

THE
RADIO CONSTRUCTOR

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A DATA PUBLICATION

RADIO . TELEVISION
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**RADIO
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FIELD
MONITOR**

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SINCLAIR Q.14 complete speaker 9 1/2" square. Fantasticly good in stereo. Each £6.19.6
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3-3 MONO

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5-10 MONO

5 valve, 10W basic amplifier kit complete. £9.19.6 (p. & p. 7/6) with passive control network and panel £11.19.6
2 valve pre-amp kit £6.12.6

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LM.3000 Record Player with 9 T.A. Stereo Cartridge. £8.15.0. Brand new as from factory.

AT.60 Mk.II Deluxe Auto-changer. £11.19.6. Die-cast T/Table. Less cartridge.

SP.25 De-luxe single record player, less cartridge, Die cast. 9 1/2 Gns. T/Table. Packing and carr. on any one of above, 7/6 extra.

Plinths. The ideal mounting for Units offered here. Will readily suit any hi-fi set-up. Teak finish with soft plastic dust cover. Packing and carriage 5/-, Clear-very rigid plastic cover 37/6, (p. & p.3/6).

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RESISTORS—Modern ratings, full range 10 ohms to 10 meg-ohms. 10% 1/4W, 4d. each; 20% 1/4W, 6d. each; 1/2W, 9d. each; 5% Hi-stab. 1/4W, 5d. each; 1/2W, 6d. each; 1.2-10 meg. 10% 1/2W, 4d. each; 1/4W, 5d. each; 1% Hi-stab. 1/4W, 1/6 each (below 100Ω, 2/- each).

CONDENSERS—Silver Mica. All values 2pF to 1,000 pF, 6d. each. Ditto ceramics 9d. Tub. 450V T.C.C., etc. 0.001-0.01mF, 10d. each; 0.1-350V, 10d. each; 0.02-0.1mF, 500V, 1/- each; T.C.C. 350V 0-25, 1/9 each; 0.5, 2/- each.

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AT-60**



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AA-22U**

20+20W TRANSISTOR STEREO AMPLIFIER. Model AA-22U. Outstanding performance and appearance. Kit **£39.10.0** (less cabinet). Assembled **£57.10.0** Attractive walnut veneered cabinet **£2.5.0** extra.

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TRANSISTOR FM STEREO/MONO TUNER, TFM-1S Styled to match amplifier above. Comprises TFM-T1 Tuning Heart **£5.16.0** incl. P.T. TFM-IS I.F. Amp. P.S. etc. **£19.2.0** Total Price Kit **£24.18.0** (less cabinet). Cabinet **£2.5.0** extra.

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NEW! PORTABLE STEREO RECORD PLAYER, SRP-1 Kit £27.15.0

Assembled price on request



Automatic playing of 16, 33, 45 and 78 rpm records. All transistor—cool instant operation. Dual LP/78 stylus. Plays mono or stereo records. Suitcase portability. Detachable speaker enclosure for best stereo effect. Two 8in x 5in. special loudspeakers. For 220-250V a.c. mains operation. Overall cabinet size 15 $\frac{1}{2}$ x 3 $\frac{1}{2}$ x 10 $\frac{1}{2}$ in.

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Finished models provide years of superlative performances

INSTRUMENTS

3" LOW-PRICED SERVICE OSCILLOSCOPE. Model OS-2. Compact size 5" x 7 $\frac{1}{2}$ " x 12" deep. Wt. only 9 $\frac{1}{2}$ lb. "Y" bandwidth 2 c/s-3 Mc/s \pm 3dB. Sensitivity 100mV/cm. T/B 20 c/s-200 kc/s in four ranges, fitted mu-metal CRT Shield. Modern functional styling.

Kit **£23.18.0** Assembled **£31.18.0**

5" GEN-PURPOSE OSCILLOSCOPE. Model 10-12U. An outstanding model with professional specification and styling. "Y" bandwidth 3 c/s-4.5 Mc/s \pm 3dB. T/B 10 c/s-500 kc/s.

