

DECEMBER 1965

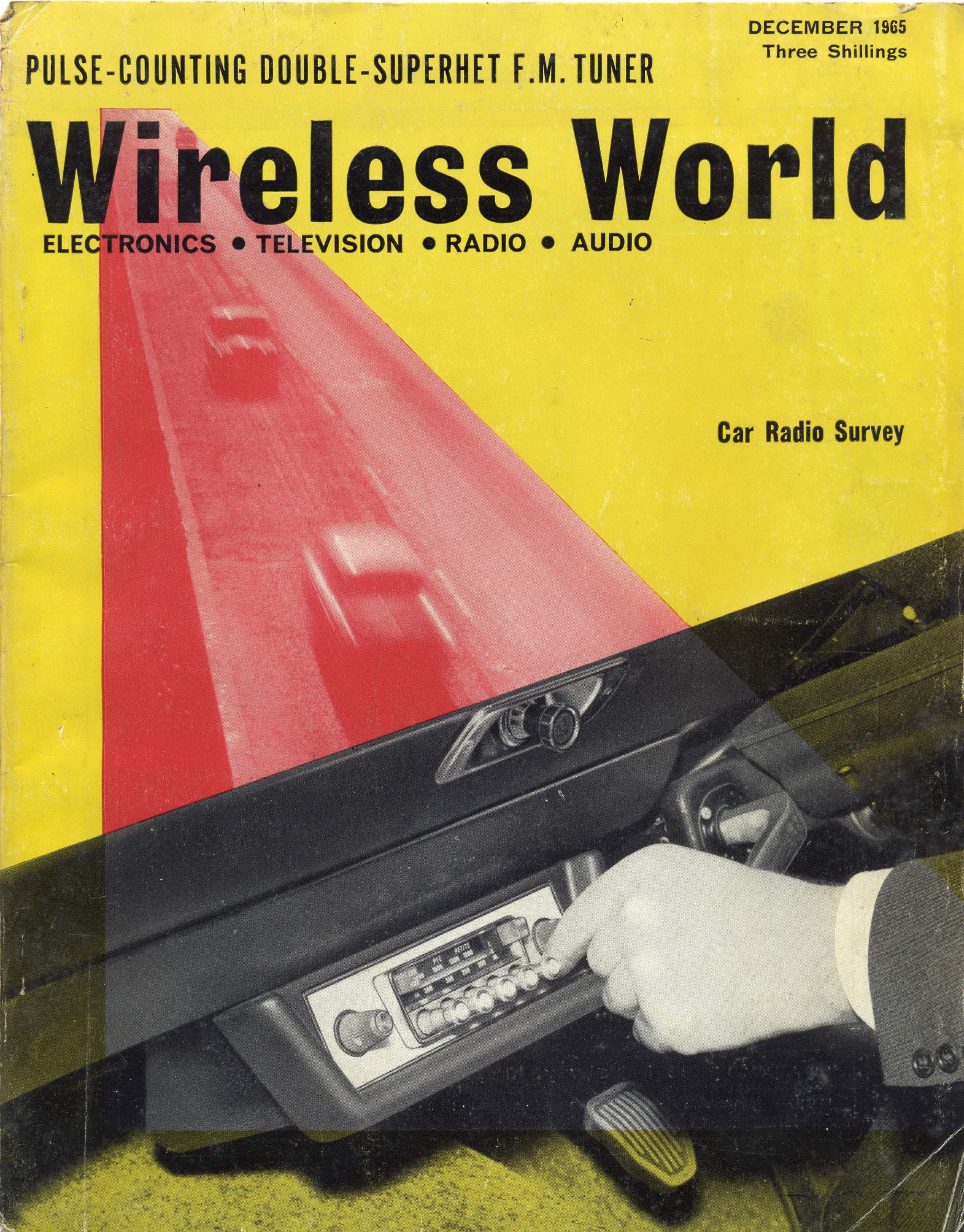
Three Shillings

PULSE-COUNTING DOUBLE-SUPERHET F.M. TUNER

# Wireless World

ELECTRONICS • TELEVISION • RADIO • AUDIO

Car Radio Survey





"Wireless World"  
Iliffe Electrical Publications Ltd.,  
Dorset House, Stamford Street,  
London, S.E.1

*Managing Director:*

**W. E. MILLER, M.A., M.I.E.R.E.**

*Editor-in-Chief:*

**W. T. COCKING, M.I.E.E.**

*Editor:*

**H. W. BARNARD**

*Technical Editor:*

**T. E. IVALL**

*Editorial:*

**D. C. ROLFE**

**B. L. SEXTON, Grad. I.E.R.E.**

**G. B. SHORTER, B.Sc.**

*Drawing Office:*

**H. J. COOKE**

*Production:*

**D. R. BRAY**

*Advertisements:*

**G. BENTON ROWELL**

*(Manager)*

**J. R. EYTON-JONES**

© Iliffe Electrical Publications Ltd., 1965. Permission in writing from the Editor must first be obtained before letterpress or illustrations are reproduced from this journal. Brief extracts or comments are allowed provided acknowledgement to the journal is given.

**VOLUME 71 No. 12**

**PRICE: 3s.**

**FIFTY-FIFTH YEAR  
OF PUBLICATION**

# Wireless World

ELECTRONICS, TELEVISION, RADIO, AUDIO

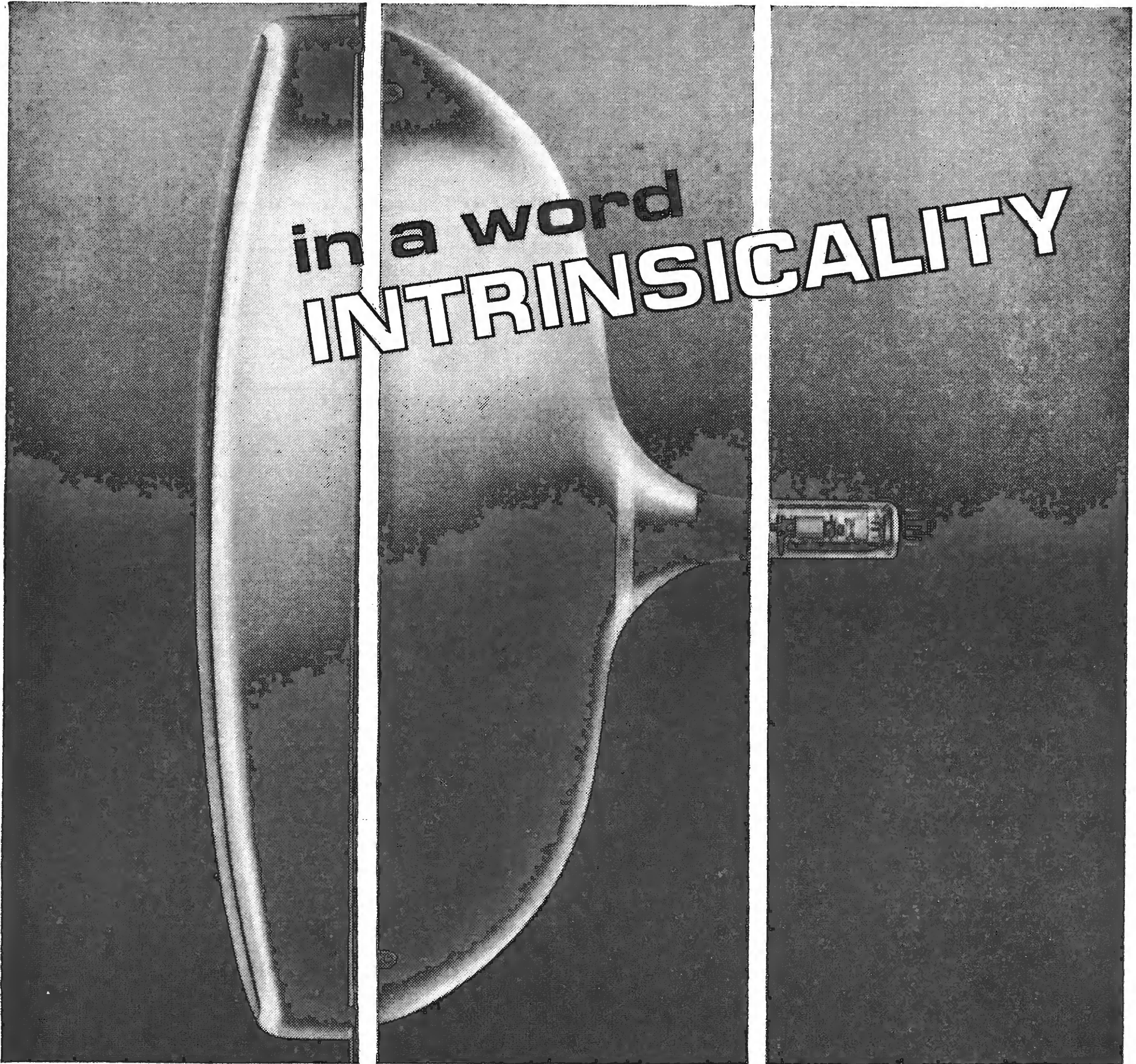
---

**DECEMBER 1965**

- 585 Editorial Comment
- 586 Pulse-counting F.M. Tuner *by E. D. Frost*
- 591 Survey of Car Radio Receivers
- 595 A Further Look at PAL Colour Television *by M. Cox*
- 600 Active Impedance Converters *by F. Butler*
- 605 World of Wireless
- 607 Personalities
- 609 News from Industry
- 610 Amateur Radio Show
- 613 Letters to the Editor
- 616 Interkama '65
- 619 Electronic Laboratory Instrument Practice—12 *by T. D. Towers*
- 624 H.F. Predictions—December
- 625 New Products
- 630 Real and Imaginary *by "Vector"*
- 632 December Meetings
- 

PUBLISHED MONTHLY (4th Monday of preceding month). Telephone: Waterloo 3333 (70 lines). Telegrams/Telex: Wiworld Iliffepres 25137 London. Cables: "Ethaworld, London, S.E.1." Annual Subscriptions: Home £2 6s 0d. Overseas: £2 15s 0d. Canada and U.S.A. \$8.00. Second-class mail privileges authorised at New York N.Y. BRANCH OFFICES: BIRMINGHAM: 401, Lynton House, Walsall Road, 22b. Telephone: Birchfield 4838. BRISTOL: 11, Marsh Street, 1. Telephone: Bristol 21491/2. COVENTRY: 8-10, Corporation Street, Telephone: Coventry 25210. GLASGOW: 123, Hope Street, C.2. Telephone: Central 1265-6. MANCHESTER: 260, Deansgate, 3. Telephone: Blackfriars 4412. NEW YORK OFFICE U.S.A.: 111 Broadway, 6. Telephone: Digby 9-1197.





**Uniform Brightness** The use of advanced screen-laying techniques and control of phosphor particle size produces even brightness over the whole screen.

**High Light Output** is achieved by high efficiency screen phosphors enhanced by precisely controlled thickness of the aluminium layer.

**Reduced Multiple Reflections** result from the new 'Panorama' technique which improves optical focus by eliminating the need for a separate panel in front of the screen.

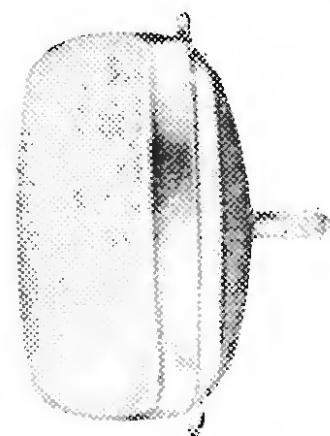
**High Contrast Ratio** is due to the 'Panorama' presentation and to a new deep-tinted glass with mechanical, optical and electrical characteristics which are rigidly controlled in Mullard's own glass factory.

**Long Life with Maintained Performance** is achieved by rigid control of materials and all processes backed by comprehensive life tests. Automation plays a vital role in ensuring consistency of performance.

**High Voltage Performance** Special finishing of gun components and prevention of contamination of these and the tube neck ensure outstanding high voltage performance.

**Sharp Electrical Focus** is ensured by hard vacuum coupled with meticulous accuracy of gun alignment.

**Advanced Performance** Continuous research into tube design and materials brings steady improvements and the advantages of the latest techniques.



# Mullard

TV PICTURE TUBES

WW-114 FOR FURTHER DETAILS.



# Wireless World

ELECTRONICS, TELEVISION, RADIO, AUDIO

## The Image of British Electronics Abroad

TRADE associations exist to promote and protect the interests of their members. We should not expect them to do any more. And yet for some reason we do expect more. Perhaps it is because they represent sectors of production which may be important to the country's economy, or perhaps because the associations themselves tend to build up grave and statesmanlike images by their public pronouncements. It seems, however, that if we expect too much we are in for an occasional disillusionment.

Recently we obtained a brief glimpse of the British electronics industry from the outside when we visited the INEL and INTERKAMA exhibitions (at Basle and Düsseldorf respectively). Both of these exhibitions featured a number of national group stands. Our immediate impression, surveying the scene as a Swiss or German engineer might do, was that the British stand put up a rather poor show in comparison with the others—not only in terms of floor area but in volume and range of exhibits as well. Why, we asked ourselves, should the big and prosperous British electronics industry be so inadequately represented? Is this how they react to the current national slogan "Export or die"?

We discovered, of course, that the joint British stands were not run by the industry at all, but by the Ministry of Aviation (together with the Ministry of Technology—the industry's sponsoring Ministry—at INTERKAMA). The exhibits had been carefully selected as work resulting from Ministry contracts which had possibilities for commercial exploitation, and the two Ministries are to be congratulated on the excellent job they did with the limited funds available from the public purse. Further enquiry revealed that the M.o.A. had received recommendations from the local British Government trade officials in Switzerland and Germany that joint stands displaying British electronics at the exhibitions would be of great value in encouraging exports. The M.o.A. then approached the Electronic Engineering Association. But the E.E.A. declined to take part.

The E.E.A. has explained its reasons for not participating: some of its members were already exhibiting individually at INEL and INTERKAMA; the "joint-venture" type of stand was considered to be of limited value except for opening up entirely new markets; such stands were not suitable for showing capital goods and systems; and better results could be obtained by concentrating on big home exhibitions like the I.E.A.

The E.E.A. may have made the right decision in its own interests, but many people will feel it was ultimately a bad decision—including those manufacturers who would have gladly taken space in joint-venture displays had they been given the opportunity. The Continental exhibition visitor certainly has no sympathy with such considerations. And the potential buyer of British electronics—probably a busy executive with little time to spare—is much more likely to be held by an impressive joint display than he is to go searching the entire exhibition for widely separated individual firms.

At INTERKAMA a great opportunity was lost for selling to the Germans, who want to buy complete systems for their steel and chemical plants. We cannot agree that a joint-venture stand is unsuitable for displaying such schemes. Systems are usually made up of equipments contributed by a variety of companies; thus each firm, restricted though it might be for space, could demonstrate the equipment it had provided while also benefiting from the reflected prestige of the overall system display.

Such a display project might be within the scope of an organization representing the whole of the industry—as, for example, the Conference of the Electronics Industry. As we have said before, a body of this kind is badly needed to speak with one voice for all in the industry. We might even hope that such a representative organization would show a proper sense of involvement in the economic problems of the country.

**VOL 71 NO 12**  
**DECEMBER 1965**



# PULSE-COUNTING F.M. TUNER

Double superhet design using commercial "head", non-aligned discriminator and suitable for use with a stereo decoder

By E. D. FROST, M.A., A.M.I.E.E.

THREE designs of "pulse-counting" f.m. receivers have appeared in the pages of *Wireless World*<sup>1, 2, 3</sup> in the past few years, but none of these has been directly suitable for the subsequent attachment of a stereo decoder for reception of the pilot-tone system (Zenith-GE) transmissions.

At the moment, only experimental transmissions are being broadcast by the B.B.C., but it seems inevitable that sooner or later these will become official, as is already happening on the Continent and in the Isle of Man, and it was thought that any new design should be capable of

lower output implied by the higher i.f., it was thought worthwhile to persevere in the design of a suitable discriminator, since the advantages, both of ease of alignment of the receiver and guaranteed linearity unaffected by drift of tuned circuits with age, are very attractive, especially when access to special test equipment is limited.

## Discriminator operation

It may easily be shown that the a.f. output from any pulse-counting detector is given by

$$V_{pk} = A \cdot \delta f$$

where  $V_{pk}$  is the peak a.f. voltage,  $A$  the area of the pulse in volt-seconds, and  $\delta f$  is the maximum frequency deviation ( $= 75 \text{ kc/s}$ ).

$A$  is of course limited by the fact that the pulse width cannot exceed one cycle of the highest i.f., and in practice it is usually less than half this. Thus, given a fixed upper limit to the i.f., the only way to increase the output of the detector is to improve the pulse shape or increase the amplitude of the pulses. The pulse-generator type of detector as used in the *Wireless World* receiver is attractive, as it gives a reasonably large output due to the rectangular pulses, but it becomes more expensive when designed for the higher intermediate frequency, since better transistors have to be used and sharper triggers generated.

The original receiver, by Scroggie, uses a simple differentiator with steering diodes as a detector, but suffers from the fact that the input/output characteristic becomes curved at the higher values of i.f. due to the loss of part of the tail of the pulse. (See Fig. 1). The exponential shape is very inefficient for this form of detector, since it has a long tail which must be allowed for if non-linearity is to be kept to a minimum, and yet this contributes little to the total area of pulse. There is also the slightly irritating fact that the onset of distortion is gradual, and there is no point up to which the characteristic can be said to be perfectly linear, though of course this effect can be minimized by using a small enough time-constant. This, however, means reduced area of pulse and therefore reduced sensitivity, and since, due to the higher i.f. required by the stereo transmissions, the time-constant must already be reduced by a factor of at least three, the loss of sensitivity becomes serious.

The advantage of the differentiator type of detector, as pointed out by Scroggie, is that provided the voltage across the capacitor has stabilized after each transition of the input signal, the output current is independent of the shape of the input waveform or the speed of its edges, and is proportional only to the size of the capacitor and the peak value of the input waveform. Even though the shape of the current pulses varies widely with the shape of the input signal, the area is constant. This means in practice that a lower standard of limiting is required.

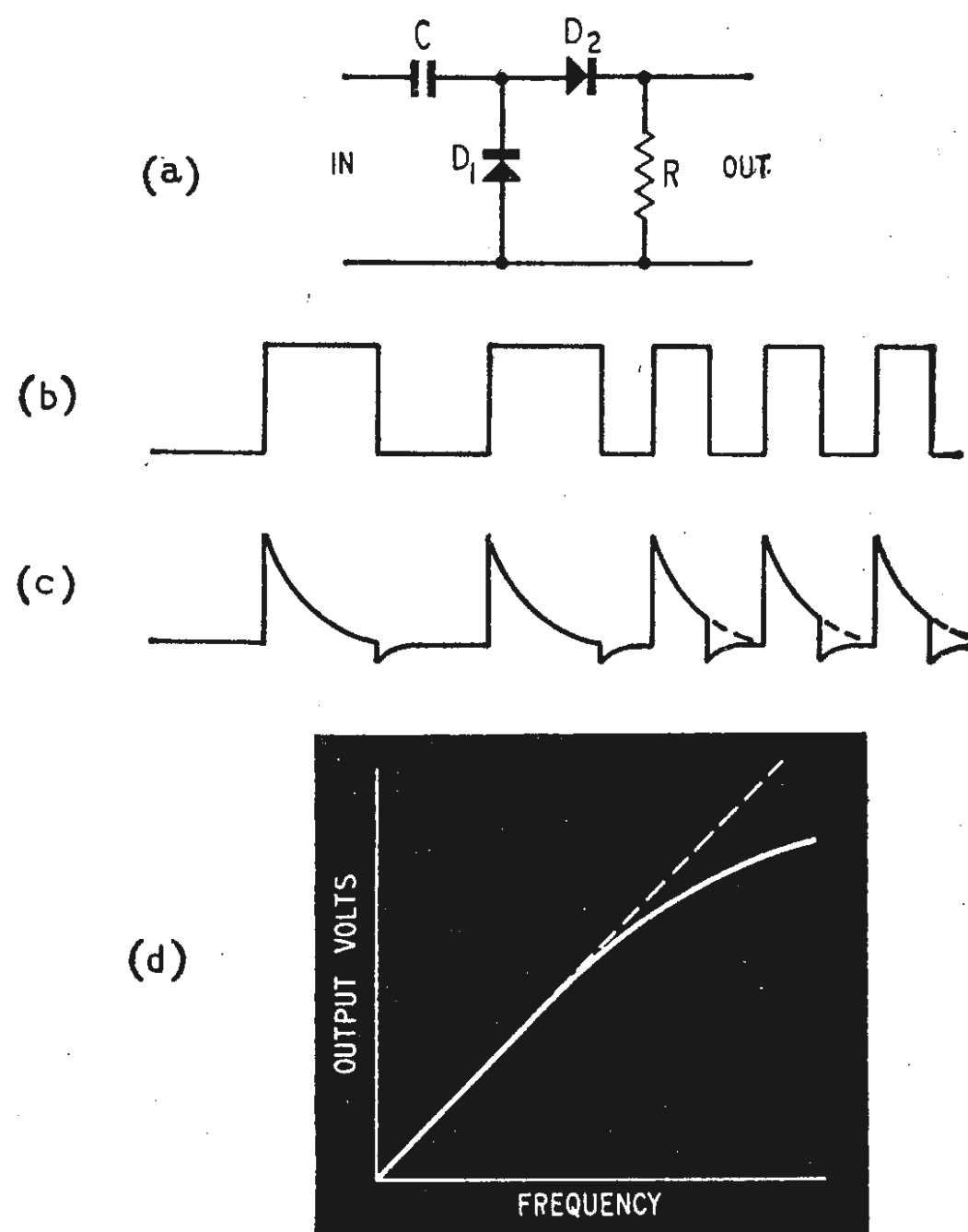


Fig. 1. (a) Basic differentiator detector circuit. (b) Input waveform. (c) Output waveform showing loss of pulse at high frequencies (exaggerated). (d) Input/output characteristic.

being adapted to receive them, even though the opportunity might not arise for a while.

Since the modulation frequencies in this system extend up to 53 kc/s, a mean i.f. of at least 300 kc/s is needed to enable subsequent filtering to be carried out easily. Such filtering must not introduce phase or amplitude distortion, which would result in cross-talk between the two channels of the binaural system, and cannot include de-emphasis which must be done after the stereo demultiplexing. In spite of the added difficulties, and the



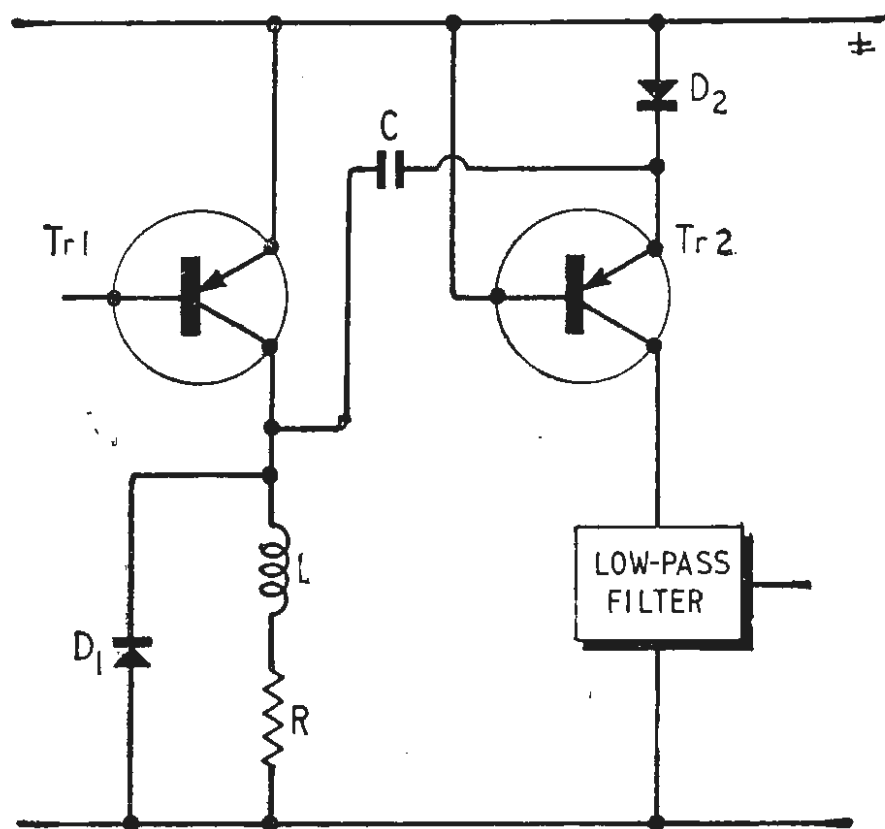


Fig. 2. Basic discriminator circuit used.

The concept of the differentiator as a current source is well suited to the use of transistors and leads to a discriminator of higher output than could normally be obtained for the same complexity.

Consider the basic circuit of Fig. 1(a) again. The resistor  $R$  is only present in order that the capacitor current may produce a voltage output suitable for a valve. This current may be fed straight into a transistor emitter, which is of low impedance and also provides the rectifying action of  $D_2$ . In Fig. 2,  $C$ ,  $D_2$  and  $Tr_2$  correspond to  $C$ ,  $D_1$  and  $D_2$  of Fig. 1(a). In this case the output side of the capacitor sees a low impedance in both directions, and the charging and discharging time-constants are determined almost entirely by the source impedances, previously assumed to be negligible in comparison with  $R$ . The requirement of linearity of response up to a clearly defined overload point means that exponential charge and discharge curves must be avoided, and the network in the collector circuit of  $Tr_1$  is provided for this purpose.

When  $Tr_1$  is switched on by base current, a constant current at high impedance flows in the collector circuit. The inductor  $L$  ensures that initially at least, this current all flows into  $C$ , and discharges it *via* the emitter of  $Tr_2$ .

The collector of  $Tr_1$  rises in potential until suddenly it "bottoms" within a few hundred millivolts of the supply voltage  $V$ . Current continues to build up towards a value  $V/R$  in  $L$  and  $R$ , but as far as  $C$  is concerned all action has finished, and the return half cycle can start at any time after this. When  $Tr_1$  is switched off by the cessation of base current,  $L$ ,  $C$  and  $R$  start a damped resonant oscillation carrying the collector negatively and charging  $C$  from the energy stored in  $L$  *via*  $D_2$ . This oscillation could take the collector more negatively than earth, but the diode  $D_1$  prevents this, and the rest of the energy in  $L$  is dissipated in  $R$ . Again, as far as  $C$  is concerned, the action has finished at this point. Thus in both half cycles the collector of  $Tr_1$  reaches either power rail at a well defined point, and the circuit can wait for any length of time in either state with no effect on the output. The output is available as current pulses at the collector of  $Tr_2$  which acts as an impedance transformer and isolator. These pulses only need integrating to produce the a.f. signal. The value of output current may easily be calculated, since each pulse consists of the charge lost by the condenser in suffering a change of voltage equal to that of the supply line. Thus at a frequency  $f$ , the current is:—

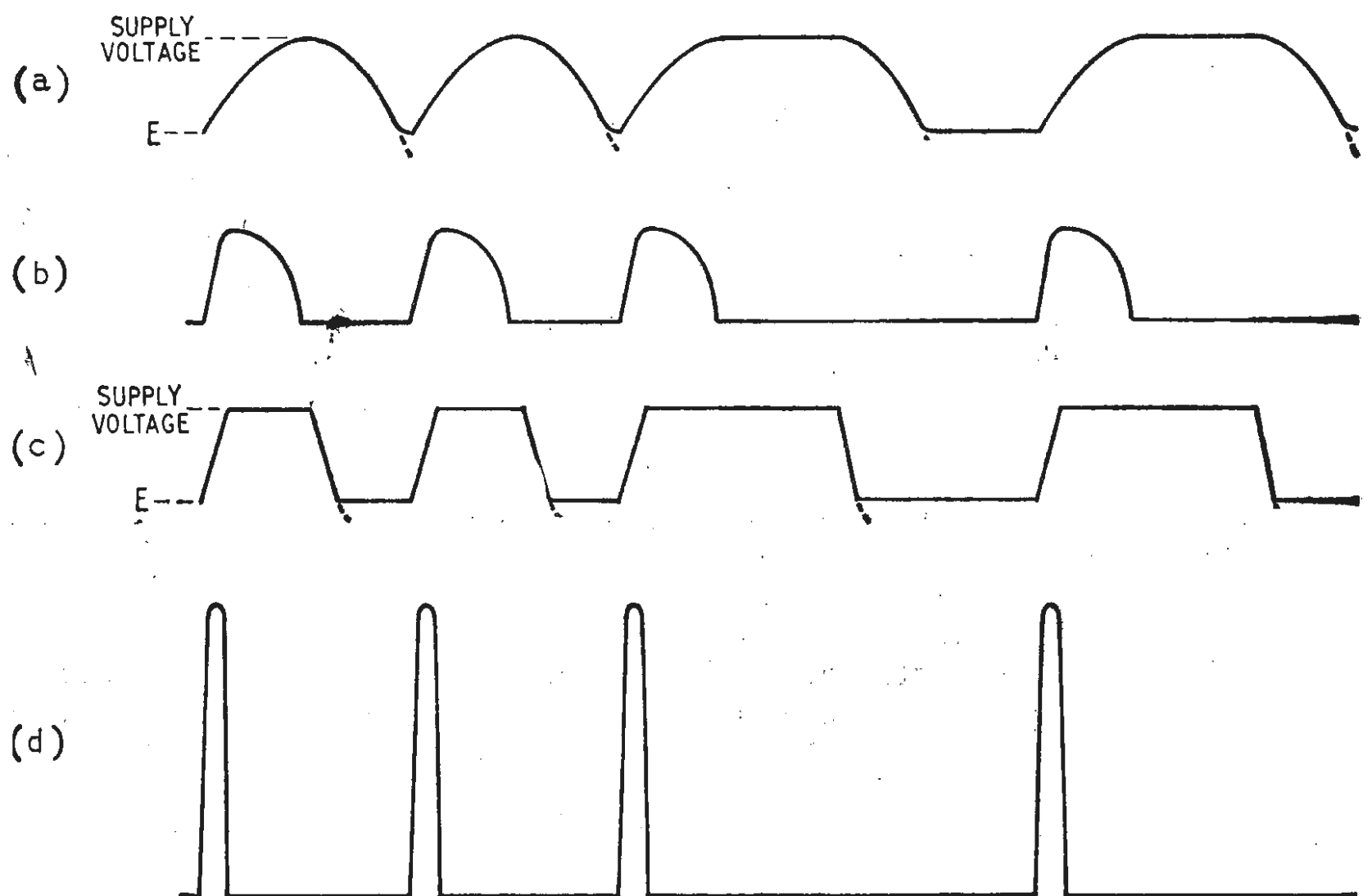
$$I = fCV$$

Sketches are shown in Fig. 3 of the waveforms at the collectors of  $Tr_1$  and  $Tr_2$  for a minimum input signal and one much larger. The change in shape of the current pulses is most noticeable, but they are of the same area and the mean output voltage is exactly the same.

With  $C = 220$  pF the output is  $198 \mu A$  per  $100$  kc/s and this is continued up to a clearly defined overload point at about  $650$  kc/s, thus if the nominal i.f. is  $300$  kc/s, there is some tolerance for mistuning.

$Tr_2$  must never be allowed to bottom, since this destroys the linearity of the discriminator. Thus it must work into a capacitive load, which is required for filtering. For mono reception a collector load of  $4.7$  k $\Omega$  and  $.01 \mu F$  in parallel provides both filtering and de-emphasis, with a modulation output of  $0.5$  V r.m.s. at  $\pm 75$  kc/s deviation. For stereo reception, de-emphasis must not be done at this stage and any filter must have linear phase and amplitude responses up to  $53$  kc/s, while providing plenty of capacitance for  $Tr_2$  to work into. The filter should cut off rapidly after  $53$  kc/s, to reduce noise which could beat

Fig. 3. Discriminator circuit waveforms. (a)  $Tr_1$  collector (minimum sufficient input). (b)  $Tr_2$  collector current corresponding to (a). (c)  $Tr_1$  collector (input three times that in case (a)). (d)  $Tr_2$  collector current corresponding to (c).





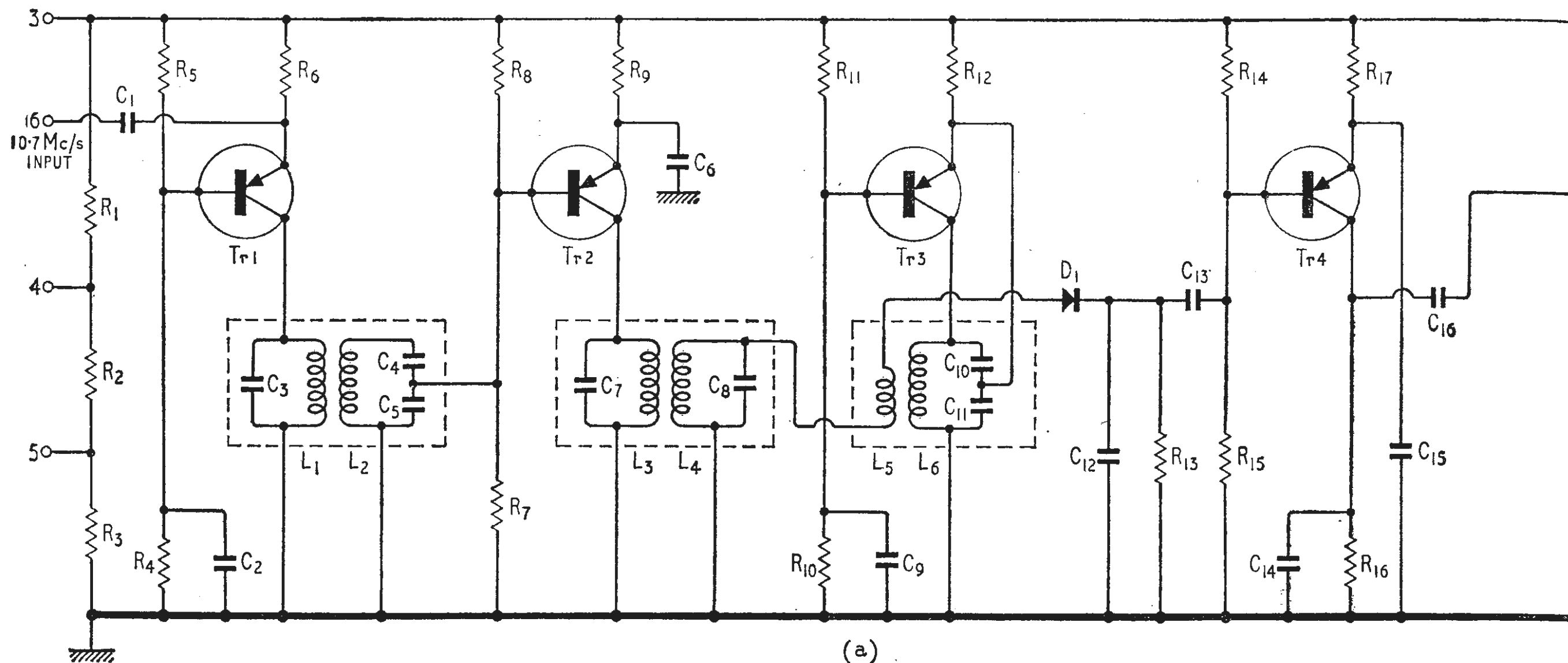


Fig. 4. (a) Complete receiver (r.f. tuner unit is omitted). (b) Tuner connections.

with harmonics of the stereo sub-carrier and add to the noise in the audio outputs.

### Complete circuit

The complete circuit of the main part of a receiver using this circuit is shown in Fig. 4. It will be noticed that it is of the double superheterodyne type. This is to avoid the troubles which beset receivers using a single low-frequency i.f., such as image-frequency interference

and breakthrough of the 2.2 Mc/s beat between pairs of local-station programmes. The first i.f. is the standard one of 10.7 Mc/s and the second oscillator is tuned to 11 Mc/s, giving a second i.f. of 300 kc/s. It was thought that pick-up of the 8th and 9th harmonics of the second oscillator might cause trouble, but in fact with a screened v.h.f. tuner, and the oscillator mounted six inches away from it, these harmonics are well below limiting level, and thus will give no trouble even in those areas where the local station happens to be close to 88 or 99 Mc/s, due to the

### LIST OF COMPONENTS

#### Resistors

R1	1k $\Omega$	R14	15k $\Omega$
R2	1k $\Omega$	R15	120k $\Omega$
R3	6.8k $\Omega$	R16	3.3k $\Omega$
R4	22k $\Omega$	R17	470 $\Omega$
R5	4.7k $\Omega$	R18	68k $\Omega \pm 10\%$
R6	1k $\Omega$	R19	1k $\Omega$
R7	15k $\Omega$	R20	27k $\Omega$
R8	220k $\Omega$	R21	1.2k $\Omega \pm 10\%$
R9	4.7k $\Omega$	R22	3.3k $\Omega \pm 10\%$
R10	56k $\Omega$	R23	470 $\Omega \pm 10\%$
R11	22k $\Omega$	R24	33k $\Omega \pm 10\%$
R12	3.9k $\Omega$	R25	47k $\Omega \pm 10\%$
R13	4.7k $\Omega$		

All resistors 1/4 W,  $\pm 20\%$  unless otherwise stated.

#### Capacitors

C1	0.01 $\mu$ F	M.P., C	C12	200pF	S.M., C
C2	0.01 $\mu$ F	M.P., C	C13	0.01 $\mu$ F	M.P.
C3	180pF	S.M.	C14	0.001 $\mu$ F	S.M., C
C4	620pF	S.M.	C15	0.1 $\mu$ F	M.P.
C5	1800pF	S.M.	C16	0.01 $\mu$ F	M.P., C
C6	0.01 $\mu$ F	M.P., C	C17	220pF	S.M.
C7	180pF	S.M.	C18	0.003 $\mu$ F	S.M., C
C8	470pF	S.M.	C19	0.0013 $\mu$ F	S.M., C
C9	0.01 $\mu$ F	M.P., C	C20	10 $\mu$ F	15V working electrolytic
C10	150pF	S.M.	C21	100 $\mu$ F	15V working electrolytic
C11	1500pF	S.M.	C22	0.02 $\mu$ F	M.P.

M.P.  $\equiv$  metallised paper. S.M.  $\equiv$  silvered mica. C  $\equiv$  ceramic.

#### Inductors. All enamelled wire.

L <sub>1</sub>	10 turns	32 s.w.g. close wound	} With 0.3 in. dia. Aladdin-type former, screening can and two dust-iron cores; windings separated by 0.27 in.
L <sub>2</sub>	6 turns	32 s.w.g. close wound	
L <sub>3</sub>	As L <sub>1</sub>		} With 0.3 in. dia. Aladdin-type former, screening can and one dust-iron core.
L <sub>4</sub>	As L <sub>2</sub>		
L <sub>5</sub>	3 turns	32 s.w.g. close to earthy end of L <sub>6</sub>	
L <sub>6</sub>	12 turns	32 s.w.g. close wound	
L <sub>7</sub>	1.5mH	175 turns 42 s.w.g. in Neosid pot core type 10D/WR.	
L <sub>8</sub>	4.2mH.	300 turns 42 s.w.g. in Neosid pot core type 10D/WR.	

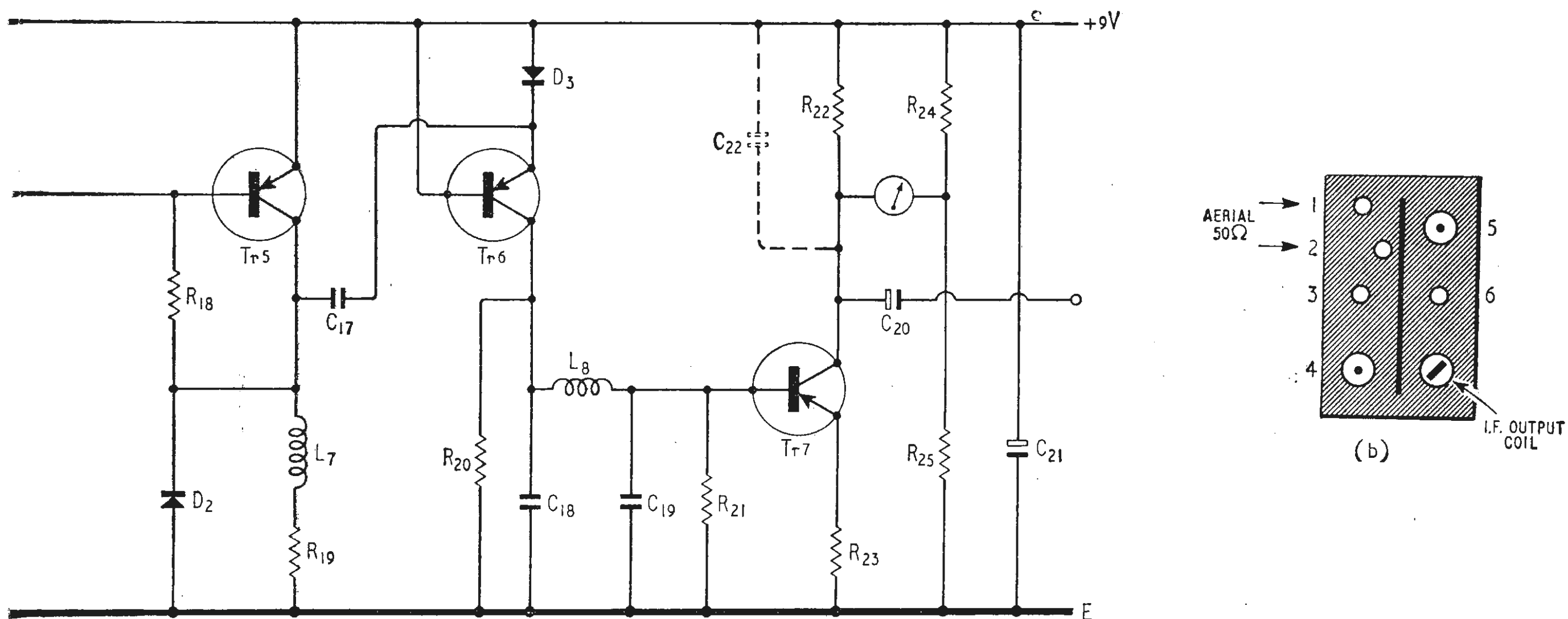
#### Semiconductor devices

Tr1	OC170, AF116	Tr6	OC44, XA102
Tr2	OC170, AF116	Tr7	2N1302, XA701, OC139
Tr3	OC170, AF116	D1	OA70, CG12E
Tr4	OC44, XA102	D2	OA70, CG12E
Tr5	OC44, XA102	D3	OA47

#### Meter

Radicator type SB-105 100 $\mu$ A f.s.d.





capture effect. This also means that this circuit from  $L_3$  onwards could be used in conjunction with any published design of f.m. tuner in place of the discriminator transformer, giving improved linearity and freedom from critical adjustment which is the main reason for using this type of discriminator.

The whole of this part of the receiver including the coils, can be built on a piece of Veroboard  $3\text{in} \times 2\frac{1}{2}\text{in}$  if the components are mounted end-on, and so there should be no trouble in fitting it. It should even be possible to fit it to a valve tuner, though this has not been attempted. If anyone wishes to try, care should be taken to ensure that the insulation in the transformer will stand 250 V. The prototype receiver used a commercially available transistor r.f. head, the Torotor 75L,\* and the pin connections shown on the right of the diagram are to suit this unit. Other types are available and the change in connections to suit them should be obvious on inspection. The use of such a unit was originally to save design and construction time, since the object was to prove the discriminator, but it has advantages for the home constructor in that it is pre-aligned, and solves what can be a difficult lay-out problem, since the performance of an r.f. amplifier at 100 Mc/s can be markedly affected by long leads and stray capacitances. Those who would like to build their own should consult ref. 4 where a suitable design may be found. This was also the primary source of design data for the i.f. transformers.

**I.F. and second mixer stages.**—The output from the r.f. head is 10.7 Mc/s at  $50\Omega$  impedance. This is coupled into the emitter of the first i.f. amplifier Tr1 which provides an approximate match. A double-tuned i.f. transformer in the collector circuit couples this to Tr2 which is coupled by the second i.f. transformer to the second mixer D1. Tr2 is operated at a low collector voltage, to provide limiting on very strong signals which can otherwise overload the discriminator.

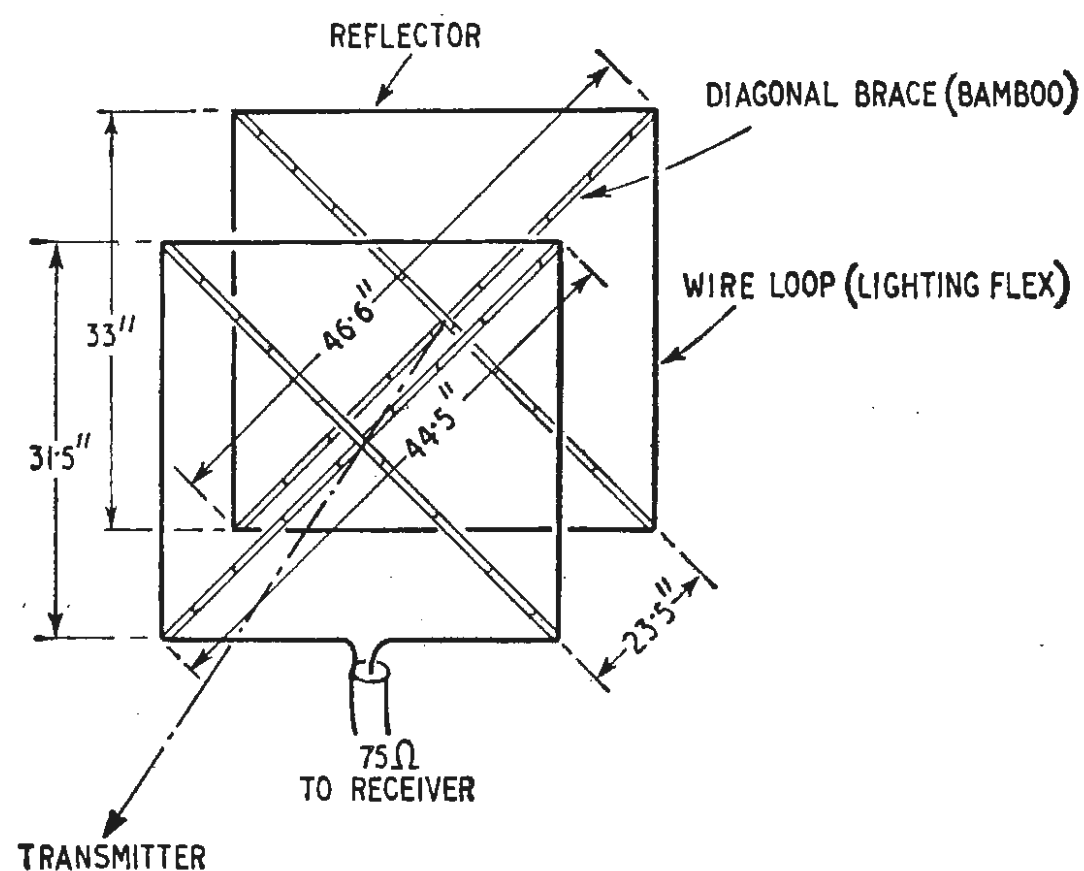
Tr3 is the second local oscillator working at 11 Mc/s. A small fraction of its output is coupled to the signal so that both are applied in series to D1 which produces the difference signal by rectification. It was found that the combination of a diode mixer plus a straight amplifier Tr4, was superior in both gain and lack of oscillator

pulling on strong signals to any attempt to make Tr4 a mixer-amplifier.

Filtering of the high-frequency components in the second i.f. is done by the condenser across the detector load, and by that across the collector load of Tr4.

**Limiter, discriminator and indicator.**—The amplified signal is applied to Tr5 which is the switching transistor for the discriminator. Forward bias has been provided for Tr5 via  $R_{18}$ . This bias is dependent on the mean level of the collector of Tr5 and provides feedback tending to preserve an equal mark/space ratio. Limiting occurs at Tr5 and Tr2 depending on signal level. The operation of the discriminator has already been described. Tr7 has been added as a buffer between the filter and the output load, and gives a gain of seven as a bonus. Obviously this could be greatly increased by the addition of emitter decoupling and adjustment of values. Tr7 also acts as a d.c. amplifier for a tuning indicator consisting of a centre zero  $100\mu\text{A}$  meter. This is a refinement and may be omitted if desired, but as well as being an indication of correct tuning it serves as an indication of signal strength, since only if a signal is limiting will it swing right across as the tuning knob is operated. This is

Fig. 5. Cubical-quad Band II aerial giving 8dB gain over dipole aerial.



\* The Torotor is available from Henry's Radio Ltd.

useful, since inexperienced users tend not to notice the increased noise on a non-limiting signal, and the sound output on such signals is quite tolerable until such time as a large modulation swing suddenly occurs.

**Sensitivity.**—The sensitivity of the complete receiver is approximately  $60\mu\text{V}$  in  $50\Omega$  for limiting to occur. This is sufficient for nearly all locations but if it were to prove not so, another i.f. stage could easily be added. It has worked well with a simple dipole eight feet from the ground at a distance of 50 miles from Wrotham, and in fact the simplest way of getting extra gain is to use a better aerial. A “cubical quad” (Fig. 5) which can be made of pea-sticks and split lighting flex, will fit in nearly all lofts and gives a gain of 8 dB over a dipole.

**Linearity.**—The linearity of the detector may be seen from Fig. 6. The flattening at 130 kc/s is due to ringing in the low-pass filter as it approaches its cut-off frequency and the flattening at 550 kc/s is due not to the discriminator but to Tr7 bottoming. The centre of the straight part of the curve is at 365 kc/s, but since most signal generators have a calibration mark at 11 Mc/s it was thought better to set the second oscillator to 11 Mc/s rather than 11.065. This is a matter of choice, but a change involves adjustment of the tuning meter zero as well.

It will be noticed that, although most of the transistors are p-n-p type, a positive power line with a negative earth has been used. This means that fewer components have to be used since the emitter decoupling capacitors also decouple the supply line to each stage, and thus no separate supply decoupling components are required.

