtually disappears, zero-bias working is feasible, dangerous over-driving is less likely and so is thermal runaway. One amplifier gave 16 W output with 0.03% distortion.

In the circuit described by R. C. Bowes, there was a transition at one particular frequency from constant-current to constant-voltage drive, this being the best compromise between conflicting requirements. A true constant-voltage drive is not in fact achieved in Bailey's design because of the 5-ohm output-stage base bias resistor, despite the presence of low resistances in the emitter leads. He would find a pronounced rise in distortion if he reduced the value of the 5-ohm resistors (while of course altering the 500-ohm resistors to give the same quiescent current). He uses no means of temperature compensation in the output stage and relies on an unusually large value of emitter resistance to check the high-temperature rise of standing collector current, whereas most other writers make use of diodes in the interests of gain and efficiency.

The diode strings across the driver transformer primary certainly give some protection against overloads

1. A. B. Bereskin, "A High-Power High Quality Transistor Audio Power Amplifier," 1957 I.R.E. National Convention Record, Part 7, Audio Broadcast Transmission Systems.
2. R. C. Bowes, "Transistor Audio Amplifier," *Wireless World*, July 1961, p. 342.
3. P. J. Baxandall (Circuit disclosed and amplifier exhibited at Physical Society Exhibition).
4. F. Butler, "Transistor 50-W Audio Amplifier," *Electronic Engineering*, December 1961, p. 792.
5. C. F. Wheatley and H. M. Kleinman, "An Ultra-Low Distortion Transistorized Power Amplifier," *I.R.E. Transactions on Broadcast and Television Receivers*, June 1961.
6. J. J. Faran and R. G. Fulks, "High Impedance Drive for the Elimination of Crossover Distortion," *Solid State Journal*, August 1961, p. 36.

but not as much as might be expected because of the low output impedance of the driver transistor. A current-source here would have given better protection at the cost of severe inter-modulation distortion. His use of a single fuse seems an obvious and elementary precaution. Here again a better idea would be to use a fuse in each emitter circuit where it could also serve as a resistor.

Neither Bailey's circuit (nor any of the others so far quoted), gives protection against a particularly vicious overload condition, very familiar to users of operational amplifiers. The condition is known as "latch-up." Briefly, in a circuit with strong negative feedback applied from the output to some earlier stage, overload results in a loss of the phase-inverting property of the early amplifiers. The original negative feedback thus becomes positive, with potentially disastrous consequences. A diode, or pair of diodes, across one of the feedback resistors will give complete protection at the price of an appreciable increase of distortion.

Next, I suspect that the core size of the driver transformer is inadequate. His curves show a rapid rise of distortion and drop in gain below 10 c/s. Inspection of the supply decoupling to the first two stages shows a 100-ohm resistor followed by a 500 μ
should give *increasing* gain at the lower frequencies, so that the transformer loss is worse than it appears on paper. I would recommend a core with four times the cross-sectional area which he specifies.

As regards operation into reactive loads, there is a substantial literature on this topic, principally concerning safe operating areas (SOAR) on the $V_c$-$I_c$ transistor characteristic curves. A particularly useful treatment has been given by P. P. Balthasar.[7]

It is difficult to see how the small inductance of coil-wound emitter resistors could possibly account for a rise in distortion at 20 kc/s, though ringing might be noticeable on a square wave. In any event the effect can be compensated by the use of shunt capacitance $C=L/R^2$ (about 2 μ
1 μH).

My final technical point concerns the design of the power transformer. With the particular arrangement chosen it would have been better to use bifilar winding of the halves of the low-voltage secondary.

Dr. Bailey has developed a simple, high-grade and reproducible amplifier of straightforward design and excellent performance, the last due principally to the ready availability of high-frequency power transistors which did not exist when the earlier work was done. Its other design features are not unique. All of them, and more, are to be seen in the circuit due to R. C. Bowes and most of them are incorporated in one or other of the arrangements which I have quoted.

Cheltenham, Glos. F. BUTLER

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7. P. P. Balthasar, "Avoid Power Transistor Failure," *Electronic Design*, 2nd August, 1966, p. 52.

*The author replies:—*

I WAS very interested to read Mr. Butler's letter; the difficulty is in replying to it without taking up too much space. However I will try to deal with his points in order, and be as brief as possible.

First the problem of giving references to work previously done—this was very difficult in view of the large number of articles that have been published on the subject in the past few years. The whole amplifier was in fact developed from "scratch" by working back from the power transistors and looking at each design parameter in turn. There was no intentional copying from any circuit, although it is impossible to design anything without making use of the work of many other people—whether in circuit design or transistor amplifier design. There was certainly no intention whatsoever to detract from previously published work, but on the other hand the circuit was not based on modifications to any particular circuit. If one bases design on a particular circuit, then unless one is extremely careful it is very easy to copy undesirable characteristics as well as the good ones. However I am sure that interested readers will find the list of references given by Mr. Butler a very interesting background to the problem of amplifier design.