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MULTIMETER. Model MM-1U. Ranges 0-1.5V to 1,500V a.c. and d.c.; 150 μ A to 15A d.c.; 0.2 Ω to 20M Ω . 4 $\frac{1}{2}$ " 50 μ A meter. Kit **£12.18.0** Assembled **£18.11.6**

R.F. SIGNAL GENERATOR. Model RF-1U. Up to 100 Mc/s fundamental and 200 Mc/s on harmonics. Up to 100mV output.

Kit **£13.18.0** Assembled **£20.8.0**

SINE/SQUARE GENERATOR. Model IG-82U. Freq. range 20 c/s-1 Mc/s in 5 bands less than 0.5% sine wave dist. less than 0.15 μ sec. sq. wave rise time.

Kit **£25.15.0** Assembled **£37.15.0**



OS-2



IM-13U



V-7A



RF-1U

Complete your motoring pleasure with this outstanding CAR RADIO, Model CR-1



Will give you superb LW and MW entertainment wherever you drive. Tastefully styled to harmonise with any car colour scheme. Available for your convenience in two separate parts, RF Amp. Kit **£1.13.6** incl. P.T. IF/AF Amp. Kit **£11.3.6**.

Total Price Kit (excl. Loudspeaker) **£12.17.0** incl. P.T. 8" x 5" Loudspeaker **£1.16.1** incl. P.T.

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"OXFORD" LUXURY PORTABLE. Model UXR-2. Specially designed for use as a domestic, car or personal portable receiver. Many features, including solid leather case. Kit **£14.18.0** incl. P.T.



UXR-2

TRANSISTOR PORTABLE. Model UXR-1. Pre-aligned I.F. transformers, printed circuit. Covers L.W. and M.W. Has 7" x 4" loudspeaker. Real hide case.

Kit **£12.11.0** incl. P.T.



UXR-1

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STEREO TRANSISTOR FM TUNER

(Mono version also available)
14 transistor, 5 diode circuit. Tuning range 88-108 Mc/s. Designed to match the AA-22U Amplifier. Available in separate units, can be built for a total price. TFM-IS Kit (Stereo) **£24.18.0** incl. P.T. TFM-IM Kit (Mono) **£20.19.0** incl. P.T. Cabinet extra **£2.5.0**.



FM Tuner

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12 × 12 watts output.

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Assembled £42.10.0

Cabinet £2.5.0 extra



FOR THIS SPECIFICATION

● 17 transistors, 6 diode circuit ● ± 1dB, 16 to 50,000 c/s at 12 watts per channel into 8 ohms ● Output suitable for 8 or 15 ohm loudspeakers ● 3 stereo inputs for Gram, Radio and Aux. ● Modern low silhouette styling ● Attractive aluminium, golden anodised front panel ● Handsome assembled and finished walnut veneered cabinet available ● Matches Heathkit models TFM-1 and AFM-2 transistor tuners.

Full range power . . . over extremely wide frequency range. Special transformerless output circuitry. Adequately heat-sinked power transistors for cool operation—long life. 6 position source switch.

FULL SPECIFICATION SHEET AVAILABLE

NEW! STEREO TAPE RECORDER, STR-1

Fully portable—own speakers

Kit £45.18.0

Assembled price £59.15.0

FOR THIS SPECIFICATION

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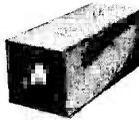
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Low-priced STEREO FM RADIO



FM TUNER FM-4U



STEREO DECODER SD-1

HI-FI FM TUNER. Model FM-4U. Available in two units. R.F. tuning unit (£2.15.0 incl. P.T.) with I.F. output of 10.7 Mc/s, and I.F. amplifier unit, with power supply and valves (£13.13.0). May be used free standing or in a cabinet. Total Kit £16.8.0 (Multiplex adapter available. as extra.)