On the prototype, to ensure stability, the i.f. transformers are mounted 2 in apart, but since the total gain is split between three different frequencies, this was probably unnecessary and a more compact layout could have been adopted. The receiver was built on an L-shaped piece of aluminium sheet,  $1\frac{3}{4} \times 1\frac{3}{4} \times 9$  in. with the coils mounted on one face and a length of tag-strip along the other. Common earth points were used for each stage but no additional screening was required in the i.f. strip. The r.f. unit was mounted at one end, and

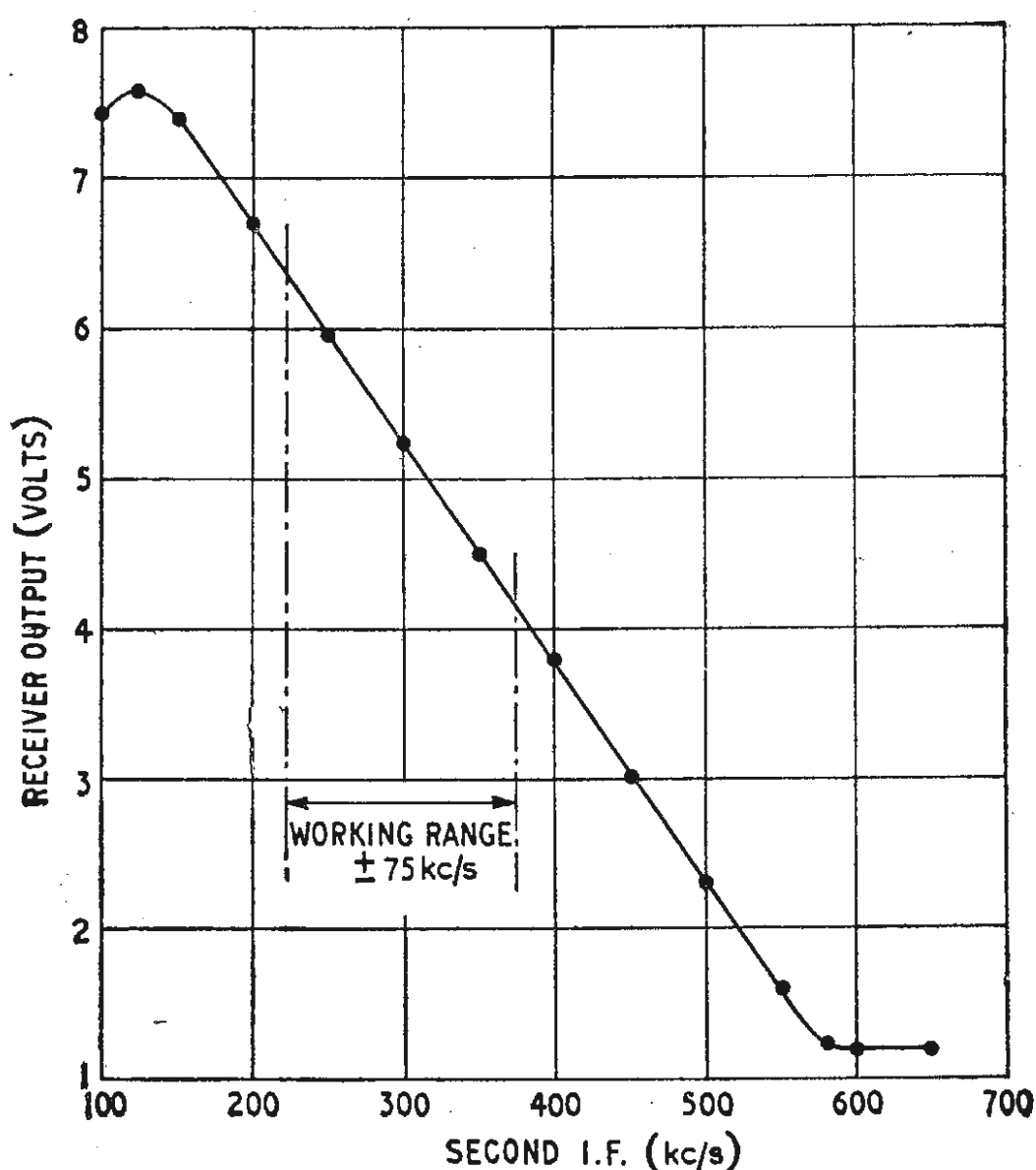


Fig. 6. Discriminator response.

the whole receiver laid on its side. This form of construction, as well as being best for stability, suits the flat style of construction of the integrated sound system in which the receiver was incorporated.

### Alignment procedure

This can best be done with a signal generator covering 10.7 and 11 Mc/s, a d.c. voltmeter and a pair of headphones.

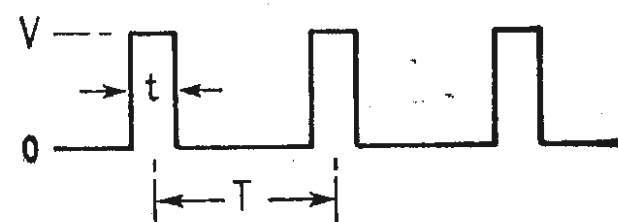
Connect headphones across  $R_{13}$  and set the signal generator to 11 Mc/s. Adjust the core of  $L_6$  for zero beat between the second oscillator and the signal generator.

Now connect the voltmeter across  $R_{13}$  and short-circuit  $R_{11}$ , thus stopping the second oscillator. Set the signal generator to 10.7 Mc/s and connect it across  $L_3$ . Tune  $L_4$  for maximum reading on the voltmeter. Connect the generator across  $L_{11}$ , and tune  $L_2$  and  $L_3$  for maximum reading, reducing the generator output if necessary to avoid overloading. Now connect the generator, still at 10.7 Mc/s, to the aerial terminals of the receiver, increasing the output if necessary to get a reading on the voltmeter. Tune  $L_1$  and the output coil of the r.f. head for maximum reading, and check the tuning of all the other coils. Finally, remove the voltmeter and the short-circuit across  $R_{11}$ , and check that the tuning indicator reads mid-scale or nearly so, and swings from one end to the other as the input frequency varies from 10.6 to 10.8 Mc/s.

**Stereo decoder.**—It is not proposed to give details of a decoder here, since this should properly form the subject of a separate article. References 6, 7 and 5 are recommended to those interested in the construction of a decoder. In the absence of a decoder, de-emphasis should be provided by a  $0.02\mu\text{F}$  capacitor across  $R_{22}$ .

### APPENDIX

Consider a train of rectangular pulses of amplitude  $V$ , width  $t$ , and repetition period  $T$ —



the mean d.c. level of this waveform is  $v = Vt/T$ . Now  $Vt$  is the area of a pulse in volt-seconds and since  $f = 1/T$ ,  $v = Af$ . For a frequency modulated wave, whose frequency varies from  $f$  to  $f + \delta f$ ,  $v_f = Af$  and  $v_{f+\delta f} = A(f + \delta f)$ . The peak modulation voltage is thus:— $V_{f+\delta f} - V_f = A\delta f$  which is independent of  $f$ .

### REFERENCES

1. Wireless World Crystal Controlled Transistor FM Tuner, *Wireless World*, July 1964.
2. Scroggie, M. G., *Wireless World*, June 1956.
3. Hopkins, J. C., *Wireless World*, September 1965.
4. Jansson, L. E. and Sargood, A., *Mullard Technical Communications*, Vol. 6, No. 58, June 1962.
5. Spencer, J. G. and Phillips, G. J., *Radio and Electronic Engineer*, Vol. 27, No. 6, June 1964.
6. Browne, G. D., *Mullard Technical Communications*, Vol. 7 No. 67, December 1964.
7. Browne, G. D., *Wireless World*, October 1962.
8. Singleton, F. B., *Wireless World*, December 1957.



# SURVEY OF CAR RADIO RECEIVERS

**A**T the 50th Motor Show held at Earls Court, London, at the end of October, a number of car radio receivers was on show. Frequency modulation reception was not provided for by any British manufacturer although two German a.m./f.m. receivers were displayed. Two-in-one receivers, which can be used either as a portable or a car radio, are coming into vogue. When the portable is fitted in the car, the power output is increased by using an additional output stage installed in a unit in the car and by the higher operating voltage from the car battery. The popularity of simple retunable preselectors linked with push buttons for station selection was reflected in a number of receivers. Some receivers use the manual tuning control to pretune the frequency to be selected by the push button; tuning is then locked

by a latching mechanism operated by the push button, other receivers, however, use separate rotary tuning controls as the push buttons. Two factors associated with a receiver working under conditions encountered in a car are the build up of electrostatic charges and the increased ambient temperature. Some circuits contain a voltage dependent resistor in the aerial circuit for protection against electrostatic charges and a thermistor in the base bias circuits of output transistors to prevent thermal runaway.

The following survey reviews some of the receivers at the show. These have been chosen as being generally representative of the receivers available. Receivers marketed under different trade names but manufactured by one group have been dealt with conjointly.

## Bluespot

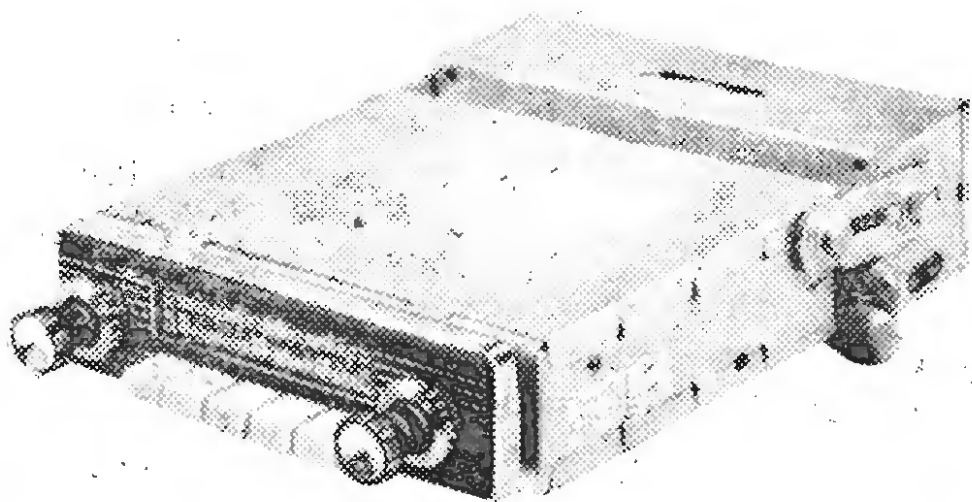
In the range of six receivers displayed by Bluespot (sold in the U.K. by Bosch Ltd.) were two a.m./f.m. receivers, the Frankfurt (52 gn) and the Köln (78 gn). Both receivers cover, in addition to the nominal long- and medium-wavebands, the v.h.f. band (87 to 104 Mc/s); while the Frankfurt also has a short-wave band (5.9 to 6.35 Mc/s), making it the only receiver of this type on the British market. Both receivers have push-button selection of waveband and five preset stations—long-wave, medium-wave, short-wave and two v.h.f. on the Frankfurt, and long-wave, two medium-wave and two v.h.f. on the Köln. Other stations are tuned manually.

Basically the circuits of both models are similar except that the Köln incorporates a motorized tuning device—the electronic station seeker. In the Frankfurt, separate r.f. amplifiers for a.m. and f.m. are used. For f.m. operation, signals are developed across a wide-band input transformer and fed to an r.f. amplifier and thence to a self oscillating mixer. The i.f. is 10.7 Mc/s and four neutralized stages of i.f. amplification are included before the signal is applied to a ratio detector. Demodulated signals are applied to a four-stage a.f. circuit containing two a.m. amplifiers, a driver and a push-pull class B output stage. Provision is made to preset the a.f. gain in

the second stage. Tone control is effected by a variable RC filter between the first and second a.f. stages. Base bias fluctuations of the output stage are compensated by a stabilizing diode and a thermistor as a temperature stabilizer. The diode also supplies stabilized base voltages to the second a.f. amplifier and driver stage.

For a.m. operation, r.f. signals are coupled to an a.m. aerial circuit and fed to the first i.f. amplifier of the f.m. circuit which is switched to operate as an r.f. amplifier for amplitude modulated signals. Automatic gain control is applied to the stage during a.m. operation. A separate a.m. oscillator is used but the second i.f. amplifier of the f.m. circuit is switched to operate as an a.m. mixer. Signals at the i.f. of 460 kc/s are then amplified by the last two i.f. stages of the f.m. circuit switched for a.m. operation, and a.g.c. is applied to the first stage. A diode is used to stabilize the base bias for the oscillator, the mixer, the second i.f. amplifier and the first a.f. amplifier.

Both the Frankfurt and the Köln can be operated from 6 V or 12 V with positive or negative earth. At 6 V and 12 V the power output is 5 W and 7 W respectively.

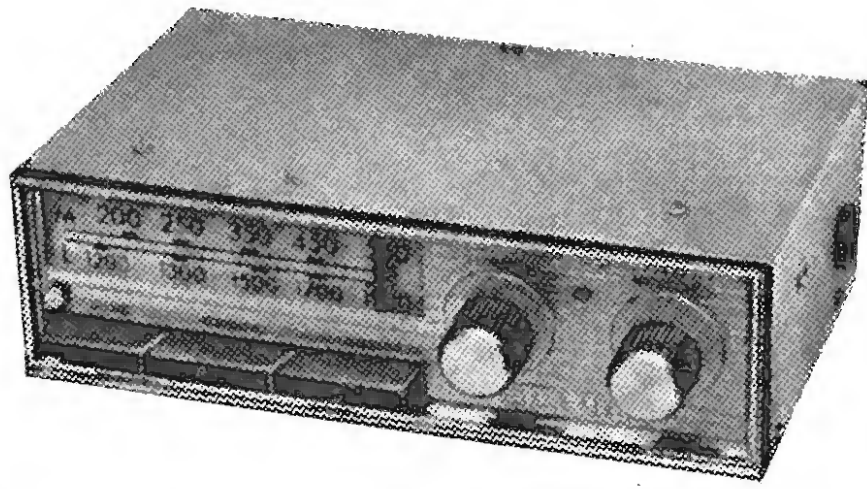


*The Frankfurt—one of the receivers displayed by Bluespot and designed for reception of f.m. programmes.*

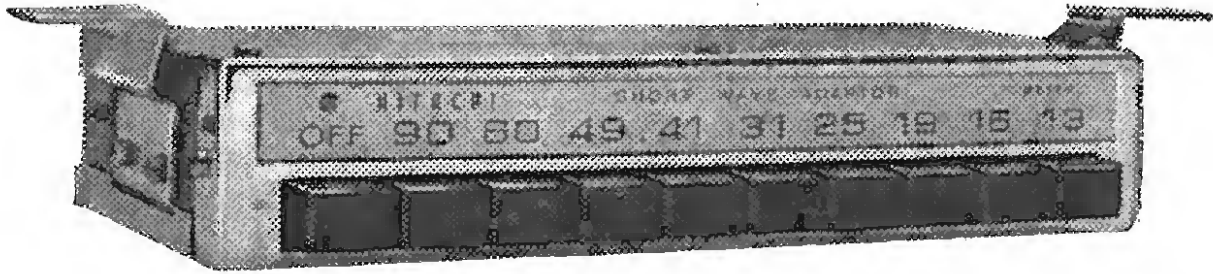
## Lee Products

A recent addition to the range of receivers from Lee Products (Gt. Britain) Ltd. is the CR655 (14 gn), a six-transistor car radio receiver which has the following stages—an r.f. amplifier, self-oscillating mixer, 475 kc/s i.f. amplifier, detector, a.f. amplifier, driver and output stage. The r.f. stage contains a voltage dependent resistor which protects the first transistor against possible damage from the build-up of electrostatic charges on the car. An a.g.c. voltage obtained from the collector circuit of the i.f. amplifier is fed back to the base of the r.f. amplifier, and for an input signal variation of 10  $\mu$ V to 1 mV the output change is 7 dB. Waveband coverage is 176 m to 550 m, and 1,180 m to 1,920 m; sensitivity, using a dummy aerial and measured for an output of 50 mW, is better than 6.5  $\mu$ V on medium wave and better than 12  $\mu$ V on long wave. Direct coupling and negative feedback is used between the a.f. stages and bias stabili-





Push button tone control is featured on the CR655 from Lee Products.



A double superheterodyne system is formed when the Hitachi Short Wave Adapter is used with a car radio receiver

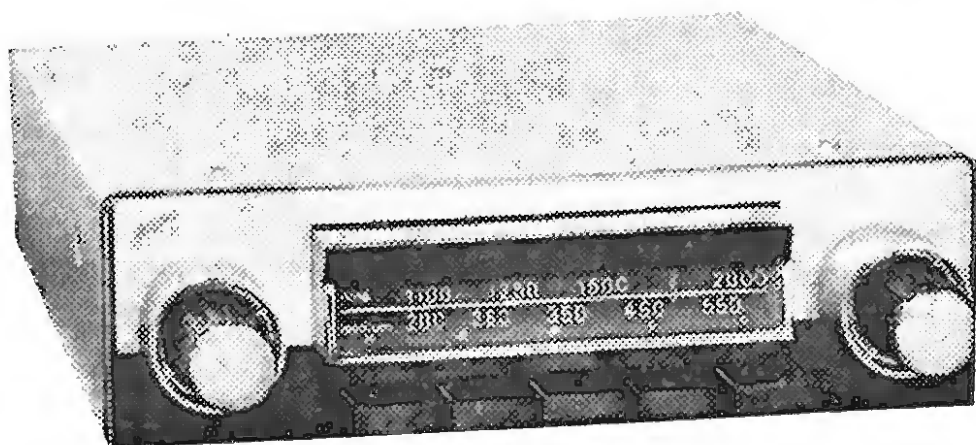
zation is effected with a thermistor connected in the base circuit of the a.f. amplifier but mounted on the heat sink of the output stage. Selection of the required wave band and bass tone condition is controlled by three push buttons. Power output is 3 W and the receiver will operate from either a positive or negative earth 12 V supply.

An Hitachi short-wave adapter for car radio is marketed by Lee Products. The adapter, model WM-20 (14 gn), is connected between the car aerial and the existing car radio receiver and in conjunction with the receiver forms a double superheterodyne system. Ten push buttons are used, one for on-off and nine for band selection. Short-wave bands covered are 90, 60, 49, 41, 31, 25, 19, 16 and 13 metres.

During operation, the receiver used with the adapter is switched to the medium-wave band, and the required station is then tuned in with the manual tuning control of the receiver. Operation of the OFF button de-energizes the short-wave adapter but leaves the car radio receiver operational. Two slide switches are fitted on the underside of the adapter and can be set for positive or negative earth and 6 V or 12 V supply.

## Motorola, Radiomobile

Announced earlier this year were two additions to the range of car radio receivers from Motorola and Radiomobile. These are marketed as Motorola model 727 or Radiomobile model 970 (23 gn each) and Motorola model 828 or Radiomobile model 980 (27 gn each). Each model, designed for 12 V positive or negative earth, incorporates permeability tuning and has five push but-



The Motorola model 828 has a push-pull output of 8-W.

tons for station selection. Two buttons select preset frequencies in the range 520-1,610 kc/s and three buttons select preset frequencies in the range 150-180 kc/s. Models 980 and 828 have an output of 8 W and use seven transistors in a circuit containing an r.f. amplifier, mixer, i.f. amplifier, a.f. amplifier and push-pull output. Models 970 or 727 have an output of 3 W and use five transistors in a circuit containing an r.f. amplifier, mixer, i.f. amplifier, a.f. amplifier and single-ended output. Both receivers have an i.f. of 470 kc/s.

## Philips

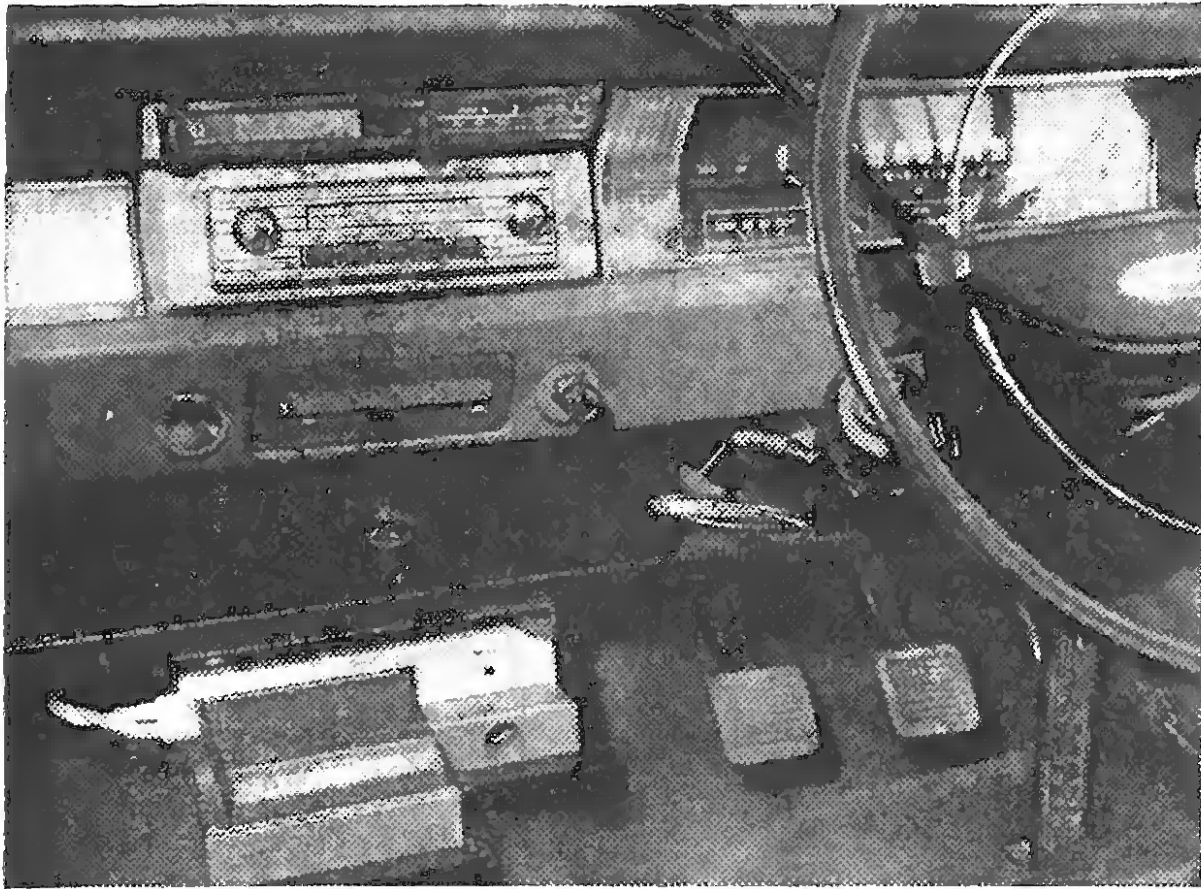
Three receivers which are recent additions to the Philips range are the models 236T, manual tuning (17½ gn), 338T, car radio-portable (20 gn) and 440T, push-button station selection (23 gn). Model 236T covers the medium- and long-wave bands (selected by push buttons) and has a combined on-off switch and volume control. Seven semiconductors are included in a circuit which incorporates an r.f. amplifier, self oscillating mixer, 470 kc/s i.f. amplifier, detector, driver and a 3 W output stage. The receiver is supplied for a 12 V positive earth system, but polarity change can be effected by internal adjustment. Current consumption at 14.5 V is 1 A.

The 338T, a two waveband receiver, has a self-oscillating mixer (AF117) two stages of i.f. amplification (AF117), and i.f. driver (OC82D) and a push-pull output stage (OC82). Waveband selection is by push button and two rotary controls are used for tuning and volume combined with an on-off switch. A diode stabilizer is included in the base bias circuit of the output stage. When the receiver is operated as a portable the diode stabilizes the operating point of the output stage, and offsets fall in potential of the internal battery. When the receiver is operated in a car the diode also stabilizes the bias point against variation in car battery voltage but a more important feature is that the diode is germanium and has the same temperature coefficient with respect to voltage as the transistors whose bias it controls. Accordingly, during any rise in ambient temperature in the car, the bias requirement, for a given collector current, falls but the stabilized voltage also falls at the same rate, thus maintaining the collector current at a constant value.

Model 440T operates from a positive or negative earth 12 V supply; the polarity being selected by an externally mounted plug. An AF117 transistor is used in an r.f. amplifier stage covering the medium-wave band, (520-1,630 kc/s), and the long-wave band (150-300 kc/s). The stage also contains a voltage dependent resistor which protects the transistor against possible damage from electrostatic charges. Stations are selected by five rotary push-button controls. Two of the controls can be used for coarse manual tuning of the the long- and medium-wave bands whereas the other three, geared down by a ratio of 12:1 are used to finely pretune any three frequencies in the medium-wave band. Type AF117 transistors are also used for a self-oscillating mixer and a 470 kc/s i.f. amplifier. A CG64 diode is used as a combined signal and a.g.c. detector. Three further stages—audio amplifier, driver and output contain an OC71, OC82DM and AD140 respectively. Power output is 3 W.

Philips cassette tape recorder model EL3301 has been housed in a car mounting kit and is available as Car Tape Recorder model NP1630 (40 gn) suitable for 6 V and 12 V supply with positive or negative earth. If desired a modification can be made to allow 24 V operation. Price of the car housing kit alone is £12 10s. With the recorder





In this illustration, the Philips cassette tape recorder is shown installed (below the fascia board) with a Philips model 347 car radio receiver.

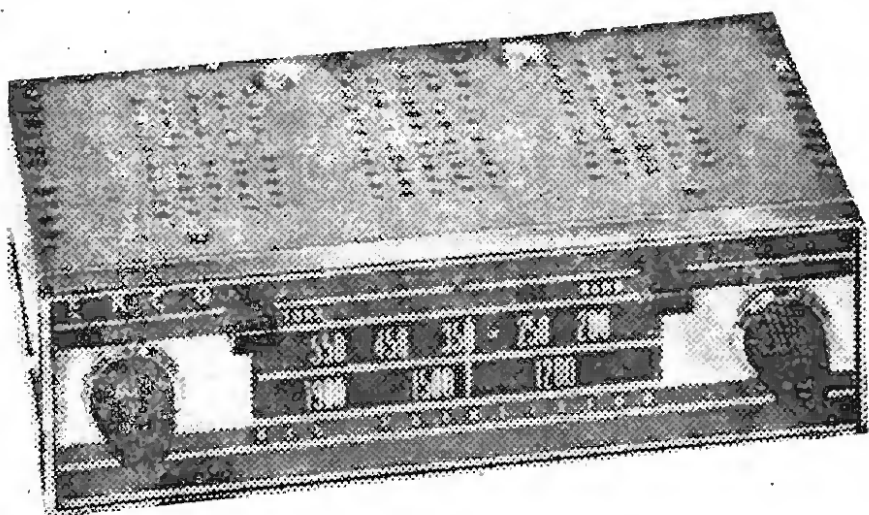
fitted the depth dimension is increased to 12 in and weight is increased to approximately 9 lb. Playing time is 30 min per side of the cassette at a fixed speed of  $1\frac{1}{2}$  in/sec. Recordings can be made with microphone or direct from car radio. Playback is via the car radio.

## Pye, Ekco

One of the recent additions to the range of car radios in this group is the Pye 20/26 ( $19\frac{1}{2}$  gn) which incorporates five push buttons for selection of stations on both medium- and long-wave bands. Separate tone and volume controls are featured and two additional push buttons are used for wavechange and on-off. An obvious advantage of separate controls for on-off and volume compared with a combined on-off and volume is, of course, that wear on the control track is decreased, but in addition each time the receiver is switched on the need for resetting to the preferred listening level is avoided.

The size of the 20/26 is significant of the trend in car design of decreased space between instrument panel and bulkhead. The depth of the receiver from the front panel is about  $3\frac{1}{4}$  in and appears to be the shallowest push-button receiver on the market. An attendant design problem is the restricted movement of the tuning cores, but this has been overcome by closely tolerancing the tuner mechanism. As a result, a change of 1 Mc/s has been achieved with a total core movement of only 0.406 in.

The circuit contains four transistors and two diodes.



The Ekco CR926 is supplied complete with speaker and installation kit for 15 gn.

The first stage uses an AF117 in a self-oscillating mixer configuration. Frequency coverage is 155-250 kc/s (long wave) and 520-1,620 kc/s (medium wave). The i.f. output at 470 kc/s is applied to a combined i.f. and a.f. amplifier stage which also uses an AF117. Signals at the i.f. are diode detected and then fed back via the volume control to the same stage for a.f. amplification. Audio signals, developed across a resistive load in the collector circuit of the stage, are then fed to a driver transistor, OC82DM, which is transformer coupled to the output stage. An AD140 transistor is used in the output stage which produces an output of 2.5 W. The 20/26 operates from a 12 V d.c. supply with positive or negative earth and at 14 V the current consumption is 0.8 A.

A lower priced modified version of the Pye 20/26 is the Ekco CR926 supplied complete with speaker and universal fitting kit for 15 gn. Frequency coverage and basic circuitry is the same for both models but the CR926 uses manual tuning and different control facilities. The on-off switch is combined with the volume control and a push-button tone control is used. A 6 V version, CR926/EX, is also available but with negative earth only.

The Pye model 2010 (21 gn excluding speaker and fitting kit) is a combined car radio and portable comprising two separate units, a portable receiver and a car radio output unit. The latter contains a separate amplifier stage to increase the output when the receiver is in use in the car. Frequency coverage of the receiver is 150 to 260 kc/s and 550 to 1,250 kc/s. Manual tuning is used and the on-off switch and volume control are combined. Two push buttons are fitted, one for wavechange and the other (AUTO) for circuit switching depending on whether the receiver is used as a portable or car radio. Six transistors are used in the circuit of the portable receiver, an AF117 for an r.f. amplifier, an AF117 for a self-oscillating mixer, an AF117 for an i.f. amplifier, an OC82D for an a.f. driver and two OC82 (matched pair) in the output stage. To minimize car interference the aerial circuit of the receiver must of necessity be well screened, but this conflicts with the use of the receiver as a portable. Accordingly, two separate aerial circuits are used; one contains a ferrite rod aerial for use during operation of the receiver as a portable and is mounted in the unscreened front escutcheon assembly whereas the other circuit is mounted inside the screening cover and energized from the car aerial. Six parts of the circuit of the portable receiver are switched to modify the circuit for operation as a car radio. This switching action is shown in a skeleton circuit, Fig. 1. Switch SW7 switches two aerial tuning capacitors from the portable aerial circuit to the car radio aerial circuit, SW8 switches the car radio aerial circuit to the base circuit of the r.f. amplifier, SW9 connects the a.f. circuits to the car battery supply, SW10 switches the internal speaker (used during operation as a portable) out of circuit, SW11 connects the r.f. and i.f. circuits to the car battery supply, SW12 modifies the base drive circuit of the OC82D a.f. driver.

If the AUTO button is inadvertently left in the portable position when the receiver is fitted in the car, the receiver remains inoperative due to a switching interlock actuated when the plug and socket car connections are made. The output unit contains an OC26 output transistor which is transformer coupled to energize a  $3\Omega$  or  $1.5\Omega$  loudspeaker. Any change in collector leakage current due to an increase in ambient temperature in the car is offset by a thermistor in the base bias circuit for the two driver transistors. Stabilization of battery voltage is effected with a NKT259 transistor, operating as a diode, in parallel with the thermistor.

The portable receiver uses a 9 V battery and has a



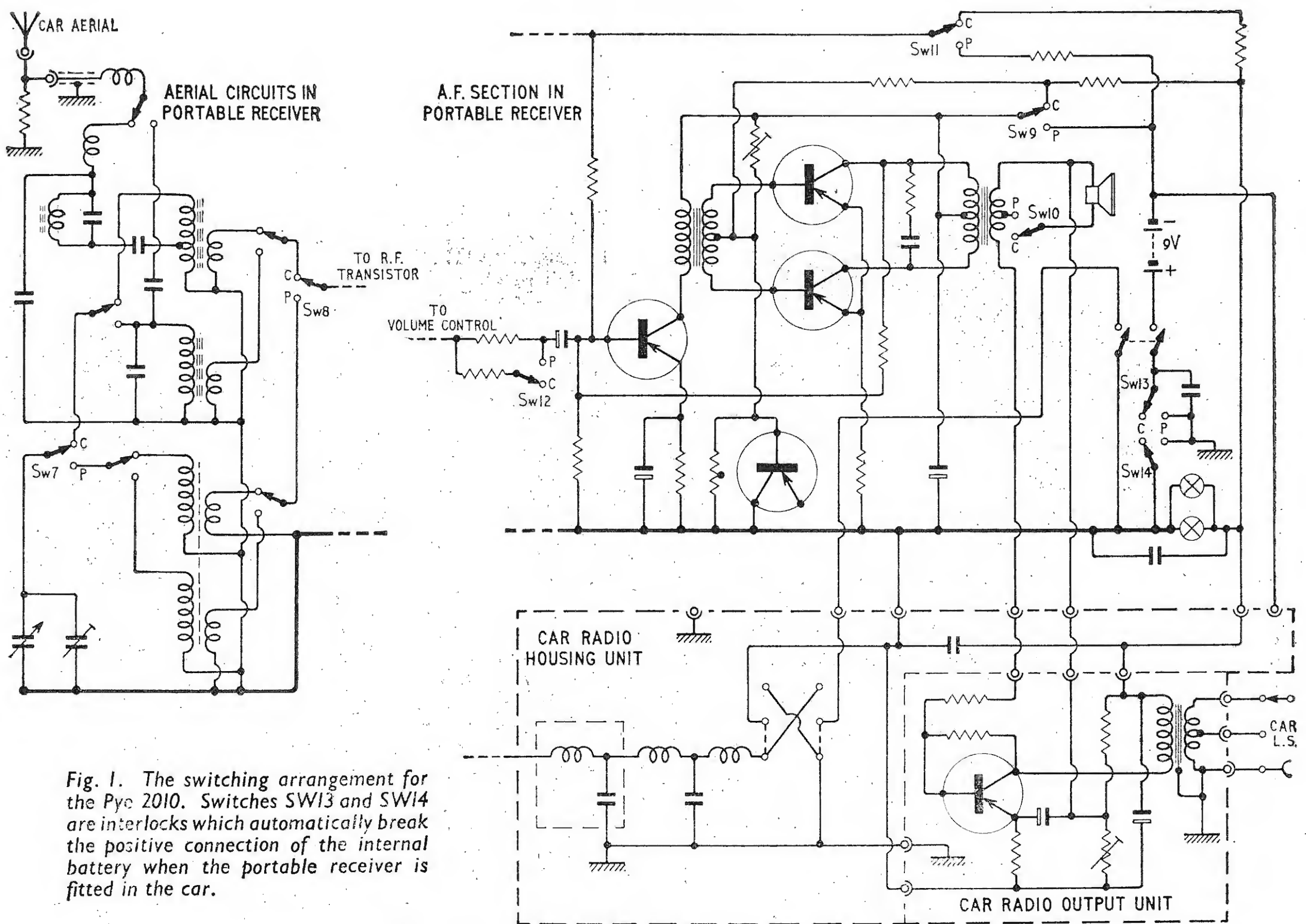


Fig. 1. The switching arrangement for the Pyc 2010. Switches SW13 and SW14 are interlocks which automatically break the positive connection of the internal battery when the portable receiver is fitted in the car.

power output of 400 mW. When operated in a car, the receiver has a power output of 3W.

Another receiver from the group is the Ekco CR923 (9½ gn). This is a hybrid receiver which uses five valves

operated directly from the 12 V supply, and a transistor output stage. Nine separate wavebands, manually tuned, lie within the frequency range of 535 kc/s to 18.1 Mc/s. A three-position tone control is used.

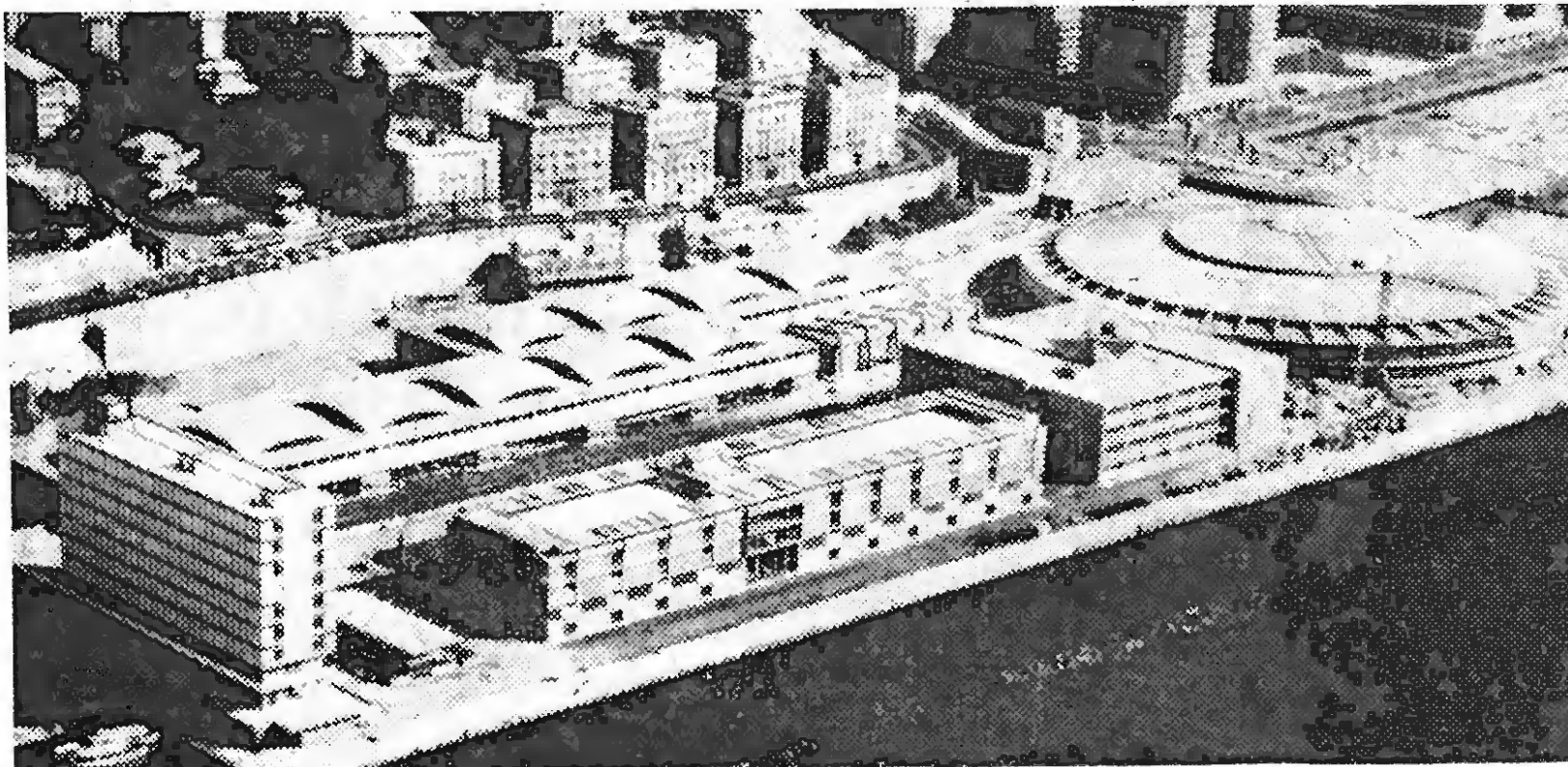
## INTERNATIONAL COMMUNICATIONS FAIR, GENOA

THE second Fiera Internazionale delle Comunicazioni held in Genoa last month covered communications in its broadest sense, whereas the first was restricted to the maritime field. A large block in the exhibition centre, which

is on reclaimed land, was devoted to telecommunications (shown on the extreme left of illustration). Although a large part of the telecommunications block was filled with exhibits from companies from all over the world, the striking

feature of the Fair—in general and in particular to this block—was the lack of communications. Many of the stands were unmanned and thus presented no more than a window display, and on those that were manned few of the exhibitors spoke other than Italian.

No British electronics companies had stands, although a few showed their products through their Italian subsidiaries or agents. Several U.K. companies have expressed interest in the biennial show and Plessey's have tentatively said they would exhibit at the 1967 Fair. One reason for the lack of British participation could be because this Fair clashed with the International Telecommunications Union's exhibition at Montreux, where a number were exhibiting.





# A Further Look at PAL Colour Television

DEVELOPMENTS IN THE SYSTEM DURING THE PAST TWO YEARS

By M. COX,\* B.Sc.(Eng.)

WHEN the previous article<sup>1</sup> on PAL was being written, the author had no idea that the colour system battle would still be raging in two years' time. It was subsequently expected that the C.C.I.R. Vienna conference in March would settle the question for all time. Every interested person must be aware that the Vienna conference broke up in indecision, and all hopes now rest on a conference in Oslo next summer. However, three facts emerged from the Vienna meeting; that N.T.S.C. had no support in Europe save from Great Britain and Holland, that Russia and France and several other countries concluded an agreement to use a system based on the SECAM system, and that the Central European, Scandinavian countries and Ireland pledged their support for the PAL system. Since then, opinion in the industry in this country has veered towards PAL, and considerably more work is being done on the system than was done before Vienna. There is hope that only two systems, probably PAL and SECAM, will be used in Europe, but little hope at present of agreement on a single system.

Let us now consider the developments which have occurred in the PAL system during the past two years.

## Variations on the original system

It will be considerably easier to describe the developments in the system if we consider the latest development first. It has long been felt in some quarters that a simplification to the receiver would result from a slight re-arrangement of the transmitted parameters. The principal change was to modulate along the  $(R-Y)$  and  $(B-Y)$  axes instead of  $I$  and  $Q$  as used in N.T.S.C., with the  $(R-Y)$  axis being switched  $180^\circ$  in phase on a line-by-line basis.

In place of dissimilar bandwidths for the two components, the  $(R-Y)$  and  $(B-Y)$  signals would be equiband signals with a bandwidth equal to the original  $I$  bandwidth of N.T.S.C.

A further change was proposed to the method of identification—telling the receiver the correct phase switching sequence. Previously, identification had been achieved by a series of bursts of subcarrier for about four lines during the vertical interval, the process being similar to that used in the SECAM system. The new identification system proposed changing the phase of the reference burst on a line-by-line basis. The change of phase is  $45^\circ$  either side of the  $-(B-Y)$  axis, with the burst at  $+45^\circ$  when a positive  $(R-Y)$  line is being transmitted and at  $-45^\circ$  when a  $-(R-Y)$  line is being transmitted.

Fig. 1 shows how the burst is made up of two components, one fixed and the other switched by  $180^\circ$  each line. It also illustrates the "mirroring" of positive and negative  $(R-Y)$  components about the  $(B-Y)$  axis. The type of circuit used in the receiver will be described later on.

At a meeting of Sub Group 1 of the E.B.U. Colour Television Ad Hoc Committee in Hanover at the end of May, 1965, these changes were agreed and are now incorporated in the PAL system.

## Receiver developments

If for any cause the phase of the reference oscillator in the receiver is not correct, the result on a delay line receiver is desaturation of the colour picture, and not hue change, as would be the case with an N.T.S.C. receiver. How-

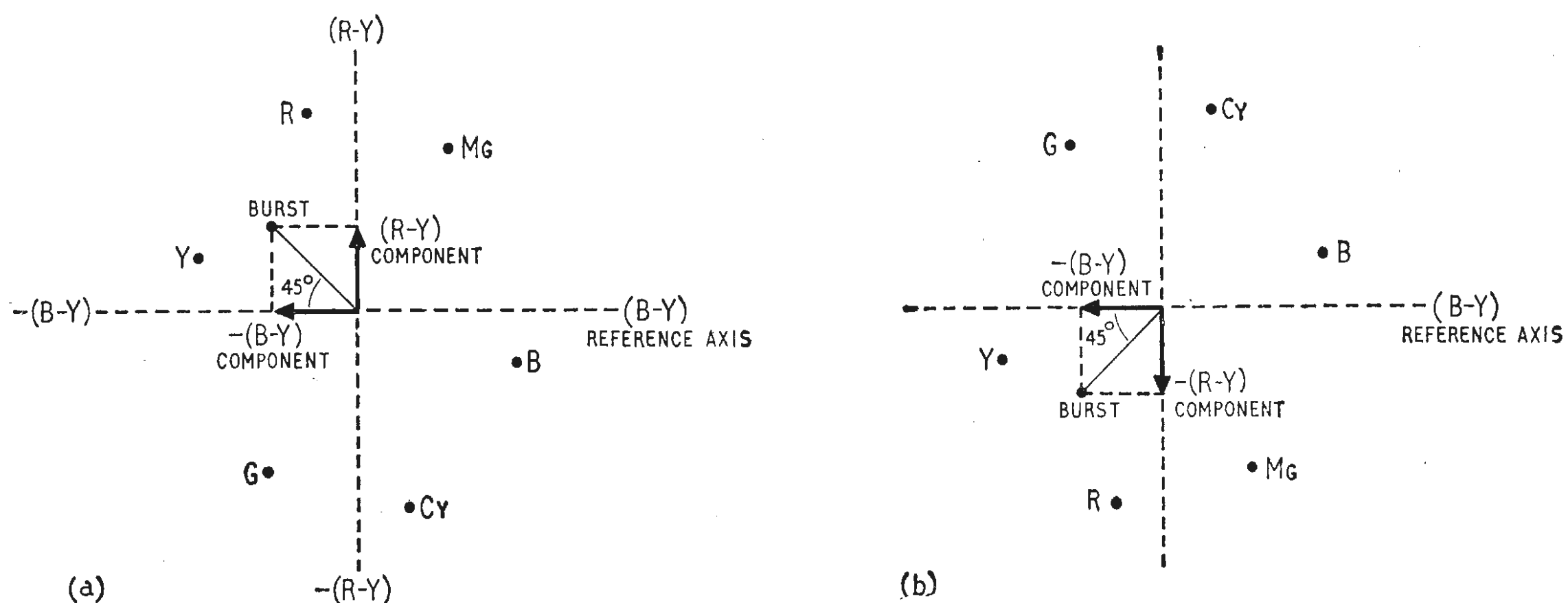


Fig. 1. Vector diagram for current PAL system: (a) vectors for colour bar signal, line  $n$ ; (b) vectors for colour bar signal,  $(n + 1)$ . The dots represent the tips of vectors.

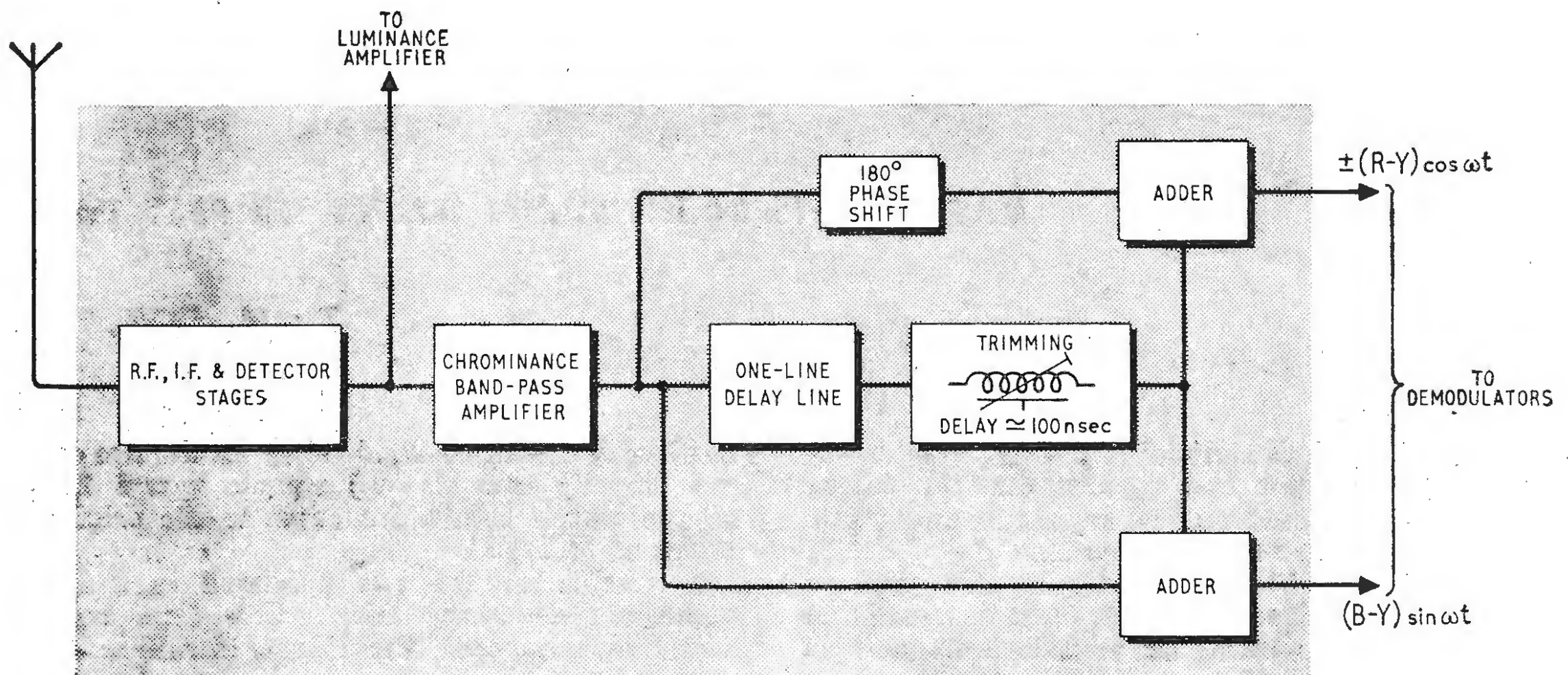


Fig. 2. Schematic of basic delay-line receiver.

ever, such saturation changes, proportional to the cosine of the phase error, would be objectionable for large phase errors. If the reference oscillator in the receiver could be phase synchronized by the subcarrier during the active line time, instead of by the burst, then phase errors between the subcarrier and the burst would be of no consequence. Work done by Telefunken at their Hanover laboratories and by R.A.I., the Italian broadcasting authority, has led to a method of achieving this aim; the technique has been called "chrominance lock". In order to understand how the technique works, it is necessary to go back to the basic delay-line PAL receiver.