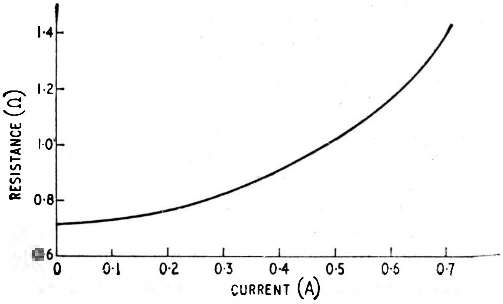


*Fig. 1. Resistance characteristic of 500 mA fuse.*

I am rather perturbed by the statement that the amplifier in reference 4 would have its distortion reduced by a factor of no less than ten times by the mere replacement of its output transistors by more modern h.f. power types. This has not been my experience, and normally a complete redesign is necessary in order to obtain the necessary gain-phase-bandwith characteristics.

Regarding the drive impedance to the output transistors, this was intentionally made relatively low. As I said previously, the amplifier was designed by, what I hoped, was a logical process. The reason for the use of this low drive impedance (about 40 Ω mid-band) was for the following benefits.

1. Reduction of distortion at low frequencies owing to the greatly reduced effect of transformer magnetizing current non-linearities.
2. Effective negative feedback from the emitter resistors of the output stage. This considerably helps h.f. stability and would be lost with constant current drive to the output stage.
3. The emitter follower being direct coupled gives performance down to d.c. and removes the extra d.c. coupling that is otherwise difficult to remove with common emitter circuits.
4. The circuit is cheaper to produce.

Incidentally even with the standing current reduced to 50 mA, crossover distortion is not a problem. The drive impedance is about 40 Ω and not 5 Ω as mentioned by Mr. Butler due to the finite output impedance of the emitter follower driver. The effect of varying the potential divider resistors in the same ratio over quite a wide range has therefore no appreciable effect.

In spite of his previous references Mr. Butler then states that I am being unconventional in my temperature compensation (or lack of it) and the size of my emitter resistors. Again this was done intentionally. The emitter resistors do cause a small loss of output power (about 1 W at full power output) but this will be just about inaudible. The thermal stability however is greatly improved by the use of these high resistor values, and this is the reason for omitting temperature compensation in the form of diodes. It was felt better to make the circuit fairly insensitive to temperature changes rather than try to compensate for them. In any case the diode voltage spread in practice would make the design of circuit rather difficult, as well as increasing the cost. Also the diode non-linearity will tend to increase distortion by feedback from the potential divider chain unless it is decoupled with a very large capacitor.

Regarding the diode protection, here there will be little or no difference between voltage or current drive from a class A driver, as the act of limiting removes the negative feedback from the main loop. This gives full drive to the driver stage, so the current in the diodes is settled by the peak current available from the driver rather than whether the output is taken from its collector or its emitter.

Protection by including fuses in the emitters of the output transistors appears very attractive at first sight. Unfortunately there is a very serious drawback due to the temperature coefficient of resistance of the fuses. Fig. 1 shows the d.c. characteristic of a standard long-break 500 mA fuse. From this curve it can be seen that the current-resistance characteristic is very non-linear due to the heating of the wire. Using 500 mA fuses in the emitters would give about the same cold resistance as the resistors that I use, but under full

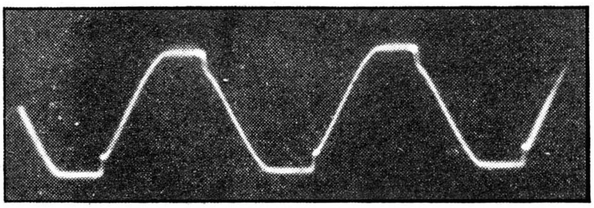

*Fig. 2. Output voltage under overdrive conditions. (17 Ω resistive load, 5 kc/s drive).*

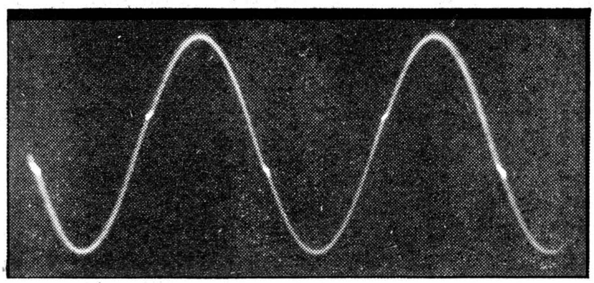

*Fig. 3. 20 kc/s output waveform at full power output using coil wound resistors. (Note "nicks" in waveform)*