STEREO DECODER. Model SD-1. Converts FM Mono receivers to stereo at low-cost. Styled to match Heathkit models FM-4U and AFM-1 Tuners. Kit £8.10.0 Assembled £12.5.0



SSU-1

SPEAKER SYSTEMS

HI-FI SPEAKER SYSTEM, Model SSU-1
Ducted-port bass reflex cabinet in the white: Two speakers, vertical or horizontal models with legs. KIT £12.12.0, without legs, KIT £11.17.6 incl. PT.



AVON MINI SPEAKER SYSTEM
6½" Bass, 3½" Treble speakers and crossover unit. Kit £4.18.0 incl. PT. Beautiful. Walnut veneered fully-finished cabinet, £8.18.0, Total price Kit £13.16.0 incl. PT.

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THE "MOHICAN" GENERAL COVERAGE RECEIVER. Model GC-1U. With 4 piezo-electric transmitters, variable tuned B.F.O. and Zener diode stabiliser, this is an excellent fully transistorised general purpose receiver for Amateur and Short wave listeners. Printed circuits, telescopic aerial, tuning meter and large slide-rule dial. Kit £37.17.6 Assembled £45.17.6

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GC-1U



RG-1

Low-cost 3 + 3W Transistor Stereo Amplifier, TS-23



Incorporating all the essential features for good quality sound reproduction from record, radio and other sources. 16 Transistor, 4 diode circuit. Good frequency response 6 position selector switch. Modern slim line styling.

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Kit (with handsome finished cabinet) £18.19.0



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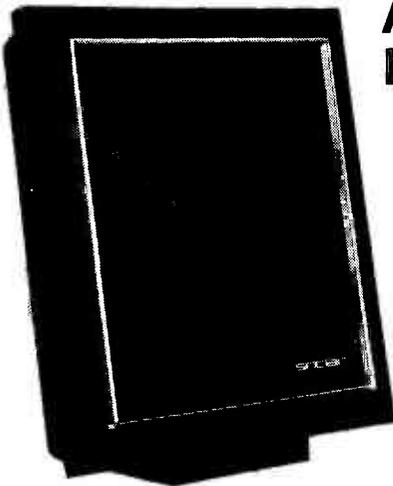
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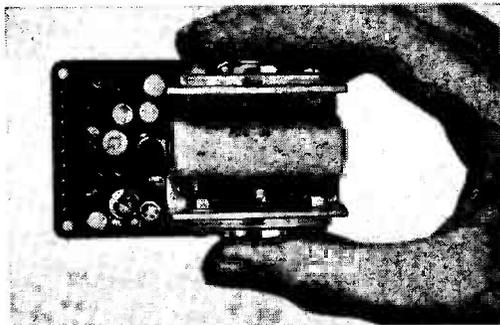
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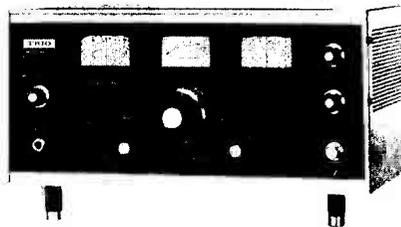
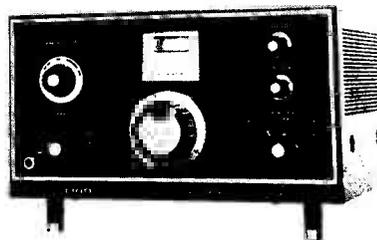
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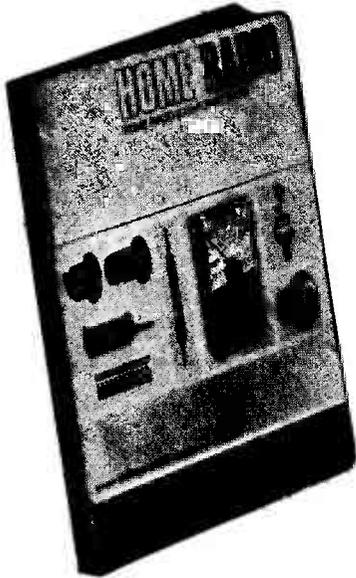
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RECEIVING B.B.C. OVER 100 MILES

by GORDON J. KING

(Member Royal Television Society)