The PAL signal may be represented as

$$E_M = E_Y' + \left[ \pm \frac{(E_R' - E_Y')}{1.14} \cos \omega t + \frac{(E_B' - E_Y')}{2.03} \sin \omega t \right]$$

where  $\omega = 2\pi f_{\text{subcarrier}}$ ,  $E_R'$ ,  $E_B'$  are gamma-corrected colour signals, and  $E_Y' = lE_R' + mE_G' + nE_B'$ , where  $l$ ,  $m$  and  $n$  are the luminosity coefficients. The notation  $C$  and  $C^*$  is sometimes used to denote the subcarrier components on adjacent lines.

The heart of the receiver is shown in Fig. 2. Note that addition with  $180^\circ$  phase shift is the same operation as subtraction.

It will be remembered that the signal from the sum circuit consists of subcarrier modulated with the non-switched component, that is  $(B-Y)$  while that from the difference circuit consists of subcarrier modulated with  $(R-Y)$  with  $180^\circ$  phase change every line. This may be expressed mathematically by considering the addition and subtraction of subsequent lines of subcarrier. Consider addition first:

$$\begin{aligned} & \left[ + \frac{(E_R' - E_Y')}{1.14} \cos \omega t + \frac{(E_B' - E_Y')}{2.03} \sin \omega t \right] + \\ & \left[ - \frac{(E_R' - E_Y')}{1.14} \cos \omega t + \frac{(E_B' - E_Y')}{2.03} \sin \omega t \right] \\ & = 2 \cdot \frac{(E_B' - E_Y')}{2.03} \sin \omega t \end{aligned}$$

Now subtraction:—

$$\left[ + \frac{(E_R' - E_Y')}{1.14} \cos \omega t + \frac{(E_B' - E_Y')}{2.03} \sin \omega t \right] -$$

$$\begin{aligned} & \left[ \frac{(E_R' - E_Y')}{1.14} \cos \omega t + \frac{(E_B' - E_Y')}{2.03} \sin \omega t \right] \\ & = 2 \frac{(E_R' - E_Y')}{1.14} \cos \omega t \\ & = 2 \frac{(E_R' - E_Y')}{1.14} \sin (\omega t + \pi/2), \text{ [at } 90^\circ \text{ to the} \\ & \quad (E_B' - E_Y') \text{ component]} \end{aligned}$$

Any phase error which can be represented by  $E$  appears as a constant term of the form  $\cos E$  which affects saturation only.

It should now be obvious that we have effectively

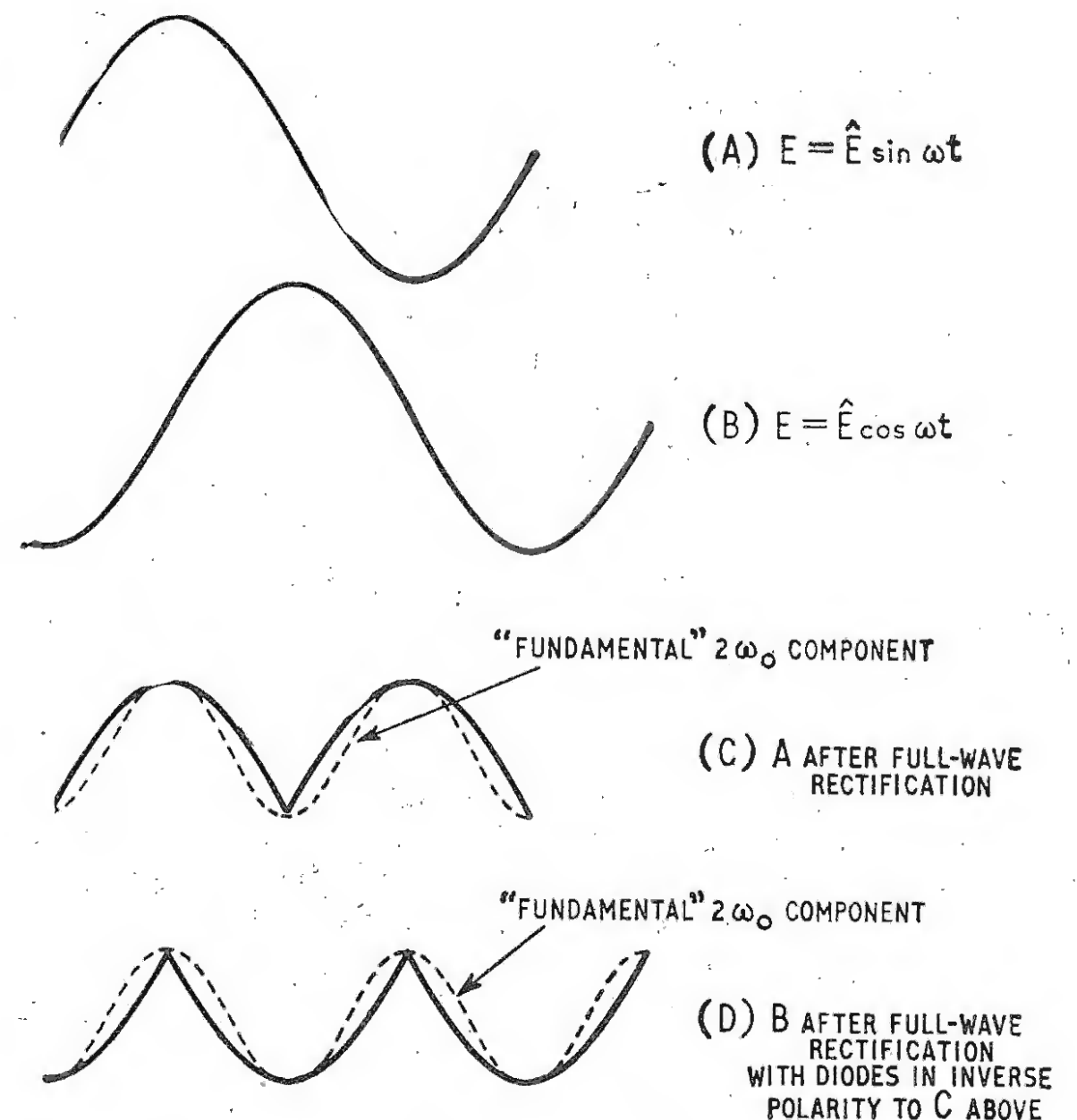


Fig. 3. Showing how components in quadrature of frequency  $\omega_0$ , after frequency doubling and  $180^\circ$  phase reversal of one component, have the same phase and may be added directly.



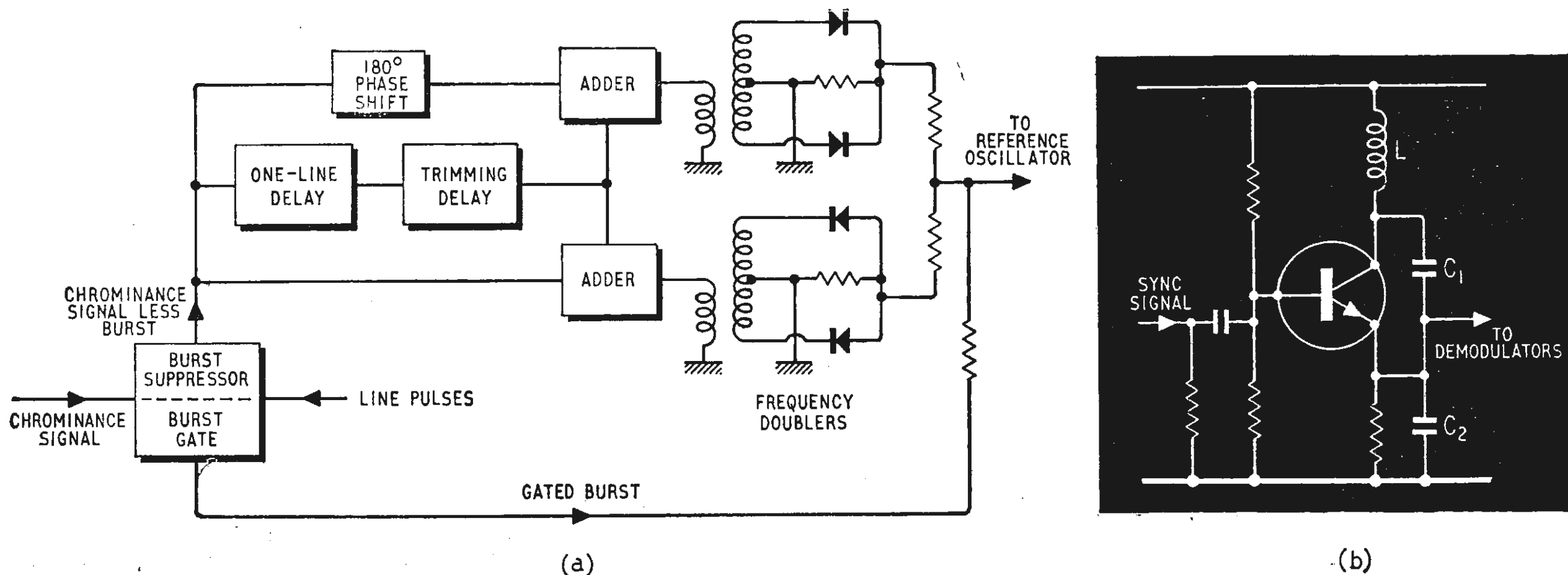


Fig. 4. Chrominance lock technique: (a) receiver block diagram; (b) type of oscillator used.

separated the transmitted quadrature components. If we go on to double the frequency of these components, by means of a full wave rectifying circuit for example, it can be seen that the  $90^\circ$  phase difference at fundamental frequency becomes  $180^\circ$  at second harmonic frequency. By a phase reversal in one channel, the frequency doubled components now have the same phase and may be added together. Also the line-by-line  $180^\circ$  phase shift at subcarrier frequency becomes  $360^\circ$  at twice frequency and this is of no consequence. Fig. 3 should help to make this clear.

The phase error relative to burst phase also becomes doubled. Now whatever the phase of the modulated subcarrier from the transmitter, we have a signal of constant phase irrespective of the hue at twice subcarrier frequency, which is phase modulated by non-linear or differential phase-error which may occur in the transmission path. We can therefore phase lock an oscillator at subcarrier frequency directly from this signal *provided* that the burst is used to start the oscillator in the right phase at the start of each line. In contradistinction to the classical subcarrier reference generator, the oscillator used is required to be able to follow quite rapid phase changes if it is to respond to differential phase changes. Such an oscillator would need a pull-in bandwidth of several hundred kilocycles, in contrast to noise bandwidths of several hundred cycles for the type of reference oscillator used in present N.T.S.C. receivers.

The application of this type of reference oscillator should be obvious; and it is claimed that it is possible to dispense with the timebase error correcting devices on video tape recorders. This removes one of the major objections to phase and amplitude modulated colour television systems when applied to video tape. This type of receiver reference generation can be seen more easily in Fig. 4. Note that full-wave rectifier frequency doubling is used, with one pair of diodes reversed to provide the necessary  $180^\circ$  phase change in one channel.

By suitable choice of the transistor and the temperature coefficient for  $C_1$  and  $C_2$  in Fig. 4(b), an oscillator can be designed with adequate temperature stability for reference generator use.

The chrominance lock technique is an interesting one and development work is proceeding in this country and in Europe to see whether it can be used in domestic receivers. It is a technique which is certain to be used

in PAL/PAL transcoders, for use at transmitters for correcting any timebase errors introduced in video tape equipment or in inter-city distribution networks.

### Single ended delay line

The delay line used in the normal receiver is the familiar zero temperature-coefficient glass type, where the glass is in the form of a rod or bar with a barium titanate or similar type of transducer at each end. However, using hybrid transformer techniques, it is feasible to have a single-ended line in which only one transducer is used. This is of course simpler and cheaper than the conventional line, and could lead to simpler techniques for grinding the line to a precise delay.

Recent work by Telefunken suggests that the delayed signal may be extracted from the direct signal without the need for hybrid transformers. In Fig. 5, the delay line has an insertion loss  $\alpha$  so that at the collector of the transistor, the signal is:—

$$-A(C + \alpha C^*) \text{ or } -A(C^* + \alpha C)$$

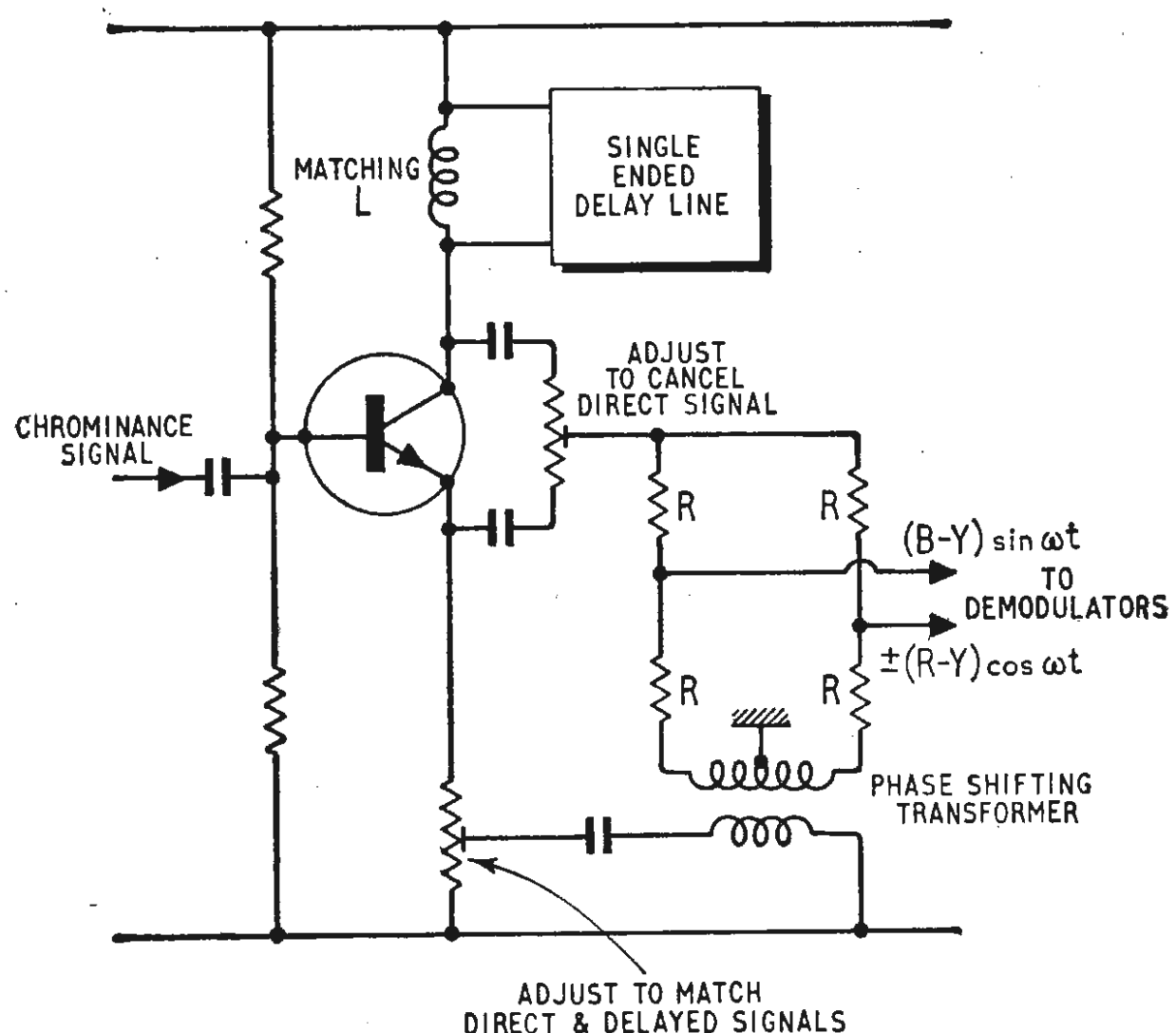


Fig. 5. Single-ended delay line basic receiver circuit.

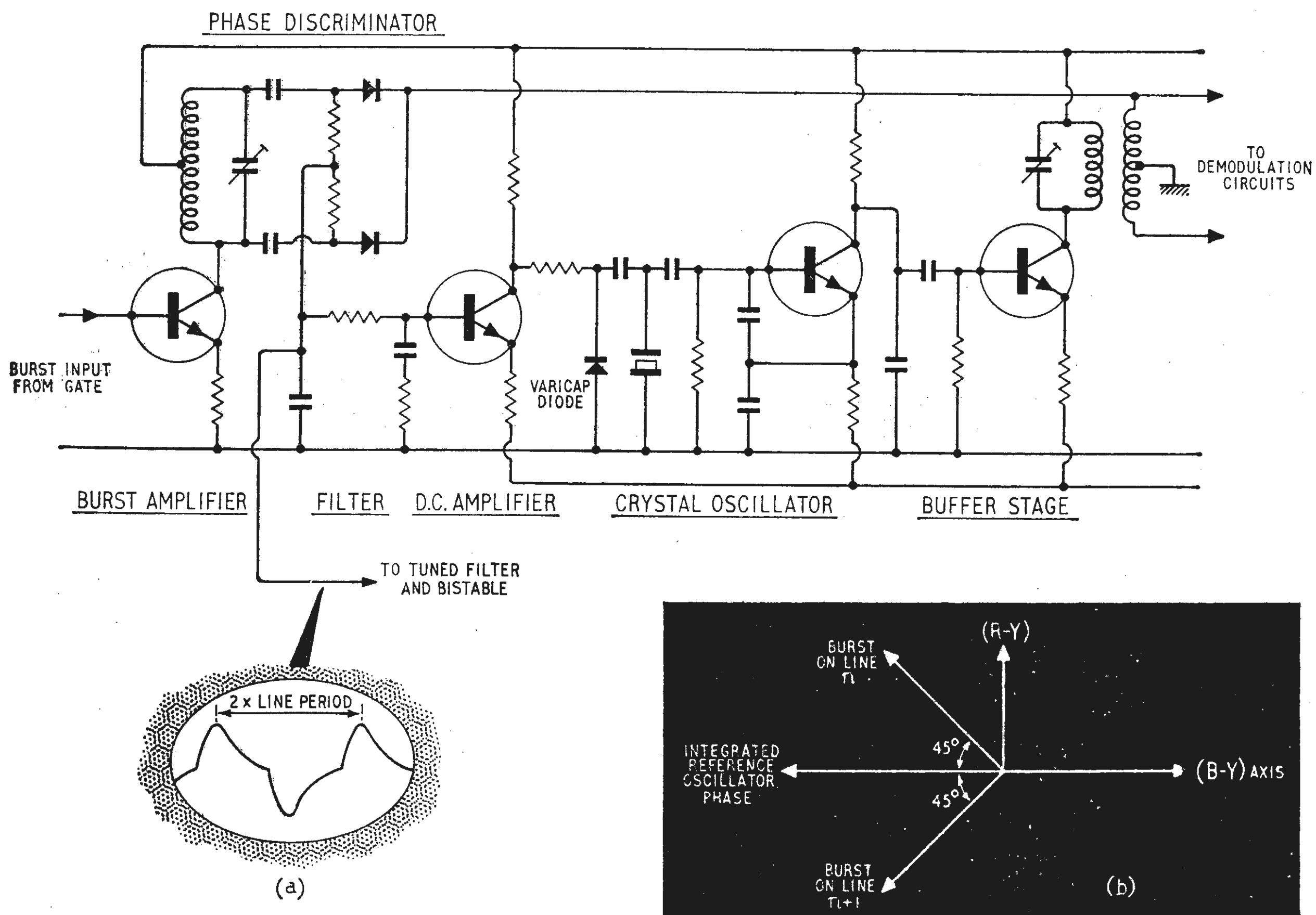


Fig. 6. Application of "swinging burst": (a) crystal oscillator and a.p.c. loop; (b) vector diagram of burst.

(where  $A$  is gain from base to collector and  $C + C^*$  represent colour components) while at the emitter the signal is  $C$  or  $C^*$ . If these two signals are added together in a resistive matrix, taking note of the relative gains, the direct signal cancels and we have the delayed signal. The direct and delayed signal can then be added and subtracted to give the  $(R - Y)$  and  $(B - Y)$  components of the chrominance signal in the usual way.

### Practical application of swinging burst

If the burst signal fed into a crystal oscillator a.p.c. loop of the form shown in Fig. 6 is alternating in phase by  $90^\circ$  on a line-by-line basis, the phase of the oscillator will take up the mean of the phase change, but at the discriminator output will be a triangular or square wave at half the line frequency, depending on the smoothing time constants.

This signal can either be amplified and clipped to provide a switching signal to switch the phase of the  $(R - Y)$  signal by  $180^\circ$  each line before it reaches its demodulator, or a conventional bistable, triggered by line flyback pulses, can be reset by this signal after it has been filtered in a high- $Q$  tuned circuit to give noise immunity.

Although the specification agreed at the Hanover meeting in May calls for a vertical interval identification signal in addition to the "swinging" burst, the recent series of transmissions of PAL in this country have only

used the "swinging" burst, which is simpler to use in the receiver, and leaves the vertical interval free for test signals, which are increasingly used, particularly by the relay companies.

It is feasible to use the "chrominance lock" technique with two oscillators, but with the burst components separated by the delay line.

The  $(B - Y)$  burst component will have the same phase on every line, while the  $(R - Y)$  component is changing by  $180^\circ$  every line. The  $(B - Y)$  burst component plus the frequency doubled and added chrominance signals synchronize one oscillator which drives the  $(B - Y)$  demodulator, while the  $(R - Y)$  burst component switches the other oscillator into the correct phase at the start of each line, obviating the need for any switching circuits. A frequency doubled component of the first oscillator keeps the two oscillators in step with regard to any phase errors.

Fig. 7 illustrates the decoding section of a receiver using "chrominance lock" and "swinging burst" together. Note that there are no switching circuits or identification circuits, so that the apparent complication of an extra oscillator is in fact a simplification over the conventional crystal oscillator reference circuit, and there is the added advantage of a linear and differential phase tolerance of  $\pm 80^\circ$ . Work remains to be done, however, on the noise performance of such a decoder.

(Continued on page 599)



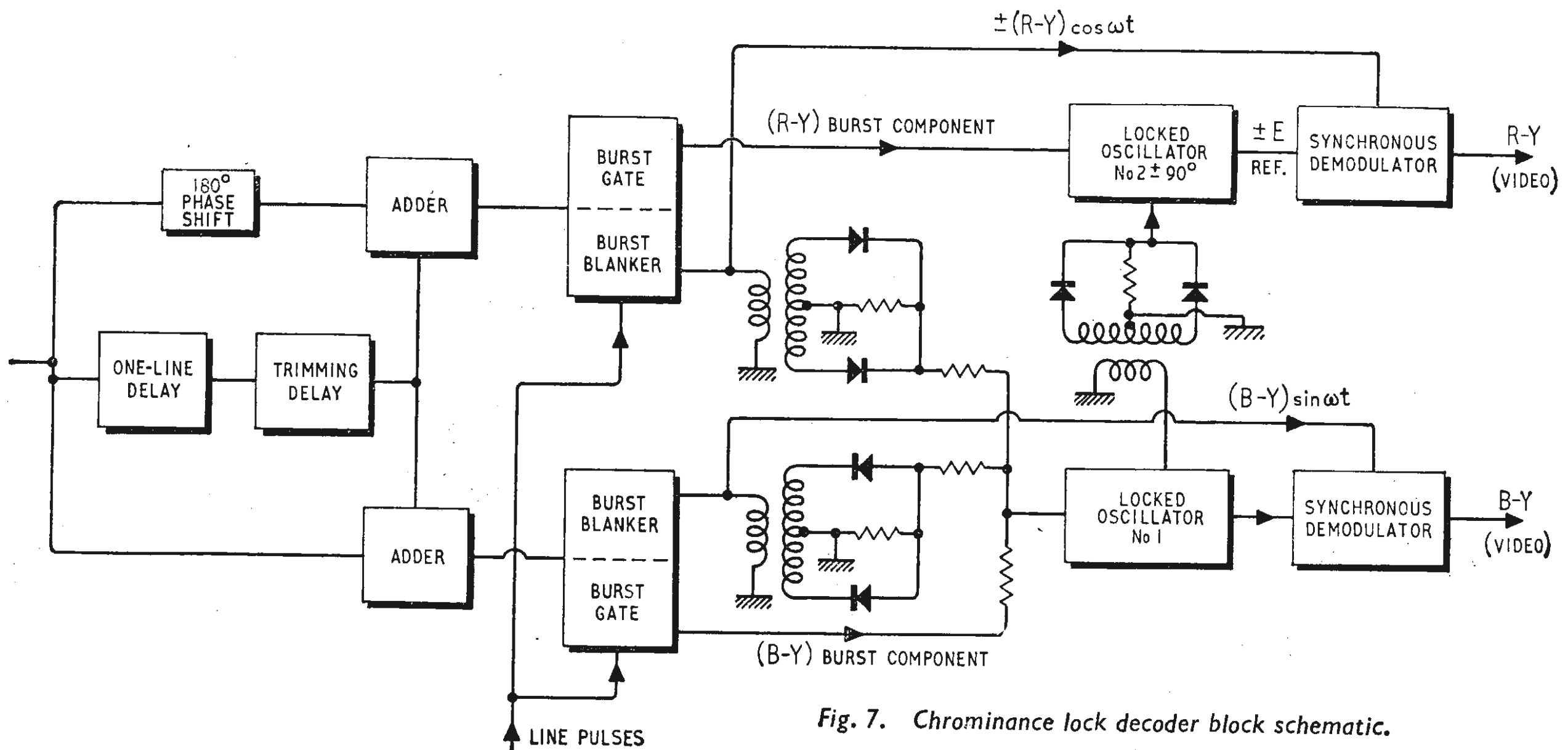


Fig. 7. Chrominance lock decoder block schematic.

## Error Correctors

It is perfectly feasible to use a delay line technique at the transmitter to correct phase errors by averaging. This would allow the use of simple PAL receivers, except in areas of severe multi-path reception.

There are two drawbacks to the basic error corrector, and these concern gain or saturation errors. It is well known that the PAL system does nothing to remove or minimize the effect of level-dependent gain distortion, and it converts phase distortion into an amplitude distortion proportional to  $(1 - \cos \epsilon)$ .

The latest type of error corrector is in two parts. The first part corrects phase errors by addition of an appropriate vector to the signal, while the second part derives a vector which is equal to the amplitude error due to phase correction  $(1 - \cos \epsilon)$ , and this is also added to the signal. The result is a corrected PAL signal without amplitude errors. In a delay-line receiver the averaging process will reduce the vertical chrominance resolution, but the averaging is only effective for the error correction signal, so that in the absence of error the vertical resolution is unchanged.

The phase correction part of the device uses a subcarrier modifier and a one-line delay to produce a vector at  $90^\circ$  to the original vector, and of amplitude and polarity appropriate to the correction. The subcarrier modifier consists of a balanced modulator with a carrier frequency equal to twice the PAL subcarrier frequency, and with the subcarrier component of the input PAL signal as the modulating signal. The output of the modulator consists of two sidebands of frequency  $f_0$  and  $3f_0$ . The lower sideband is the conjugate of the input, that is, if the input signal has a phase relative to a reference of  $+\phi$ , the output from the modifier will have a phase of  $-\phi$  relative to the same reference. The PAL signal consists of a subcarrier signal and its conjugate on alternate lines, and by use of the modifier, a one-line delay, a  $180^\circ$  phase shift circuit and an adding circuit, it is possible to derive a signal of the form  $-jC \sin \epsilon$  or  $-jC^* \sin \epsilon$ , where  $\epsilon$  is the error, with the  $-j$  indicating the rotation with respect to the original vector. A complex circuit is then used to make a signal of the same phase as the original correct vector but of amplitude equal to the modulus of

$\sin \epsilon$ . The signals are added to the required signal, and a corrected PAL signal results.

Note, however, that the only method of correcting level-dependent gain errors is to use the Lewis pilot-burst system (see *Wireless World*, March, 1965, p. 113).

## 405-line PAL

Some work has been done in this country on adapting the PAL system to 405-line operation. This has been undertaken in view of the difficulties involved in changing B.B.C. 1 and I.T.A. services over to 625-line operation.

Some radiated tests have been conducted on the London B.B.C. 1 and I.T.A. transmitters to assess compatibility of PAL relative to N.T.S.C. on 405 lines. The subcarrier frequency chosen for this work is the N.T.S.C. frequency plus quarter-line offset, which equals 2.660344 Mc/s. Preliminary results suggest that on 405 lines, PAL and N.T.S.C. are equally compatible, with a marginal advantage to PAL on some scenes.

**Acknowledgement** is due to ABC Television Ltd. for permission to publish this article. I am much indebted to Stuart Sansom and Michael Tooms of ABC Television and to Bernard Rogers of Rank Bush Murphy for their helpful comments and suggestions.

## REFERENCES

1. Cox, M. "PAL," *Wireless World*, December, 1963.
2. Townsend, G. B. and Carnt, P.S. "Colour Television, N.T.S.C. System, Principles and Practice. Iliffe, London (1961).
3. Bruch, W. "New approaches to subcarrier regeneration in PAL colour TV receivers," *Telefunken Zeitung* 37 (1964) No. 2 pp.100-115.
4. Bruch, W. "Demodulation circuits for PAL colour television receivers," *Electronic Engineering*, Vol. 36 (1964), August and September.
5. Townsend, G. B. "Colour TV system parameters," *Electronics Letters*, 1965, Vol. I, No. 1 p.11.
6. La Rosa, A. and Salvadorini, R. "Decoder developments in the PAL colour TV System," RAI report DTTV/DIR0033 July 1964, also as EBU Ad Hoc Group document Com T (E) 127.

# Active Impedance Converters

PRINCIPLES AND SOME PRACTICAL CIRCUITS—INCLUDING NEGATIVE IMPEDANCE CONVERTERS

By F. BUTLER, O.B.E., B.Sc., M.I.E.E., M.I.E.R.E.

EVERYONE is familiar with the use of a transformer as an impedance converter. If an ideal transformer of turns ratio  $n$  is loaded on the low-impedance side by an impedance  $Z$ , the impedance looking into the other winding is  $Z_1 = n^2Z$ . By transposing the source and load, we find that  $Z_1 = Z/n^2$ . The nature of the transformed impedance is unchanged by the conversion and the phase angle or power factor retains its original value. Real transformers are imperfect devices with core and copper losses. They have leakage inductance, winding capacitance and dielectric losses which collectively degrade the performance, notably by causing an insertion loss and a phase shift, both of which are objectionable.

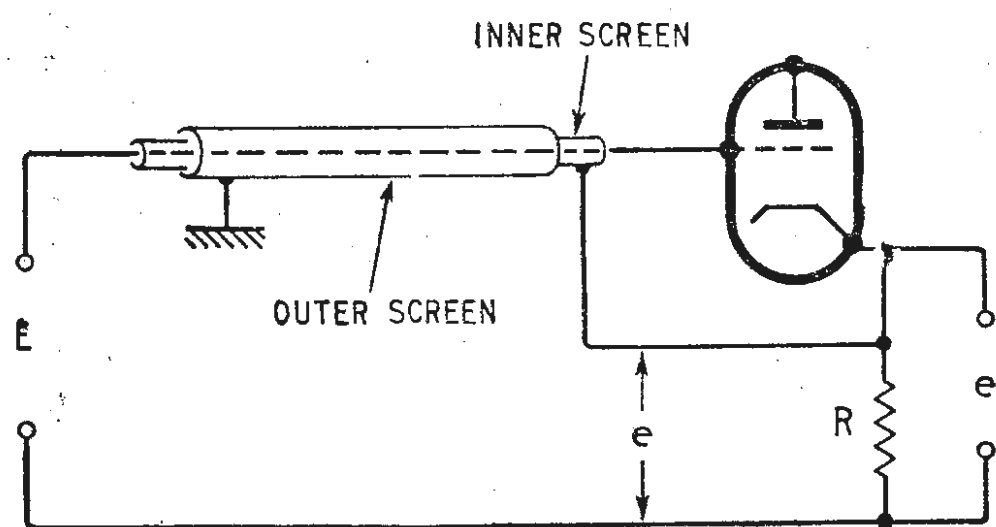
Other passive impedance converters take the form of matching networks such as  $T$ ,  $\pi$ , or  $L$ -connected reactances. These also have an insertion loss and the performance is frequency-dependent.

To offset the inherent losses of passive networks requires power amplification somewhere in the circuit, and once we accept the use of active devices there is no fundamental obstacle in the way of designing an ideal converter. For example, one could convert a lossy inductance into an ideal component of the same or any different value, selected at will.

An example of an active impedance converter is the well-known Miller integrator. If a feedback capacitor  $C$  is connected between the input and output terminals of an ideal phase-reversing amplifier of voltage gain  $A$ , the apparent input capacitance becomes  $(1 + A)C$ .

Another interesting case is that of the cathode follower. Here there is no phase reversal and the gain  $A$  is close to but rather less than unity. Any capacitance  $C$  between grid and cathode appears at the input terminal as  $(1 - A)C$  and can be made very small. Fig. 1 shows how this technique can be used to reduce the effect of cable capacitance. A cable with a double screen is used. The inner conductor is connected to the amplifier grid and the inner screen is connected to the cathode terminal. The potential difference between the inner conductor and the inner screen is  $E - e$ , which is only a small fraction of  $E$ .

Fig. 1. Cathode follower with low input capacitance.



The inner screen is live (at a potential  $e$ ), and is in practice covered by an earthed outer screen. The inter-screen capacitance is immaterial, since it is effectively in parallel with the load resistance  $R$  and is driven from the low source impedance of the cathode follower.

It should be noted particularly that this technique does nothing to reduce the grid-anode capacitance although some extensions of the principle allow this to be done.

Amplifiers incorporating these ideas are available commercially (see "Admittance Neutralizer," *Wireless World*, August 1965, p. 405).

The purpose of this article is to discuss in an elementary way the working principles of an active impedance converter and to describe practical circuits which exploit the effect.

## The ideal impedance converter

Given an impedance  $Z = R + jX$ , the problem is to convert this to another impedance  $Z_1 = mZ$ , where  $m$  is some given multiplier, real or complex. It would be still more attractive if the resistive component could be cancelled and the converted impedance changed into a

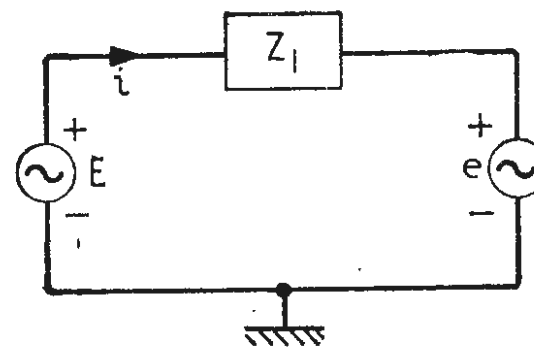


Fig. 2. Illustrating principle of active impedance converter.

pure reactance. This can indeed be done, and the conversion ratio can be made variable, control being effected manually or by some purely electronic means.

The basic theory of impedance conversion is best understood by studying the simple circuit shown in Fig. 2. Here  $E$  is the signal source and  $e$  is an auxiliary generator with a terminal voltage which can be adjusted in magnitude and phase. The ground connection merely serves as a reference point against which the relative voltages are measured in magnitude and phase. Suppose first that  $e$  is zero. The circuit current is  $i = E/Z_1$ . This current could be increased by bringing in the auxiliary generator  $e$  in a series-aiding connection with  $E$ . As seen from the terminals of the generator  $E$ , the impedance  $Z_1$  has apparently been reduced in value, since it now draws a larger current. Conversely, if the polarity of  $e$  is such as to oppose  $E$ , the circuit current is reduced and  $E$  sees an impedance which is larger than  $Z_1$ . The amount by which  $Z_1$  is increased or decreased clearly depends on the relative magnitudes of  $E$  and  $e$ . So far it has been assumed that  $e$  is either in phase with  $E$  or in exact phase opposition. By choosing some



intermediate value of phase difference it is possible to modify the Q-factor or power factor of the converted impedance. As a limiting case, the original impedance can be turned into a pure reactance. Even more intriguing is the possibility of turning an impedance into a negative resistance or reactance. Some elementary theory is sufficient to demonstrate the various possibilities.

In the circuit of Fig. 2 and with the polarities of  $E$  and  $e$  as marked:—

$$i = \frac{E - e}{Z_1}$$

Let  $Z_2$  be the impedance looking into the network from the terminals of  $E$ .

$$\text{Then: } Z_2 = \frac{E}{i} \quad \text{or } i = \frac{E}{Z_2}$$

Combining this with the first expression for  $i$ :—

$$\frac{E - e}{Z_1} = \frac{E}{Z_2} \quad \text{and finally:—}$$

$$e = E \left( 1 - \frac{Z_1}{Z_2} \right) \quad \dots \quad \dots \quad \dots \quad \dots \quad (1)$$

This equation gives the auxiliary generator voltage  $e$  required to convert an impedance  $Z_1$  into the new value  $Z_2$ , assuming a signal source voltage  $E$ . Some special cases are of interest. The first is a trivial one. Suppose  $Z_2 = Z_1$  so that the converted impedance is the same as the original value. Clearly  $e = 0$  as would be expected.

Next, suppose that  $Z_1 = R + j\omega L$ , corresponding to a lossy inductance, and that we wish to convert it to a pure inductance given by  $Z_2 = j\omega L_1$ . Substituting for  $Z_1$  and  $Z_2$  in (1):—

$$e = E \left( 1 - \frac{R + j\omega L}{j\omega L_1} \right)$$

$$= E \left[ \left( 1 - \frac{L}{L_1} \right) - \frac{R}{j\omega L_1} \right]$$

$$= E \left[ \left( 1 - \frac{L}{L_1} \right) + j \frac{R}{\omega L_1} \right] \quad \dots \quad \dots \quad \dots \quad (2)$$

Equation (2) is of the form  $e = (a + jb)E$ . The magnitude of  $e$  is thus  $\sqrt{a^2 + b^2}$ .  $E$  and the phase angle  $\phi$  is given by  $\tan \phi = b/a$ . Finally,

$$e = E \left[ \left( 1 - \frac{L}{L_1} \right)^2 + \frac{R^2}{\omega^2 L_1^2} \right]^{\frac{1}{2}} \quad \dots \quad \dots \quad \dots \quad (3)$$

$$\tan \phi = \frac{R}{\omega L_1 \left( 1 - \frac{L}{L_1} \right)} = \frac{R}{\omega(L_1 - L)} \quad \dots \quad \dots \quad (4)$$

If we merely require to cancel the series resistance of a lossy inductance without changing its value, i.e.  $L = L_1$ ,

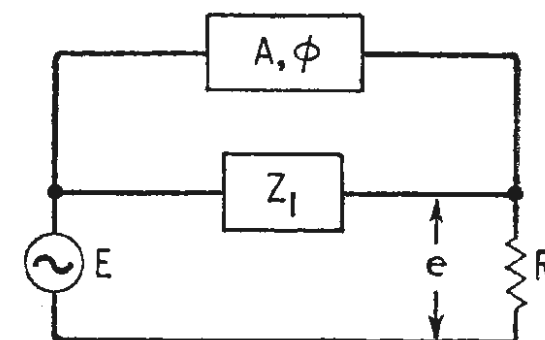
(2) shows that  $e = \frac{jR}{\omega L_1} \cdot E$ . Thus  $e$  leads  $E$  by  $90^\circ$  and its

required magnitude, for exact resistance cancellation, is  $E.R/\omega L$ . Further examination of (2) shows that, for pure inductances, so long as the converted inductance

$L_1$  is greater than the original value  $L$  the term  $\left( 1 - \frac{L}{L_1} \right)$  is

positive and  $e$  and  $E$  are in the same phase. If  $L_1 < L$ ,  $e$  and  $E$  must be opposite in phase. In the first case the gain  $e/E$  is less than unity. In the second it is numerically greater than unity.

Fig. 3. Implementation of Fig. 2.



The case of capacitance conversion can be treated in the same way, merely by substituting  $1/j\omega C$  for  $j\omega L$ .

To convert an impedance  $Z_1$  into a negative resistance  $R$  calls for the substitution  $Z_2 = -R$  in (1), giving  $e =$

$$E \left( 1 + \frac{Z_1}{R} \right).$$

If, for example,  $Z_1 = r + j\omega L$ , then:—

$$e = E \left( 1 + \frac{r + j\omega L}{R} \right)$$

$$= E \left( \frac{R + r}{R} + \frac{j\omega L}{R} \right) \quad \dots \quad \dots \quad \dots \quad (5)$$

One must be wary of conversions of this type involving negative resistance, since there is a risk that the system will be unstable. In effect we are cancelling losses by positive feedback.

### Some practical circuits

Practical implementation of the circuit of Fig. 2 involves some method of generating the auxiliary voltage  $e$  from the source  $E$  and setting the voltage ratio and the phase angle at the calculated values. To do this we use an amplifier of adjustable gain and phase shift, driven from the source  $E$ . The idea is shown in Fig. 3. The block

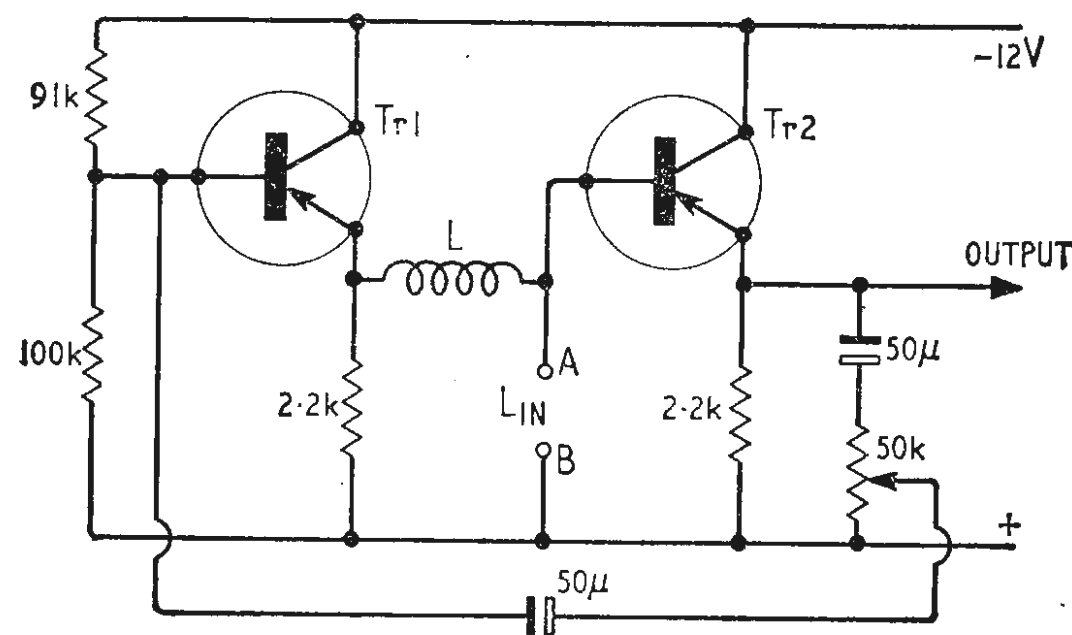


Fig. 4. Inductance multiplier circuit.

marked  $A, \phi$  represents an amplifier of voltage gain  $A$  and phase shift  $\phi$ . As before,  $Z_1$  is the impedance which is to be converted to some different value. At its output end,  $Z_1$  is terminated by  $R$ , the load resistance of the amplifier, in parallel with the output impedance of the amplifier. If this resistance or impedance is appreciable it will affect the Q-factor of  $Z_1$  and will modify its phase angle. To minimize this effect, the output impedance must be very low. This suggests the use of a cathode follower or emitter follower output stage, or the use of some form of negative feedback amplifier. At the same time, the input impedance of the amplifier should be large, so as to avoid loading the source  $E$ . Again, the use of a cathode-follower or emitter-follower input stage is suggested.

When a simple inductance multiplier is required and it

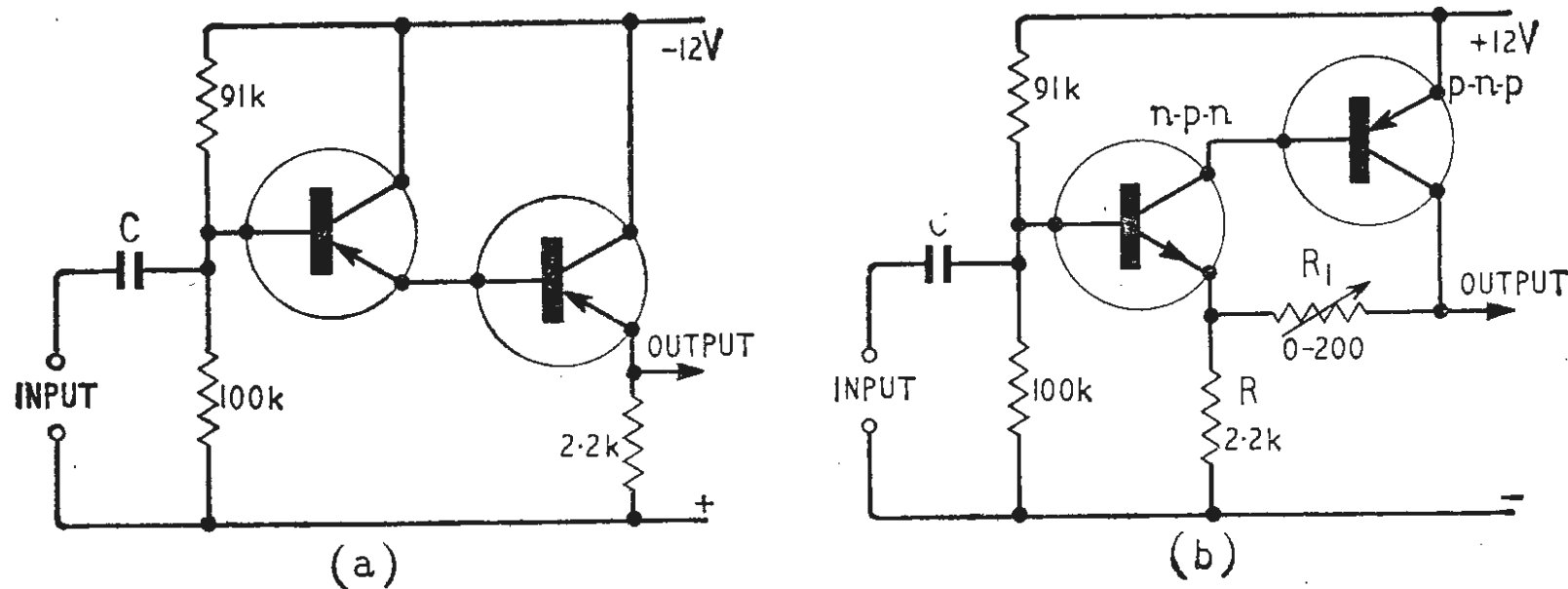


Fig. 5. Amplifiers with voltage gains close to unity.

is not required to cause an appreciable change in  $Q$ -factor, the circuit of Fig. 4 is recommended. The input terminals AB are the points across which the increased inductance is seen. In practice a blocking capacitor is required in series with A if the signal source is resistive, otherwise the operating conditions of the emitter followers will be upset. The maximum gain of a simple emitter follower is about 0.9. Two in tandem give a gain of 0.81 (say 0.8). The maximum possible inductance multiplication is then given by  $1 - L_1/L_2 = 0.8$  or  $L_2 = 5L_1$ . A higher multiplication factor calls for an overall gain much closer to unity. This can be achieved by the use of compound-connected transistors as in Fig. 5(a), or by using a complementary pair of transistors as in Fig. 5(b).

By adding the resistance  $R_1$  (a few ohms, set by trial), the gain can be made exactly unity or even greater. If  $R_1$  is made too large, the system will be unstable and will run into self-oscillation.

The input inductance seen at the marked terminals of Fig. 4 can be varied over a 5 : 1 range by adjustment of the 50 k $\Omega$  gain control potentiometer. The circuit can be turned into a variable-frequency Colpitts oscillator by the addition of two capacitors and a feedback resistor as shown in Fig. 6. Some form of amplitude limiter must be added if a pure sine-wave output is required but a reasonably good waveform can be secured by selection of the value of the feedback resistor  $R_f$ .

If in Fig. 4 we substitute a capacitor for the inductance  $L$  and add base bias resistors to the right-hand transistor, a capacitance is seen at the terminals A B. The value of this depends on the overall gain. Whereas the inductance is multiplied in value, the effective capacitance is reduced in value but can still be varied over a wide range. Fig. 4 can be made into a tunable amplifier by connecting capacitance across A B and feeding the point A from a constant-current source, or through a blocking capacitor and high resistance. The resonant frequency is controlled by the setting of the gain potentiometer. Output

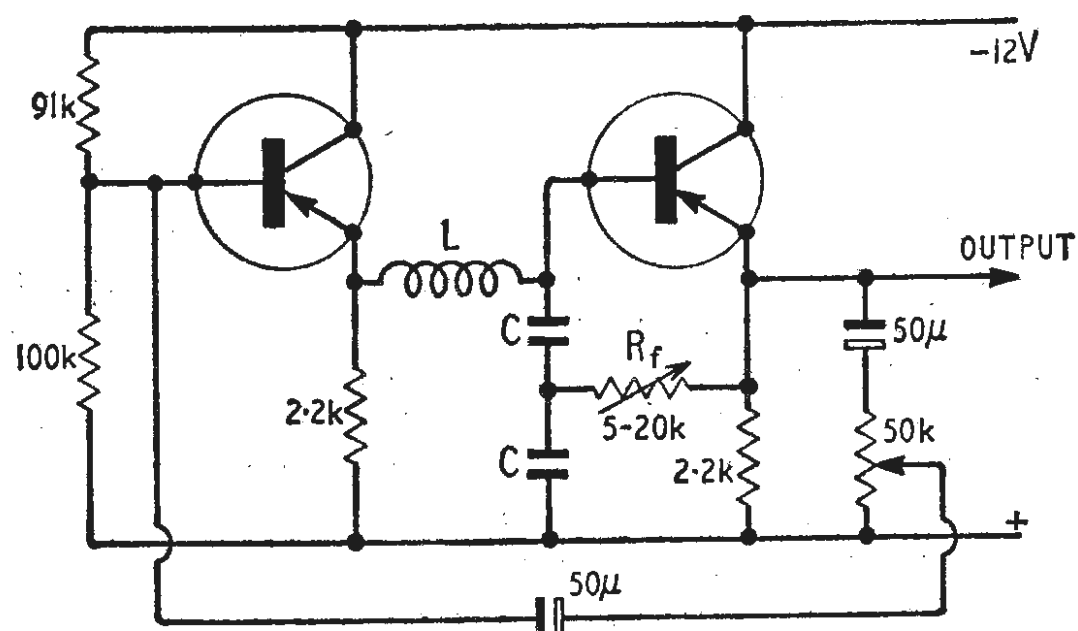


Fig. 6. Resistance-tuned oscillator based on Fig. 4.

can be taken at low impedance from the emitter of Tr2.