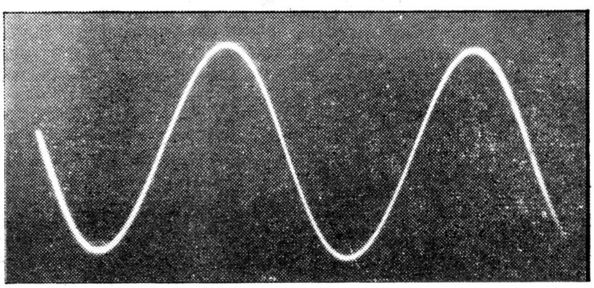

*Fig. 4. As Fig. 3. but output emitter resistors wound in non-inductive manner.*

sine-wave drive conditions their value would be over one and one half times that of the zero drive condition. For the transistors in use this would cause the manufacturers rated reverse emitter-base voltage to be exceeded with the corresponding risk of catastrophic failure of the output transistors. In addition, the output power would be reduced by a further 1 W. Even if this extra emitter resistance could be withstood by the circuit, it would be preferable to use increased value emitter resistors of the type specified as increased thermal stability would be obtained.

I am rather puzzled by the reference to "latch-up" as it is not present to any degree in the circuit. The first transistor is driven in common base so far as feedback is concerned, and the second transistor is common collector connected. In neither case is there any phase-inversion that could be reversed by overload. The output stages are the only ones that would appear to possess any possibility of phase-reversal on overload. If the amplifier is overdriven so that it squares off, then the only effect appears to be at the extreme end of the treble range where the collectors "stick" for a few microseconds before resuming their correct waveform. The resulting nick in the output waveform is very small (Fig. 2) and only occurs when limiting takes place. There is no tendency whatever to latch-up as in d.c. amplifiers and therefore no protection has been provided for it.

Regarding the size of the driver transformer core, this was optimized to give the best performance over the audible spectrum. For the purposes for which the amplifier was designed a rapidly rising distortion below 20 c/s was felt to be of no consequence. I agree that the l.f. performance can be extended below 10 c/s by a larger core, but the increase in transformer winding capacitance will impair the performance at 20 kc/s. In any case how many valve amplifiers will give full power output below 20 c/s?

The emitter resistors were made non-inductive for the simple reason that coil-wound types were found to be the cause of unexpected "nicks" in the 20 kc/s waveform. Figs. 3 and 4 show, respectively, the 20 kc/s waveform with and without coil-type winding. The reason is due to the switching mode inherent in class B, so the individual class B output stages must have a clean performance to well above the maximum frequency to be reproduced. Even one microsecond of error in changeover is very noticeable on the output waveform.

I would like to thank Mr. Butler for the point about a bifilar secondary on the mains transformer. This has obvious advantages in leakage inductance and would be preferable. I suspect that the effect in practice, however, may be negligible.

Regarding the last statement in Mr. Butler's letter, I would merely point out that it is very difficult to be original in basic circuit design. Engineering, however, involves optimization as well, and this is where much of the difficulty lies. One has only to look at the *complete* specification of current transistor power amplifiers (filling in omitted information where necessary) to realize that the design of high-performance circuits is not particularly
(such as the Sharma amplifier referred to by Mr. Butler) often causes extreme complexity and the economics become very difficult to justify. The Sharma protection circuit for "lo-zee" has to be seen to be believed—eight transistors and at least an equal number of diodes for the stereo amplifier.

Very complex amplifiers have appeared—and rapidly disappeared, as complexity in general gives too many phase-shifts for feedback amplifiers.

In conclusion, I would like to state that the amplifier described was not intended to give the ultimate performance regardless of cost—the performance can be considerably improved if much more expensive transistors are utilized in the design of transistor amplifiers. The circuit given is a carefully optimized design and gives a performance that is comparable with the best valve amplifiers while remaining low in cost. That is all that I would wish to claim.

ARTHUR R. BAILEY

## Light Modulated Pickup

ALTHOUGH the "Miniconic" pickup is not a current subject of discussion in *Wireless World,*[†] a recent experience with a baffling "fault" unique to a semiconductor pickup would, I am certain, be of interest to many of your readers.

A friend recently installed such a pickup which performed with the expected excellence except for a noticeable 50 c/s hum. It was easily determined that this emanated from the pickup head, in view of the fact that a magnetic head in the identical position was entirely hum-free the mind boggled at thoughts of induced hum in semiconductors.