Are you in a locality where u.h.f. TV reception is poor? Our contributor, well known for his considerable experience with TV engineering and relay systems, describes his approach to obtaining BBC2 reception over an extremely long distance

LIVING IN ONE OF THOSE AREAS NOT SCHEDULED for a u.h.f. station this side of 1971, yet being in very urgent need of an off-the-air colour-encoded signal and by no means wishing to change house to a district within the service area range of a suitable transmitter, the author set out to explore the possibility of obtaining usable colour signals from a distant transmitter employing ordinary domestic receiving equipment.

As there must certainly be many television enthusiasts in similar parts of Great Britain who are also desirous of trying Dx on u.h.f., it is hoped that this article will help or, at least, encourage them.

The author's receiving site is approximately 100 miles in a straight line from the nearest u.h.f. station—Rowridge on the Isle of Wight. Fortunately, this station uses a low-frequency u.h.f. channel, number 24 at the low-frequency end of Band IV, embracing a spectrum from 494 to 502 Mc/s. The aerial gives the station an effective radiated power of 500kW and a fair amount of signal energy is radiated in a westerly direction towards the receiving site.

Although the hill contour of the receiving site is some 200ft above sea level and about 500yds

from the sea, the dwelling itself is towards the base of a slight basin with rising ground towards the east—in the direction of the transmitter. This rise is fairly local to the receiving aerial and reaches a local maximum over a distance of about 200yds.

A mile or so farther on, the signal path cuts through the top of a cliff rising to some 300ft. After this, the path is clear to the Isle of Portland, where once again it cuts through coast-line cliff tops at the Bill of Portland. The path is then clear once again to Rowridge. Some idea of the topography is shown in Fig. 1, while the more distant signal path is shown in Fig. 2.

It will be observed that a substantial part of the signal path is across sea. Nevertheless, after studying Fig. 1 it must surely appear that one would have to be really desperate to attempt u.h.f. reception under the conditions shown! Standing on the top of the rise at point A, the top of the u.h.f. aerial is seen to be about level with the road. In fact, it "looks" through rather massive houses built upon this cliff contour. Point B is not visible at the receiving site.

Before continuing, and to show that this article is not a waste of time, it must next be stated that u.h.f. reception is by no means impossible under these conditions, as is confirmed by the off-screen colour Test Card F in Fig. 3. This was obtained during a reasonable spell of tropospheric activity, and it must be made clear that reception is not like this all of the time.

For monochrome reception a Pye 40F 19in set was chosen. This incorporates a transistorised integrated push-button tuner with a transistorised i.f. section attached. The tuner transistors are germanium, though more recent models of this set (the New Pye) adopt silicon which, it would seem, have the edge in terms of noise on germanium counterparts. This point has not, however, been checked by the writer.

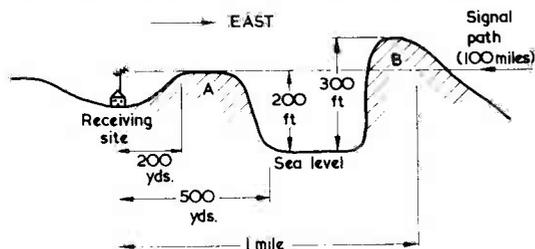


Fig. 1. Topography at the author's receiving site

Aerial Mounting

The author's dwelling is of contemporary design with a fragile-looking, single-flue chimney stack. All v.h.f. aeriels are located in the roof-space, so this stack was available for carrying the u.h.f. aerial system without fear of proximity effects.

Maximum height was obviously required, but it was very important to take into account the fact that force 10 winds are not uncommon in the district. Consultation with the builder, in conjunction with calculations based on the wind resistance of a complex multi-element array, revealed that the chimney stack stresses would veer on the wrong side of a given safety tolerance if the array were mounted much higher than 16ft above it.