### Capacitance multiplication

This can be achieved as shown in Fig. 7. In this case a phase-reversing amplifier of adjustable gain and low output impedance is required. A standard feedback amplifier is ideal for the purpose. Its gain is stable, being set by the ratio of two resistances and its performance is not much degraded by transistor parameter changes.

Using the theory already discussed, the capacitance seen at the input terminals is  $(1 + \frac{R_2}{R_1}) C$ . Multiplying

factors up to 50 or so can be achieved with stability. If an inductance is substituted for the capacitor  $C$ , the inductance seen at the input terminals is reduced. It is

given by  $L / (1 + \frac{R_2}{R_1})$ . A suitable feedback amplifier is

shown in Fig. 8. The circuit of Fig. 7 is ideally suited for use as a tuned amplifier if its input is shunted by a suitable inductance and fed from a constant-current (high resistance) source. A low-impedance output is available across the load resistance  $R$ , although the actual level will depend on the input voltage and on the gain setting of the amplifier. Thus a higher capacitance multiplication will need higher gain and this will give a larger output. In the elementary theory previously given, a tacit assumption has been made that the input signal source is of zero output impedance so that feedback from the amplifier output (Fig. 3 or Fig. 7) cannot upset the assumed working conditions. These conditions will be disturbed if the signal source  $E$  has appreciable internal impedance, as is inevitable if the circuit is to be converted to a tuned amplifier by shunting the input terminals by an inductance or tuned circuit fed from the signal source through a high resistance. The effect of feedback is to modify the magnitude and phase of the net signal voltage developed across the input terminals and there is a real risk of instability, manifested by self-oscillation at some undesired high frequency.

To obviate this effect it is sufficient to introduce a deliberate compensating phase shift into the amplifier path. This can be accomplished by connecting a shunt capacitance  $C_1$  to a tapping on the feedback resistor  $R_1$  in the circuit of Fig. 7. For use in the audio frequency range,  $C_1$  may be about 0.1  $\mu$ F, with a resistance of about 2 k $\Omega$  between  $C_1$  and the input end of  $R_2$ . With this simple modification, capacitance changes up to 100 : 1 are possible, though a tuned amplifier covering the corresponding frequency range (10 : 1) will naturally show marked variations in selectivity over the range. This is



only to be expected and the effect is simply due to the large changes in  $L/C$  ratio over the tuning band.

### Uses of impedance converters

From what has been said already it is clear that impedance converters can be used as  $Q$ -multipliers, as resistance-tuned selective amplifiers, as resistance-tuned  $LC$  oscillators and as a means of producing very large or very small variable reactances from fixed inductors or capacitors. The possible range of reactance variation is enormous and becomes still greater if, for example, a capacitance converter is used in series or in parallel with an inductance converter.

So far, only manual adjustment of the amplifier gain has been considered, but it is fairly simple to do this operation by purely electronic means. For example, several forms of voltage-controlled resistance are available, including biased diodes, unijunction devices, bipolar and field-effect transistors. Photo diodes and thermistors react respectively to changes in light intensity or temperature. Using these it is possible to build oscillators in which the operating frequency can be varied by a control voltage, a changing light source or by changing temperatures. Automatic frequency control systems, phase-locked oscillators, variable delay lines, frequency and phase modulators, pressure and strain transducers are all devices which are adaptable for use with impedance converters.

### Negative impedance converters

A negative impedance converter (n.i.c.) is a four-terminal negative-feedback active network which, when terminated at one pair of terminals by an impedance  $Z$ , presents an

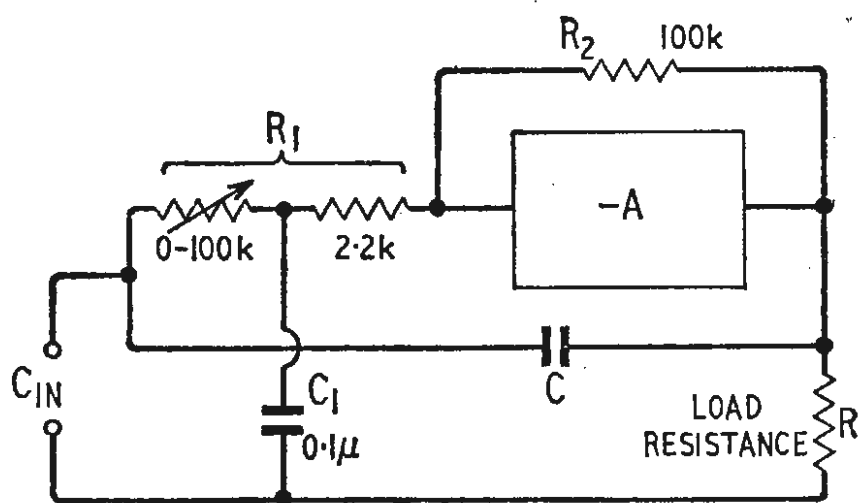


Fig. 7. Circuit for capacitance multiplication. (Adjustable gain and phase shift.)

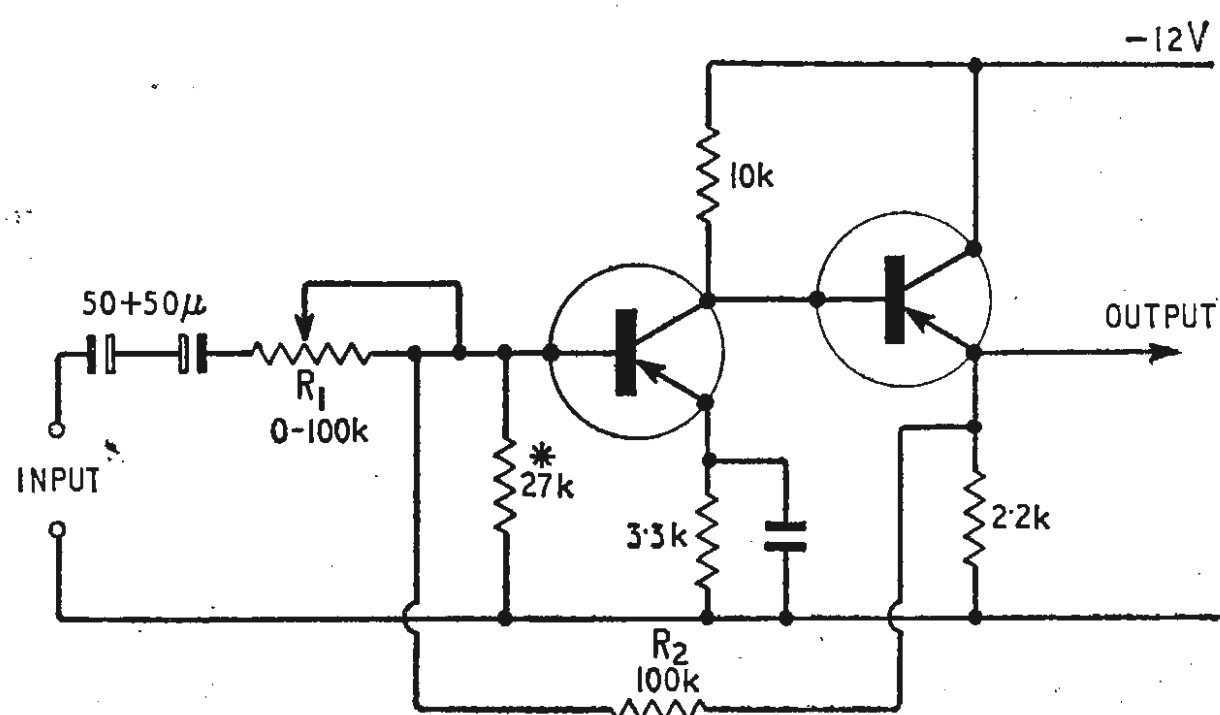
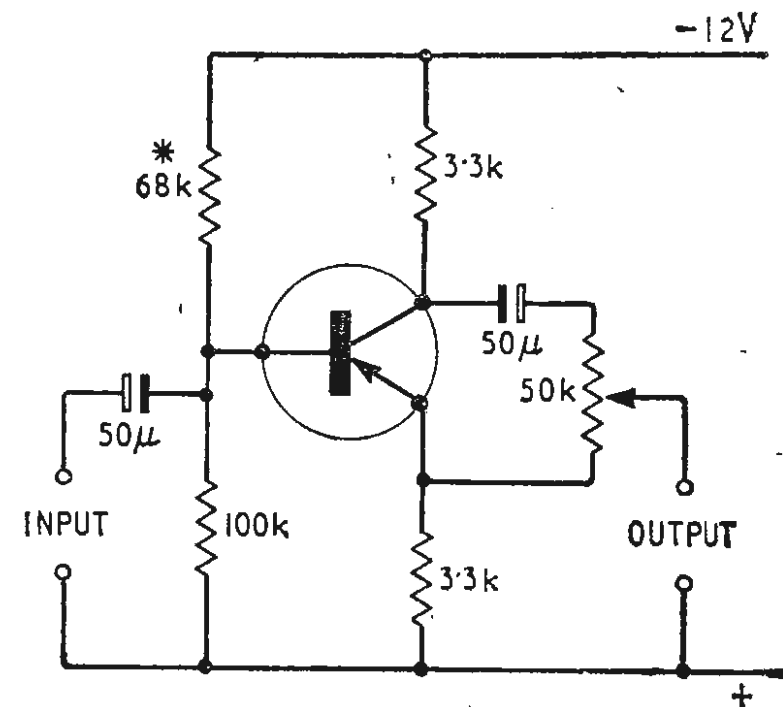


Fig. 8. Feedback amplifier as used in Fig. 7. Component marked \* may require adjustment for maximum undistorted output.

Fig. 9. High impedance preamplifier for use with Fig. 8., with gain continuously adjustable between  $+1$  and  $-1$ . Component marked \* may require adjustment for maximum undistorted output.



impedance  $-Z$  at the other pair. There is an extensive literature on the subject and designs for many practical circuits have been published. The main field of application of the n.i.c. is in network synthesis. This is because the n.i.c. allows one to eliminate inductors and transformers. For example, one can design  $RC$  filters with properties resembling conventional  $LC$  networks. Since such converters are likely to be required in large numbers they should be simple, reliable and inexpensive. It is also convenient if there is one common input and output terminal which should preferably be one terminal of the power supply.

The theory already given is sufficient to show the working principle of the n.i.c. From (1), by setting  $Z_2 = -Z_1$  it can be seen that  $e = 2E$ . The circuit of Fig. 3 meets this requirement if the amplifier has a voltage gain  $A = 2$ , with zero phase shift. In effect, the impedance  $Z_1$  is driven at one end by the signal source  $E$  and at the other end by the amplifier output  $2E$ . The current through  $Z_1$  is exactly equal to the current which would have been supplied by the signal source, acting alone, but it is in the opposite direction. The apparent impedance seen by the signal generator is thus  $-Z_1$ . If  $Z_1$  is replaced by a pure resistance  $R_1$ , this appears as  $-R_1$  at the input terminals. This negative input resistance is a potential source of instability. If the input terminals are short-circuited the system is stable. If open-circuited, we encounter instability. More specifically, if the generator source resistance  $R$  is smaller than  $R_1$  the system is stable; if greater than  $R_1$  it is unstable. If the two resistances are equal the circuit is in a critical condition of marginal stability. In effect  $R_1$  and  $R$  form a potential divider across the output of the amplifier of voltage gain  $A = 2$ . The fraction  $R/(R + R_1)$  of the output constitutes the amplifier input. Clearly the system will oscillate if this fraction exceeds 0.5, since the feedback is positive and the loop gain is greater than unity. If the fraction is less than 0.5 the system is stable. If it is exactly 0.5 the stability is conditional.

Some of the best designs of n.i.c.s have reached a state very close to the ideal in respect of performance, stability and accuracy of conversion. The foregoing brief and rather naïve account of the mode of operation does less than justice to the subject but even a primitive type of converter is good enough to permit a range of operations which would otherwise seem impossible. For example, it is possible to reduce or cancel undesired resistance or reactance across any given pair of terminals, as in the admittance neutralizer mentioned previously.

The writer has used such devices to cancel part of the standing capacitance of a varicap diode, thus increasing enormously the percentage change of capacitance. One can increase the ratio of maximum to minimum capacitance of tuned circuits and thus broaden the tuning

range. At the same time the Q-factor can be increased to give higher selectivity. The range of uses is in fact limited only by the ingenuity of the designer and it is not too much to expect that, with improvements in techniques of miniaturization, a complete n.i.c. could be packed into a single transistor case.

It is surprising that in the wide literature on negative impedance converters there are so few papers of a tutorial nature to which one may turn for information on the basic principles of design and operation. An exception is an article "Filtarnics" \*(active filters with n.i.c.s). A study of this will equip the reader to follow the more recent developments, several of which have been briefly described in the new I.E.E. publication *Electronics Letters*. It is not too easy to forecast design trends in this particular field but one guess is that more use will be made of tandem-connected operational amplifiers. These have been developed to the point of near perfection, with properties closely defined by passive components. Microminiature versions have already been produced by some manufacturers and will soon be more widely available at a cost which will eventually be lower than that of equivalent discrete components.

#### FURTHER READING

Network Synthesis Using Negative Impedance Converters, D. J. Storey and W. J. Cullyer, *Proc. I.E.E.* Vol. 111, No. 5, May 1964, p. 891 *et seq.*

Directly Coupled Negative Impedance Converter, A. J. Drew and J. Gorski-Popiel (Correspondence), *Proc. I.E.E.* Vol. 111, No. 7, July 1964, p. 1282 *et seq.*

Synthesis of Reactance Converters, D. A. Tsirel'son, Translation from *Elektrosvyaz'* (U.S.S.R.) August 6th 1964, p. 41 *et seq.*

\*Filtarnics, Thomas Roddam, *Wireless World*, August 1960, p. 370.

#### APPENDIX

The theory of an impedance converter used as a selective amplifier is exactly the same as for a generalized feedback amplifier of the virtual earth type, which was discussed by the writer in *Wireless World*, February, 1962, p. 77, under the heading "Transistor Amplifier Pairs." Some readers may find this treatment more satisfactory than the largely descriptive account in the main body of the present paper.

Referring to Fig. A it can be shown that the voltage gain  $m$

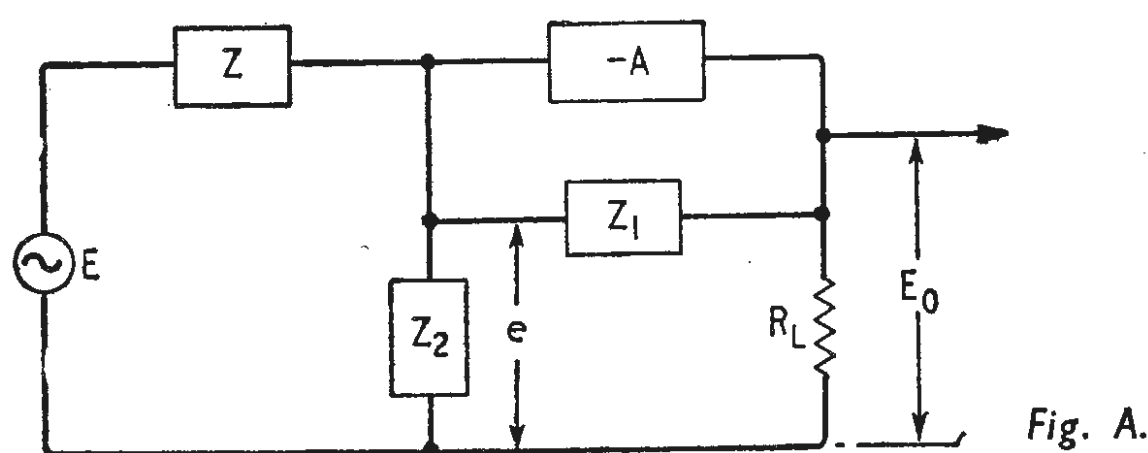


Fig. A.

and the input impedance  $Z_i$ , seen by the generator  $E$  are given by:

$$m = \frac{E_0}{E} = \frac{-A}{1 + Z \left( \frac{1}{Z_2} + \frac{A+1}{Z_1} \right)} \dots \dots \dots (1)$$

$$Z_i = Z + \frac{1}{\frac{1}{Z_2} + \frac{A+1}{Z_1}} \dots \dots \dots (2)$$

The input impedance seen across the terminals of  $Z_2$  looking into the amplifier is:—

$$Z_i' = \frac{1}{\frac{1}{Z_2} + \frac{A+1}{Z_1}} \dots \dots \dots (3)$$

It corresponds to the parallel connection of  $Z_2$  and  $Z_1/(A+1)$ . From this it can be seen that the effect of feedback is to leave unchanged the value of  $Z_2$  and to reduce the value of  $Z_1$  by the factor  $(A+1)$ .

Equation (1) describes all the properties of the amplifier, including gain, phase shift, selectivity and stability margin for prescribed values of  $A$ ,  $Z$ ,  $Z_1$  and  $Z_2$ .

## EARLY BIRD AGAIN

SOME additional information on the HS303 (Early Bird) satellite communication system was presented at an I.E.E. colloquium held recently on this subject.

The orbit-to-equator inclination was initially within  $0.1^\circ$ , but this figure has increased since launching and at August 25th, this stood at  $0.47^\circ$ . The hydrogen peroxide jets are not apparently used to correct this drift but to correct for longitudinal variation, which at launching was  $0.05^\circ$  per day from  $27^\circ$ W. Since any corrections made are only occasional, adjustments to the receiving aerials are necessary, and to some extent these can be made by altering the aerial feed position. After the polar diagram has shifted by about  $1^\circ$ , the shape begins to deteriorate and dish corrections then become necessary, the control information being obtained from conical scanning of the feed. It was pointed out that since operation of the European stations is not continuous programmed aerial steering and auto-follow correction are not necessary and often not convenient.

At present, 68 (out of 240) HS303 telephone circuits are in operation. The estimated increase in transatlantic traffic is 100 circuits per year, but it was stated that a larger aerial dish would not be required for future systems involving, say, up to 900 circuits. The coaxial cable link from the Goonhilly station to London will be replaced with a 960 channel radio link *via* the Post Office Tower.

Some indication of the reliability of the HS303 system can be gained from the table below:—

28/6/65 to 1/10/65	Goonhilly	Andover	Pleumeur Bodou	Raisting	Total
Interruptions ..	4	10	4	3	21
Time lost by faults	0.09%	0.25%	0.16%	0.05%	0.55%
Stand-by changes	—	—	1	2	3

The relatively high number of faults at the Andover station is to be expected, since this is the only station in continuous use, and one might expect roughly three times the number of faults. In addition to the above stations, a low-capacity station at Fucino, near Rome, operates at weekends only, when traffic density is lower. It is interesting to note that only Goonhilly is not fitted with a Radome, with the advantage that the increased loss and noise temperature, due to a wet Radome surface, is avoided.

A decision on the choice of a global satellite communication system has not yet been made but is expected within the next few months. One of the most important factors affecting the decision will be the question of the time delay of about 270ms. Although this may appear to be only marginal, it was stated that the public had not been exposed to this delay sufficiently during telephone conversations to enable public reaction to be assessed.



## PAL Demonstrations

AGREEMENT on a common colour television system for Europe seems as far away as ever and the next hope lies in a C.C.I.R. meeting in Oslo in June, 1966. Meanwhile, a strong body of technical opinion in Britain seems to be veering away from the country's declared preference for the N.T.S.C. system towards the PAL system. There is certainly a great deal of interest in PAL in Britain at the moment, as could be seen when Dr. W. Bruch of Telefunken, the man responsible for the development of the system, gave a lecture-demonstration on PAL to a packed joint meeting at the I.E.E. of the Television Society, the I.E.E. and the I.E.R.E. Convincing demonstrations were given of the ability of the system to counteract hue distortion resulting from phase errors, though some people felt that the use of simulated phase distortions as large as 50° on still pictures with large areas of strongly saturated colour (transmitted by line from near Broadcasting House) was somewhat unrealistic. However, Dr. Bruch's final, charmingly modest claim that "PAL is the best form of N.T.S.C." was warmly approved by the audience.

The British Radio Equipment Manufacturers' Association has voiced its preference for the improved PAL as being the system "capable of consistently yielding the best quality colour pictures, particularly under poor reception conditions." The Association, in collaboration with the B.B.C. recently staged in London a series of special demonstrations using domestic receivers produced by five British manufacturers. Two of the manufacturers—Bush and Philips—were demonstrating both a simple PAL receiver and one with a delay-line. There was a marked difference in picture quality between the two types of receiver—incidentally, Dr. Bruch in his lecture freely admitted the superiority of the delay-line receiver. The other manufacturers demonstrating receivers were G.E.C. (delay-line) Pye (simple) and Ferguson who had modified an American N.T.S.C. receiver for delay-line PAL.

Developments in PAL since the system was last reviewed in *W.W.* (December 1963) are surveyed on p. 595.

## Aeronautical Communication

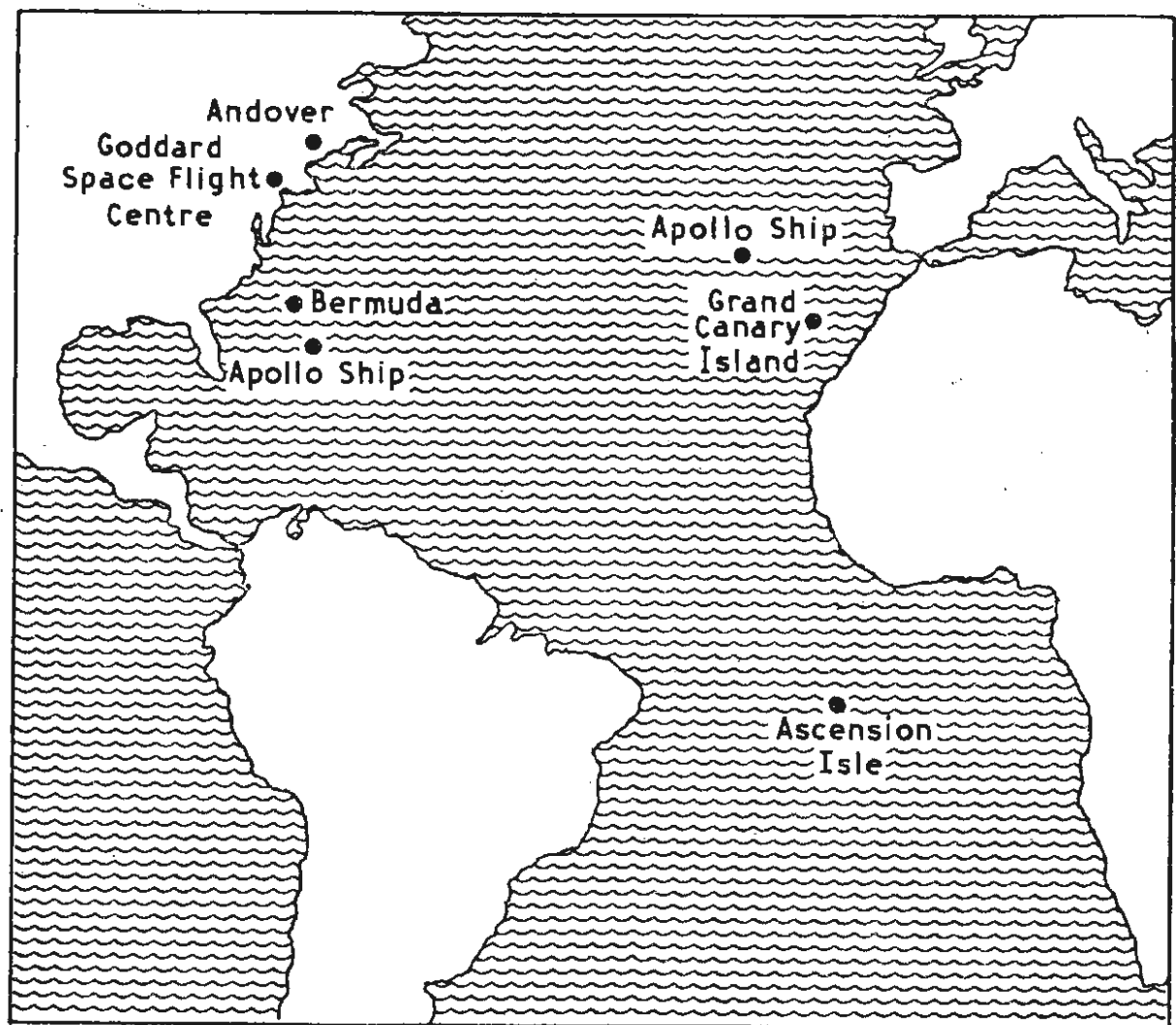
THE use of synchronous satellites for relaying v.h.f. transmissions between aircraft and ground stations is a possibility being closely investigated by the Air Transport Association of America (A.T.A.). Aerial design is one of the major problems because in normal v.h.f. communications, signals do not shift their polarization from one plane to another. However, v.h.f. signals from a satellite must travel through the ionosphere to reach the aircraft and during travel the plane of polarization is changed. As a result, both vertical and horizontal polarization must be allowed for on the aerial system of the aircraft so that it can match the plane of polarization of the incoming signals as closely as possible. Experimental results to date are encouraging.

An American aircraft using a special aerial and modified receiving equipment over the Pacific has transmitted messages to and received messages from a ground station in California via Syncom III. Also an American aircraft flying over the North Atlantic has listened to radio telemetering signals from Early Bird—this satellite is not equipped to receive v.h.f. signals and thus can be used only for listening tests. However, these one-way tests are important in that the experience can be used in the solution of basic technical questions such as deciding the design and optimum location of the aerial on the aircraft and, for determining the amount of radiated power that is needed for the satellite transmission to the aircraft. The most obvious advantage of the use of a synchronous satellite is of course the enormous increase in coverage. At altitudes of 30,000 to 40,000 ft, com-

monly used by jet aircraft, line-of-sight distance is usually not more than 250 miles but by using a synchronous satellite relay approximately one third of the earth's surface is brought into line of sight. Opportunity for further study of the problems has been provided by the decision of NASA to provide aeronautical v.h.f. relay facilities aboard ATS-1, the first application technology satellite.

## British Communications for Apollo

ASCENSION ISLE is to be the site of a £1M British satellite communications earth terminal station for the American man-on-the-moon-by-1970 Apollo project. The station is to be built by the Marconi Company for Cable and Wireless who is to own and operate the station. Commercial use is to be secondary to that of space communications. The station will communicate with the Goddard Space Flight Centre in Maryland, via the Andover, Maine, earth station through a synchronous satellite to be "stationary" 6°W over the Atlantic. The satellite—a modified version of Early Bird—will receive on a frequency of 6 Gc/s and transmit on 4 Gc/s with an e.r.p. of 25 W. A second similar satellite will be positioned between 130° and 170°E over the Pacific.



The map shows part of the Apollo communications network containing the Ascension and Bermuda stations. Andover will link via a satellite over the Atlantic with any two of three stations—Ascension, Grand Canary or the East Atlantic Apollo ship. Approximate positions of the two Apollo ships are shown.

Signal power, in the order of  $10^{-14}$  W, will be received at the Ascension station by a 42 ft diameter, steerable parabolic dish aerial with a focal length of 12 ft. The paraboloid will be rotatable through 370° in azimuth. Mounted on the aerial platform, will be the majority of the receiving and transmitting equipment. Signals between the platform-mounted equipment and the main base station will be fed by cable at an intermediate frequency of 70 Mc/s. Extremely high amplification is required for the very low signal level received; the noise problem will be dealt with by a cryogenic parametric amplifier operating at  $-253^{\circ}\text{C}$  in helium. For maximum reliability, power supplies and the major sections of the transmitting and receiving systems are fully dupli-

cated. The station is to be operational in 1966 and by December this year engineers will be on the island to prepare for the arrival of the equipment.

A second contract worth £500,000 has also been awarded to the Marconi Company by Cable and Wireless for a high-frequency communications station in Bermuda which is to use two high-speed data transmission circuits, a speech channel and three teleprinter channels. The station and an Apollo ship located approximately 1000 miles S.E. of Bermuda will be in contact with the Goddard Space Flight Centre. The Bermuda station is of particular importance because it will be the only one in a position to track the Saturn launch rocket during the critical moments immediately after the launch.

**PAL Transmission Times Altered.**—Until further notice the schedule of B.B.C. experimental PAL colour television transmission from Crystal Palace channel 33, vision 567.25 Mc/s, sound 573.25 Mc/s) is as tabulated. The test card periods consist of 15 minutes of test card in black and white, 10 minutes of colour bars and 35 minutes of colour slides in each hour.

	Test Card, Colour Slides, Colour Bars	Live Studio Pictures, Films
Monday	14.00—17.00	
Tuesday	14.00—17.00	
Wednesday	14.00—16.00	16.00—17.00 & 18.10—19.00
Thursday	14.00—17.00	18.10—19.00
Friday	14.00—16.00	16.00—17.00 & 18.10—19.00

\*Films only

**New Status for Instrument Technologists.**—After formal approval by the Board of Trade, new Articles of Association and Rules were passed at an extraordinary general meeting of the Society of Instrument Technology. The revised articles differ from the previous ones by the institution of six fee paying classes of membership—Member, Companion, Graduate, Associate, Student and Subscriber. In addition, provision has been made for examinations for the various classes of membership. Copies of the revised Articles of Association and Rules will be available in January from the Society at 20 Peel Street, London, W.8.

A 1966 series of four-day courses for scientists and engineers has been planned by the Bristol College of Science and Technology as follows. "The Synthesis and Analysis of Electronic Materials," January 18th-21st; "The Physics of Semiconductor Junction Devices," February 1st-4th; "Applications of Semiconducting Compounds," February 15th-18th; "Applications of Magnetic and Dielectric Materials," March 2nd-4th. The fee for each course is £7 10s, and further details are available from The Secretary, Centre for Adult Studies, Bristol College of Science and Technology, Ashley Down, Bristol 7.

**Baird Museum.**—Strathclyde University, Glasgow, have named their new Hall of Residence after John Logie Baird. A museum is to be instituted there by Radio Rentals who over the years have collected Baird equipment, papers and photographs. At Strathclyde, they have installed two large display cabinets—one houses historical photographs, the other a replica of the first commercial television receiver, the 30-line Televisor.

**American Synchronous Satellite for Television.**—The American Broadcasting Company recently filed an application with the Federal Communications Commission for permission to launch its own satellite for relaying programmes to stations within its television network. A.B.C. has offered free use of the satellite to non-commercial educational stations.

**Her Majesty The Queen** presented a Royal Charter to the Council of Engineering Institutions, at a reception at the Science Museum, South Kensington, on November 10th. The Charter was received by The Prince Philip, founder president of the Council which was formed in 1962 as the Engineering Institutions Joint Council. A list of the 13 constituent institutions, which have a total corporate membership of some 130,000, was given on p. 424 of our September issue. About 500 members and their ladies attended the reception.

A one-day course on **Recent Advances in Semiconductor Applications** is to be held on December 3rd at Napier Technical College, Colinton Rd., Edinburgh, 10. Four lectures are to be given, "Recent Developments in Semiconductor Devices," "Solid State Circuits," "Electroluminescence in Semiconductors" and "Recent Applications of Semiconductors to Micro-waves." The fee for the conference is 2gn with a registration fee of 1gn. Enrolment forms are available from the Principal.

**New Television and Sound Services Wanted.**—A fourth television service, local sound broadcasting and an early announcement of the date for the introduction of colour television were some of the points discussed by a delegation of representatives from the Broadcasting Division of the Electronic Engineering Association received recently by Sir Ronald German, Director General of the Post Office. The E.E.A. feels that new television and broadcasting services are needed to stimulate production in the industry so that the country can take advantage of increasing world markets and so help to increase exports.

**7% of Viewers Receive Wired Television.**—At the annual luncheon of the Relay Services Association of Great Britain, the chairman, Commander E. N. Haines, R.N.(retd.), mentioned that there were about 1 M subscribers to wired television. This represents about 7% of the figure for licence holders, as at the end of September.

The three-year **subscription television experiment** will be started by Pay TV Ltd. on January 7th. Programmes will be transmitted over the network of British Relay to subscribers in the London borough of Southwark and Westminster.

**A National Instrument Service.**—Earlier this year, the Science Research Council, in collaboration with the Ministry of Technology and the Office of Scientific and Technical Information set up a panel under the chairmanship of Professor G. Parker (Sheffield University) to consider the feasibility and economics of a centralized instrument service. By means of the service, expensive physico-chemical instruments would be available to provide a rapid service for routine measurements, on a repayment basis, for all scientists. It is considered that the provision of such a service would enable physical-analytical techniques to become more widely available, and thereby encourage the use of new instrumental techniques. Other interesting possibilities with a centralized arrangement of this nature would be the provision of an interpretation service and data-store facility.

A publication entitled **List of Computer and Associated Courses** recently prepared by the Education Committee of the British Computer Society is a comprehensive tabulation of 224 academic, industrial and commercial courses run by universities, colleges, institutes and consultancies and held in the United Kingdom. The list is comprehensive not only in the number of courses listed but also in the analysis of course content. A division is made between courses which deal primarily with computers and those concerned with computer techniques. Details of length, syllabus, level, bias, etc., of each course are included. Copies price 4s are available from the British Computer Society, Finsbury Court, Finsbury Pavement, London, E.C.2.



# PERSONALITIES

**F. Neil Sutherland, C.B.E., M.A., M.I.E.E.**, managing director of the Marconi Company since 1958 and also deputy chairman for the past three years,



F. N. Sutherland

has been appointed chairman of the company and of Marconi Instruments. **Sir Gordon Radley** has relinquished the chairmanship of these two companies in order to devote his time to English Electric's business in computers and automation. Sir Gordon remains a director of the English Electric Company and the Marconi Company and Marconi Instruments and chairman of English Electric Leo-Marconi Computers and English Electric Valve Co. Mr. Sutherland joined Marconi's in 1946 as chief executive after 24 years' service with English Electric. He is president of the Television Society and of the Electronic Engineering Association and vice-chairman of the Conference of the Electronics Industry. Mr. Sutherland is also one of the industry's representatives on the Postmaster-General's Television Advisory Committee.

**Robert Telford, M.A.(Cantab.), M.I.E.E.**, general manager of the Marconi Company since 1961 and a mem-



R. Telford

ber of the Marconi Board for the past two years, has been appointed managing director in succession to Mr. Sutherland. Mr. Telford, who is 50 and a graduate of Christ's College, Cambridge, joined Marconi's in 1937 and became assistant to the works manager in 1939. A year later he was appointed manager of the Hackbridge Works where he was responsible for the wartime production of a wide range of airborne and portable radio equipment. He was appointed managing director of Marconi Brasileira in 1946. On his return in 1950 he became assistant to the general manager at Chelmsford and three years later became general works manager.

**Lord Bowden, M.A., Ph.D., M.I.E.E.**, has resigned from the Government as a joint Minister of State, Department of Education and Service, and returned to Manchester College of Science and Technology from which he was granted leave of absence on his appointment in the Government. Lord Bowden, who was appointed a life peer in December 1963, had been at the college, of which he is principal, since 1953 and was dean of the Faculty of Technology at Manchester University. After graduation in 1931 at Emmanuel College, Cambridge, he spent three years at Cavendish Laboratory and several years teaching before joining T.R.E. in 1940. Lord Bowden who is 55, was for three years a partner in Sir Robert Watson-Watt's consulting organization until 1950. He then joined Ferranti's where he stayed until re-entering the academic world.

**E. W. Hayes, O.B.E., M.I.E.E.**, head of the B.B.C.'s Planning and Installation Department since 1959, is retiring. He joined the Corporation in 1933 and after serving at several high-power short-wave transmitting stations became engineer-in-charge at Ramspisham, Dorset, in 1945. In 1948 he was appointed resident engineer, British Far Eastern Broadcasting Service, Singapore, where he was responsible for the building and later the operation of the high-power short-wave transmitting station at Tebrau. He returned to the U.K. in 1951 as head of the transmitter equipment section of the Planning and Installation Department.

To meet the continuing increase in the number and complexity of the projects being handled, the Planning and Installation Department is being re-organized and three new appointments have been made following the retirement of Mr. Hayes. **F. D. Bolt, B.Sc. (Eng.), M.I.E.E.**, who joined the B.B.C. in 1934, becomes head of transmitter service planning. Since 1961 he has been head of the transmitter equipment section of the Planning and Installation Department. **D. R. Morse, M.I.E.E.**, becomes head of studio planning and

installation. He has been with the Corporation since 1947 and in the Planning and Installation Department since 1951. **D. E. Todd, B.Sc.(Eng.), M.I.E.E.**, who has become head of transmitter planning and installation joined the B.B.C. in 1946 after eleven years with Standard Telephones and Cables. Since 1963 he has been head of the transmitter group in the Department.

**G. Boris Townsend, B.Sc., A.K.C., F.Inst.P., M.I.E.E.**, manager of Rank Cintel Television, has received a doctorate of philosophy from the University of London for a thesis on colour television. Dr. Townsend, who is immediate past chairman of the Television Society and past president of the British Amateur Television Club, joined the Rank Organisation in 1963 as technical manager of the professional television equipment



Dr. G. B. Townsend

division of Rank Cintel. He was formerly with the G.E.C., having joined their Research Laboratories at Wembley in 1940 where he worked on radar and secret weapons and was subsequently responsible for the research work on television problems. In 1961 he transferred to G.E.C. (Electronics) Ltd., as manager of the new Television Equipment Department. He is joint author, with P. S. Carnt, of the Iliffe book "Colour Television."

**Dr. William Shockley**, who with Drs. W. H. Brattain and J. Bardeen, was awarded the 1956 Nobel Physics Prize for their work on semiconductors, has rejoined Bell Telephone Laboratories which he originally joined in 1936 and left in 1954. Dr. Shockley has been professor of engineering sciences in the Department of Electrical Engineering at Stanford University for some time and will continue in this post in addition to being executive consultant on applied research and development of electronic components with Bell Laboratories.



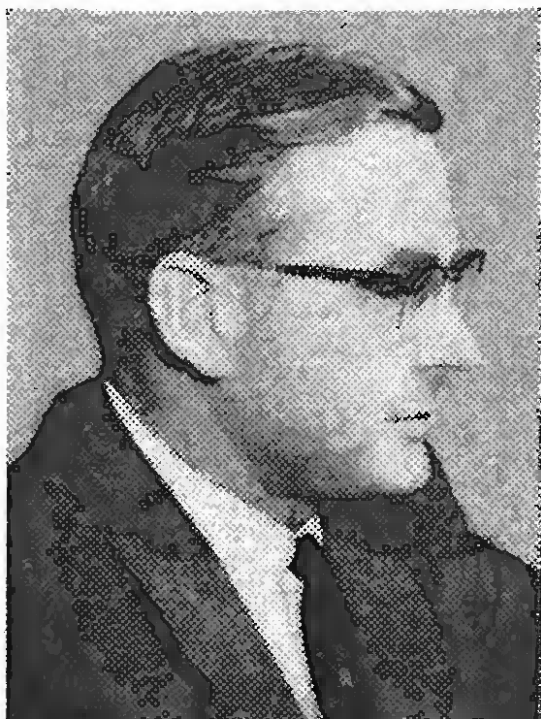
**T. W. Straker, M.Sc., Ph.D.**, manager of Marconi's Radar Division for the past four years, has been appointed general manager of the Telecommunications Group (one of three major groups into which the Company has been



*Dr. T. W. Straker*

divided). Dr. Straker, born in New Zealand, graduated at Canterbury University College where he undertook research on the absorption of h.f. in the ionosphere and in 1938 received his M.Sc. In 1945, after war service, he returned to the College as assistant lecturer in physics and a year later went to Cambridge University to study at the Cavendish Laboratory. He received his Ph.D. in 1950 for research on the ionospheric propagation of low frequencies. Dr. Straker joined the Defence Research Board of Canada on leaving Cambridge and in 1954 was appointed defence research liaison officer, on the Canadian Joint Staff in London. He joined Marconi's in 1957 and became deputy manager of the Radar Division in 1960. In his new position he is responsible for the following divisions:—Broadcasting, Radio Communications, Line Communications, Space Communications, and Mercantile Marine.

**B. J. O'Kane, Ph.D., B.Eng., A.M.I.E.E.**, who has been manager of Marconi's Aeronautical Division since 1959, has become general manager of the Electronics Group under the Com-



*Dr. B. J. O'Kane*

pany's re-organization. Dr. O'Kane was in the G.E.C. Research Laboratories from 1935 until 1941 when he was seconded to the Telecommunications Research Establishment, Malvern. For his work on the development of radar—particularly the north-seeking p.p.i.—he was granted an award by the Royal Commission on Awards to Inventors in 1952. Dr. O'Kane returned to the G.E.C. in 1945. Two years later he became chief engineer of International Aeradio Ltd. and in 1952 joined Marconi's as chief air radio engineer. The new Electronics Group comprises the Radar, Aeronautical, Computer, Closed-Circuit Television and Mechanical Products Divisions.

**M. Morgan, M.Sc.**, Marconi's deputy director of engineering and research since 1962, is now general manager of the Company's new Components Group. He is responsible for the Specialized Components Division, Microelectronics Division and the Hackbridge "crystals" establishment. Mr. Morgan joined



*M. Morgan*

Marconi's in 1935 and was from 1950 until 1962 closely associated with the development of Doppler Navigators. In 1962 he was awarded (with G. E. Beck) the Johnston Memorial Trophy of the Guild of Air Pilots and Air Navigators for work on the development of the airborne Doppler Navigator for both civil and military aircraft.

**P. D. Hall, B.Sc., M.I.E.E.**, executive director of International Computers and Tabulators Ltd., is giving the 1965/6 Faraday Lecture of the I.E.E. It is entitled "Computers, automation and control." Mr. Hall, who is a graduate of Queen Mary College, London University, worked on the development of radar and radar counter-measures in the Air Ministry throughout the war and in 1947 joined the Atomic Energy Research Establishment. Four years later he went to Ferranti where he initially led a team developing high-power X-band klystrons and travelling-wave tubes. In 1959 he was appointed manager of Ferranti's computer department and on I.C.T. taking over the department he became a deputy director.

**John V. Dunworth, C.B.E., M.A., Ph.D., M.I.E.E.**, the new director of the National Physical Laboratory, graduated at Clare College, Cambridge, with first class honours in 1937. In the same year he joined Lord Rutherford's



*Dr. J. V. Dunworth*

nuclear physics research team at the Cavendish Laboratory and subsequently was elected a Fellow of Trinity College, Cambridge. During the war he was a member of Sir John Cockcroft's team working on radar and in 1944 he was seconded to the National Research Council of Canada. At the end of the war Dr. Dunworth returned to Cambridge University as a lecturer in physics and in 1947 he became a member of the staff of the Atomic Energy Research Establishment at Harwell. He was appointed deputy director of the National Physical Laboratory in 1962 and has been acting as director since the resignation of Sir Gordon Sutherland in 1964. He is 48.

**E. D. Frost, M.A., A.M.I.E.E.**, who describes a pulse-counting f.m. tuner in this issue, has been with the Ferranti Computer Department, now part of I.C.T., since 1960. He is concerned with the engineering of computer prototypes; the design of the tuner he describes being a spare-time activity. After graduating in physics from Worcester College, Oxford, in 1953, he spent five years with the English Electric Valve Company followed by two years with Leo Computers before joining Ferranti.

## OBITUARY

**Air Vice-Marshal Colin P. Brown, C.B., C.B.E., D.F.C.**, who was director of radar at the Air Ministry during 1943-45, died on October 19th aged 66. He joined the Royal Naval Air Service in 1917 and qualified as a signals specialist in 1924. For two years during the early part of the War A.V/M Brown was senior air staff officer of No. 60 group R.A.F., and from 1949 to 1950 was chief signals officer R.A.F. Mediterranean and Middle East Command. A.V/M Brown was elected a vice-president of the I.E.R.E. in 1959.



## British Electronics to be fitted to R.A.F.'s American-built Hercules Aircraft

FOLLOWING representations to the Ministry of Aviation by the Electronic Engineering Association, it has been announced that British electronic equipment will be fitted in the long-range transport aircraft the Royal Air Force is buying from the American Lockheed Georgia Company. Twenty-four of these Hercules C.130-K aircraft have been ordered and it is expected that the R.A.F. will purchase 50 to 60 more to meet their requirements.

Making their case for British equipment, the Association pointed out that besides a possible currency saving of over £50,000 per aircraft, the R.A.F. would benefit from standardization, for example, in respect to servicing, training personnel and spares holdings, etc.

Lockheed's are now re-engineering the aircraft to accommodate the British equipment. The electronics manufacturers concerned on this side of the Atlantic are: Cossor Electronics Ltd., I.F.F.; Decca Navigator Company, navigation computing and display system; Ekco Electronics, weather radar; Marconi Company, v.h.f. communications, V.O.R./I.L.S. and A.D.F.; Plessey Company, v.h.f./u.h.f. communications; Smith & Sons, autopilot; Standard Telephones and Cables, radio altimeter; and Ultra Electronics, cabin address system and intercom system.

**Component Production Plant and "know-how" for China.**—Under a contract with the China National Technical Import Corporation, of Peking, the Plessey Components Group are to provide the technical "know-how" and the necessary plant and machinery—including instruments and tools—for the manufacture of moulded carbon track potentiometers in China. The plant, which is expected to take two-and-half years to complete, is planned to produce several million potentiometers a year. Under the contract the two organizations will collaborate over a five-year period in a reciprocal exchange of technical information. Work has begun, with Plessey engineers supervising its installation and helping in the training of the Chinese plant engineers and technicians. Some Chinese engineers will come to Britain for special training.

**EMI's Sales Exceed £100M.**—In the year ended 30th June, 1965, the overall sales of EMI exceeded £100M and set a new record; last year's sales amounted to £94.70M. An interesting point in the company's history is that the profit after taxation, which this year totalled £5.11M, has risen steadily in the past

ten years from 1.8% to 5.1% of the company's sales. The company's overseas interests represent 62% of the total group profits. In his chairman's report, Sir Joseph Lockwood stated that both turnover and profits had again increased in the company's electronics business. "One new and exciting project is a study on a British communications satellite which we have undertaken with other British companies and with Hughes Aircraft of California in order to assist the Ministry of Aviation."

**Record Year for Plessey.**—Reporting record results for the year 1964-65 to shareholders, Lord Kilmuir stressed the importance of research and development "to which we have given our major attention in the past five years." Turnover in the year ended 30th June, 1965, amounted to nearly £105M as against £96M in the previous year. Pre-tax profits rose from £13.00M to £15.19M and net profits from £7.04M to £10.09M over the same period. Over 20% of the entire U.K. output of the Plessey organization is exported. In some lines the export figures are very much higher, for example, over 75% of the record-changers made by Garrard are sold overseas—mainly to the United States.

**V.H.F. Network for Kenya Police.**—G.E.C. (Telecommunications) Ltd., of Coventry, have received a contract to supply a nationwide v.h.f. radio network for the Kenya Police. Five- and nine-circuit v.h.f. communications equipment will be used in the network to connect the regional and divisional headquarters throughout the country with the central administration.

**Multiplex Equipment for Malaysia.**—A contract worth £250,000, for solid state telephone multiplexing equipment has been received by Standard Tele-

phones and Cables Ltd. The type of equipment to be supplied is already being used by the British Post office and a number of overseas administrations.

**Order for 3M Semiconductors.**—A contract to supply 3.1 million gold-bonded semiconductor diodes for use in the peripheral equipment of I.C.T.'s new 1900 series of computers has been received by Mullard Ltd. These semiconductor devices—as with all Mullard semiconductor devices—will be manufactured by Associated Semiconductor Manufacturers Ltd., a joint company formed three years ago by Mullard and the General Electric Company. Other items being made by Mullard's for I.C.T.'s 1900 series of computers includes matrix stacks for a core store of one of the central processors, indicator tubes, ferrites, capacitors and other types of diode.

**The Welmec Corporation Ltd.**, of 27 Chancery Lane, London, W.C.2, will in future be known as AEG (Great Britain) Ltd., in order to link it with its European parent.

**The Carr Fastener Company** have recently celebrated their Golden Jubilee.

**W. L. Gore & Associates**, of Delaware, U.S.A., have formed a British subsidiary at 32B Pampistord Road, Purley, Surrey. (Tel: Uplands 3658.)