However, hum can be induced in this type of element by means of photo-conductivity and therein lay the answer. A 15 W pilot bulb installed to assist record changing gave sufficient light to modulate *one channel only* of the transducer. (Presumably the other element was shielded from illumination by the shadow of the first one).

I may add the answer did not come to us by Sherlock Holmes type deduction but by half an hour's process of elimination in complete bafflement.

Durham. D. V. ELLIS

† But see "Audio 1966," *Wireless World,* June 1966, p. 269.—Ed.

# BOOKS RECEIVED

**Phasor Diagrams,** by M. G. Scroggie, B.Sc., M.I.E.E. The author introduces what is believed to be the first integrated system for dealing with a.c. circuits, valid in all branches of electrical engineering. The book commences by criticizing the current methods of presenting the basic theory of electrical engineering, pointing out that there is no common language between different branches. Mr. Scroggie then presents the arguments for, and introduces his system. It is the aim of the book to provide a clear and concise method of dealing with a.c. circuits compatible with such concepts as Kirchhoff's laws duality and Maxwell's cyclic currents. The method is applied to a wide range of a.c. technologies including valve, transistor and electrical engineering. Present methods are discussed and compared with the new method. Appendices discuss the difference between p.d. and e.m.f. and summarize the rec

42s (limp cover 27s 6d). Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1.

**Measuring Methods and Devices in Electronics,** by A. C. J. Beerens. This book from the Philips Technical Library translated from Dutch by E. Grubba deals with general as opposed to specialist measuring techniques. Divided into three parts, this work is suitable for advanced amateurs, students of electronics as well as practising technicians. Part 1 describes a variety of the more common type of measuring instruments, including digital voltmeters, under the following headings: Principle, Operation, Properties and Application. Part 2 covers the measurement of components and networks concluding with a chapter devoted to practical hints. Part 3 covers the simple theory of errors in measuring techniques. Pp. 182. Price 35s. Macmillan & Co. Ltd., Little Essex Street, London, W.C.2.

**Principles and Applications of Boolean Algebra for Electronic Engineers,** by Salvatore A. Adelfio and Christine E. Nolan. Suitable for those who wish for a comprehensive grounding in the subject, this book starts by discussing basic number systems and finishes by applying Boolean principles to electronic circuitry. Early chapters describe the various binary number systems and arithmetical operations with them. Venn and Veitch diagrams are used as a visual aid to assist in the understanding and proving of Boolean concepts and identities. A complete chapter is devoted to solving illustrative Boolean problems. D.C. principles, network theorems, semiconductor physics together with other electronic fundamentals, diode logic circuits, transistor logic circuits and electronic counters form the remainder of the subject matter of this book. Each chapter is concluded with a number of problems to enable the student to assess his progress. Pp. 319. Price 45s. Associated Iliffe Press Ltd., Dorset House, Stamford Street, London, S.E.1.

**Television Receiver Theory,** Part 1, by G. H. Hutson. Aimed at those engaged on television servicing or those preparing for the intermediate or final examination for the City and Guilds Television Servicing Certificate, this book describes the composite television signal, vision detectors, video amplifiers, sync separators, differentiators and integrators, interlacing and field pulse processing circuitry. As well as describing the British 405- and 625-line standards, the French and Belgian 819-line and American 525-line systems are also discussed. A large number of diagrams together with associated waveforms are included. Pp. 238. Price 35s. Edward Arnold (Publishers) Ltd., 41, Maddox Street, London, W.1.

**Radio Valve Data.** This completely revised 8th edition is produced by Iliffe Books Ltd., and not, as in the past, by the staff of this journal. The title is perhaps something of a misnomer since the section dealing with semiconductor devices has been greatly expanded and now occupies nearly one half of the issue. Separate sections deal with germanium p-n-p and n-p-n transistors, silicon p-n-p and n-p-n transistors, small signal diodes, power rectifiers (up to 10 A), thyristors (s.c.r.s. only, up to 16 A), rectifier stacks and voltage references diodes. A number of devices are not included, e.g. tunnel diodes, field-effect transistors, and voltage-variable capacitors; but a few four-layer diodes are included in the signal diodes section. Almost all of the semiconductor devices listed are current types; some obsolescent or replacement types have not been listed—for instance most of the OC series of transistors including such well-known types as OC35, OC71, and OC170 are missing. Another set of absentees is the OA series of diodes.

The thermionic device section follows the format set in the past, but with the exception that American types have been omitted. Television cathode-ray tubes are included but not instrument c.r.ts. Valve and transistor connections are included and valve, but not transistor, equivalents are listed. Pp. 230. Price 9s 6d. Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1.