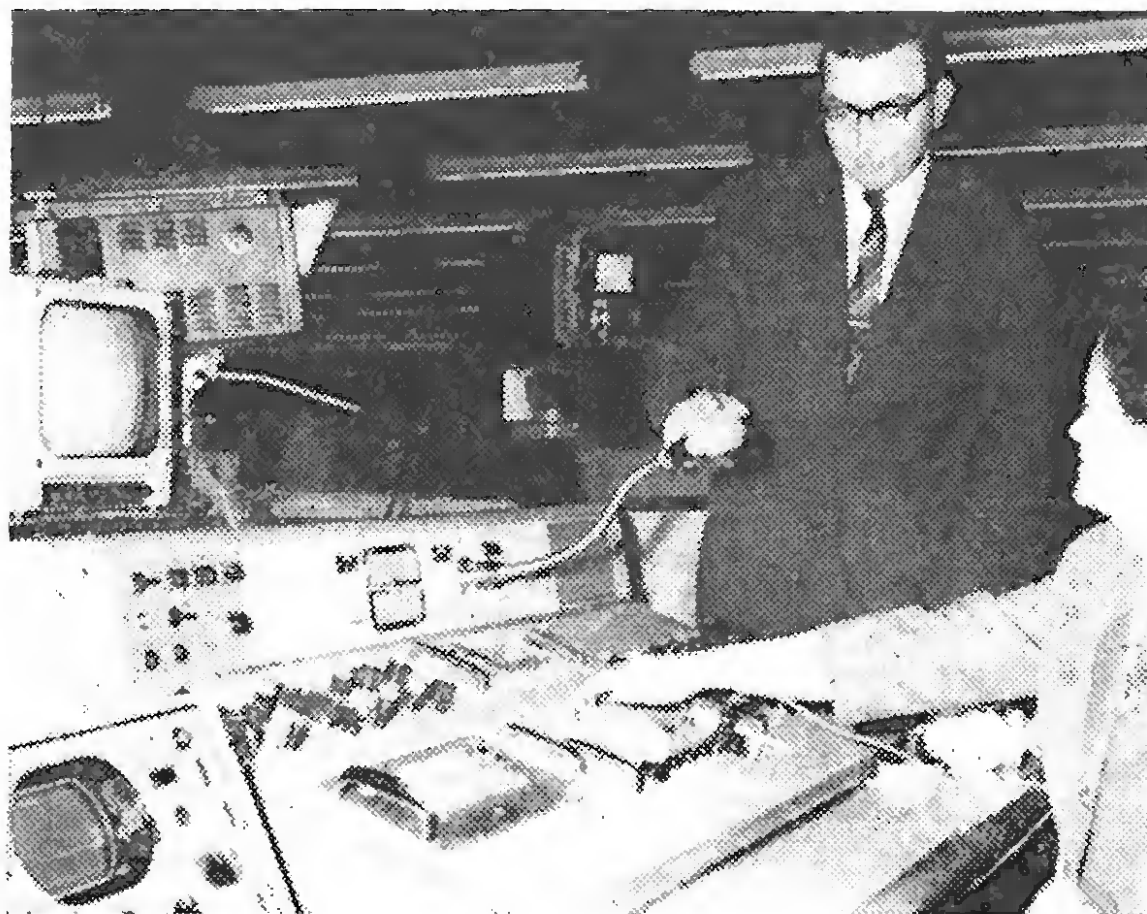
**Brush Clevite**, of Southampton, who earlier this year stopped manufacturing semiconductor devices, have acquired the electroplated copper foil business of N. M. Rothschild & Sons.

**English Electric-Leo-Marconi Computers** announce the first export orders for their System 4 computers (see last month's New Products)—two machines worth £345,000 to South Africa.

**Hornton's Electronics Ltd.** announce that the first supplies of Ikegami videotape recorders will not be available in this country until early next year.

### GIFT TO MEXICO.

Following an offer made by Prince Philip during his recent tour of Mexico, the British Government has sent the Mexicans a complete television studio. The equipment, made by Pye TVT Ltd., will be installed in the Instituto Politécnico Nacional, Mexico City, for educational purposes. Miss Dorothy Nicholls of the Ministry of Overseas Development and Mr. Tom McGann of Pye are shown in the photograph.







# AMATEUR RADIO SHOW

R.S.G.B. RADIO COMMUNICATIONS  
EXHIBITION

**T**HE engineer-in-chief of the General Post Office, D. A. Barron, C.B.E., opened this year's exhibition sponsored by the Radio Society of Great Britain, which was again held at Seymour Hall, London, W.1. In his address he made reference to the reciprocal licensing arrangements for amateurs, stating that six countries have now signified their willingness to participate and negotiations are in progress with 22 other countries. He also commented on the high quality of the equipment entered for the various construction competitions and said that in his opinion a lot of amateurs must be professional engineers or vice versa, judging from the exhibits.

A new method of measuring output power of amateur s.s.b. transmitters was mentioned by Mr. Barron. This breaks away from the traditional method of measuring the d.c. input power to the final stage inasmuch as the actual radiated power is measured. It is a simple matter to measure voltage and current in order to determine the d.c. power supplied to the anode circuit of the final stage, which can then be used to calculate the transmitter's output power—assuming an efficiency of about 66 $\frac{2}{3}$ %. This, however, does not apply to single sideband working as the transmitter operates in a linear condition. Hence, the Post Office have—after consultation with the Radio Society of Great Britain—specified a new measuring procedure in which the permitted pk-pk from an s.s.b. transmitter does not exceed that allowed for telegraphy (A1) and double sideband telephony (A3) working.

To conduct this test it is necessary to have a resistive load of the appropriate wattage rating and impedance value, an oscilloscope (to see the r.f. envelope), an audio signal generator capable of producing two a.f. tones of equal amplitude, and either an r.f. ammeter, or an r.f. voltmeter capable of measuring the mean r.f. output.

Two non-harmonically related sinusoidal tones of equal amplitude are applied to the s.s.b. transmitter and, with the carrier fully suppressed, the output is adjusted to give a mean r.f. output power (under linear operation) of 200 watts, or less according to the band of frequencies being used. Under this condition the pk-pk deflection indicated on the scope is noted and the two tones replaced with normal speech. Speech spikes should not exceed the recorded deviation marks.

Although a licensee is not yet obliged to provide himself with this test equipment, Post Office engineers inspecting amateur stations will use the new method to determine output power. More detailed information is obtainable from the P.O. Engineering Department, WI 3/3, 2-12 Gresham Street, London, E.C.2.

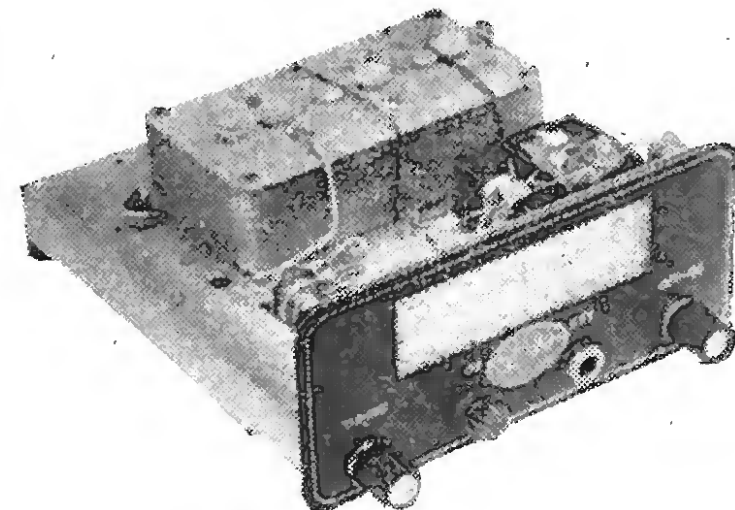
Mr. Barron presented the Mullard Award, which this year went to two former Air Force signals officers, Joseph Woolley (G3ESR) and his wife, Francis Woolley (G3LWY), for their outstanding services to the Radio Amateur Invalid and Bedfast Club, of which they are the honorary treasurer and honorary secretary respectively. This Club was founded 11 years ago and now has a membership of over 200, with a further 200 supporters and representatives who regularly visit members



Mr. and Mrs. J. Woolley, recipients of the Mullard Award.

to keep their equipment in order, etc. The Mullard Award takes the form of books or equipment to the value of £25, plus a commemorative plaque.

This year's president of the R.S.G.B., Eric Yeomanson (G3IIR), presented the society's design and construction awards. The manufacturers' award—a silver plaque—went to Tom Withers of T. Withers (Electronics) Ltd., Enfield, Middx., for a solid state 144 Mc/s bandspread v.f.o. Quite a lot of interest was

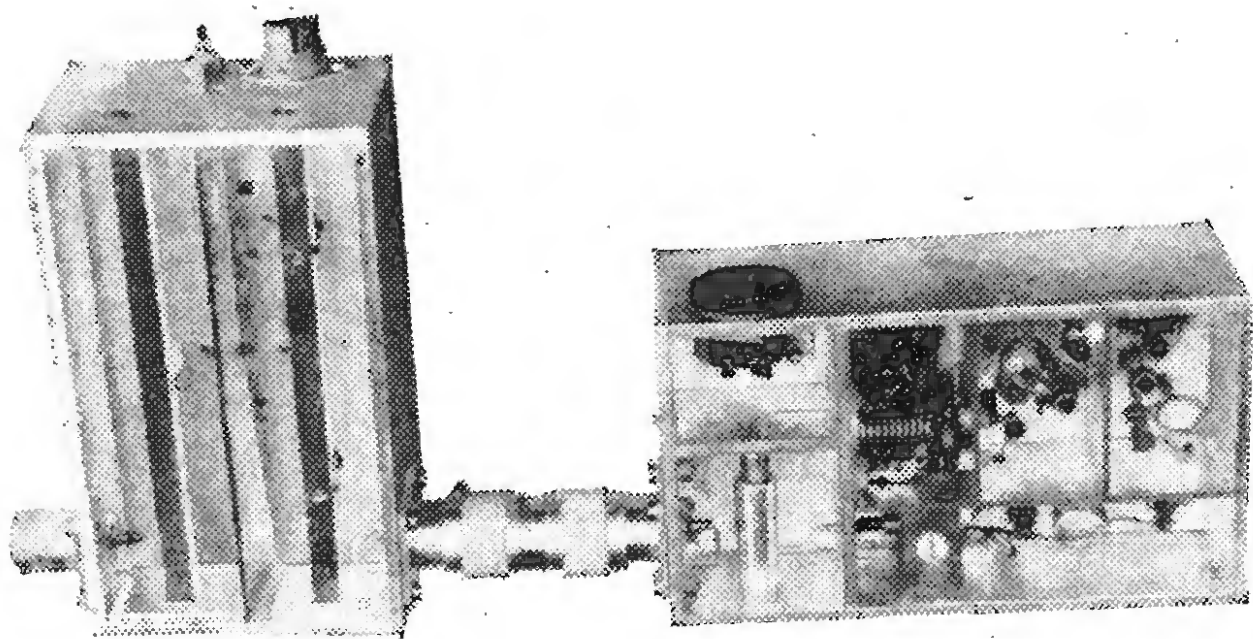


144 Mc/s bandspread v.f.o. from T. Withers (Electronics) Ltd.

shown in this little unit which is not surprising when one considers how congested the 144 Mc/s band is nowadays making it almost impossible to use a crystal-controlled transmitter. Three OC170 transistors are employed in this unit which is suitable for operation with any transmitter working from 6, 8, 12 or 24 Mc/s crystals. Stability is such that the manufacturers claim it is suitable for s.s.b. working, and also for 70 cm operation.

The Horace Freeman Trophy went to J. J. Pink (G30QB) for a solid state 23 cm convertor. Comprising two units (as can be seen from the illustration at the top of next page), it contains a wide-band amplifier operating with a centre frequency of 1,296 Mc/s, a balanced mixer and a 22-24 Mc/s i.f. amplifier. A crystal-controlled oscillator running at





Solid-state 23 cm. converter constructed by J. J. Pink which won the Horace Freeman Trophy

79.65 Mc/s is employed in this unit, the output of which is first doubled and amplified before being multiplied by a factor of eight by a varactor diode to obtain the final frequency of 1,274 Mc/s.

The Organizer's Award for the best home-constructed equipment which, incidentally, had a record entry, went to E. Sydenham (G3LOK) for his multi-waveband mobile receiver. Twenty-six transistors are used in this receiver, which has been specially tailored to fit the glove compartment of the owner's Morris 1000. From its appearance it could easily have been taken to be a professionally built job.

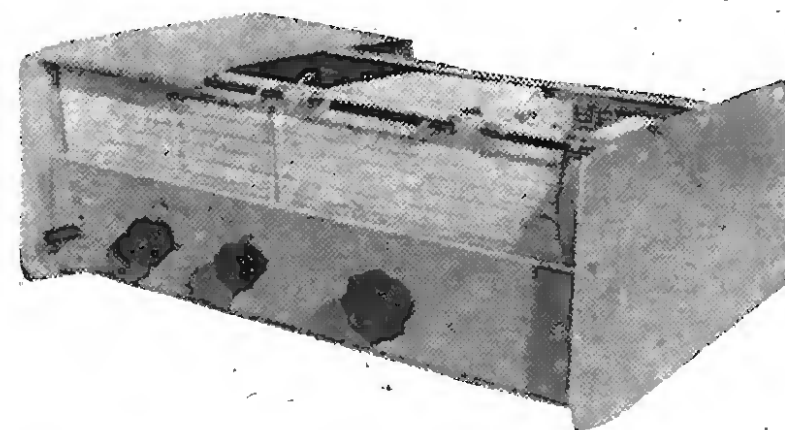
From the block schematic (shown below) it can be seen that the receiver has s.s.b. facilities and utilizes a tunable i.f. amplifier. Features which cannot be seen from this include voltage stabilized power supplies (by zener diodes) to all circuits except the power amplifier stage, which contains a pair of NKT303 transistors. Additional stabilization is provided for the carrier insertion oscillator and for the variable frequency oscillator.

Best exhibit from an amateur outside the London Region was judged to be R. C. Marshall's (G3SBA) s.s.b. transceiver. A single-conversion design is used in this unit which covers 10 to 80 metres and is intended for use with a separate p.a./preamp. Bi-directional modulators are featured and allow everything except the i.f. amplifier and microphone amplifier to be used in both send and receive modes.

Through lack of space, it is not practicable to give even brief summaries of the other prize-winning equipment; however, a list of the recipients follows: Cabinet Work, E. Sydenham (G3LOK) for a tape recorder; Test Gear, T. Baker for a capacitance meter; Transistor Equipment, W. Foster for a pocket, top-band transmitter; Miniature Equipment, D. Boman (G3LUB) for an s.s.b. transmitter; U.H.F. Equipment, J. Gazeley for a 7 cm masthead amplifier; V.H.F. Equipment, A. R. Hirst (G3SIC) for a 2-metre transmitter; and Receiver Attachments, W. Blanchard (G3JKV) for a panoramic receiver.

Some interesting communications

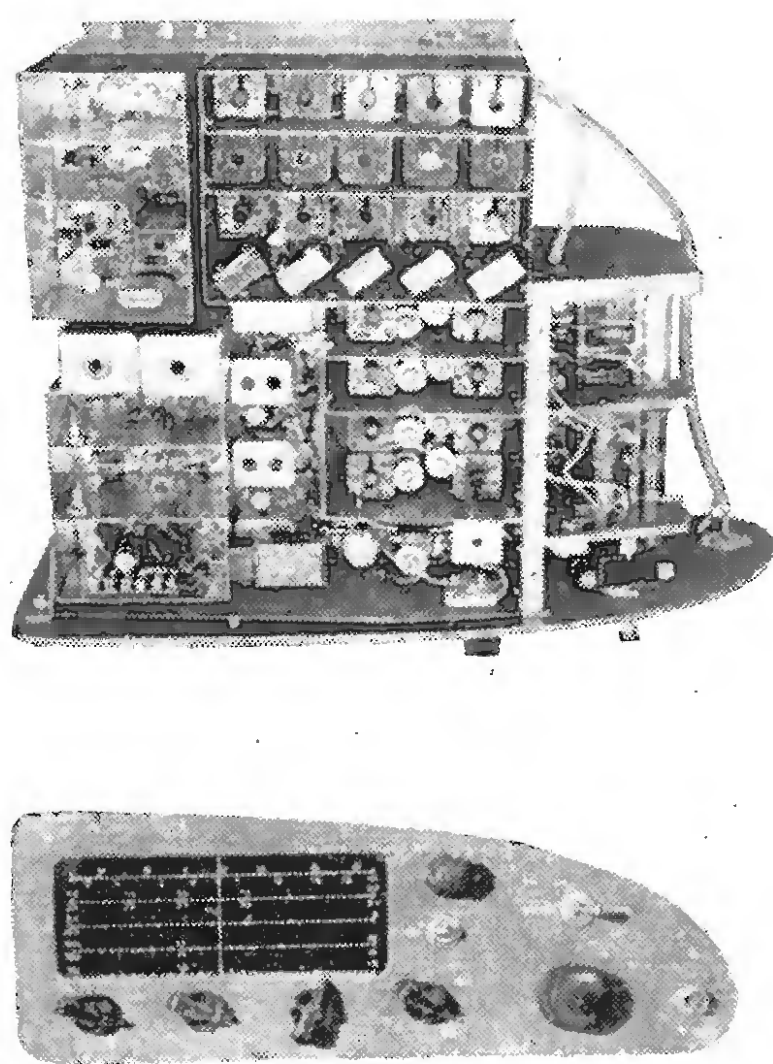
equipment was seen on the commercial stands at the exhibition. Two of the latest communications receivers from Japan are the Star SR-600 (95 gn) and the Lafayette HA-350 (75 gn), seen on the Brian J. Ayres stand. The SR-600 has seven tuning ranges between 3.4 and 29.7 Mc/s. Except for the range 3.4 to 4.0 Mc/s a triple heterodyne technique



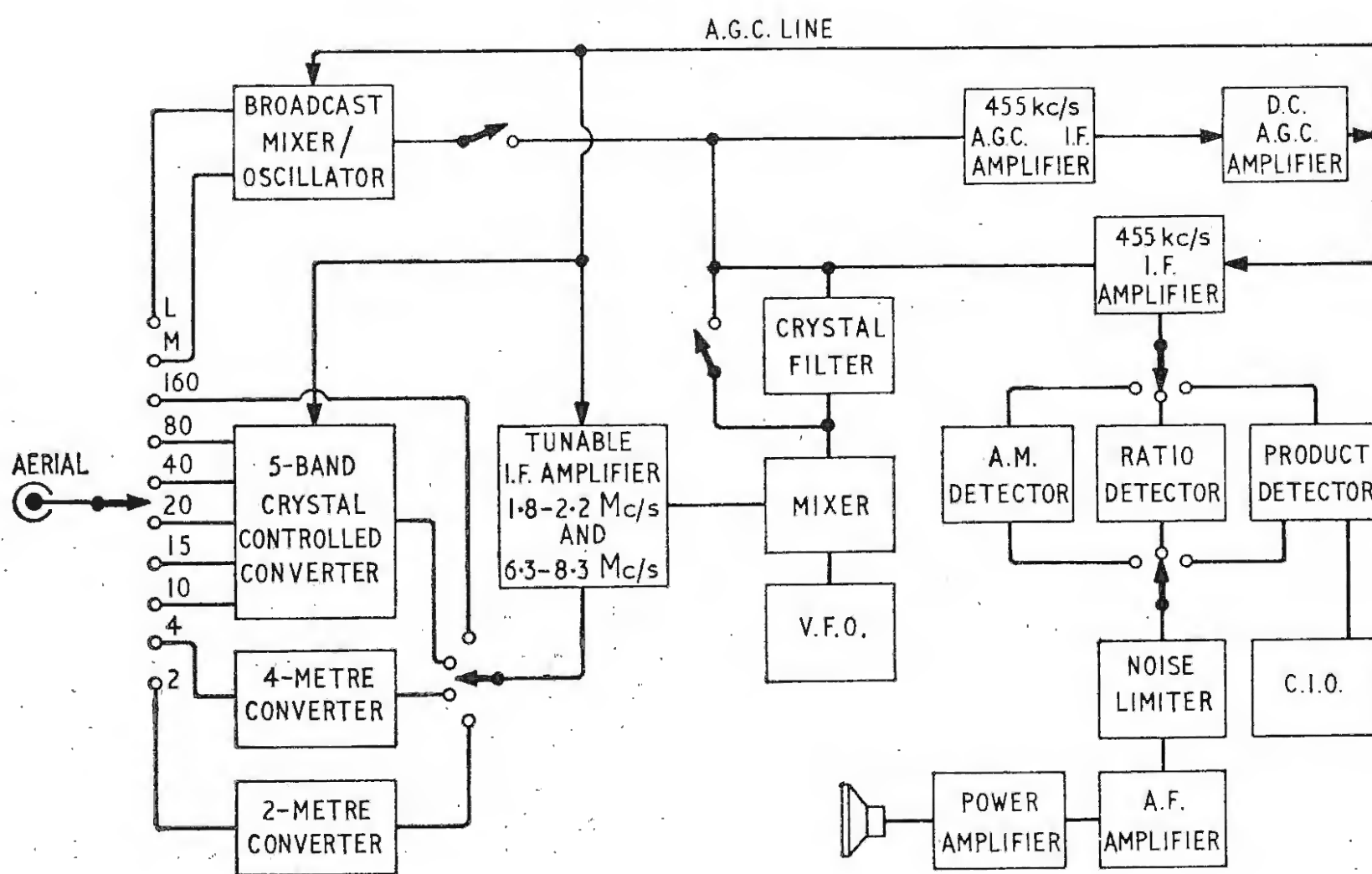
S.S.B. transceiver built by R. C. Marshall.

is employed and a block diagram of the circuit is shown overleaf. The first i.o. is crystal controlled and the first i.f. is tunable between 3.4 and 4 Mc/s. The second oscillator is a permeability tuned v.f.o. and produces a fixed second i.f. of 455 kc/s whereas the third oscillator has a fixed frequency of 510 kc/s and produces an unusually low i.f. of 55 kc/s.

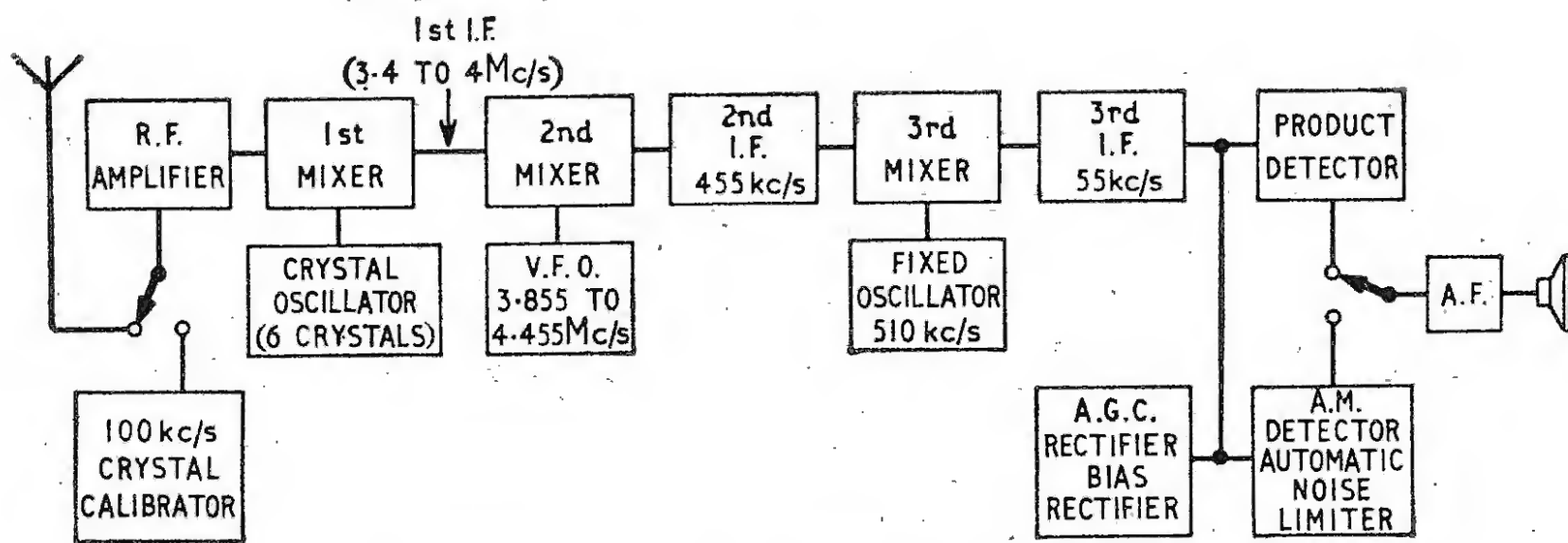
A product detector is used for the detection of s.s.b. and c.w. signals. Frequency variation of the b.f.o. is made by adjustment of the tuning core of the oscillator coil; one complete turn of the core varies the frequency by approximately 5 kc/s. An automatic noise limiter is also incorporated. Two a.g.c. time constants are used and the a.g.c. voltage is superimposed on a negative voltage of approximately -20 V whose



Mr. Sydenham's multi-waveband mobile receiver which received the award for the best home constructed equipment.







Block schematic of Japanese Star SR-600 receiver.

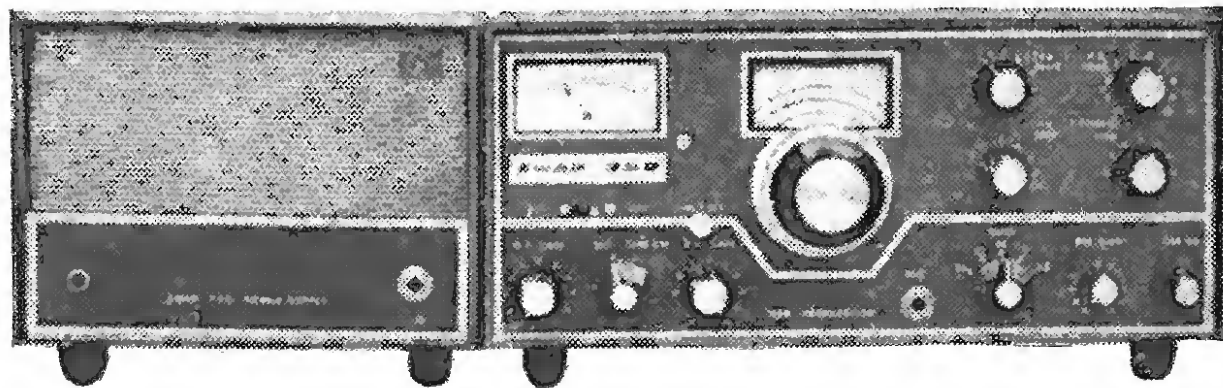
level is adjusted by the r.f. gain control. A 100 kc/s crystal controlled calibrator facility is provided.

Model HA-350 is a double superheterodyne communications receiver, covering the 40, 20, 15 and 10 m bands, for the reception of c.w., a.m. voice and s.s.b. signals and also has provision for tuning standard frequency transmission on 15 Mc/s to check a built-in crystal calibrator. During s.s.b. operation either the upper or the lower sideband can be selected by a front panel control. The 80 m band is also covered but the receiver does not then operate as a double superheterodyne. A crystal controlled first oscillator and a v.f.o. for the second oscillator are used. A 455 kc/s mechanical filter, after the second oscillator, provides a high degree of selectivity.

Double and triple conversion techniques were not favoured by the American designers of the s.s.b. Swan

The 6HF5 valve is also favoured by S.S.B. Products in their new Pyramid linear amplifier (£59) in which four operated in class AB1 produce an output of 700-800 W p.e.p. This amplifier was shown in prototype form at the show last year. An addition to the S.S.B. range is the Canonball (£28) s.s.b. transmitter covering 1.8 to 2 Mc/s (a 3.5 to 4 Mc/s version is also available) for a.m. and c.w. operation. Single sideband suppression is 35 dB and carrier suppression 50 dB.

Imhofs, the sole London retail distributors for Eddystone equipment displayed the new EB35 (£71 5s) broadcast receiver which, in addition to v.h.f. (f.m.) and the long- and medium-wavebands, covers 1.5 to 22 Mc/s in three ranges. For a signal-to-noise ratio of 15 dB, sensitivity is better than 5  $\mu$ V on the latter three ranges and better than 15  $\mu$ V on long- and medium-wavebands. On v.h.f. (f.m.) sensitivity is



Swan model 350 transceiver.

350 Transceiver (£205)—shown on the stand of the sole importer, Peter Seymour. The disadvantages of multiple conversion with its associated high mixer noise and spurious responses were avoided by using a single conversion circuit. The receiver covers the 80, 40, 20, 15 and 10 m bands and a nominal frequency of 5174.5 kc/s is used for the i.f. An output of over 400 W p.e.p. (measured by the two-tone test described earlier in this article) is produced by two 6HF5 American line-output colour-television valves. Input under average speech conditions is in the region of 500 W p.e.p. During c.w. and a.m. operation 320 W and 125 W respectively are available. A combined power supply and speaker unit for use with the receiver is available.

20  $\mu$ V at 22.5 kc/s deviation for a 20 dB signal-to-noise ratio.

Another all transistor receiver was one of the new items shown by Green Electronic and Communication Equipment. The receiver model TMR-5 (£35) for s.s.b., c.w. and a.m. reception, has a circuit containing 20 semiconductors—ten transistors and ten diodes. Frequency coverage is 1.8 to 2 Mc/s, 3.5 to 3.8 Mc/s and a 2 to 4 Mc/s band which can be extended by using the new Mark 5 range of 4 m, 2 m, 23 cm, and 70 cm "plug-in" converters for v.h.f. and u.h.f. coverage. When operated with a converter, the receiver forms a tunable i.f. amplifier; double conversion is used on 2 and 4 m and triple conversion on 23 and 70 cm. The receiver features selection of upper and lower

sidebands. A speaker and battery unit is available.

Codar also displayed an all transistor 80 and 160 m receiver, the T28 (£15 10s). As yet only advance details are available. Nine transistors and one diode are used. Printed circuit modules are used for the mixer, i.f. and a.f. stages.

An aerial of the type used by the Puerto Rican amateur KP4G on the 2 m moonbounce was shown on the J Beam stand. A feature of this type of aerial (2/10XY) is the method of controlling the direction of circular polarization—a most important factor in space communication. Two Yagi arrays, one horizontal and one vertical, are mounted on the same boom and spaced a  $\lambda/4$  apart. This arrangement produces circular polarization when the aerials are fed in phase. Direction of polarization is then reversed by altering the length of either feeder by  $\lambda/2$ . A 70 cm version of the aerial (70/14XY), suitable for satellite tracking and communications, comprises two crossed 14-element Yagi arrays fed via two baluns and has a gain of 16 dB.

A range of aerials displayed by Minimitter included the Minibeam Mk. III which costs £20. Basically, the Minibeam is designed primarily for use on the 10 and 15 m bands and consists of a radiator element fitted with resonators, a tuned director element and an untuned reflector. The arrangement, it is claimed, produces results better than a four-element array on each of the two bands.

Among the new items displayed on the Electroniques stand, were the two new versions of the Qoilpax tuner, models HB166T and GC166T (14 gn each), which utilize high-frequency low-noise silicon planar epitaxial transistors of the type BF152. Model HB166T covers all ham bands in six ranges each band having 170° of bandwidth. Model GC166T covers the medium-wave and five slightly overlapping short-wave bands covering 200 m to 10 m. Each model uses an i.f. of 1.62 Mc/s and the circuit contains three identical transistors for the r.f., mixer and oscillator stages. A transistor visual alignment unit Model VAU/T1\* (7 gn) is also available which covers the popular intermediate frequencies of 85 kc/s, 100 kc/s, 460 kc/s and 1.6 Mc/s. The unit is intended to operate from a 20 V sawtooth output from an oscilloscope. Frequency variation about the specified frequencies is obtained by adjustment of a front-panel control. Other frequencies up to 20% off the specified frequencies can be obtained by internal adjustment of tuning coils.

\* Based on the circuit described by M. W. Rignal in *Wireless World*, May 1965, p.218.



# LETTERS TO THE EDITOR

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

## Hi-Fi Television

YOUR editorial in the October issue rashly invited readers to air their views on the above subject. The aspects of performance that I would like to see improved when, or if, a hi-fi television set is marketed, are, starting with the most important:—

- (1) D.C. restoration, or the equivalent.
- (2) Linearity of the response over the contrast range, i.e. the ability to reproduce a whole range of grey tones and still show a fully saturated black and/or white if these are present in the picture.
- (3) Perfect interlacing at all usable settings of line hold, vertical height, and mains input voltage.
- (4) Improved linearity of line *and* frame scans.
- (5) Full bandwidth, i.e., the ability to clearly distinguish the 3 Mc/s bars without ringing on vertical edges of picture elements.
- (6) Improved bass output from sound channel.
- (7) Avoidance of switch contacts on r.f. tuner. Present designs always seem to get dirty after four or five years and adversely affect the frequency stability and fine tuning. (I expect to use my set for at least eight years.)
- (8) Suppression of frame flyback lines.

Your comment on the need for a good aerial is, of course, true, but my observation of friends' sets rarely shows any evidence of interference or low signal strength, and I would certainly not endorse your view that the aerial is the weakest link. It is obviously the receivers, frequently made even worse by poor adjustment of the controls.

Let us have hi-fi television by all means, but unless the signal transmitted is more consistently up to the quality that is attainable by the best live studio productions, I would not be willing to pay more than an extra £5 to £10 retail for such a receiver. I would rather have stereo sound on f.m. Third Programme only, for example.

Newcastle-on-Tyne 4.

R. J. MILBURN

*Below are some of the points from a few of the many other letters received on this subject:—*

EVEN if manufacturers are reluctant to produce a hi-fi television receiver as such, perhaps the following compromise might appeal to them. They should produce a version of their sets with a push-pull audio output stage, and provide for the addition of a compact loudspeaker enclosure for those who demand even higher quality sound. This would add little to the cost of producing a set for general sale, and it would of course be an attractive buy for the more critical listener.

Crumlin, Co. Antrim.

H. D. WESTWOOD

I AGREE with your comments on present day television receivers. Many seem to be designed with economy as their main objective, and quality can suffer. But as you point out, some aerial installations prevent the sets from working at their best.

But even with a good aerial, there are improvements

which can be made to produce a hi-fi television set. Black level stabilization would be one of the more important things on the video side, and, on the audio side, the sound is particularly bad on modern sets.

I should be very pleased if you would publish a design for a tuner to receive television sound which I can then feed to my existing audio system. This would be a vast improvement on the present 3in loudspeaker which we have to suffer in our present television set.

Barry, Glam.

G. W. WATERS

I HAVE for several years "obtained" my television sound via a Jason Mercury tuner and a Mullard 510 amplifier. The sound quality is understandably higher than that of the television receiver; the fact that the source of the sound is about four feet from the television screen is not normally noticeable.

At the moment I am converting to a transistor set up, Dinsdale stereo amplifier and W.W. f.m. tuner. I would be extremely pleased to see a transistor unit to tune B.B.C. and ITV sound. I am loth to return to TV receiver sound.

Harlow, Essex.

N. F. HOOD

IT is most gratifying to see the points aired in your October leader, and I, for one, agree fully on the facts mentioned. Apart from the second choice of programme on BBC-2, one does wonder if the advent of the 625 transmission could be justified had the viewing public had the opportunity of seeing the picture in their own home as transmitted by the B.B.C. and I.T.A. on 405 lines.

It is appreciated of course that the cost of manufacture and design of television receivers does in fact control this, but at the same time, I am very sure that a vast number of excellent sets are functioning under very inferior aerial installations. I must also agree that the quality of the sound is again inferior, and is again the result of cost, i.e., very small speakers and side cabinet speakers usually facing the wall.

Seven Kings, Essex.

G. H. PURKISS

REGARDING hi-fi television receivers, as you say in your editorial, better sound is a prime necessity, but I would opt for d.c. stabilization and sync pulse gain control as being equally important; perhaps the incorporation of flywheel synchronization to prevent ragged verticals is even more necessary but is almost standardized anyway. The linearity, nowadays, is usually adequate, although not perfect, but if the B.B.C. and ITV put full diagonals on their test cards I feel that the manufacturers would very soon improve this aspect!

I suggest that a big improvement in the received picture quality could be produced quite simply by the better use of studio lighting, particularly of the background lighting. Sharp contrasts may please some producers, and even some television critics, but "soot and whitewash" does not reproduce well, especially on those receivers having a.g.c. operating on the mean picture level and thus produce excessive contrast when the back-

**"W.W." PUBLICATION DATE**

Our printing schedule having been rearranged *Wireless World* will in future be published on the third Monday of the month preceding the date of the issue, i.e., the January issue will appear on December 20th.

ground is black. The result, in photographic terms, is the equivalent of "over-exposure."

Welwyn Garden City, Herts. R. B. GREEN

**Loudspeaker Enclosures**

DR. BAILEY'S loudspeaker design which he described in the October issue of *Wireless World*, is a resurrection of the almost forgotten labyrinth enclosure which was popular many years ago, and is still regarded in some quarters as being potentially superior in performance to bass reflex types. It bears no direct relationship to the labyrinth enclosure to which Dr. Bailey attaches the name, and in its usual form its chief disadvantage is the monstrous size required to attain the low frequency performance demanded by modern standards.

It is surprising at first sight, that the excellent bass response, shown by the curve Dr. Bailey gives us, can be produced by a phase inverting line only some 7ft. long. This will have its "free air," half-wave resonance, necessary to achieve the phase inversion required between the rear of the loudspeaker cone and the port opening, at 80 c/s. Below 40 c/s this results in the output from the port containing a component which is in antiphase with that from the loudspeaker cone, decreasing the total output and increasing the rate of fall off.

This is not the case with Dr. Bailey's enclosure, the output being well maintained to frequencies appreciably below 30 c/s, and it must be inferred that the phase inversion occurs by some means other than the free air resonance. There is a retarding effect on the waves within the enclosure, decreasing the frequency of its resonance, and thereby lowering the frequency at which phase inversion occurs. As the wool filling is the only difference between this enclosure and the simple labyrinth, it would appear that this is responsible for this effect, and there is a simple, if perhaps incomplete, explanation which indicates that this is the case.

If we consider two waves of the same frequency, but having different velocities, then:—

$$\frac{\lambda_0}{\lambda_1} = \frac{v_0}{v_1}, \text{ where } \lambda_0 \text{ and } \lambda_1 \text{ are the wavelengths}$$

corresponding to  $v_0$  and  $v_1$ .

But  $v = \frac{E}{\rho}$ , where  $E$  is the elasticity of the propagating medium and  $\rho$  its density.

Hence  $\frac{\lambda_0}{\lambda_1} = \frac{\sqrt{E_0}}{\sqrt{E_1}} \sqrt{\frac{\rho_1}{\rho_0}}$ , where  $\lambda_0$ ,  $E_0$  and  $\rho_0$  correspond to free air conditions and  $E_1$  and  $\rho_1$  correspond to those in the filled inclosure.

With two assumptions, we can simplify this expression and relate it approximately to the amount of material added to the enclosure.

Firstly, it appears reasonable to assume that with a loosely packed filling, little air will be displaced. Also the

fibres are themselves relatively incompressible compared with the remaining air. We can therefore say that  $E_0 = 1$  approximately since we can expect little change in  $E_1$  the elasticity due to the filling.

Secondly, it seems quite probable that, for frequencies where there is little attenuation in the filled line, the filling, being highly compliant, will respond to the air movement, and its mass will effectively add to that of the air. Thus the density of the propagating medium will be higher than that of air, and to a fairly close approximation, can be assumed to be the density of air plus the filling rate.

The expression given above now reduces to

$$\frac{\lambda_0}{\lambda_1} = \sqrt{\frac{\rho_1}{\rho_0}} = \sqrt{\frac{\rho_0 + r}{\rho_0}}$$

where  $r$  is the filling rate.

It would appear that the half wavelength resonance of Dr. Bailey's enclosure occurs at 30 c/s, corresponding to a free air wavelength of 36ft. But the wavelength corresponding to the unfilled enclosure is  $2 \times 7 = 14$ ft.

Hence  $\lambda_0 = 36$ ft.,  $\lambda_1 = 14$ ft., and  $\rho_1 = 6.6 \rho_0 = 0.5 \text{ lb/ft}^3$ , taking  $\rho_0 = 0.075 \text{ lb/ft}^3$  at room temperature.

This means that the filling must be added at a rate of  $0.425 \text{ lb/ft}^3$  or 1 lb to every  $2.3 \text{ ft}^3$  of enclosure, which is within the range recommended by Dr. Bailey.

It is interesting to note that the line can be tuned to the required resonance by addition or subtraction of filling; this was always a difficulty with the simple labyrinth, since the fundamental resonance of the system changes with a change of line length, and "cut and try" could be expensive on timber. Furthermore, the use of other media is indicated since it is the weight added which is important. Provided that the low-pass characteristic can be correctly maintained, higher packing densities could be used to reduce still further the enclosure size.

So far as the reduction of spurious resonances is concerned, many of the small airtight enclosures currently available are filled with a fibrous damping medium. But it is doubtful if any of them use the velocity retardation effect at undamped frequencies other than by accident. Certainly none could use it to better effect than the labyrinth, where not only does it in this case provide a reduction of 2.6 times in the line length, but also in the other dimensions. The required volume has been shrunk from a gargantuan  $100 \text{ ft}^3$  to a domesticated  $5.5 \text{ ft}^3$ .

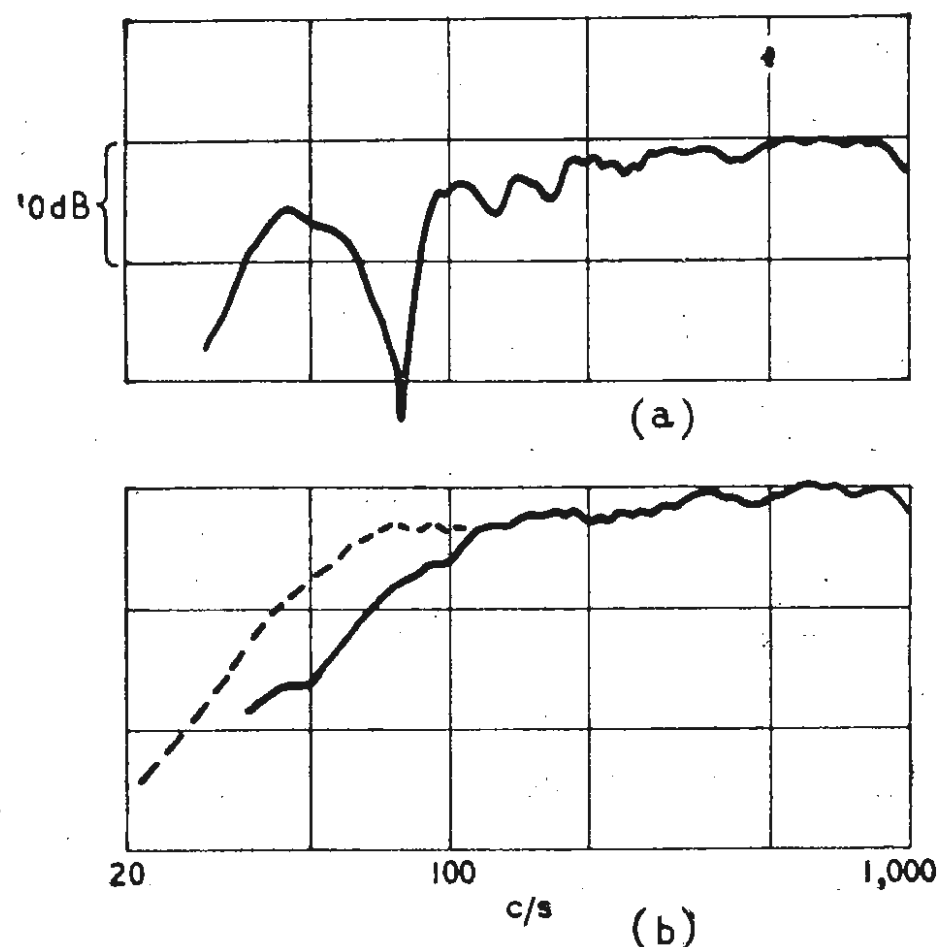
This is a remarkable achievement and with its possibilities for further improvement and application is of far greater importance than the other, coincidental, properties of Dr. Bailey's enclosure.

Chorley, Lancs.

E. A. HARMAN

SIX years ago, the writer tested a labyrinth cabinet almost identical to that described as an acoustic transmission line cabinet by Dr. Bailey in the October issue. Response curves taken under free-field conditions are shown in the Figure. Variations of cabinet and absorbent gave the same result of numerous resonances, as also did a folded horn. The curve for a totally enclosed cabinet of less than half the volume is included for comparison; provided the cabinet is not long and narrow, only the fundamental is present. These results were given in a lecture to the (then) Brit.I.R.E. on January 24th, 1962. Similar results were obtained many years ago by H. J. Leak and J. Bolingbroke. The original labyrinth was essentially a resonant device, in which the resonances and anti-





Mr. Barlow's response curves. (a) labyrinth lined with  $\frac{1}{2}$  in thick cotton wool; impedance peaks: 87, 140, 180, 230, 330, 460, 720 and 870 c/s (fundamental 44 c/s); (b) labyrinth completely filled with cotton wool; impedance peaks: 74, 100 and 340 c/s (fundamental 23 c/s). The dotted curve is for a totally enclosed cabinet half filled with cotton wool; impedance peaks: fundamental only 65 c/s.

resonances were used to equalize the speaker output. It will be noted that the rate of cut off of the totally enclosed cabinet is similar to that of the absorbent-filled labyrinth, and can be varied if need be by design. When measured standing against a wall, as is done by Dr. Bailey, the response of the labyrinth may tail off more gradually, but this would apply also to the totally enclosed cabinet. If it is desired to tail off the bass gradually from a relatively high frequency, there are simpler and less resonant devices than the labyrinth for doing this.

H. J. Leak & Co.,  
London, W.3.

D. A. BARLOW

*The author replies:*—I read Mr. Harman's letter with great interest as his theory is borne out in practice. The velocity of sound in wool is considerably slower than in free-air, and is also slower than can be accounted for by the difference between isothermal and adiabatic compression of the air. The wool mass is definitely slowing down the wave front, but as there cannot be perfect coupling between the wool and the air the effect will be somewhat less than given by Mr. Harman's calculation. On the other hand the wave will be slowed by the isothermal effects of the wool as well, so the error in assuming perfect coupling will be reduced.

As Mr. Harman surmises, the velocity of sound can be slowed down very greatly in a high packing density, but unfortunately this gives rise to high back pressure on the loudspeaker cone due to the very restricted air passages. There is therefore a maximum packing density that can be used without giving a strangled effect to the sound. This maximum density varies with speaker design and cabinet design, but is far greater than the density used in the cabinet described.

Regarding Mr. Barlow's letter, I feel that he must have misunderstood the article. This may have been my fault, but the cabinet design is based on a transmission line (which should have no reflections) having energy absorbing properties at all but the lowest frequencies. There is no desire to form a labyrinth (dictionary definition—with many turnings) at all. In fact every turning tends to cause reflections and these are contrary to what is required.

Without knowing what design of cabinet Mr. Barlow used, it is difficult to be analytical of his results. It may be of interest, however, to note that cotton wool has not proved to be a suitable material from the tests that I carried out. I would disagree that the rates of cut-off are the same in the second figure, my constructed asymptotes on the mean rate of cut-off give the labyrinth a 5 dB per octave slower rate of fall.

Incidentally my own response curve was taken with B. & K. equipment with the speaker back to the wall of a 60 ft long laboratory, the microphone being 1 ft in front of the speaker midway between the speaker and vent axes. A free-field response was not given as this is intolerably bass-heavy if a flat characteristic is obtained. A floor and a wall were felt necessary to simulate the effect of normal domestic listening conditions.

If Mr. Barlow is still convinced that a closed cabinet gives better performance, then I will be only too happy to give him a demonstration of the system's capabilities. A 25 c/s pure sine wave can be generated acoustically by the system. A very large enclosed cabinet would be needed for this as the cone resonance is increased by the enclosed air. Incidentally, the effective system resonance of the transmission line speaker is below 15 c/s for the design given. The cone resonance as such may be above or below its free-space figure depending on the sign of the reflected reactance of the transmission line. This factor, however, has little significance as line loads the cone resistively to such a degree that reactive effects are negligible within the audible range.

ARTHUR R. BAILEY

### "Electronics in Medicine"

I WRITE to correct your report on the European Symposium on Medical Electronics in one important point. The technique described in my paper [on ultrasonic stereotaxic surgery] is a surgical one requiring the removal of a considerable part of the skull so that the beam travels throughout its course through an acoustically homogeneous medium.

Bone has a much higher velocity than water or brain and it consequently produces reflection and refraction. Furthermore, as it is irregular in shape its effect cannot be predicted. This greatly restricts the information that is obtainable in routine echo-encephalography. A paper describing both techniques will shortly be appearing in the *Proceedings of the Royal Society of Medicine*.

DOUGLAS GORDON

Willesden General Hospital,  
London, N.W.10.

### Dinsdale Amplifier

MR. HIBBERD wrote ("Letters," April 1965) criticizing Mr. Dinsdale's method of improving s/n ratio of the crystal pickup input of his redesigned pre-amplifier. At first I agreed with his comments that the system could do no better than reduce signal and noise equally. However, having seen Mr. Dinsdale's experimental results, and carried out tests of my own, I can confirm that the system is in fact satisfactory, although not optimum.

It is known that by loading a piezo-electric gramophone transducer with a suitably low resistance, an approximation to "velocity characteristic" can be obtained, producing a signal similar to that from a magnetic type transducer. In general, however, the piezo-electric signal is greater than that from the magnetic transducer. For

this reason Mr. Dinsdale has provided a 100 : 1 resistive attenuator, so that the cartridge is loaded by 68 k $\Omega$  and 100 k $\Omega$  in parallel, while the source impedance seen by the transistor input stage is only 1 k $\Omega$ .

This provides a signal of suitable amplitude and frequency content to be corrected by the same network as the signal from the magnetic transducer. While this method is not optimum, the noise level from the circuit is inaudible at normal listening levels, but the frequency correction is somewhat approximate

I have shown that a feedback network consisting of a series capacitor and resistor gives much improved results. Furthermore the s/n can be optimized by direct connection of the velocity loaded transducer to the input circuit,

and then choosing the correct operating current for lowest noise from the input transistor. For this set up, the feedback around the first stage has to be increased to compensate for the removal of the 100 : 1 attenuator.

While Dinsdale's system is satisfactory for gramophone transducers, the signal level from piezo-electric microphones is too low to permit good s/n to be obtained, but using the improvements mentioned above, I estimate an improvement of 26 dB is possible. Results are still not wonderful, far better to build a field-effect transistor amplifier into the microphone case. Might not this combination become "the thing" for future domestic and some professional use?

Bristol.

J. S. CHURCHILL

## INTERKAMA '65

### DIGITAL TECHNIQUES PREDOMINATE IN ELECTRONIC SYSTEMS AND INSTRUMENTS

#### SEEN AT THE DÜSSELDORF EXHIBITION

THE prevailing impression left by the electronics content of the third Interkama exhibition and conference (held at Düsseldorf, W. Germany, in October) was the tremendous increase in digital measuring and control techniques that has taken place since the last Interkama in 1960. To some extent this impression resulted from the greater number of exhibitors (738 this year compared with 472 in 1960), but the basic reason was, of course, the general trend towards digital and away from analogue techniques that has been witnessed in the past few years. *Wireless World* readers need not be reminded of the advantages of digital instruments for measuring electrical variables in the laboratory. With industrial applications of electronics there are two main influences at work: the need for greater accuracy and the need for performing more complex and extensive operations. These factors, in turn, result from a demand for higher levels of plant productivity than can be achieved by established analogue control methods.

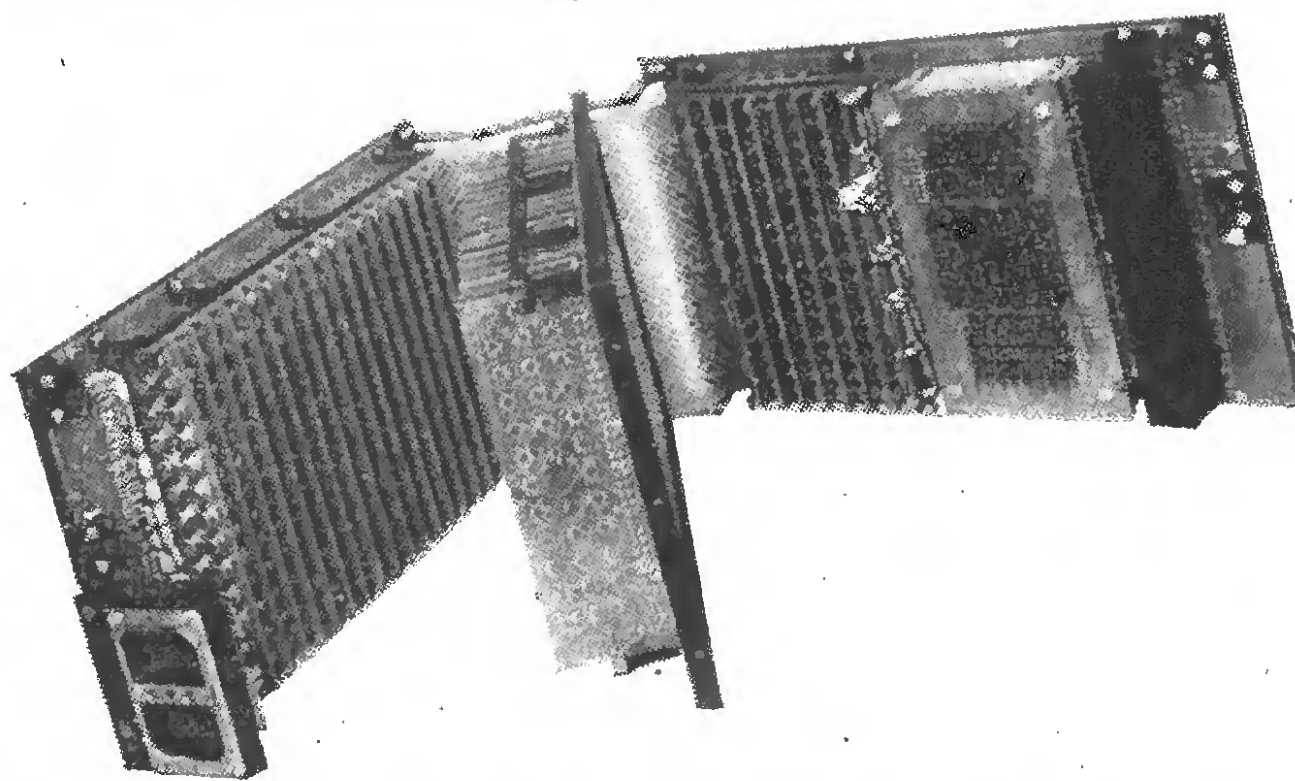
#### Flexibility in the time domain

Greater accuracy can be obtained, of course, because physical variables can be represented by numbers containing as many digits as are necessary to achieve the desired precision. Another reason is that digital systems are inherently more stable in representing information than are analogue systems. More complex operations can be performed by digital systems because of the greater flexibility of digital equipment in the time domain, resulting from the fact that information storage can be provided very easily. Sequential manufacturing processes or machine actions can be controlled in a manner which ensures a logical interrelation between the controlled events and, where necessary, interlocking for safety purposes. Information which may be available only at particular instants can be held in storage until required. In large plants computer controlled manufacturing operations can be readily linked to computer systems

used for production planning, stock control, accounting and other commercial functions.

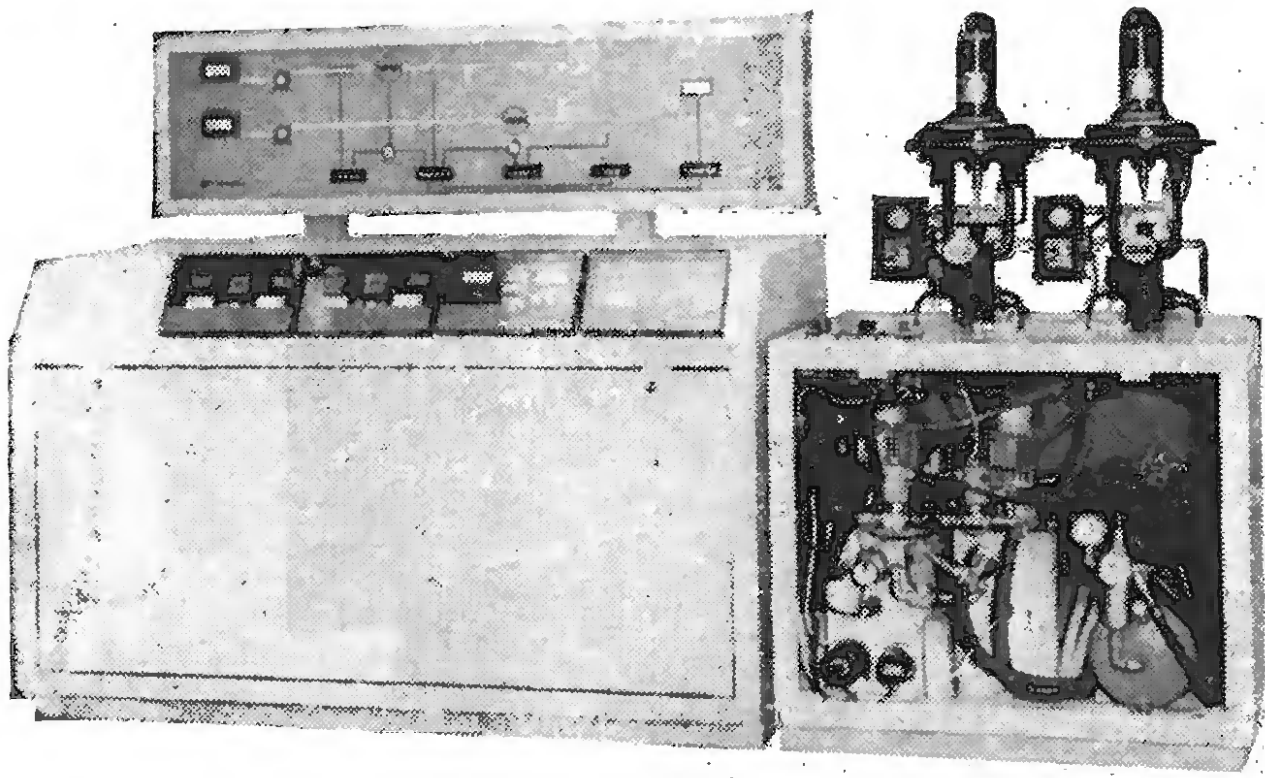
The digital process control computer, as the high point of this new technology, was, in fact, well represented at the exhibition. Philips (Hamburg) showed a new machine, the PR8000; Brown Boveri displayed their DP200 computer; Elliott-Automation had ARCH systems demonstrating traffic control and catalytic process optimization; AEG (Berlin) showed their Geamatic process computing system; AEI Automation presented the CON/PAC 4000, manufactured under licence from a General Electric (U.S.A.) design, while International General Electric (New York) showed their GEPAC 4000; and Hawker Siddeley introduced the DCC-1 computer for industrial data handling and recording.

The star of the collection, however, at least as far as electronic design technology was concerned, was the Ferranti Argus 400—an integrated-circuit computer with a central processor occupying about 0.5 cu ft (see picture) which performs equivalent functions to the earlier Argus computers constructed by conventional methods. The



Central processing unit of the Ferranti integrated-circuit process control computer Argus 400.





*Digital blending control equipment shown by Brown Boveri. Material proportions are measured and set by a pulse counting technique.*

machine is a 24-bit serial computer with 4096 words of magnetic-core storage. Adding or subtracting operations are performed in  $12\ \mu\text{s}$ , multiplication in about  $80\ \mu\text{s}$  and the core store cycle time is  $2\ \mu\text{s}$ . Power consumption of the central processor plus one 4096-word store is 50 W. The logic circuits are single-chip silicon integrated circuits mounted in 8-lead TO-5 transistor cans, and, for the central processor, fewer than 600 such circuits of 14 types are used. The circuit units are mounted on six-layer printed-circuit boards which, in turn, are connected to a multi-layer interconnection circuit by wrapped joints. In the core store (which is about the same size as the processor) 0.03-in diameter ferrite cores are mounted in sets of 4096 on six printed-circuit panels. A parallel version of the machine, called Argus 500, has also been introduced.

### Telemetry systems

If a process control computer or other central data handling system has to be situated some distance from the plant, the values of physical variables in the plant can be transmitted digitally to the computer over telephone lines. Control signals from the computer can be likewise transmitted back to the plant. At the exhibition several examples of such digital telemetry and tele-control equipment were demonstrated. One of the latest was the Digitel system shown by Bell Telephones of Antwerp. This will handle up to 64 variables, which are transmitted cyclically at a rate of 0.12 sec per variable in a channel of 480-c/s bandwidth or at a rate of 0.3 sec per variable in a 120-c/s channel. Electrical analogues of the variables are first fed to a scanner which applies them in sequence to an analogue/digital converter. This produces for each analogue value a 7-bit parallel number, which is then converted into a serial pulse train and transmitted as part of a 24-bit word—the remaining 17 bits being made up of address and synchronization digits, a parity check digit and spaces. Transmission is by frequency shifting—an a.f. carrier being displaced  $+30\ \text{c/s}$  to signify a "1" digit and  $-30\ \text{c/s}$  to signify a "0" digit. Corresponding decoding equipment is used at the receiver.

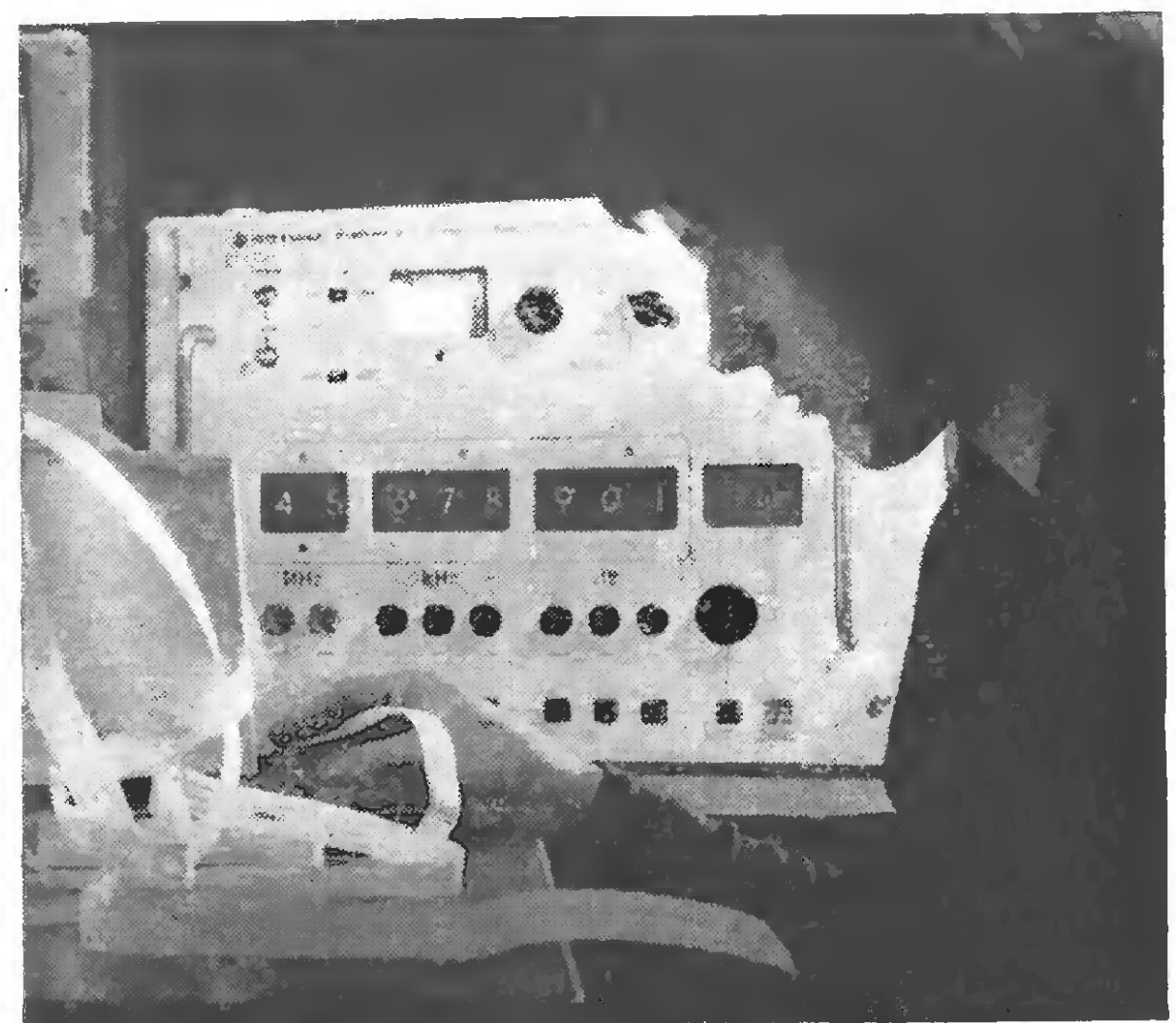
A similar time division multiplex principle is used by Brown Boveri in their "DZF" equipment (normal capacity 48 variables) which is designed for working in conjunction with their DP200 process control computer mentioned above. Both makes of equipment give

a transmission accuracy of  $\pm 0.5\%$  of the analogue value.

Among the many devices for converting mechanical displacements into digital signals was a new two-dimensional device shown by Standard Elektrik Lorenz (Stuttgart) for reading values from contour lines on maps or surveyors' plans. The plan is pinned to a horizontal board and the operator positions a pointer unit on the contour lines as required. Attached to the pointer unit are two spring-loaded cables which operate two widely spaced bi-directional rotary pulse generators; thus for each position on the plan the pulse generators produce numbers of digits which represent the lengths of cable drawn out and are therefore, in effect, co-ordinates of the pointer position. This information is held in a store, and when the operator presses buttons on a keyboard to identify the contour the stored data is punched into a card on a paper tape. Subsequently the punched cards or paper tape can be fed into a digital computer for deriving topographical information from the contour readings.

### Digital test instruments

In the field of electrical test instruments digital techniques were seen in a variety of functions. In the new Rohde & Schwarz decade r.f. signal generator, for example, the output frequency, derived by frequency synthesis from a crystal oscillator, can be selected automatically by a punched-tape programme supplied through a decoding unit. The frequency—anything up to 50 Mc/s—is adjustable in 1-c/s stages, and the steps are switched electronically within  $100\ \mu\text{sec}$ . Another new signal source was a General Radio modular pulse generator enabling a vast range of different pulse shapes, as well as binary patterns up to 112 bits long, to be produced. In addition to ordinary rectangular pulses the instrument will generate pulse bursts, double pulses, pulses with pedestals, staircases, triangles, and trapezoids. The many facilities provided include digital scaling, provision of time delays and ability to add noise or sine waves to the pulses. It is claimed that 38,400



*Rohde & Schwarz decade r.f. signal generator with punched-tape programming of frequency selection.*

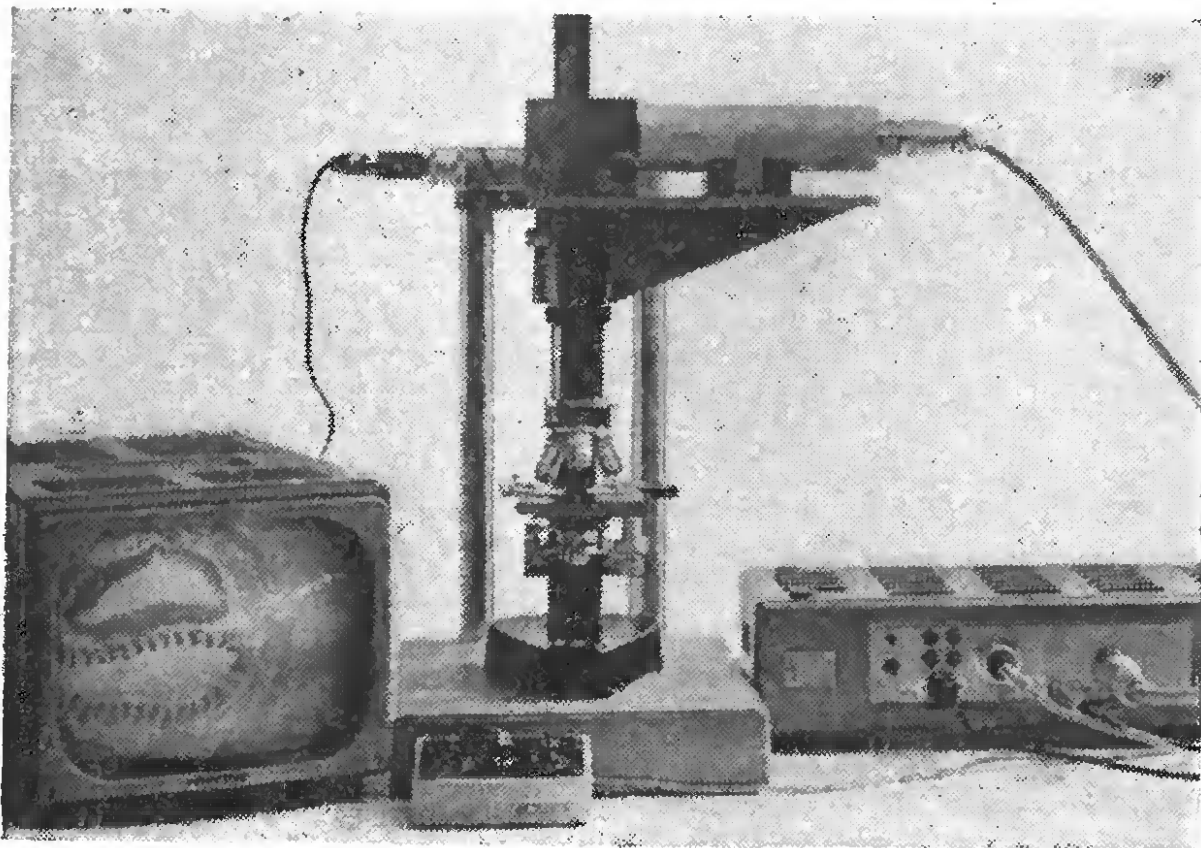


combinations of modules are possible. The Hewlett Packard Autovoltmeter, a digital d.c. voltmeter and ohmmeter, provides automatic seeking of the correct measurement range and voltage polarity for any applied voltage between  $\pm 5$  mV and  $\pm 1500$  V or any resistance between  $5 \Omega$  and  $1.5 \text{ M}\Omega$ .

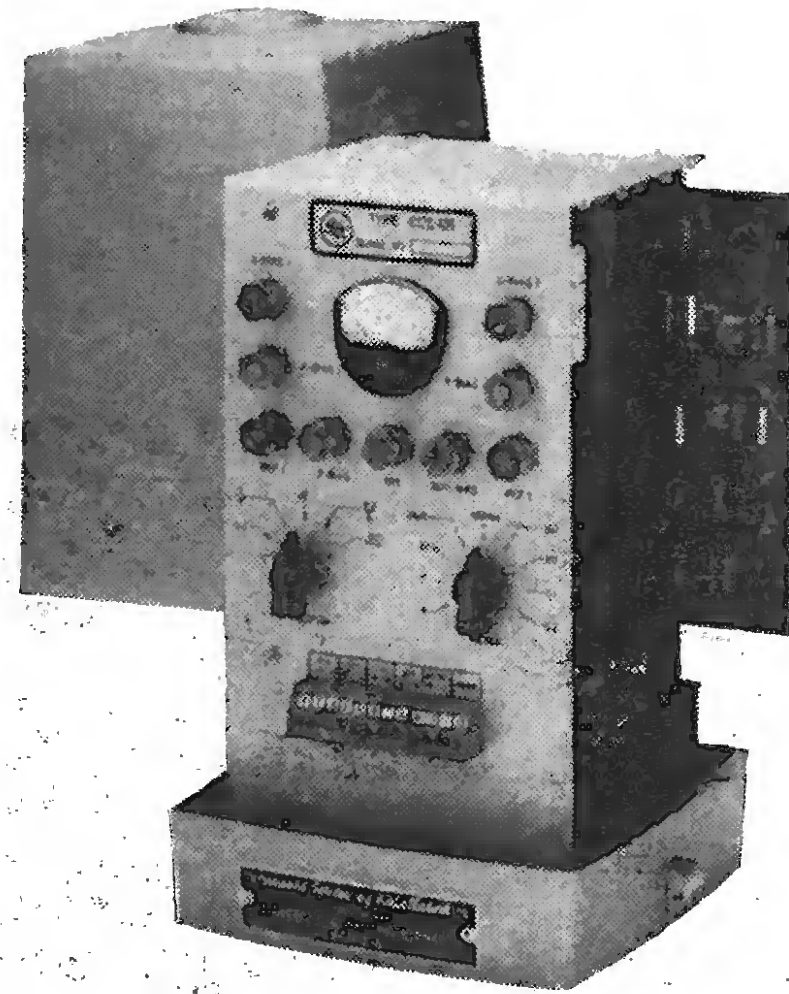
It would be wrong, however, to give the impression that the exhibition contained nothing of interest in analogue systems and instruments. There was a universal pen recorder, for example, offering a range of plug-in units (pre-amplifiers) for different types of measurements after the fashion of modern oscilloscopes (Polymetron of Zurich). Grundig showed a high-resolution 875-line television microscope with an electronically generated pointer arrow which could be moved to any position on the screen by a manual control. The surface texture of small tubular or cylindrical engineering components such as wires or ball-race grooves can be measured by a Rank Taylor Hobson instrument called the Rotary Talysurf: as the component is rotated, radial displacements of a stylus are detected by an inductive transducer and the measured changes are indicated by an electronic unit. Standard Telefon og Kabelfabrik of Oslo have introduced a range of solid-state electronic process control equipment; the analogue computing unit, for example, based on multiplication by pulse-height/pulse-width variation, allows calculation of process variables which cannot be directly measured, and will give the output functions:  $xy$ ,  $x/y$ ,  $\sqrt{x}$ ,  $xy/z$  and  $\sqrt{xz}$ .

### Servo hot-wire anemometer

Automatic measurement of the real and imaginary components of an a.c. voltage, relative to a reference voltage, is made possible by a complex ratio bridge shown by Areco Electronics of Stockholm. Intended for continuous testing on production runs, the bridge gives digital indication of the real and imaginary parts and can be supplied with a sequencing unit for automatically running a series of tests. Another Scandinavian firm, Disa Elektronik of Copenhagen, gave demonstrations of air flow measurement and turbulence-field correlation based on the hot-wire anemometer principle. By using a servo principle to maintain constant the resistance, and hence the temperature, of the hot-wire probe in the air flow, the equipment minimizes the thermal lag and so increases the measurement upper frequency limit by a factor of about 100. As a result dynamic flow events up to



Grundig high-resolution 875-line television microscope with adjustable marker arrow.



Analogue computing unit of Standard Telefon og Kabelfabrik range of solid-state process control equipment.

60 kc/s can be measured. Cross-correlation between the spatial components of a turbulence field in, say, a wind tunnel can be measured with a unit containing a random signal generator and a correlation coefficient analogue computer.

The next Interkama will be held in Düsseldorf in 1968 and it was announced by the organizing authorities that the event would in future take place every three years, the intention being that the intervening two years would be left free for the I.E.A. (London) and Mesucora (Paris) exhibitions, which are similar in character.

## Amateur Satellite—Oscar IV

A FURTHER satellite in the Project Oscar series is expected to be launched from Cape Kennedy on December 2nd. The satellite will be the fourth in the series, which is intended for use by radio amateurs. (Notes on Oscar III were published in the January 1965 issue.)

The launch vehicle is a Titan IIIc research and development rocket, and the programme involved requires that the payload be placed in a near-synchronous orbit. The payload, Oscar IV, is expected to be spin stabilized and will orbit at an altitude of 18,200 nautical miles with a  $30^\circ$  eastward drift per day and radio coverage will extend to  $81^\circ$  N. and S. The satellite axis and aerial axis will be parallel to the axis of the earth. "Solar" cells will provide the satellite power and the expected lifetime is one year.

Since Project Oscar had received only short notice of the possibility of launching a further amateur satellite, the exact form of the equipment had not been decided at the time of going to press. If a translator is used, the input frequency will be 144 Mc/s and the output frequency 431.945 Mc/s. A beacon would also be provided at 432.92 Mc/s. The more likely alternative is beacons only, in which case possible frequencies are 144.05, 432.15 and 129.45 Mc/s. The power output will probably be in the region of 1-3 W.

Other future amateur projects include a 2m translator satellite with 2m and 70 cm beacons (ARIES/OSCAR), a low-altitude translator satellite built by the German amateur DJ4ZC (EURO-OSCAR) and an Australian translator satellite working on 2m and 70 cm with an eight-channel telemetry system.



# Electronic Laboratory Instrument Practice

## 12.—POWER SUPPLIES

By T. D. TOWERS,\* M.B.E., A.M.I.E.E., A.M.I.E.R.E.

**A** POWER supply, in some form or other, is a basic requirement in most electronic circuit work. Portable general-purpose power supply units (or "power packs") are therefore widely used in electronic laboratories. Since the advent of semiconductors, the design of these power supplies has changed quite a bit. This article deals with semiconductor as well as valve types, because nowadays one meets with them both in the ordinary electronics laboratory.

### A.C. power supplies

The mains supply is a convenient source of 50 c/s a.c. power at around 240 V in Great Britain. The voltage available may not be convenient, of course, so a laboratory has to have equipment to convert to a lower or higher level. Again, the mains voltage is subject to quite wide variations, and laboratories sometimes require a stabilized a.c. supply.

*A.C. Power at Mains Voltage.*—We all take the mains supply itself for granted, but a little time devoted to your lab. installation can be profitable. If you cannot arrange for all the sockets to be a single standard (such as the modern 13A flat pin type), at least limit the number of types. If you *must* have different sockets, see that a supply of adapters ("cheaters") is always handy. If a guardian angel had to count the number of hours wasted by expensive engineers changing plugs with small screwdrivers, he would purse his lips and shake his head sadly!

Always use fuses, either in the equipment, the plug or the socket. Fit a single master switch with a neon pilot indicator to your bench so that you can ensure conveniently that "everything is switched off" at the end of a session. Finally look to the earthing of your lab. mains supply, because experimental measurements at low levels can be wildly out due to hum from unsatisfactory earthing.

*A.C. Power at Voltages Other than Mains.*—To get a.c. at less than mains voltage you can, as a temporary measure, fit a potential divider directly across the mains, but this is inefficient and can be dangerous. Most labs. therefore have some form of transformer power supply to provide a.c. at voltages other than the mains. At the one end of the scale, you will find a simple step-down transformer with one or more secondary windings. (You will find many advertisements for these in *W.W.* and other journals.) At the other end, are the variable auto-transformers, which engineers usually call "Variacs"—although this is the trade name of the General Radio version only. The British made Berco "Regavolt" is widely used in this country. Variable auto-transformers are often specified at the maximum VA they can take from the mains, but on the bench you will find yourself more interested in the maximum current you can take from it at the step-down voltage. You will find that engineers tend to describe them as " $\frac{1}{2}$ A," "1A," etc.

If you really want a handy universal variable voltage a.c. supply, you can go to the extent of building something like the switched-transformer supply to give 0-511 V in half-volt steps described in "Variable Output Mains Transformer" by H. E. Styles in *Wireless World*, June 1958, pp. 262-263. I myself use the exotic arrangement illustrated in Fig. 87 where a high-capacity variable transformer controls the mains input to a step-down transformer with seven separate secondary windings of 1, 2, 2, 5, 10, 10, 10 V. Outputs (direct to screw terminals to avoid switch troubles at high currents) are available up to 4A at high voltages up to 250 V directly from the "Variac" output and at low voltages up to 40 V from

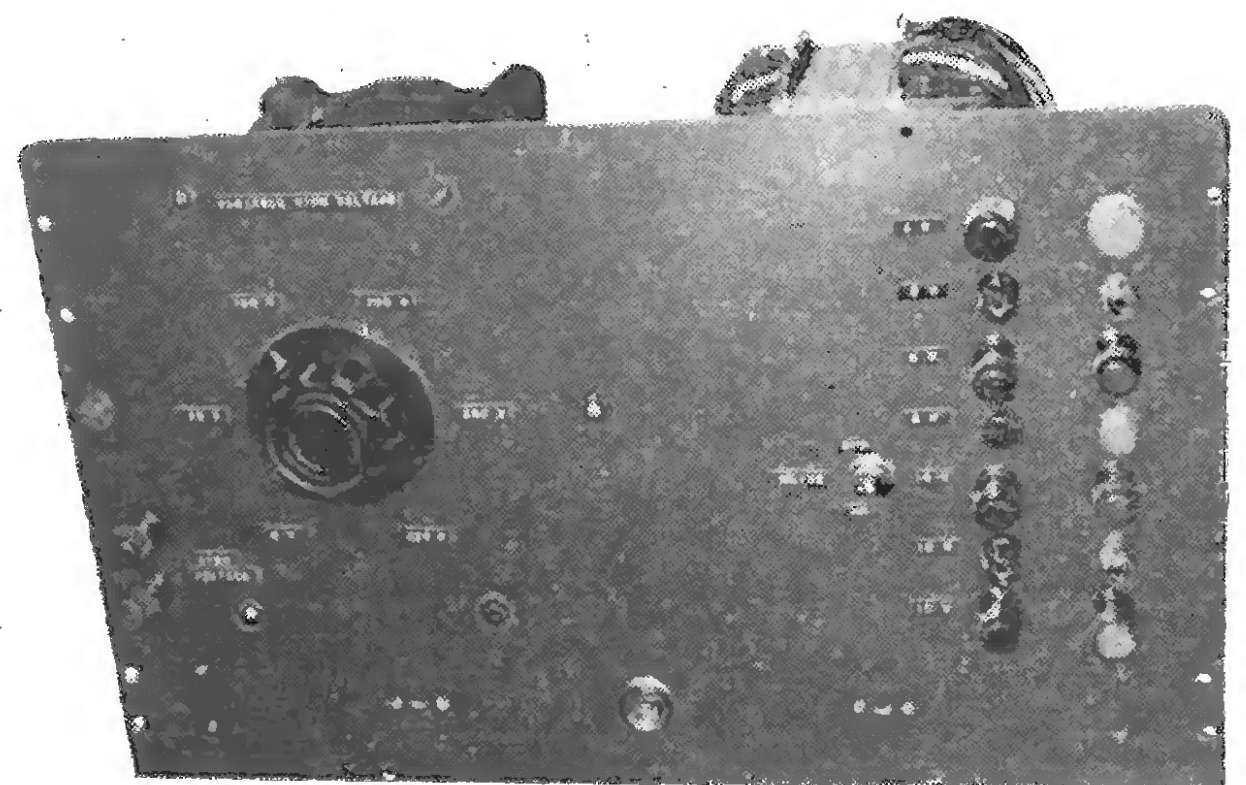


Fig. 87. Author's 50 c/s a.c. power pack capable of supplying continuously variable high voltage at 4A from 40 to 250V and low voltage continuously variable or in steps from 0.2-40V.

the secondary windings, which can be wired in series in various combinations.

*Regulated A.C. Voltage Supply.*—Some laboratories (e.g., photographic research) may not be able to tolerate the mains voltage variation that has become so much a part of modern life, but few run-of-the-mill laboratories require a stabilized a.c. supply in the normal course of events. Those who find themselves needing such a supply should consult one of the standard references such as "Automatic Voltage Rectifiers and Stabilizers" by G. N. Patchett, Pitman, 1958.

### Battery d.c. supplies

Electronic laboratories tend to require a d.c. power supply much more often than a.c. In the days of valves only, lab. d.c. supplies were usually mains driven, but

\*Newmarket Transistors, Ltd.

with the rise of the transistor we have seen a curious renaissance of battery d.c. supplies.

**"Dry" Batteries.**—Batteries fall into two main classes—primary ("dry") batteries and secondary cells. Dry batteries in common use are either Leclanché cells with nominal 1.5 V per cell (the traditional "dry battery") or mercury primary cells with nominal 1.35 V per cell (which to some extent are complementary to Leclanché cells). Where very small size and volume are of critical importance, Mallory cells are commonly used; otherwise, Leclanché dry cells are more suitable. Output for output, the Leclanché dry cell is a good deal cheaper. Typically a U2 type gives a watt-hour for about 2d as compared with about 20d for an RF1 mercury cell.

A wide range of dry batteries is commercially available. For experimental work, probably the most popular is the standard "grid bias" unit with wander-plug sockets for 1.5, 3, 4.5, 6, 7.5 and 9 V. It may look a comparative power weakling, but cunning engineers have been known to take up to 1 A out of it for short periods! Probably the convenience of easy voltage selection explains the continued popularity of this relic of early valve wireless-set days! Another reason why dry batteries have not been completely superseded by mains power packs is that they provide economically *humless* d.c. for floating supplies with low capacitance to earth, such as are required, for example, in some low-level d.c. amplifiers.

**Rechargeable Batteries.**—Secondary cells (i.e. rechargeable "accumulators" or storage cells) are the other type of battery d.c. supply in common lab. use. Most often you will find them as standard 12 V lead-acid car batteries or nickel-iron-cadmium cells.

The car battery has six 2 V cells in series providing nominal voltages of 2, 4, 6, 8, 10, 12 V at its terminals. Voltage variation of the nominal 2 V cell voltage is 2.2 V freshly charged to 1.8 V due-for-recharge, giving an overall voltage variation of 13.2-10.8 V on a nominal 12 V. Kept properly charged and topped-up, a lead-acid accumulator can have a lab. life of up to five years, but usually three years is the limit. It is attractive as a power source, because it can supply very large currents (up to several tens of amps) for short periods without damage. Its principal drawback in an electronics laboratory is that it gives off corrosive fumes deleterious to delicate apparatus. Also the need to keep recharging is irksome.

Rechargeable sealed batteries with a nominal single-cell voltage of 1.2 V, have some advantages over lead-acid accumulators. They do not give off corrosive fumes or spray, they have a very long potential life (15-20 years), and are able to hold their charge for very long periods. They are virtually indestructible because the cells may be short-circuited, left uncharged or overcharged without harm. As always, however, there is another face to the coin—rechargeable sealed batteries are, output for output,

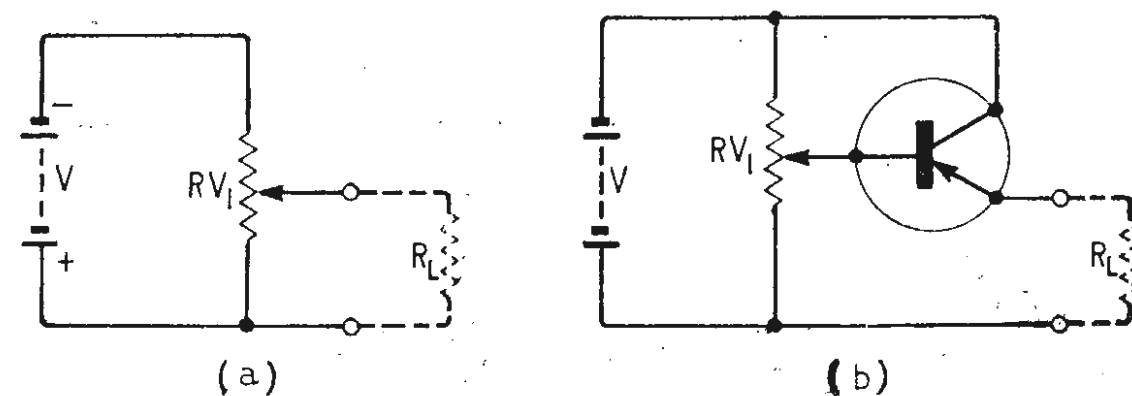


Fig. 88. Obtaining voltages intermediate between cell voltages of a battery. (a) Using potentiometers, (b) Using transistor emitter follower.

much more expensive initially than lead-acid accumulators.

Whatever kind of rechargeable cells are used, care should be taken to keep them regularly charged and "topped up". Nowadays economical 12 V/6 V chargers are readily available for a few pounds so there is little excuse (except human frailty) for neglecting this important matter.

**Variable Voltage Supply from Battery.**—If you need voltages intermediate between taps available on a battery, you can use a heavy-current sliding potential divider, as shown in Fig. 88(a). To get reasonable voltage regulation across the load, you would have to make the standing "bleeder" current down the divider,  $RV_1$ , five or more times the current into the load  $R_L$ . This is obviously expensive in battery current and a practical solution often resorted to is a high-resistance, low-current potential divider, with a transistor emitter-follower current-amplifier, as illustrated in Fig. 88(b).

## Mains-derived d.c. supplies

Many laboratories avoid the inconvenience of batteries discharging, by buying or making up general purpose mains-operated d.c. power supplies. These fall into three classes—"e.h.t." up to several thousands of volts, "h.t." up to several hundreds of volts and "l.t." up to several tens of volts. Nowadays with so much transistor circuitry, the l.t. supply has become a lab. "must", and later we will largely concentrate on this. Before we do so, however, we ought to take a look at the "old fashioned" e.h.t. and h.t. supplies.

## E.H.T. d.c. supplies

There are, of course, two common methods of supplying d.c. at e.h.t.: either (a) 50 c/s mains voltage stepped up by a transformer and subsequently rectified and smoothed, or (b) d.c. low-voltage used to power an r.f. LC oscillator and the a.c. output from a high-voltage winding on the oscillator transformer used to provide a

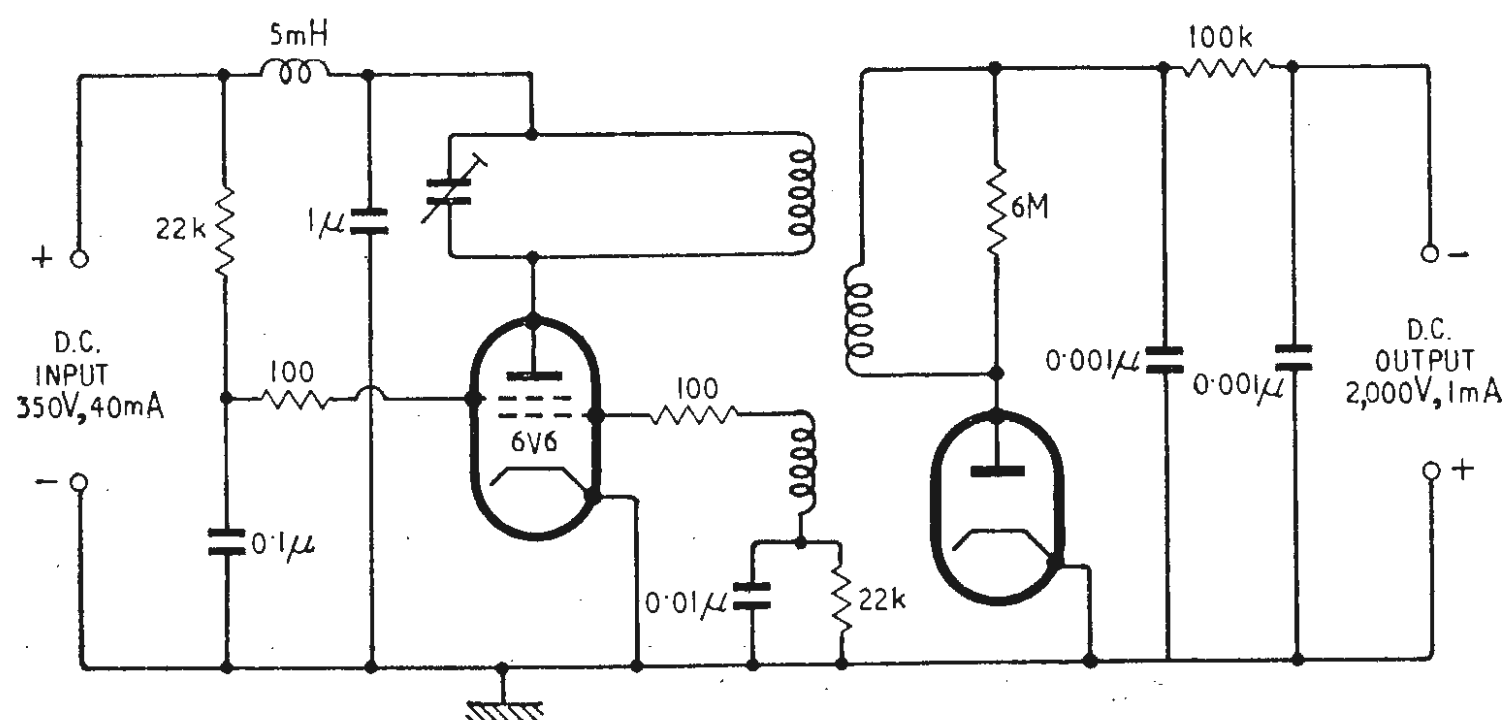


Fig. 89. Typical e.h.t. circuit using an r.f. oscillator and giving 2000V, 1mA output from 350V, 40mA d.c. input.



rectified-smoothed e.h.t. d.c. output. Whichever method is used, since the current demand on an e.h.t. supply is usually less than 1 mA, half-wave rectification and resistance-capacitance smoothing are the rule.

The direct generation of e.h.t. by stepping up 50 c/s mains voltage is not popular nowadays. This is because it calls for high-value smoothing capacitors of very-high voltage rating (which are expensive), and these capacitors can carry a lethally large energy. Engineers used to call them "blood and thunder" e.h.t. supplies, and wise men dislike working with them. They disappeared from television receivers a long time ago for these reasons.

In r.f. e.h.t. supplies, on the other hand, because the frequency is high, the high-voltage reservoir and smoothing capacitors can be several hundred times smaller in value than in the 50 c/s case, giving a capacity insufficient to hold a lethal charge. Fig. 89 gives the circuit of a typical 2,000 V, 1 mA supply for which constructional details were given in "E.H.T. from an R.F. Oscillator" by C. J. Dickinson, *Wireless World*, February 1951, pp. 70-72.

### H.T. d.c. supplies

It is convenient to have around the lab. a general purpose h.t. power supply to give up to about 100mA at 350V d.c. output. A typical circuit is given in Fig. 90(a) for such a power pack, which for this purpose is usually full-wave rectified and choke-capacitor smoothed. (Readers seeking fuller design information should consult a standard reference such as Chapters 30 and 31 of "Radio Designer's Handbook" by F. Langford-Smith, Iliffe Books.) In a power supply of this type, the most likely trouble to arise is excessive hum. This can usually be traced to a low-emission rectifier valve or dried-out filter capacitors. Incidentally, the a.c. voltage range of a multimeter is not suitable for measuring hum voltages. A peak-to-peak hum voltage measurement should be made with a peak-reading valve voltmeter or a calibrated oscilloscope.

**Stabilized Supplies.**—The typical power supply discussed just above has an effective output resistance of the order of 100Ω so that the output at 100mA is generally considerably below the output at zero load current. Moreover the output voltage for a given load current varies directly with the mains input voltage to the power pack. For many laboratory purposes these variations of output voltage may not be important, but some bench work *does* require a stable d.c. high tension supply.

Commonly, stabilization of d.c. supplies against mains voltage variation is effected by means of a voltage-regulator tube on the lines of the typical circuit of Fig. 90(b). The voltage across the two cold-cathode-diode regulator tubes (150+150V) remains constant so long as the unstabilized input voltage does not fall below 300V. While the use of cold-cathode regulators considerably reduces the effect of mains voltage fluctuation on the power pack d.c. output voltage, it is not very effective in reducing the output impedance which is still of the order of a hundred ohms. However, for constant load currents (as in precision oscillators or differential amplifiers, for example) it provides a convenient stable d.c. supply source.

To secure an h.t. output unaffected by varying load current, it is necessary to use electronic stabilization. This compares the output voltage with a reference voltage (usually provided by a cold-cathode-diode voltage reference tube) and amplifies the difference to control the output resistance of the power-pack to keep

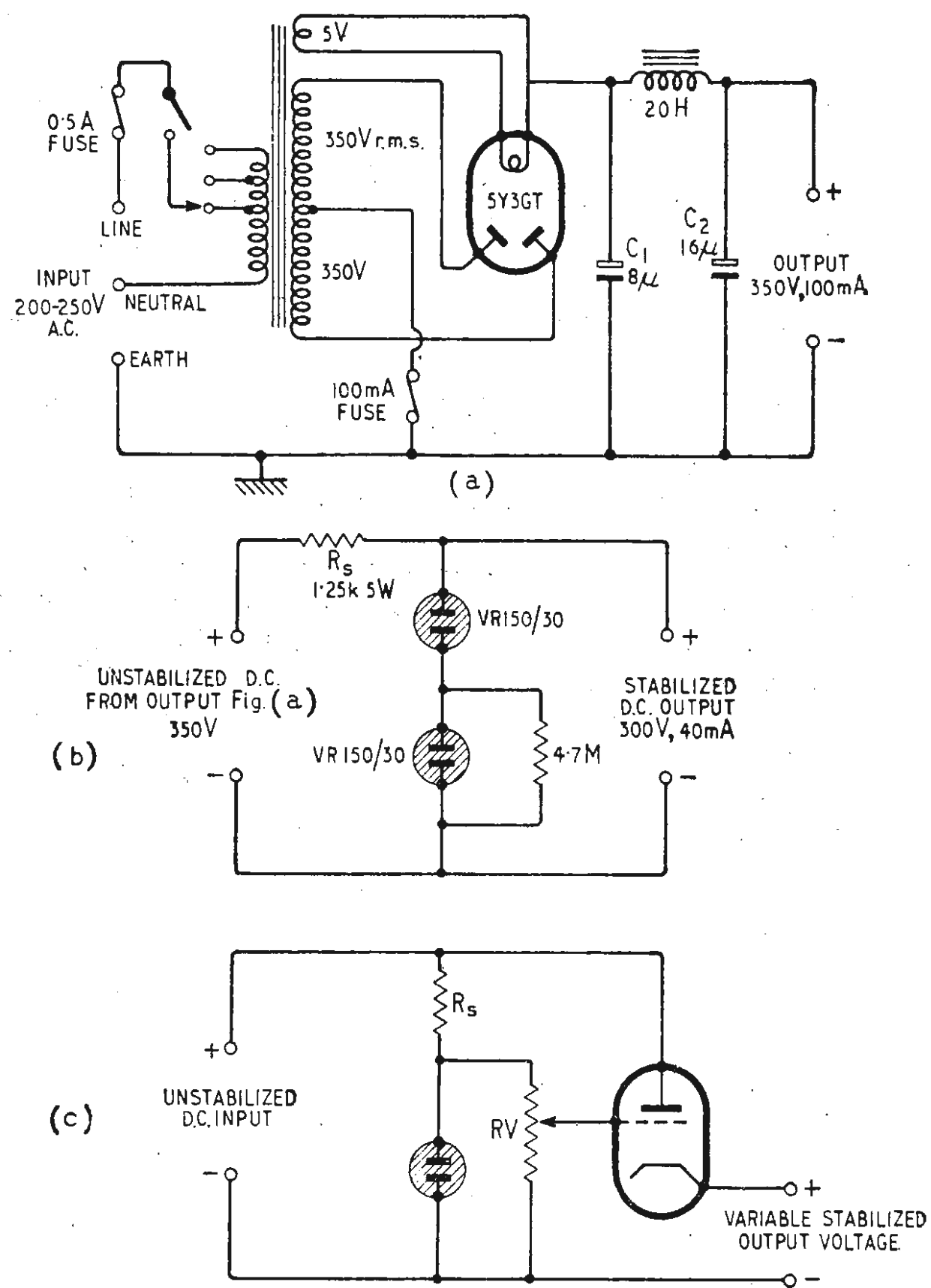


Fig. 90. Typical h.t. mains-derived d.c. supplies:—(a) Unstabilized power supply to give output of up to 100mA at nominal 350V d.c. (b) Stabilization of an unstabilized h.t. supply with cold-cathode-diode voltage regulator tubes to give 300V at up to 40mA; and (c) Principle of variable control of stabilized output voltage.

the output voltage constant. There are many valve stabilizer circuits of this type but discussion of these is beyond the ambit of this article.

**Variable Supplies.**—The h.t. supplies so far discussed give only a preset output voltage. In circuit work a variable h.t. supply is convenient. Control by a variable resistor in series with the load would give very poor regulation. Control by a variable potentiometer across the supply output is unsatisfactory because, for reasonable regulation, the resistance value of potentiometer required is so low that it bleeds a great deal of current wastefully. What is usually done is to supply the output voltage from the cathode of a cathode-follower valve whose grid voltage is varied by a potentiometer across the h.t. output as shown in principle in Fig. 90(c). Since the valve grid current will be negligible the control potentiometer can have a high resistance value thus avoiding the difficulty of a heavy standing bleeder current.

### L.T. d.c. supplies

The transistor brought with it a need for low-voltage high-current d.c. supplies, which it would be difficult to provide by means of valves. Luckily the transistor provided its own answer to the problem and nowadays mains-driven transistor d.c. power supplies giving out-

puts of several tens of volts and several amps are to be found in some form or another in any ordinary electronics laboratory.

**Unstabilized Supply.**—Technical journals occupy themselves so much with the interesting circuit design problems of closely regulated low-voltage d.c. supplies that engineers tend to forget that an unregulated supply will do for 80% of laboratory requirements, provided the regulation is not offensively bad. The circuit given in Fig. 91(a) for a 40V, 0.5A d.c. supply is typical. Mains voltage is stepped down in transformer *T*, rectified in bridge rectifier *D*<sub>1</sub>-*D*<sub>4</sub>, smoothed by capacitor *C* and partially bled by shunt resistor *R*<sub>2</sub> (to hold down the output voltage off load). *R*<sub>2</sub> also discharges the electrolytic on switch off. *R*<sub>1</sub> is a surge current limiting rectifier protection resistor. *T* can be a readily available standard component such as the Radiospares 20V rectifier transformer. The bridge rectifier *D*<sub>1</sub>-*D*<sub>4</sub> can be a medium current selenium type such as the Radiospares REC23A (54A r.m.s. at 1A), but with most labs. using (or abusing) transistors, you will generally find in the "junk box" some alloy power transistors with good base-emitter junctions. These can often be used to make effective high-current low-forward-voltage-drop, rectifiers with the transistors arranged as shown in Fig. 91(b).

If you want a variable output from the power pack of Fig. 91(a) you can simply connect a 500Ω wire wound potentiometer across the output and take the voltage from its slider. This will give poor regulation, however. A more "scientific" way is to use the arrangement shown in Fig. 91(c). Here *Tr* is a standard high voltage ger-

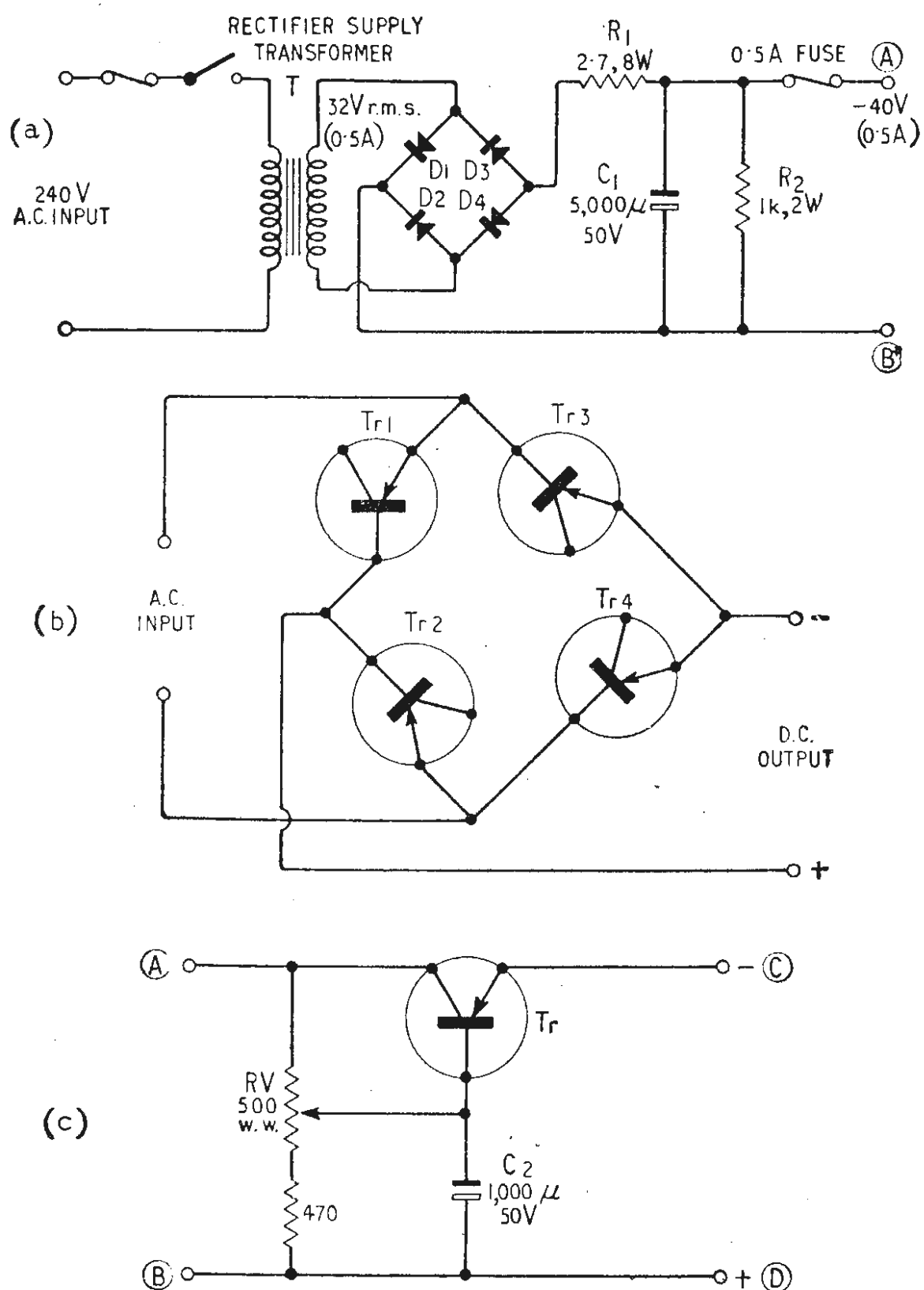


Fig. 91. Unregulated d.c. supplies:—(a) Typical 40V, 0.5A d.c. supply; (b) Using power transistor base-emitter junctions as rectifiers; and (c) Variable-voltage output arrangement.

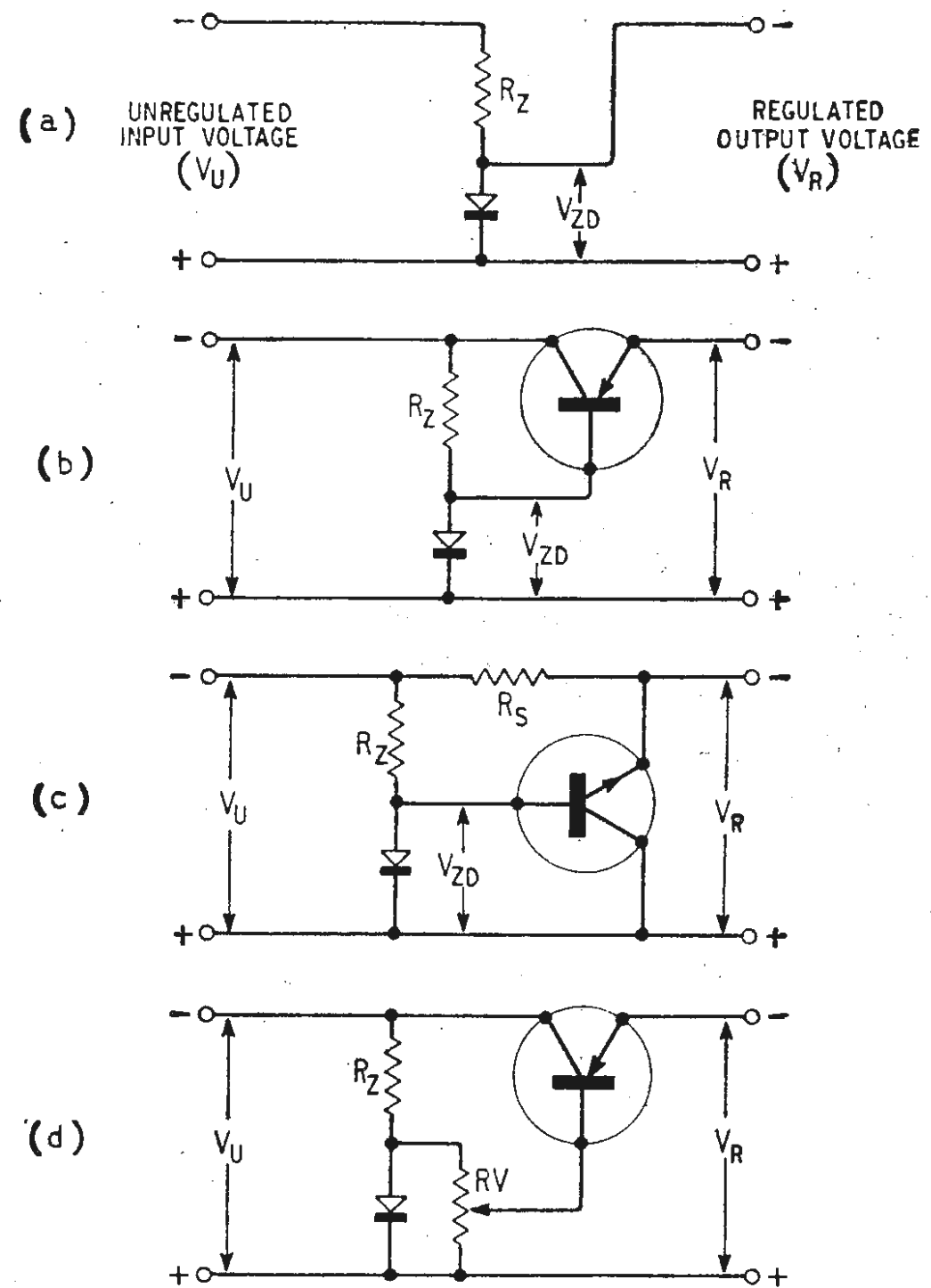


Fig. 92. Clamp-stabilized l.t. supply circuits:—(a) Basic Zener diode regulated voltage; (b) Series regulator transistor controlled by Zener diode; (c) Shunt regulator transistor controlled by Zener diode; and (d) One arrangement for obtaining variable regulated voltage from fixed value Zener diode.

manium power transistor (e.g. NKT404) mounted on a 4×4in piece of 16 s.w.g. aluminium but insulated from it with the bushes, etc., normally supplied with the transistors. The circuit is connected to the output of Fig. 91(a) and the output voltage at (C) can be varied down to about half voltage by adjusting the slider on the potentiometer *RV*. The capacitor *C*<sub>2</sub> gives additional smoothing at most settings of the potentiometer.

**"Clamp-stabilized" Supply.**—Many laboratory experiments call for some form of stabilized l.t. d.c. supply. The simplest arrangement is to clamp the output voltage of the mains power pack to some internal fixed voltage reference.

The fixed reference for low voltage work most commonly used nowadays is a Zener diode arranged as in Fig. 92(a). Up to a certain output current the regulated output voltage *V*<sub>R</sub> will remain substantially constant, approximately equal to the nominal Zener diode voltage *V*<sub>ZD</sub>. Zener diodes can be obtained with nominal voltages to a 5% tolerance from about 4 to 80V. They are also available in various power ratings from 200 mW up to several tens of watts.

The arrangement of Fig. 92(a) has the advantage of simplicity but the disadvantages that the available output voltage is fixed at one preset value and the output current maximum is limited to less than the Zener diode standing no-load bias current. Both these difficulties can be met by using a transistor amplifier stage between the Zener diode and the load as shown in Figs. 92(b) or (c).

In Fig. 92(b), a transistor emitter-follower sets the output voltage *V*<sub>R</sub> within a few hundred millivolts (i.e., the transistor base-emitter voltage drop) of the fixed Zener-diode voltage *V*<sub>ZD</sub>. The load current is virtually

(Continued on page 623)



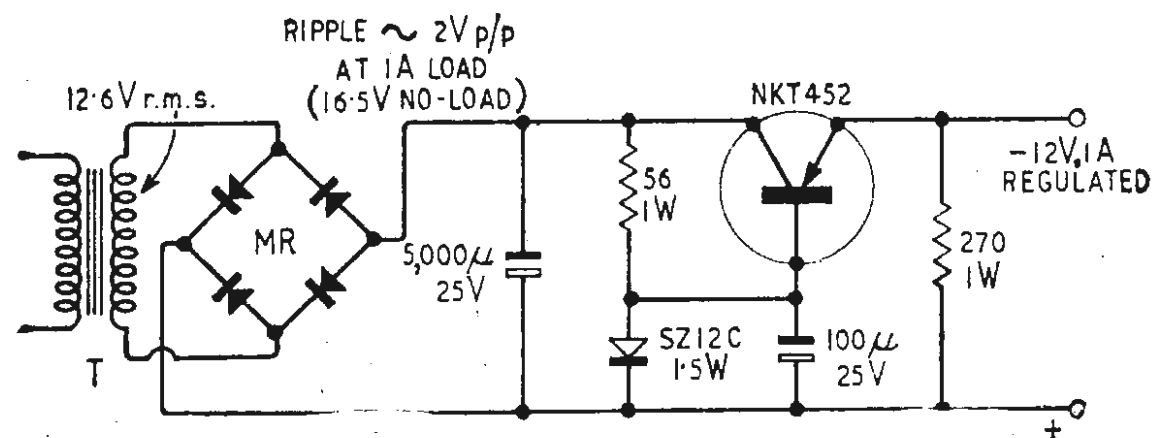


Fig. 93. Circuit for an economical series-stabilized Zener-diode-clamped 12V 1A d.c. supply. The transistor should be mounted on a 7×7in. 16 s.w.g. aluminium heat sink.

all supplied from the unregulated input, by-passing the Zener diode. Only the relatively small base current of the transistor has now to be supplied from the Zener diode which can therefore be run at a lower standing current and hence lower dissipation. Also the major dissipation is now in the series regulator transistor.

In Fig. 92(c) we have another variant of a transistor amplifier following the Zener diode. In this case the transistor is shunted across the load, and must be an n-p-n type to give a common positive "deck."

Both the circuits of Figs. 92(b) and (c) give a fixed output voltage approximately equal to the selected Zener diode voltage. Now a variable output has obvious convenience. A simple way of achieving this is shown in Fig. 92(d), where the emitter-follower series regulator circuit of Fig. 92(b) is adapted by taking the base of the transistor to the slider of a potentiometer *RV* across the Zener diode.

A practical circuit for a series-type Zener diode-clamped stabilized power supply to give approximately 1 A at 12 V output as given in Fig. 93. This is a useful sort of power pack but it must be realized that the degree of regulation achieved is not very high, mainly because the transistor base-emitter voltage and the Zener diode voltage both vary with load current and with temperature.

**Feedback-stabilized Supplies.**—Where a more closely regulated l.t. d.c. supply is required than is possible with a simple clamp-stabilized unit, resort must be had to some form of feedback which compares the output volt-

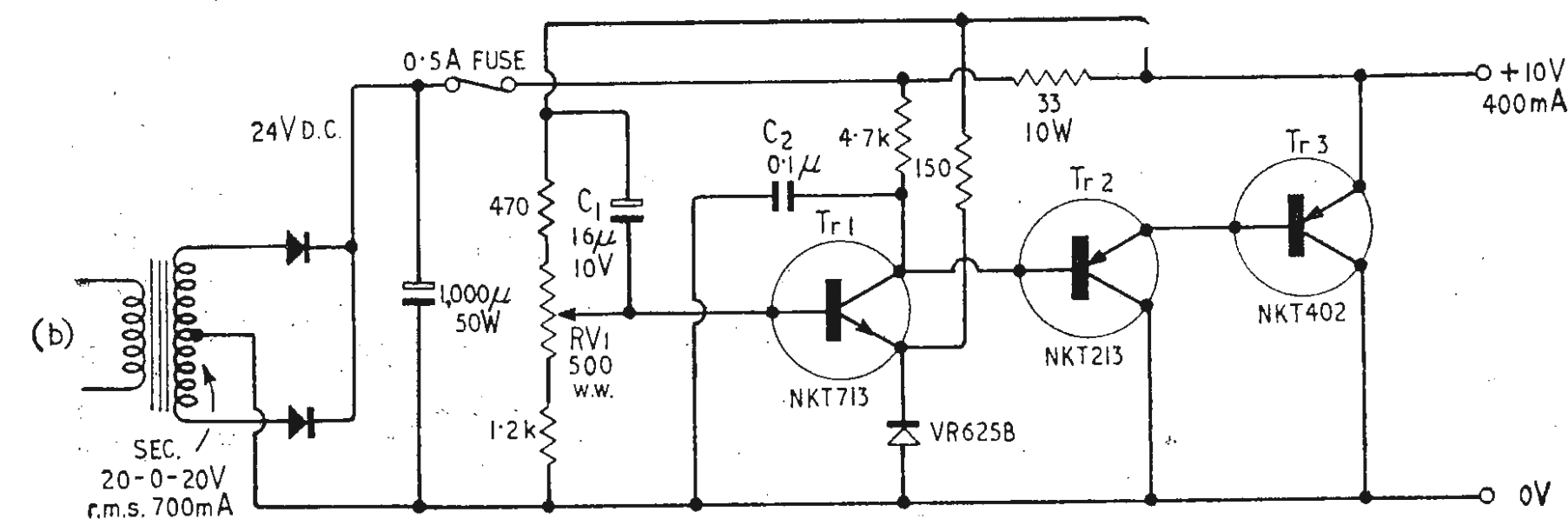
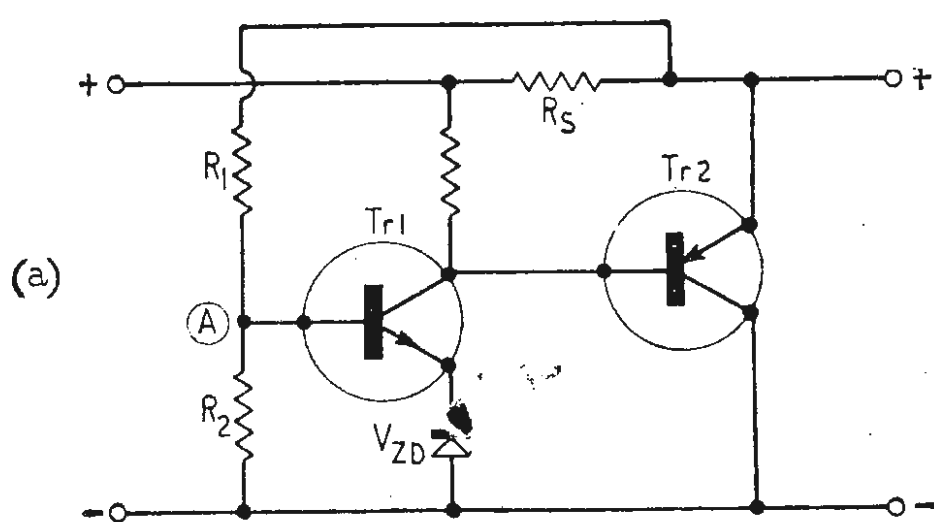


Fig. 94. Feedback stabilization of l.t. supplies:—(a) Error sensing amplifier compares output voltage with internal reference and adjusts output by means of shunt transistor *Tr1*. (b) Complete 10V, 400mA feedback-stabilized shunt regulated power pack. *Tr3* should be mounted on a 4×4in. 16 s.w.g. aluminium heat sink.

age with an internal reference voltage and compensates for changes in load current.

An arrangement often used for this purpose is shown in basic form in Fig. 94(a). Here a proportion of the output voltage at the centre of the potential divider  $R_1$ ,  $R_2$  is compared, via the base-emitter junction of transistor *Tr1*, with the Zener diode reference voltage  $V_{ZD}$  and any change is amplified in *Tr1* and applied to *Tr2* to correct the output appropriately.

Fig. 94(b) gives the practical circuit of a feedback-stabilized voltage regulator circuit of the above type to give up to 400mA at 10V (derived from "Low Voltage Stabilizer Using Semiconductors" by D. E. O'N. Waddington and M. R. Ainley, *Wireless World*, September 1961, pp. 479-482). The single transistor *Tr2* of the basic circuit is replaced by a compound emitter-follower pair *Tr2-Tr3*. The feedback potentiometer network has a variable preset potentiometer  $RV_1$  to set up the output to exactly 10V taking up resistor, Zener diode and transistor tolerances. The 16µF capacitor  $C_1$  increases negative feedback and reduces ripple at the output. The 0.1µF capacitor  $C_2$  prevents the circuit going into oscillation at high frequencies, a common failing of feedback-stabilized circuits due to amplifier phase shift.

In the shunt-regulation stabilizer of Fig. 94(b) the shunt transistor *Tr3* works at full dissipation when there is no load applied. The dissipation falls as load current increases. This is obviously less efficient than a series regulator type (where the dissipation in the series regulator transistor starts low and rises with load current) but for laboratory use the shunt regulator has the great advantage that you cannot overload it. You can even short circuit it without damage, provided the series resistor ( $R_s$  in Fig. 94(a)) is rated high enough to stand the short circuit current. With series-regulation, some form of short-circuit protection arrangement has to be used to provide for screwdrivers falling across terminals, etc.

### Overload protection circuits

Fuses and mechanical circuit breakers have been used to protect semiconductor power supplies against overloads, but their response time can be so long that a fast-acting transistor has broken down before they can operate. Commercial l.t. power packs most often use some form of electronic trigger protection circuit. The commonest arrangement is to use the voltage across a series sampling resistor to switch on a cut-out circuit when the load current exceeds a predetermined value. Usually the cut-out circuit is latched so that, once it has operated, it has to be manually reset.

A typical practical overload protection circuit of this monitor-series-resistor type is given in Fig. 95(a)—applied to a 12V, 1A power supply. In this circuit, the value of the sensing resistor  $R_x$  is selected so that the

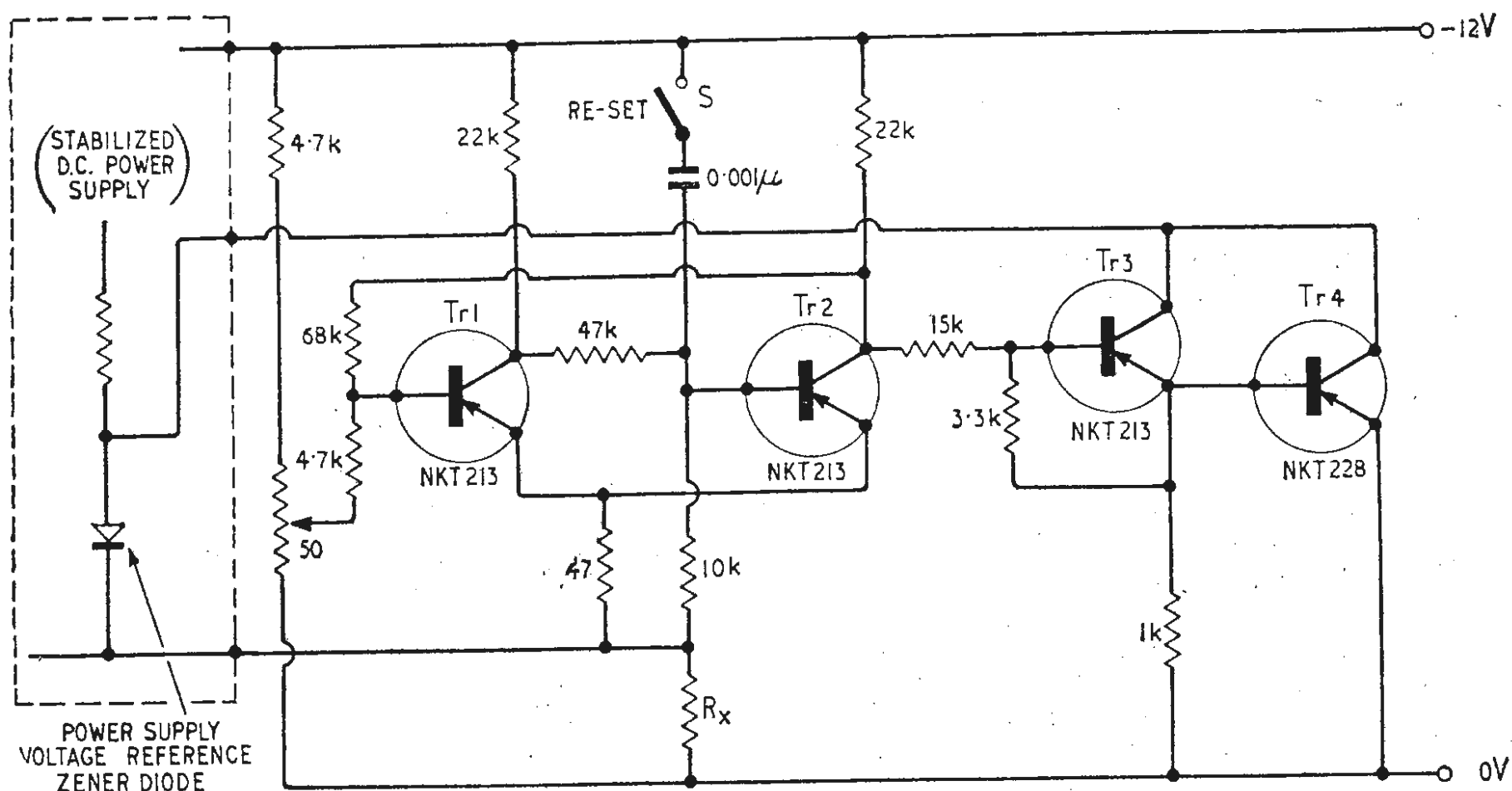


Fig. 95. Typical overload protection circuit of 12V, 1A d.c. power supply with Zener-diode internal reference voltage.

voltage drop across it at 1A is of the order of 200mV. At this level the Schmitt trigger Tr1, Tr2 is driven on, and the Zener diode bias current is almost completely bled away by Tr3 and Tr4 so that the reference voltage falls to virtually zero. The output voltage also falls to zero by the series-transistor emitter-follower action. Once the output overload has been removed the circuit is reset by the spring-loaded switch S which resets the Schmitt trigger circuit.

### Care of Power Supplies

In using laboratory d.c. power supplies, it is wise to follow good instrument handling practice generally, but particular attention should be paid to the following points.

(a) Do not exceed the current rating of the equipment, and especially do not fit fuses of a larger capacity than the specified ones.

(b) Keep the supply output terminals clear of stray wires, etc., that can cause a short-circuit or heavy overload.

(c) See that your power supply has an adequate pilot light in working order.

(d) Watch out for hum on mains-driven power supplies, checking with a scope rather than a multimeter.

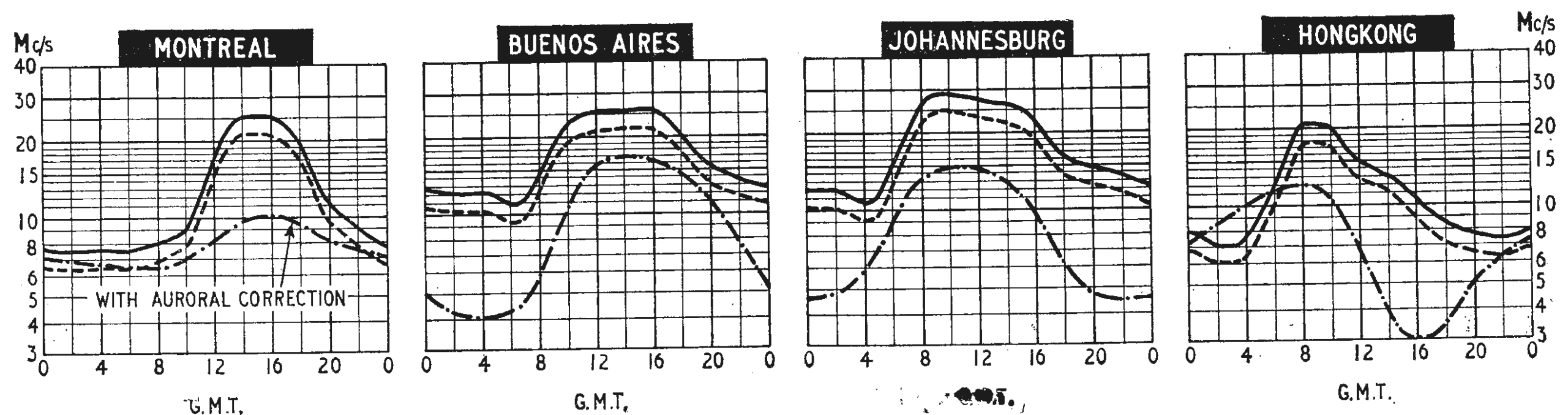
(e) Check the earthing of your supply periodically.

(f) If you have meters as integral parts of your power supply, ensure that they are adequately protected against overload damage and check their calibration regularly.

(g) Remember that in general semiconductors do not stand short heavy overloads as successfully as valves.

Before closing this final article of the series of twelve on Electronic Laboratory Instrument Practice, I should like to record my appreciation of the help I have had from the *Wireless World* editorial staff, and from the various instrument companies whose products have been referred to in the articles.

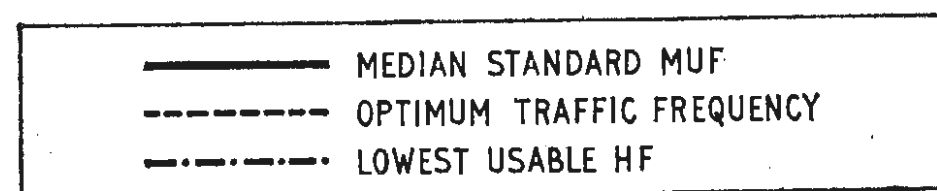
## H. F. PREDICTIONS — DECEMBER



The maximum usable frequency is, by definition, the frequency at which communication should be possible for 50 per cent of the time. Satisfactory communication will, of course, be possible slightly above the MUF, but only for smaller percentages of time. The optimum traffic frequency is usually taken as 85 per cent of the MUF.

The prediction curves show the median standard MUF, optimum traffic frequency and the lowest usable frequency (LUF) for reception in this country. Unlike the standard MUF, the LUF is closely dependent upon such factors as

transmitter power, aerials, local noise level and the type of modulation. The LUF curves shown are those drawn by Cable and Wireless for commercial telegraphy and assume the use of transmitter power of several kilowatts and rhombic type aerials.





# NEW PRODUCTS

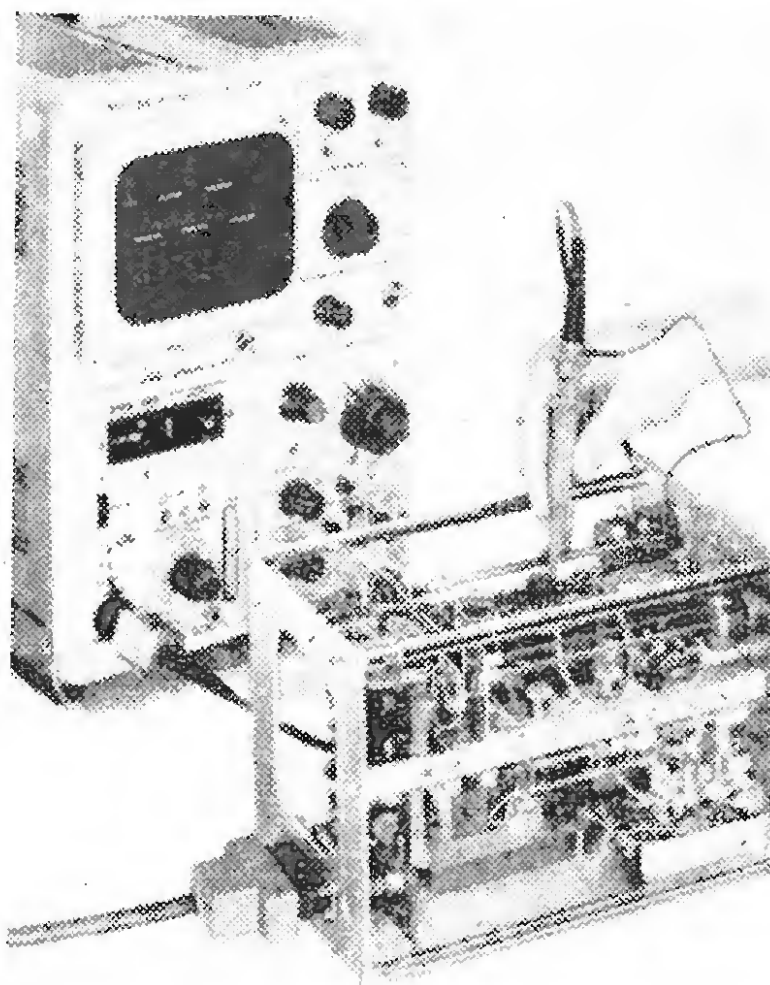
equipment      systems      components

## PLUG-IN SCOPE AMPLIFIER with automatic volts/division selection

AN "automatic-seeking" circuit which, upon electrical command from a special probe (supplied with the instrument) or by a front-panel control, automatically selects the appropriate volts/division setting for amplitude in the new plug-in scope amplifier from Tektronix Ltd. In the "automatic-seek" position this amplifier, which is known as the Model 3A5, limits signals to within plus/minus three divisions of the centre-line on the c.r.t. Height can, however, be varied through a front-panel control if required.

Illuminated digits are employed to give readout data including the volts/division setting, input coupling, and uncalibrated operation of the variable volts/division control. The readout also indicates any volts/division correction when the instrument is used with a 10X probe. In addition to the "automatic-seeking" and the manual controls, the amplifier can be remotely programmed, a multi-pin connector being provided on the front-panel for this purpose.

The bandwidth of the amplifier, with vertical sensitivities of 1, 2 or 5 mV/div, is from zero to 5 Mc/s, and with



sensitivities of 10 mV to 50 V/div from zero to 15 Mc/s.

Although designed for the Tektronix 560 series of oscilloscopes, this amplifier is not suitable for all the scopes within the 560 series. Tektronix U.K. Ltd.'s address is Beaverton House, Station Approach, Harpenden, Herts.

WW 301 for further details

## Crystal Units

BY using an all-glass crystal holder, Cathodeon Crystals Ltd. have found it possible to maintain a vacuum which improves considerably a crystal's ageing characteristics and also increases its activity value and its Q factor, when compared with all-metal holders. Glass encapsulated versions in the 2M style, having the same frequency range, frequency stability with temperature, and operating temperature range as the all-metal holders, are now available.

The address of Cathodeon Crystals Ltd. is Linton, Cambridge.

WW 302 for further details



WIRELESS WORLD, DECEMBER, 1965

## Integrated Logic Circuits

THE second generation of SUHL (Sylvania Universal High-level Logic) integrated circuits is announced by the British Agents, Thorn-AEI Radio Valves and Tubes Ltd., whose new address is 7 Soho Square, London, W.1 (Tel.: GERrard 5233). The new range, known as the SUHL II and now in production, consists of 6 nsec gates and 30 Mc/s J-K flip-flops designed to operate from a single 5 V supply.

All the circuits in the SUHL II range are compatible with the 18 circuits in the SUHL I range and both ranges contain circuits for military applications working at temperatures within  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  and for industrial use from zero to  $+75^{\circ}\text{C}$ .

Circuits in the new range, which is claimed to meet high-speed requirements without compromising any performance characteristics, are available in military flat-pack encapsulations or in Sylvania's new flat rectangular, 14-lead plug-in packages. These new packages have been designed for low-cost assembly on two-sided printed circuit boards, and incorporate index notches on one end to facilitate orientation before insertion. Good thermal conductivity is obtained with the new packages, which are hermetically sealed and alumina filled.

The circuits in the new range are as follows: expandable dual 4-input OR gate; quad 2-input NAND/NOR gate; quad 2-input OR expander; dual 4-input NAND/NOR gate; expandable quad 2-input OR gate; single 8-input NAND/NOR gate; dual 4-input OR expander; J-K flip-flop for AND inputs; and a J-K flip-flop for OR inputs. Other features of the SUHL range include isolated input and output circuits, and low power requirements (typically 20 mW per gate).

WW 303 for further details

## SILVER MICA CAPACITORS

THE first of a new range of silver mica capacitors is announced by the London Electrical Manufacturing Company, of Bridges Place, Parsons Green Lane, London, S.W.6. Designated 611SM, this capacitor has the same sintered blade construction as that employed in the 1106S range, and covers the range 10 pF to 500 pF at 750 V. At 350 V the capacitance range is extended to 1,500 pF. The overall dimensions of the 611SM, which is moulded in epoxy resin, are  $15.4 \times 10.5 \times 4.0$  mm.

WW 304 for further details

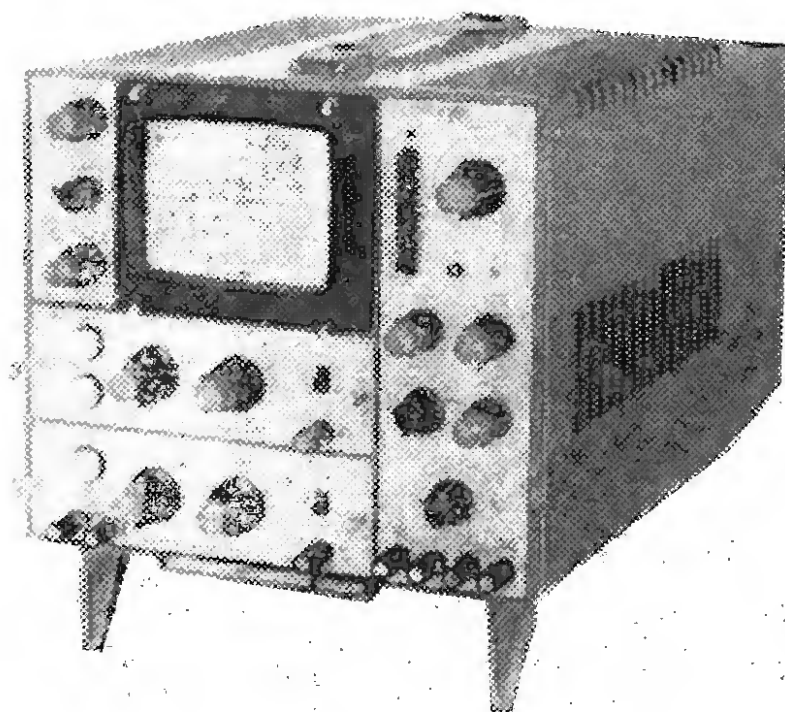


## SPLIT-BEAM SCOPE

THE new split-beam rectangular tube being manufactured by the M-O Valve Company has been fitted to Telequipment's latest oscilloscope, the D53, which has integral sweep and signal delay facilities. The main advantage of the new mesh p.d.a. tube, apart from space saving, is that a higher p.d.a. ratio can be used which results in a brighter trace and a higher sensitivity.

Other features of this new scope include an *x* amplifier with two sweep delay ranges and two new *y* amplifiers. The sweep delay ranges of the *x* amplifier in the D53 are up to 5 msec and up to 50 msec, each with variable uncalibrated delay controls. The time base has 22 calibrated speeds from 5 sec/cm to 0.5  $\mu$ sec/cm in a 1:2:5 ratio. There is also a variable gain control for continuous coverage between ranges, and a single shot facility with provisions for lock-out. Bandwidth of the *x* amplifier is zero to 1 Mc/s (-3 dB) and sensitivity is approximately 100 mV/cm at maximum gain. Expansion on the *x* axis is continuously variable up to 10 screen widths, the trace expanding symmetrically about the centre. The two new *y* amplifiers, Types CD (high-gain) and HD (wide-band) are also available with up to 0.25  $\mu$ sec signal delay.

The existing range of *y* amplifiers associated with the Telequipment S43 and D43 laboratory oscilloscopes are suitable for the Model D53. The display



area for each beam is 6 cm high  $\times$  10 cm wide and is covered by a removable illuminated graticule. The overall dimensions of the Model D53 are 10 $\frac{3}{4}$   $\times$  11 $\frac{3}{8}$   $\times$  19in; weight with amplifiers is approximately 50lb.

Complete with a pair of Type CD amplifiers, the price in the U.K. is £225. When fitted with a pair of Type HD amplifiers the instrument costs £235. The company's address is 313 Chase Road, Scuthgate, London, N.14.

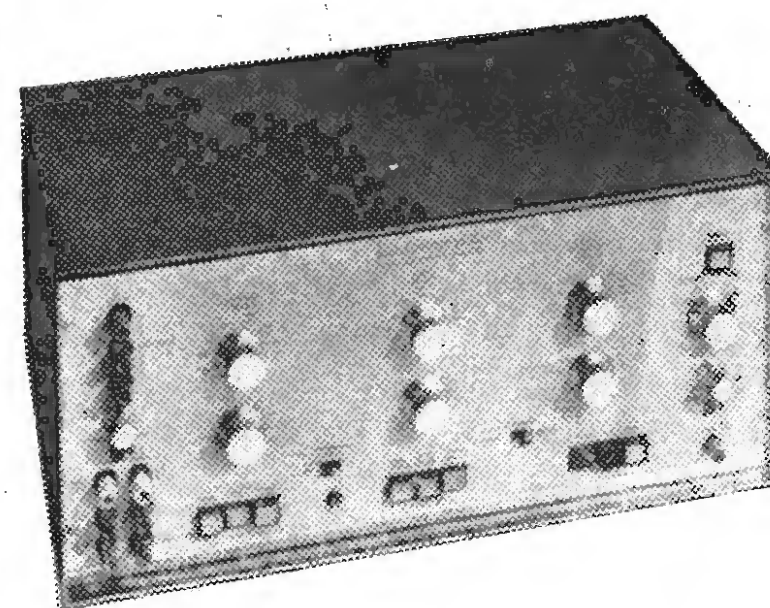
WW 305 for further details



## DECADE PULSE GENERATOR

A STABLE and accurate square-wave generator, covering the range 0.1 c/s to 10 Mc/s, is contained in the new decade pulse generator being produced by Calne Electronics Ltd., of Calne, Wilts. The output may be used directly or as a repetition rate source for the delay and pulse forming circuits in this instrument, which is designated Model PG 101. These circuits are independently variable over the range 1 sec to 0.1  $\mu$ sec and can be set to produce either single or double pulses of either polarity.

The output is quoted at 10 V into 75  $\Omega$  load and an internal switched attenuator is provided to allow the output to be reduced to 100 mV; an uncalibrated variable control is fitted for fine



adjustment. External triggering facilities are provided with front-panel control of trigger level and slope. A 10 nsec rise time is quoted.

Features of this instrument include solid state circuitry, circuits for coherence gating, and pre-pulse and negative triggering outputs for oscilloscopes and other ancillary equipment. Another is that the square-wave generator can be linearly frequency modulated externally, thus allowing the instrument to be phase locked to an external system and also to allow tests to be conducted on f.m. data recording equipment. In conjunction with a suitable output filter, the generator can also be used to demodulate f.m. signals.

The Calne decade pulse generator is marketed by Aveley Electric Ltd., of South Ockendon, Essex.

WW 307 for further details

## Neon Ballast Resistors

FOUR types of carbon composition resistors specially developed for use as ballast resistors with low-voltage neon indicator lamps are offered by Morganite Resistors Ltd., of Bede Trading Estate, Jarrow, Co. Durham. They are fitted with either solder-coated copper leads or with copper-clad mild steel terminations for welded assemblies.

WW 308 for further details

## A.F. Microvoltmeter

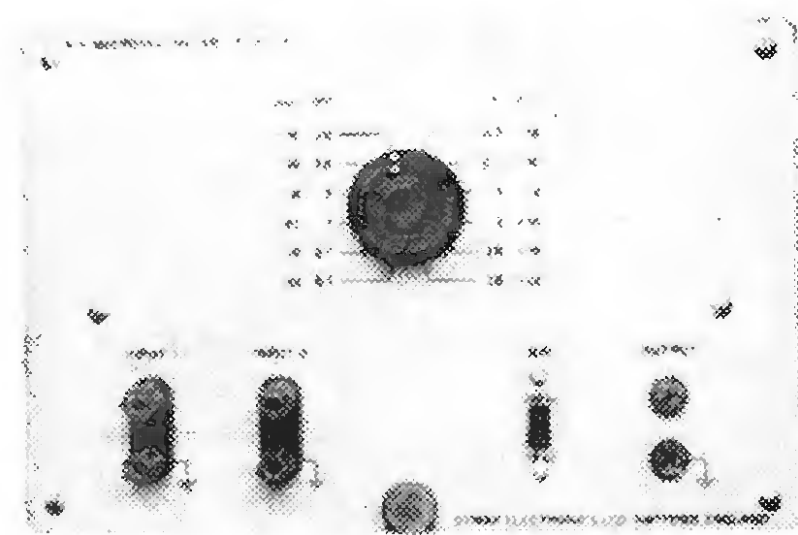
THE latest unit in the Dymar range of plug-in instruments is the Model 705 a.f. microvoltmeter. It covers 100  $\mu$ V to 30 V f.s.d. in 12 ranges (in a 1, 3, 10 sequence) and has an accuracy of 3% between 100 c/s and 100 kc/s.

A feature of this valve voltmeter is that it has a "balanced input" which permits direct measurement of push-pull voltages with respect to earth. "In-

phase" rejection over most of the frequency range (20 c/s to 300 kc/s) is greater than 60 dB and thus allows the measurement of balanced voltages in the presence of much larger interfering voltages. The inherent noise level of the instrument is less than 20  $\mu$ V and can be further reduced (to 8  $\mu$ V) by restricting the bandwidth to 10 kc/s. Either input can be used for measurement of unbalanced voltages with respect to earth. Input impedance on each line is 10 M $\Omega$ .

This instrument may also be used for driving oscilloscopes and power amplifiers, etc., an output of 800 mV r.m.s. being made available on the front panel at full scale deflection. The price is £58 and the address of Dymar Electronics Ltd. is Rembrandt House, Whippendell Road, Watford, Herts.

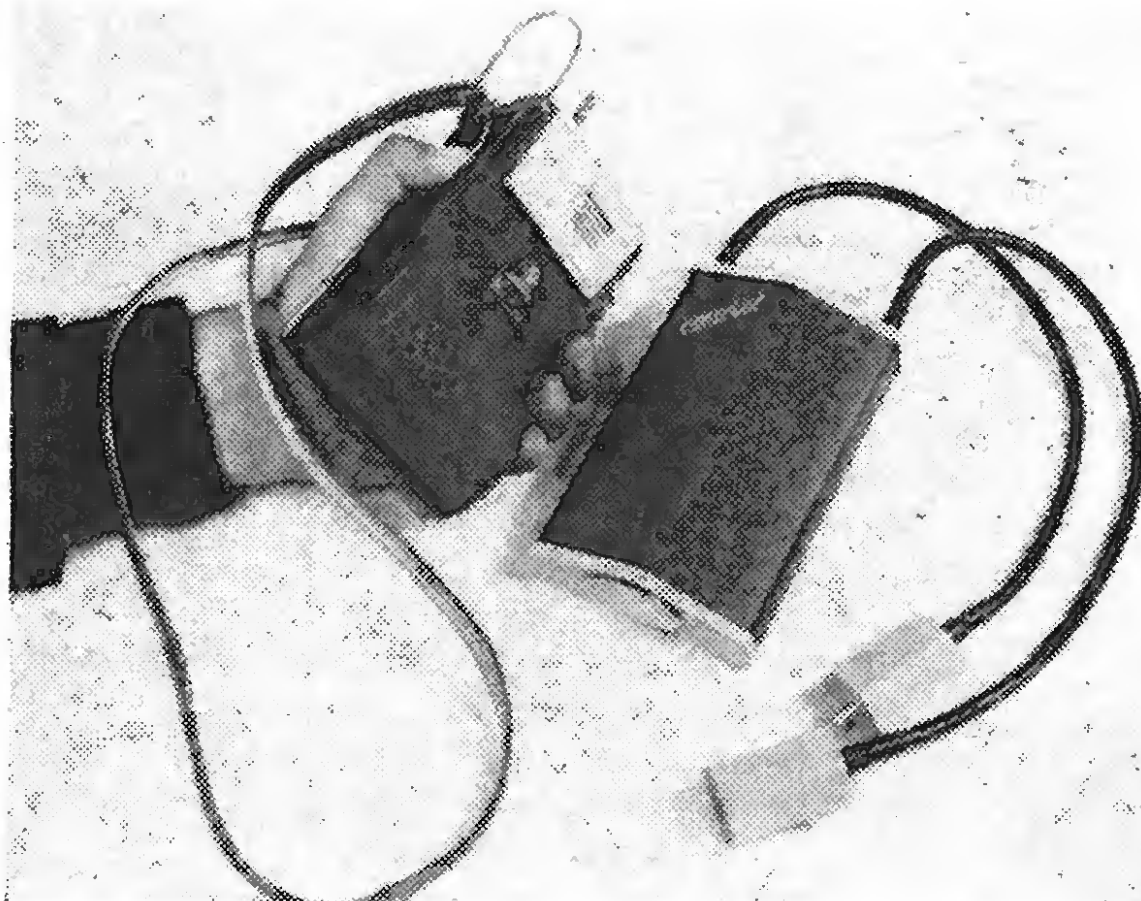
WW 306 for further details





## V.H.F. Transceivers

TWO new "pocket-sized" v.h.f. transceivers, one for a.m. and the other for f.m. working, have been introduced by G.E.C. Electronics Ltd., of Spon Street, Coventry. Both of these transceivers, known as the Courier AM and the Courier FM, employ transistors throughout and have been fully approved by the British Post Office. The transceivers operate on three fixed frequencies in the range 70 to 180 Mc/s. Operational



range is about five miles from set-to-set.

Experience gained in the manufacture of the Lancon transceiver, now in use with the British Police Force, has been utilized in the development of these new equipments. Although the a.m. version (shown on the left) is suitable for pocket or hand-held operation, the f.m. version has been specifically designed to be carried in an inside pocket or on a concealed lightweight harness (as is the Lancon). An aerial is contained in the f.m. unit's microphone

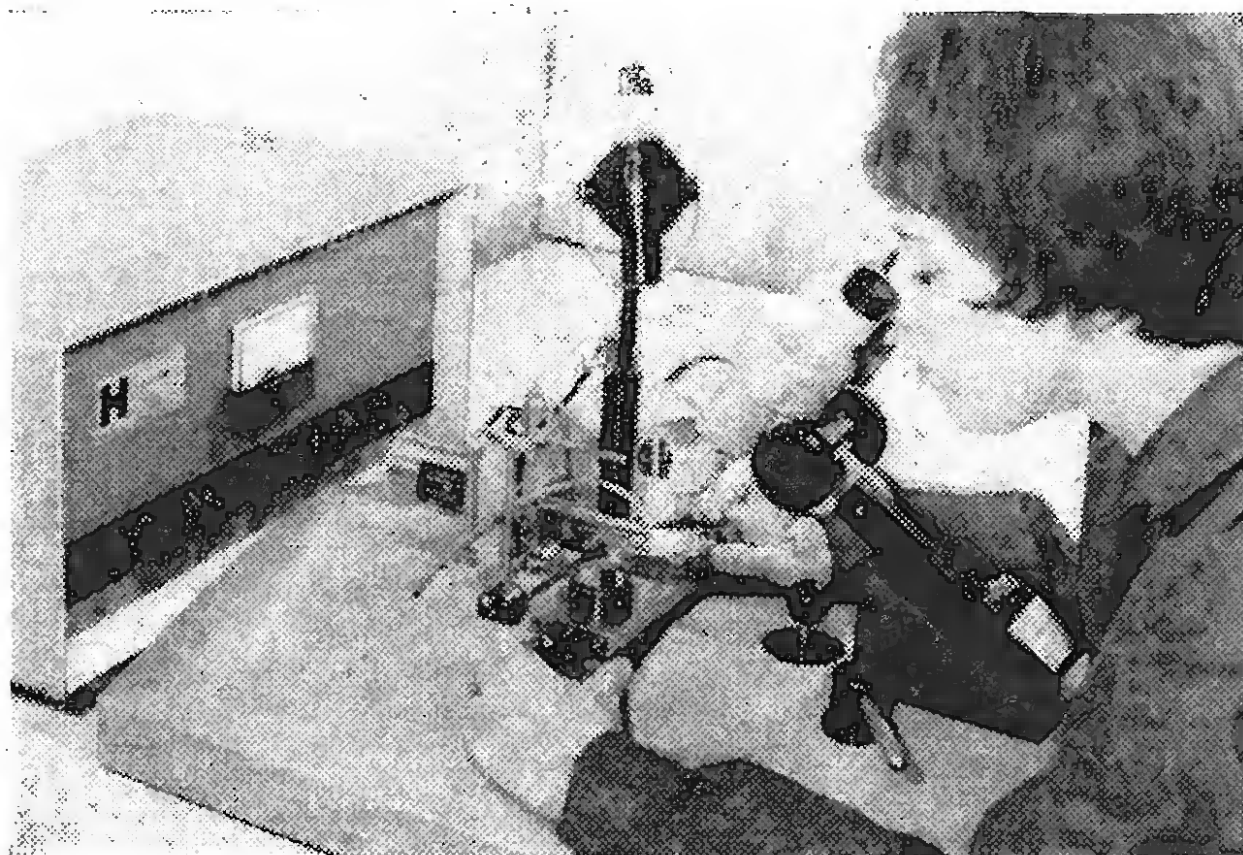
lead and provides adequate radiation since the microphone is worn behind the user's lapel. The case size of the f.m. version is  $4\frac{1}{8} \times 6\frac{7}{16} \times 1\frac{3}{8}$  in and the weight—including a rechargeable battery—is only 23 oz.

The a.m. version is a little smaller, the case size being  $6\frac{5}{16} \times 3\frac{1}{16} \times 1\frac{1}{4}$  in, but is slightly heavier—24 oz. Interchangeable extending whip or flexible wire aerials can be used with this unit, which is also powered by a rechargeable battery.

WW 309 for further details

## ULTRASONIC SEMICONDUCTOR MOUNTER

ABLE to bond multi-chip devices directly onto thin-film or thick-film substrates is the Hughes Ultrasonic Flip Chip Die Mounter Model 2901. Making use of the "bumps" on their own range of "flip chip" integrated circuit components, it is a comparatively simple task to mount them accurately (within 0.0005in) onto substrates.



The frequency of operation is 60 kc/s and power output and the pulse duration can be varied from 0 to 20 watts and from 0.020 to 1.020 seconds respectively. Up to 300 chips an hour can be mounted with this device, which can also be used for conventional wire bonding and wire welding. A wire spool is included among the accessories, which include a holding chuck for TO-5 or TO-18 headers, and a number of welding tips for different chip sizes.

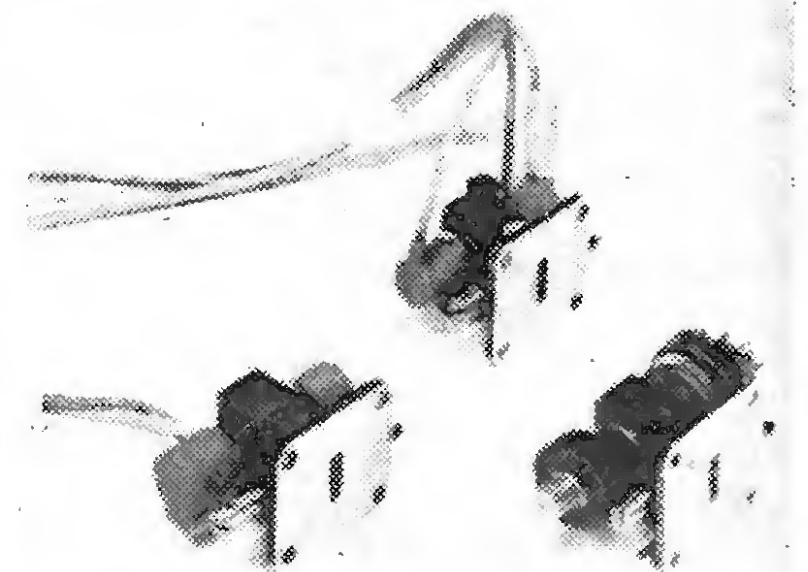
The British subsidiary of the Hughes Aircraft Company, of California, is Hughes International (U.K.) Ltd., Heathrow House, Bath Road, Cranford, Hounslow, Middx.

WW 310 for further details

## X-Band Reflex Klystrons

A NEW series of compact, "fully ruggedized," X-Band reflex klystrons are being produced by the English Electric Valve Company, of Chelmsford, to meet the demand for relatively inexpensive local oscillators having a wide range of frequency/temperature coefficients. As an example, the K3007 has a coefficient of  $-130$  kc/s per degree Centigrade, which the makers claim is comparable with most commercially available X-Band magnetrons. Another feature of the range is that—through improved manufacturing techniques—the performance parameters can be permuted to suit individual requirements for non-standard klystrons.

The frequency drift on these devices is quite small and the manufacturers state that one of the klystrons in the series (a K3003) has remained within



$\pm 10$  Mc/s during testing of over 3,000 hours. The frequency range of these tubes varies according to type from 8.5 to 9.55 Gc/s, as does the electronic tuning range (the narrowest being 32 Mc/s and the widest 60 Mc/s) and the output powers (from 40 to 70 mW).

WW 311 for further details

## Miniature Electrolytics

LONG-LIFE electrolytic capacitors for industrial applications are announced by Mullard Ltd. The new series, designated C428, offers a greater CV product for a given size when compared with their C427 series and at the same time has all the service life and reliability characteristics of the existing C427 range. Typical service life figures at 40°C are 200,000 hours continuous operation, at an estimated failure rate of 0.025% per 1,000 hours at the full rated voltage.

The capacity range of the new series covers the same values as the C427 range— $2.5 \mu\text{F}$  to  $160 \mu\text{F}$  with an extension up to  $320 \mu\text{F}$ . Working voltages are from 4 to 64V.

WW 312 for further details

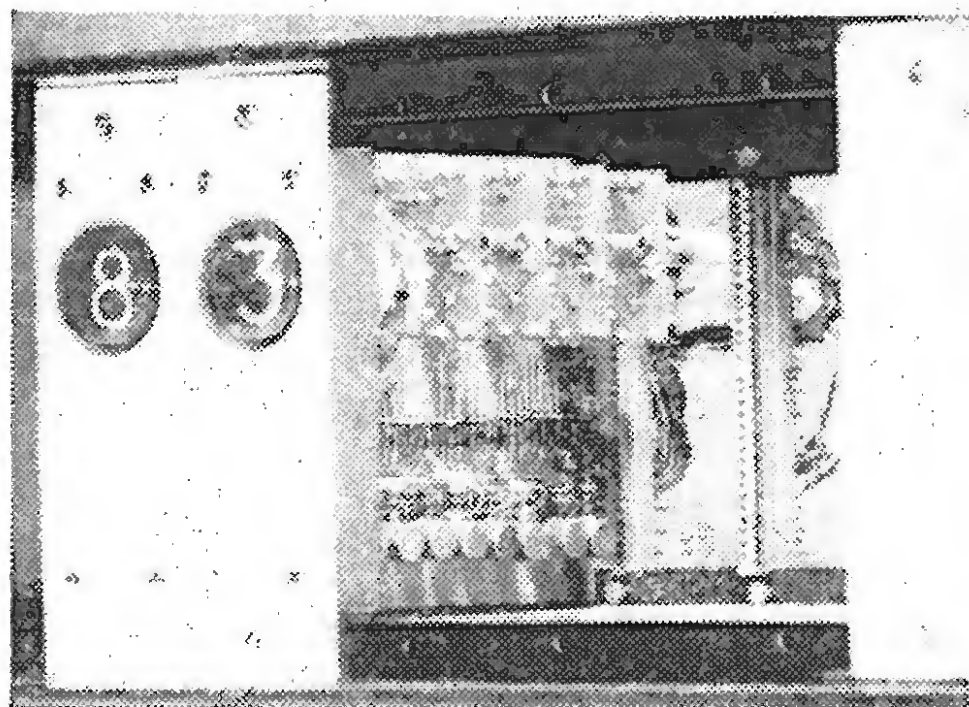


# DECADE COUNTER MODULES

DESIGNED for industrial systems and also for laboratory use where the expense of a complete counter is not justified, is the new range of decade counter modules being produced by Quarndon Electronics Ltd., of Slack Lane, Derby. As can be seen from the illustration (showing two units) standard numerical display tubes are employed in these modules, which have a front panel area of  $4\frac{3}{4} \times 1\frac{1}{2}$  in and require a cabinet depth of  $5\frac{1}{2}$  in. A decimal point is provided

by a miniature neon bulb which is operated externally.

Two basic types are available, one containing germanium and the other silicon semiconductor devices. The former have counting speeds of 1, 5 and 12 Mc/s and the latter speeds of 200 kc/s, 2 and 30 Mc/s. The speed of operation depends, of course, to some extent upon the input pulse and the manufacturers state that for maximum speed a 2.5 V pulse with a rise time of 500 nsec is required. The output of the modules is sufficient to drive a further unit, hence it is possible to construct a multi-digit counter from these modules. Also 8-4-2-1 binary code digital decimal outputs are available for remote display applications. To enable complete counters to be built, Quarndon offer a selection of frequency standards, gating units and remote display units.



WW 313 for further details

## Waveform Shaper

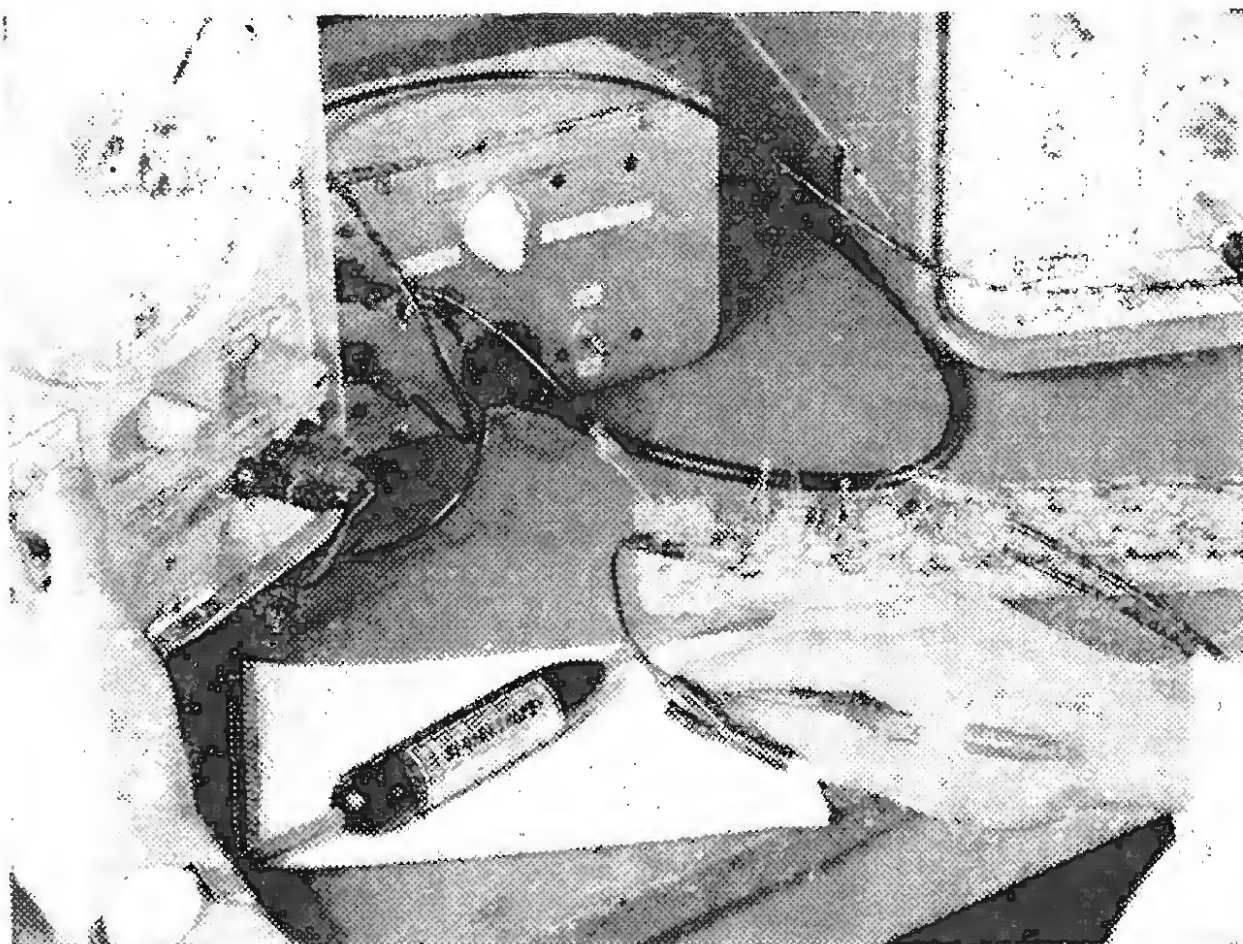
A SIMPLE unit for sine-wave to square-wave conversion is announced by Dawe Instruments Ltd., of Western Avenue, Acton, London, W.3. Called the Type 438A Squareshaper, it comprises a two-stage transistor feedback circuit and has been designed for use with the Dawe Type 440B oscillator.

Amplitude and frequency of the output of the Squareshaper is governed by

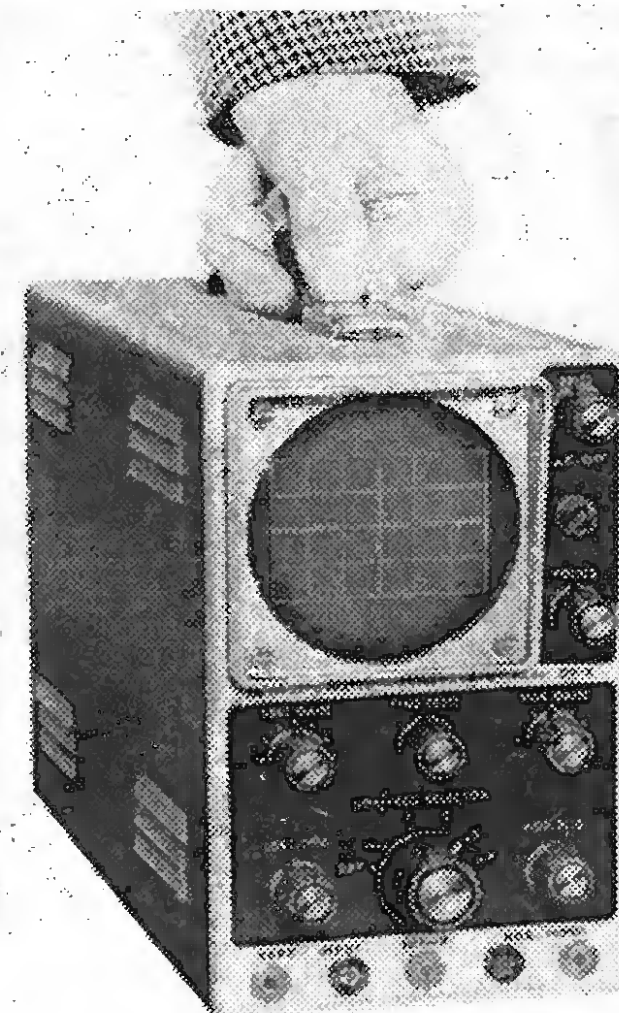
the driving oscillator—up to 30 V within the frequency range 1 c/s to 1 Mc/s. Output amplitude of the negative square-wave produced by the unit for a 25 V r.m.s. input is approximately -30 V on open circuit. A risetime of 50 nsec is quoted when working into a 2-k $\Omega$  load.

Tilt is 5% at 5 c/s and is negligible from 100 c/s to 1 Mc/s; overshoot is always less than 1%.

No power supply is required for this probe, which is torpedo-shaped and measures 1 in diameter by 5 in long; it weighs 4 oz complete with leads. The cost of the 438A is £9.



WW 314 for further details



## Small Scope

A THREE-INCH portable oscilloscope with a bandwidth of 2 c/s to 3 Mc/s has been introduced by Daystrom Ltd., of Gloucester, as Heathkit Model OS-2. This instrument has a Heathkit patented timebase circuit in which a self-limiting cathode follower is used to provide automatic lock-in synchronization. The time base generator covers 20 c/s to 200 kc/s in four ranges, with a blanking amplifier operating on all ranges.

The sensitivity of the y amplifier is 100 mV/cm and the input impedance is 3.3 M $\Omega$  shunted by 20 pF. Sensitivity of the x amplifier is identical to the y amplifier, while frequency response is from 2 c/s to 300 kc/s and input impedance is 10 M $\Omega$  shunted by 20 pF.

The overall dimensions of the instrument are  $7\frac{3}{8} \times 5 \times 12$  in; weight is  $9\frac{3}{4}$  lb. In kit form, the cost is £22 18s, and assembled and tested £30 8s.

WW 315 for further details

## Microminiature I.F. Amplifiers

A RANGE of transistor amplifiers with centre frequencies in the range 10 to 250 Mc/s and bandwidths varying from 5 to 30 Mc/s has been introduced by Microwave Associates Ltd., of Cradock Road, Luton, Beds. Gain characteristics of 60 to 80 dB are quoted with a stability of  $\pm 3$  dB over a temperature range of  $-55^\circ$  to  $+100^\circ$  C. The noise figure is 4 to 5 dB.

I.F. pulse amplifiers, logarithmic amplifiers and dual-channel versions are included in the range, which is designed to operate from a single d.c. power supply of 15 V, 15 to 30 mA. The smallest of the units measures  $\frac{1}{2} \times \frac{1}{2} \times 2\frac{1}{2}$  in and the largest  $\frac{1}{2} \times \frac{1}{2} \times 4$  in.

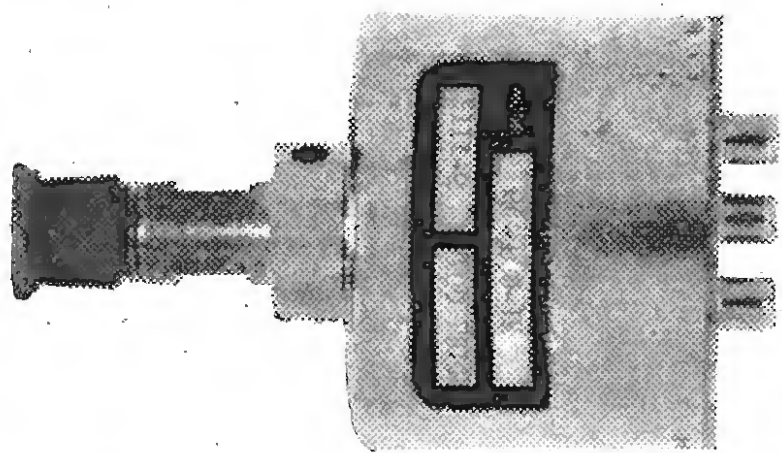
WW 316 for further details



## Pressure Transducers

NO amplifiers are needed for the new Coutant range of pressure transducers, Type CE26, which—in 14 pressure ranges—cover from 0-15 to 0-5000 p.s.i.g. A Bourdon tube element is used and coupled to a precision-wound  $\frac{1}{2}$  W potentiometer, the resistance of which is either 1, 2 or 3 k $\Omega$ ; with higher or lower values available to order.

A response time of 35 msec is quoted for these transducers which are operable within the temperature range  $-25^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$ , with a temperature coefficient of 1% per  $25^{\circ}\text{C}$ . For simple pressure indication these transducers may be connected directly to a d.c. supply and



meter; the potentiometers having a half-watt rating allows quite high voltages to be used. The price varies between £40 and £54 according to the pressure range covered.

A heavy-duty, oil-filled version will be available shortly.

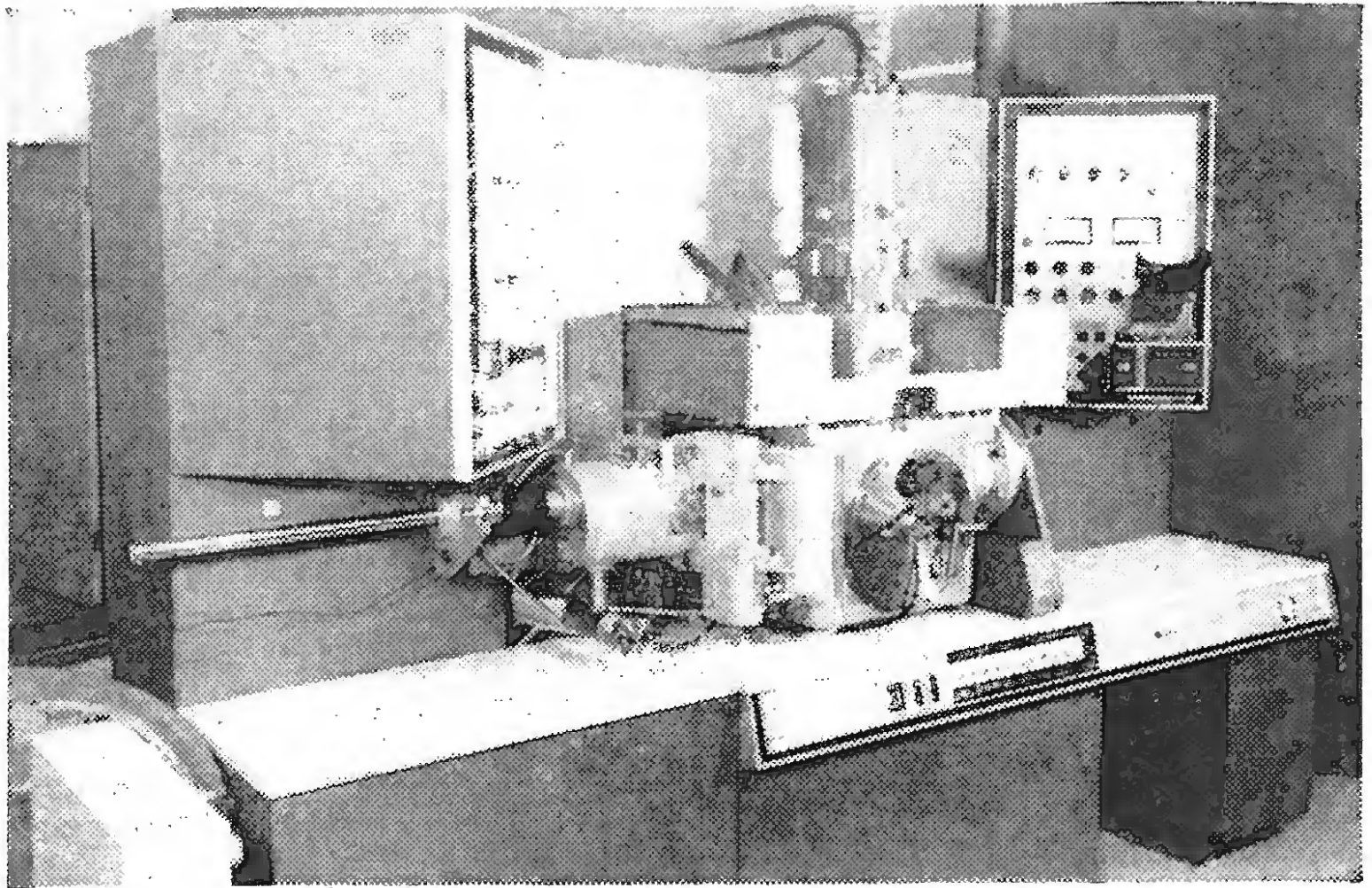
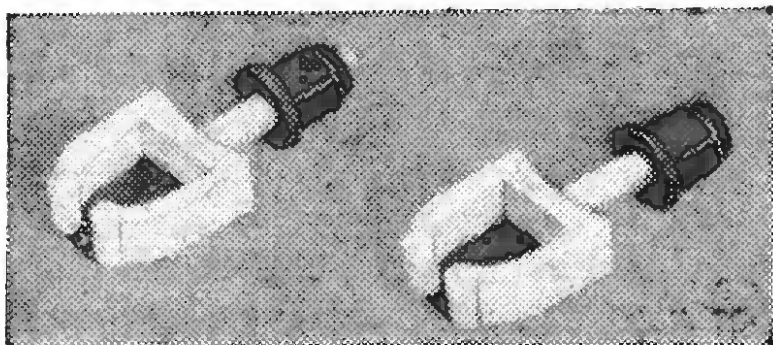
The address of Coutant Electronics Ltd. is 3 Trafford Road, Richfield Industrial Estate, Reading, Berks.

WW 317 for further details

## Plastic Transistor Holders

NYLON transistor clips designed to take TO-5 cases are available from Jermyn Industries Ltd., of Vestry Estate, Vestry Road, Sevenoaks, Kent. A 6 BA stud is included in the bottom half of the moulding and can be mated with either a spring clip or with a soft polythene nut. The latter has been found particularly useful on production lines as it is simply pushed over the nylon stud.

WW 318 for further details



## Electron Microscope

A GREAT depth of focus is claimed for the high-magnification scanning electron microscope now commercially available from the scientific equipment department of the Westinghouse Electric International Company, of 200 Park Avenue, New York, N.Y. 10017, U.S.A. A television-like method of operation is used in this microscope and the information is presented in the form of a photographic enlargement of the original. This method of presenting the information is particularly useful when compared with other electron microscopes, which present pictures requiring interpretation by specially trained personnel.

No special sample preparations are necessary for this microscope, which contains an electron gun and magnetic lenses that can focus the beam to a spot of less than 0.25 micron (1 micron = 0.00003937 in) in diameter. Magnification is variable from  $40\times$  to  $25,000\times$ . The complete installation can be mech-

anically isolated from surrounding equipment to minimize vibration.

As an example of the results obtainable from this microscope, the group of four illustrations show how the amount of detail can be progressively increased. For the example a 500-mesh nickel microscope grid is used, viewed at a 45-degree angle.

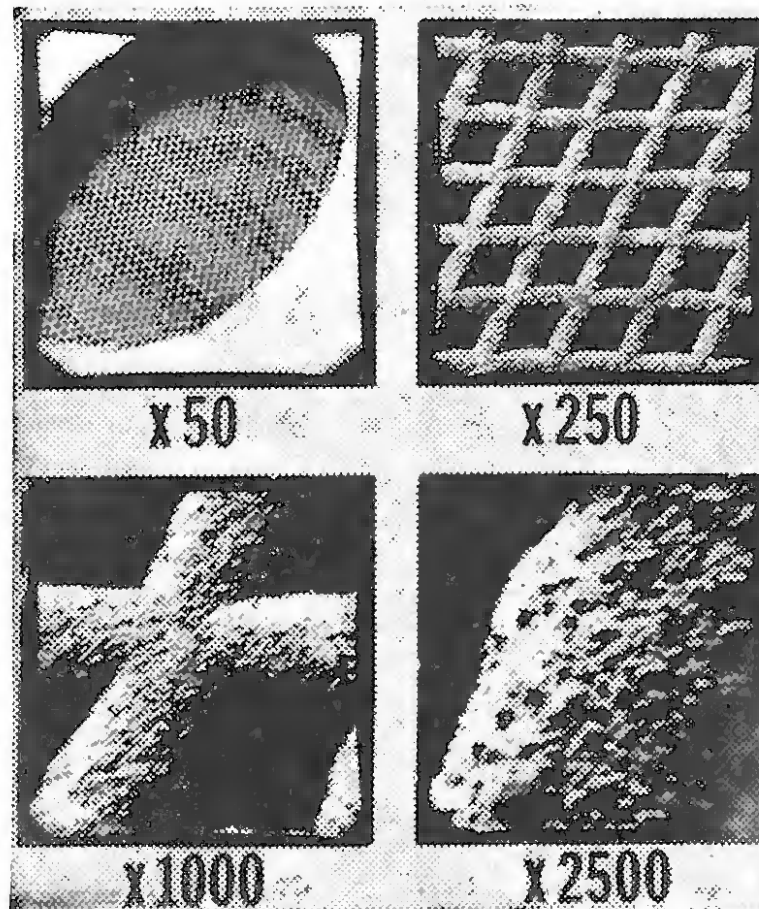
WW 319 for further details



## PROBABILITY SLIDE RULE

THOSE concerned with the measurement and analysis of random data may be interested in a probability slide rule recently introduced by the Rolatape Corporation, of 1301 Olympic Boulevard, Santa Monica, California. On one side of the rule probability values are given for Normal (Gaussian), Rayleigh and Maxwell distribution. And on the other, the rotatable inner disc may be used to calculate the probability "of no successes, or at least one success in N independent trials." Depending upon the scale used, computations are accurate to three or four significant figures.

WW 320 for further details



## "Angels and ministers of grace, defend us!"

THE O.E.D. tells us that "to minister" is to render aid or service; to be helpful or contribute; to furnish or supply (help, etc.). How right it is, as always! Where would one find, other than in the Ministries, such a dedicated body of officials all leaping over one another in their anxiety to render aid or service? To be more specific, where would the farmers, the miners and the doctors be without them?

The electronics industry, too, has much to be thankful for in this direction. Pausing to wipe the perspiration from our respective brows, let us devote a moment's silent contemplation to those philanthropic donors of challenging contracts and work studies—many of them challenging Ohm's law itself—the end products of which are demanded in such an excitingly short space of time. Let us think, too, of those sudden cancellations which bring us to the very portals of that earthly haven, the Labour Exchange, just when the impossible is being achieved and the inscrutable unscrewed.

And when a reckless improvident Management has landed a lucrative contract for the supply of Mark VII electronic bird-scarers to a certain foreign power which shall be nameless, who is it that slaps an embargo on just as the first consignment is heading for the docks? Why, none other than that ever-vigilant chap at the Ministry who, alone among us, sees quite clearly what a terrible offensive weapon an electronic bird-scarer could be forged into if war broke out. Shall we ever fully realize the debt of gratitude we owe these splendid fellows, these guardian angels who protect us from our follies with no prospect of reward other than a K.C.B.?

Not the least wonderful thing about a Ministry is its ability to devote the same unremitting attention to the smallest as to the greatest matters. Let us, in illustration, follow for a few moments the career of one P. A. Rameter, a Group Chief in the laboratories of Gargantuan Electronics Ltd., who some months previously has had the urge to write a technical article with a view to publication. As our scene opens he has already passed this through the proper internal channels (i.e., his Divisional Chief Engineer) who has, of course, insisted on improving it (all D.C.Es. are born with a built-in Parker) and now feels justified in approaching an Editor. He does just that, and the editor replies:—

Dear Mr. Rameter,

Thank you for your synopsis of an article entitled "Recent Developments in Macroelectronics." The subject is topical and I shall be pleased to look at your paper. May I have it as soon as possible?

Horatio Hyperbole,  
Editor, "Obscure Electrotechnics."

to which our author replies:

Dear Sir,

Thank you for your interest in my article, which I hope to be sending within a few days. As one short paragraph in it mentions a work study carried out by my Company for the Ministry of Improvisation I have thought it best to get it approved by them first. As you know, macroelectronic techniques have been extensively written up in both

the U.S.A. and the U.S.S.R., so I do not expect any security trouble.

P. A. Rameter.

Little does he know! Three months and ten letters of enquiry later he receives a postcard, addressed to Mr. A. C. Ammeter, which reads as follows:

Dear Sir/Madam,

This is to acknowledge receipt of your communication of the ..... entitled ..... which is receiving attention.

A. Blythe-Spirit (Ft.-Lt.) Dept, 1BF,  
Ministry of Improvisation.

The wheels of the machine are now in motion. A mere five months elapse before a tattered manuscript, accompanied by a memo from Dept. 1BF, is received by the Assistant to the Deputy Deputy Commander of the Indeterminate Warfare Establishment at Killikwick, Caithness. The memo runs:

Take a peep at this rot will you, old man? Found it while looking for a golf ball behind the filing cabinet. Blythe-Spirit, my predecessor, seems to have been using the envelope as a receptacle for his Freudian relics (not enclosed). Love to Amanda. Merry Christmas.

Humphrey.

Reaction is immediate; the urgency of the occasion is recognized by no less a person than the Arch-Comptroller-in-Chief of the Ministry. He issues a memo at the speed of light:

All personnel are reminded that in the interests of efficiency the text of memoranda must conform to the procedure laid down in my XYZ/123/ABC/754321/HUP of Feb. 30th.

Time passes; a further three months, to be exact, and then in answer to our impetuous author's seventeenth letter, comes some brisk action from Dept. 1BF. It takes the form of a postcard, addressed to Miss Daisy Gasmeter. It comes straight to the point:

Dear Sir/Madam,

This is to acknowledge receipt of your communication of the ..... entitled ..... which is receiving attention.

H. Bugloss (Sq. Ldr.) Dept. 1BF.

Things are really hotting up now, as witness the arrival of half the manuscript and a memo from Indeterminate Warfare Establishment, Caithness, upon the desk of the Security Officer, Electronic Hostilities Experimental Station, Trepolpen, Cornwall.

Your pigeon, I think. Nobody here knows what this chap is babbling about. As far as I can make out, the technique of macroelectronics involves building a transmitter the approximate size of Yorkshire. I suppose there is a point.

Peregrine Faucet (Capt.)

Unfortunately, the Security Officer is on extended leave, and as he is known by one and all to have the strongest views about his juniors taking decisions in his absence, the manuscript gathers dust in his IN tray pending his return. And when he does get back, priority has to be given to matters of grave national importance, like the Penzance shark-fishing;



nevertheless, in a trifling seven months the precious document is despatched (via Caithness and Londonderry) to the Director of Polemics, Ministry of Improvisation, London. With it travels this memo:—

Enclosed is a paper submitted for security clearance. I find the text to be technically accurate, except for a primary service area diagram on p. 14 which is shown as a perfect circle, and is therefore unrealistic. On the other hand, it may be an inadvertent tea-cup stain. Whilst there is no objection to publication security-wise, the information presented is much out of date; I suggest that the author of this article gets in touch with the Group Chief, Macroelectronics Division, Gargantuan Laboratories Ltd., where a considerable amount of work has been done in this matter over the past year. Please advise Dept. 1BF accordingly.

M. I. Fife (Major), Security Officer.

Naturally, as the Dept. of Polemics lies a full floor above Dept. 1BF no one does anything of the kind. In the meantime, a considerable vendetta has been going on between Dept. 1BF and our author, P. A. Rameter. This comes to a climax with the following communication from the former, addressed to Mr. Iambic Pentameter:

Dear Sir,

After the most exhaustive searches through our files we have established to our satisfaction that no article bearing your name has ever been received here.

It is suggested that to clear the matter you send us a copy of your article in quadruplicate, when it will receive our customary attention.

H. Bugloss (Sq. Ldr.)

This is the retort courteous, if ever there was one. Unfortunately its general effect is somewhat marred by a pencilled slip which has somehow been left attached. The note says briefly: "Give this nut-case the brush-off."

Upon receipt of this, the author, never a patient man, makes an end of himself by walking in front of the beam from a 10<sup>9</sup> joule laser. By doing so on a Thursday he earns the transient gratitude of the large circulation Sunday newspapers who devote many column inches to the manner of his demise ("Scientist Self-Slain by Searchlight").

The editor of *Obscure Electrotechnics* at the first inkling of Ministry involvement, has astutely washed our author from his memory and cabled New York for a macroelectronics story which was published the following month.

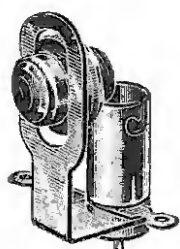
The Ministry of Improvisation, without whose aid this story could never have been told, lived happily ever after.



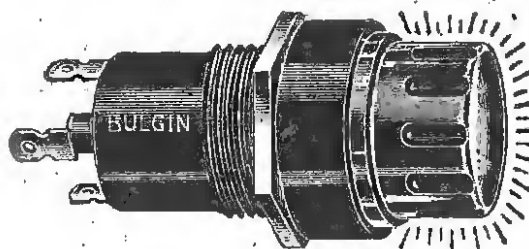
## THE HOUSE OF BULGIN AT YOUR SERVICE

### OVER 4,000 SIGNAL LAMPS AVAILABLE A SMALL REPRESENTATIVE SECTION SHOWN BELOW

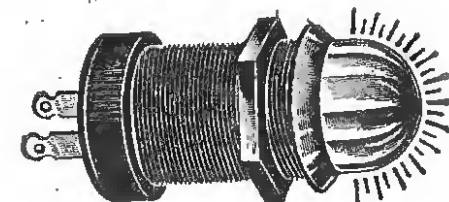
Miniature, small, standard or large models, for Mains or low voltage use, accepting many sizes of bulb from L.E.S. to B.C. all with a choice of lens colours, Neon types, Legended models and many others all listed in leaflets 1502/C and 1512/C available free on request.



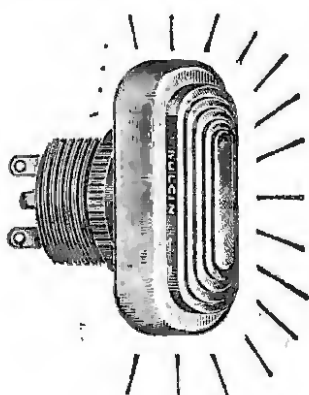
List No. D.180/M.B.C.  
Small bracket type,  
M.B.C. lamps.



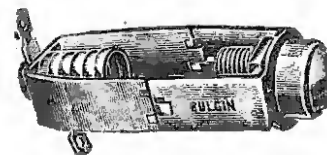
List No. D.680  
J.S. approved model in  
three versions.



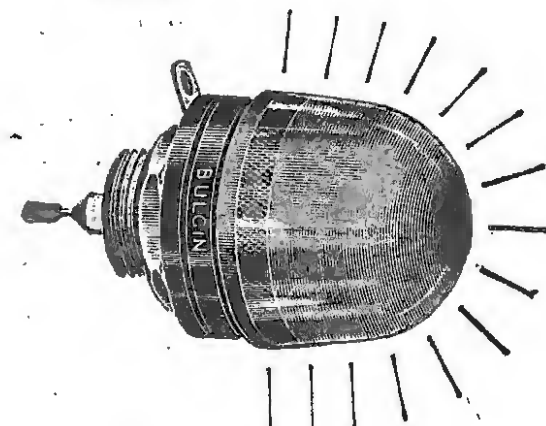
List No. D.662/M.B.C.  
Domed lens, M.E.S. or  
M.B.C. lamps, one hole  
fixing.



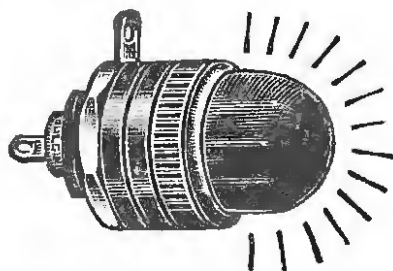
List No. D.715  
Wide-view neon indi-  
cator, one hole fixing.



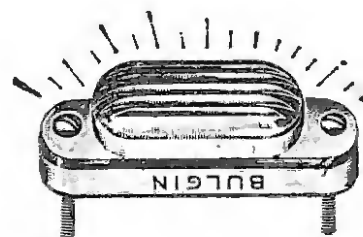
List No. D.270  
Open type with M.E.S.  
or M.B.C. lampholders.



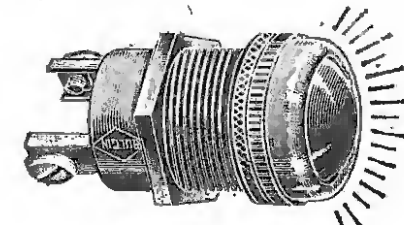
List No. D.676  
Large "sealed" model  
for services use, etc.



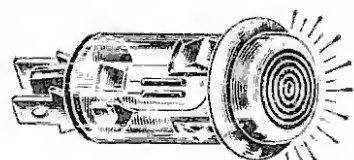
List No. D.678  
Small services model with  
J.S. numbering.



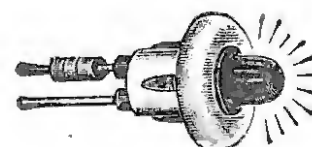
List No. D.740  
Surface mounting neon  
unit with wide angle lens.



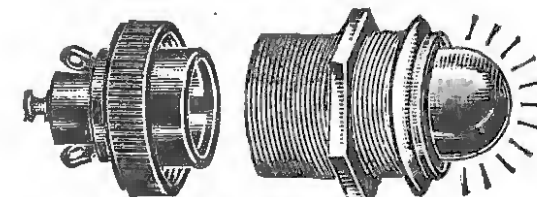
List No. D.9/1 M  
General purpose model,  
generous terminal con-  
nections.



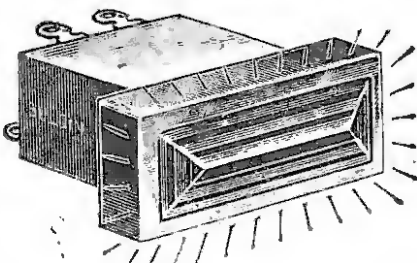
List No. D.925  
Quick fit neon model  
110 or 250 v. working.



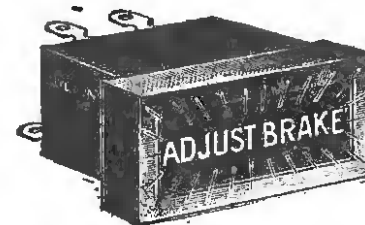
List No. D.808  
Push fixing neon model  
of modern design.



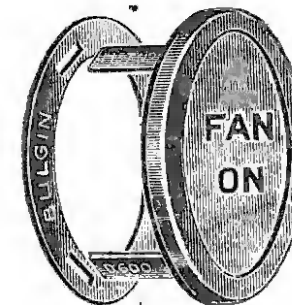
List No. D.860  
High voltage model with  
pilfer-proof lens.



List No. D.825  
Medium sized type  
using two M.E.S. or  
M.B.C. lamps.



List No. D.720  
Small Legended type  
M.E.S. or M.B.C. lamps.



List No. D.600  
Legended quick fixing  
lens bush, simple and  
inexpensive.

Send for Brochures No. 1502/C & 1512/C  
Illustrations approx. two-thirds full size.

**A. F. BULGIN & CO. LTD.,**  
Bye Pass Rd., Barking, Essex.  
Tel: RIPpleway 5588 (12 lines)

MANUFACTURERS AND SUPPLIERS OF RADIO  
AND ELECTRONIC COMPONENTS TO

ADMIRALTY	MINISTRY OF WORKS	B.B.C.
WAR OFFICE	MINISTRY OF AVIATION	G.P.O.
AIR MINISTRY	MINISTRY OF SUPPLY	I.T.A.
HOME OFFICE	RESEARCH ESTABLISHMENTS	N.P.L.
CROWN AGENTS	U.K.A.E.A.	D.S.I.R.

# DECEMBER MEETINGS

*Tickets are required for some meetings: readers are advised, therefore, to communicate with the secretary of the society concerned*

## LONDON

1st. I.E.E. & I.E.R.E.—Discussion on "Telemetry in medicine" at 2.30 at Savoy Pl., W.C.2.

1st. I.E.R.E.—"Non-linear effects in acoustics, radio and optics" by Dr. V. G. Welsby at 6.0 at 9 Bedford Sq., W.C.1.

2nd. I.E.E.—First Appleton Lecture on "Appleton's contribution to radio science" by J. A. Ratcliffe at 5.30 at Savoy Pl., W.C.2.

3rd. I.E.E.—"Reliability of electronic systems" by Dr. I. Bosinoff at 6.0 at Savoy Pl., W.C.2.

3rd. Television Soc.—"A survey of television receiver development" by B. Eastwood, A. Landman and P. L. Mothersole at 7.0 at I.T.A., 70 Brompton Rd., S.W.3.

6th. I.E.E.—Discussion on "Acoustic-wave amplification" at 5.30 at Savoy Pl., W.C.2.

8th. I.E.E.—Discussion on "A review of the present situation of electronic switching" at 6.0 at Savoy Pl., W.C.2.

8th. I.E.R.E.—Symposium on "Semiconductor scanning circuits" at 6.0 at London School of Hygiene and Tropical Medicine, Keppel St., W.C.1.

8th. B.K.S.T.S.—"The need for audio amplifier controls" by R. H. Fisher at 7.30 at Central Office of Information, Hercules Rd., S.E.1.

9th. I.E.E.—"Cylindrical arrays with electronic beam scanning" by Dr. D. E. N. Davies & Dr. B. S. McCartney and "Beam-positioning radar systems utilizing continuous scanning techniques" by Dr. D. E. N. Davies at 5.30 at Savoy Pl., W.C.2.

10th. I.E.E.—Discussion on "The O.N.C.: better opportunities for failure?" at 5.30 at Savoy Pl., W.C.2.

13th. I.E.E.T.E.—"Medical electronics" by Dr. D. W. Hill at 6.0 at Savoy Pl., W.C.2.

14th. I.E.E.—"Recent developments in nuclear instrumentation" by E. H. Cooke-Yarborough at 5.30 at Savoy Pl., W.C.2.

15th. I.E.R.E.—Discussion on "Reliability of marine radar equipment" opened by Captain F. J. Wylie at 6.0 at 9 Bedford Sq., W.C.1.

16th. I.E.E. & I.E.R.E.—Colloquium on "Computer storage—future possibilities" at 2.30 at Savoy Pl., W.C.2.

16th. I.E.E.—Discussion on "Recording Instruments" at 5.30 at Savoy Pl., W.C.2.

## ARBORFIELD

8th. I.E.R.E.—"Frequency standards" by R. Bailey at 7.15 at the School of Electronic Engineering.

## BIRMINGHAM

6th. I.E.E.—"Telemetry—the present position and future trends" by R. E. Young at 6.30 at M.E.B., Summer Lane. (Joint meeting with Instn. of Post Office Electrical Engineers.)

## BRISTOL

8th. I.E.R.E.—"Associative storage in the analysis of multi-parameter data" by I. N. Hooton at 7.0 at the University Engineering Laboratories.

14th. Television Soc.—"Experiences before the camera" by G. Thomas at 7.30 at the Royal Hotel, College Green.

## CAMBRIDGE

9th. I.E.R.E. & I.E.E.—"Infra-red engineering" by V. Roberts at 8.0 at the University Engineering Dept., Trumpington St.

## CARDIFF

1st. I.E.E.—Faraday Lecture "Computers, control and automation" by P. D. Hall at 6.30 at Sophia Gardens Pavilion.

3rd. Television Soc.—"Post Office television links" by R. Moles at 7.30 at the Royal Hotel.

8th. I.E.R.E. & I.E.E.—"Modern aspects of integrated circuits" by M. S. Alderson at 6.30 at the Welsh College of Advanced Technology.

## CHELMSFORD

6th. I.E.E.—"Ergonomics—human factors in equipment design" by D. Beevis at 6.30 at the Lion and Lamb Hotel.

## DUBLIN

9th. I.E.E.—"The future of the electron tube" by Dr. C. M. Sexton at 6.0 at the Physical Laboratory Extension, Trinity College.

## EDINBURGH

7th. I.E.E.—"Research and development in control engineering" by Prof. J. H. Westcott at 6.15 at the Carlton Hotel.

8th. I.E.R.E.—"Nanosecond exposures with image converter tubes" by K. Coleman at 7.0 at the Department of Natural Philosophy, The University, Drummond St.

## EVESHAM

7th. I.E.R.E.—"Some thoughts, experiments and experiences with transistor circuits" by P. J. Baxandall at 7.0 at the B.B.C. Club, High St.

## FARNBOROUGH

9th. I.E.R.E.—"Cosmic electric field and discharges, a new Universal synthesis" by Dr. C. E. R. Bruce, at 7.30 at Farnborough Technical College.

## GLASGOW

9th. I.E.R.E.—"Nanosecond exposures with image converter tubes" by K. Coleman at 7.0 at the Institution of Engineers and Shipbuilders, 39 Elmbank Crescent.

## HIGH WYCOMBE

2nd. I.E.E.—"Computers and process control" by Dr. D. N. Truscott at 7.15 at the College of Technology and Art.

## HULL

2nd. I.E.E.—"A review of laser devices and applications" by N. Forbes at 6.30 at the Y.E.B. Offices.

## LEEDS

1st. I.E.E.—"Radio meteorology" by J. A. Lane at 6.30 at the University.

2nd. I.E.R.E.—"Machine tool control systems" by K. J. Coppin at 7.0 at the University.

7th. I.E.E.—"Telemetry—the present position and future trends" by R. E. Young at 6.30 at the University.

## LEICESTER

7th. I.E.E.—"Medical electronics" by E. Trinder at 6.30 at the University Engineering Building.

10th. I.E.E.—Hunter Memorial Lecture "Lasers and associated devices" by Dr. G. C. Macfarlane at 7.15 at the College of Technology.

## LIVERPOOL

15th. I.E.R.E.—"Industrial applications of electroluminescence" by D. Reaney at 6.30 at the Walker Art Gallery, William Brown St.

## MAIDSTONE

6th. I.E.E.—"An introduction to digital and analogue computers—their differences and their uses" by K. C. Parton at 7.0 at the Wig and Gown Hotel.

## NEWCASTLE-UPON-TYNE

8th. I.E.R.E.—"Direct digital control" by R. Feldman at 6.0 at the Institute of Mining and Mechanical Engineers, Neville Hall, Westgate Rd.

## SALISBURY

13th. I.E.E.—"Electronics through the looking glass" by Dr. R. E. Hayes at 6.30 at the Salisbury and South Wilts College of Further Education.

## SHEFFIELD

1st. I.E.E.—"Telemetry—present position and future trends" by R. E. Young at 6.30 at the Industries Exhibition Centre.

## SOUTHAMPTON

6th. I.E.E. & British Computer Soc.—"Design automation" by Dr. C. H. Lindsey at 7.30 in the Mathematics Lecture Theatre, the University.

14th. I.E.E.—"Video transmission by delta modulation" by M. M. Zepler and D. G. Taylor at 6.30 in the Lancaster Theatre, the University.

## SWANSEA

9th. I.E.E.—"Telemetry—the present position and future trends" by R. E. Young at 6.15 at College House, University College, Singleton Park.

## TORQUAY

9th. I.E.E.—"The ballistic missile early warning system" by B. S. Batt at 2.30 at Electric Hall, Union Street.