Now, when weak signal fields demand the accurate orientation of a high-gain and very directional u.h.f. aerial to abstract the last decibel of signal energy, aerial wobble becomes an important factor. Indeed, u.h.f. Dx work often calls for a stayed aerial system to keep the top steady when wind is high. Wobble can cause cyclic variations in aerial orientation and plane of polarisation, and while the resulting few decibels of signal voltage "bounce" at the aerial termination might mean virtually nothing to a set working from a strong signal with its a.g.c. systems "hard on", the effect can be disconcerting at very low signal levels when there is no significant a.g.c. action at the set. The effect of wobble is aggravated when the u.h.f. aerial is mounted within a wavelength or so of metal objects or the v.h.f. aeriels, for proximity effects can then cause cyclic variations in u.h.f. aerial impedance in addition to the other factors just mentioned.

The author was not in favour of mast staying, and set out to test aerial wobble with the u.h.f. aerial mounted right at the top of a 16ft alloy pole of 2in diameter. For safety reasons, the pole was clamped to the chimney stack using heavy-duty double lashings, and these were erected with greater than normal care to avoid side play which would be considerably amplified at the top of the mast.

The mast and final aerial system has now been erected for over 8 months and in spite of strong gales the installation is still strong and sound. Very little wobble occurs at wind velocities up to about force 7.

Signal Measurement

The next job was to discover the best type of aerial for this range of reception. Many aeriels were tested on the top of the 16ft pole, including stacked and broadside arrays, and to obtain a fair appraisal of their performance it was necessary to devise some means of measuring u.h.f. signals down to about $5\mu\text{V}$. There are plenty of signal strength meters on the market for both v.h.f. and u.h.f. The author is in possession of some of these but none was sufficiently sensitive for reading the very low signals that were encountered at certain times.

The problem was conveniently solved, by using a Taylor valve voltmeter Model 172A to read vision a.g.c. bias in the set. In the author's case it was

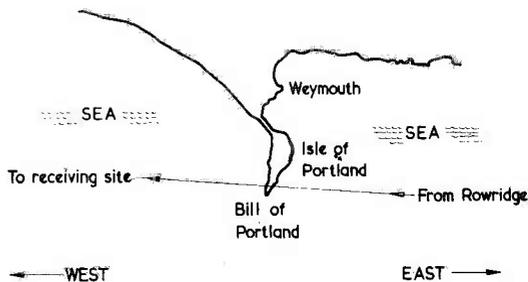


Fig. 2. Sea path of the Dx signal

found that this instrument read directly in terms of microvolts on the 0-500V scale when switched to the 5V range, the correct reading being obtained by dividing by 2. Thus, a reading of 200V indicated a signal strength at the aerial socket of $100\mu\text{V}$. The large scale of this instrument makes it possible to read down to $5\mu\text{V}$, which is one division on the scale. The instrument has a "set zero" control, as found on the majority of valve voltmeters, and it was found possible to use this to "back off" the standing bias on the a.g.c. amplifier at any particular setting of the contrast control. The meter could then be zeroed with the aerial removed and the contrast control adjusted about half-way on. The aerial was then simply plugged into the set and the signal strength read directly from the scale as just explained.

It is appreciated, of course, that few enthusiasts will have this combination of set and valve voltmeter, but there is no reason at all why similar results could not be obtained from a different set and valve voltmeter, using the same principle.

Fig. 4 shows the basic a.g.c. arrangement in the Pye 40F set and the connecting points for the valve voltmeter. The setting of the contrast control determines the standing bias on the a.g.c. line and this makes it necessary to have some method of backing off at the meter.

Maximum strength at the end of the feeder has been about $150\mu\text{V}$, so at all times it has been necessary to employ a low-noise u.h.f. booster amplifier



Fig. 3. An example of the reception possible under good conditions

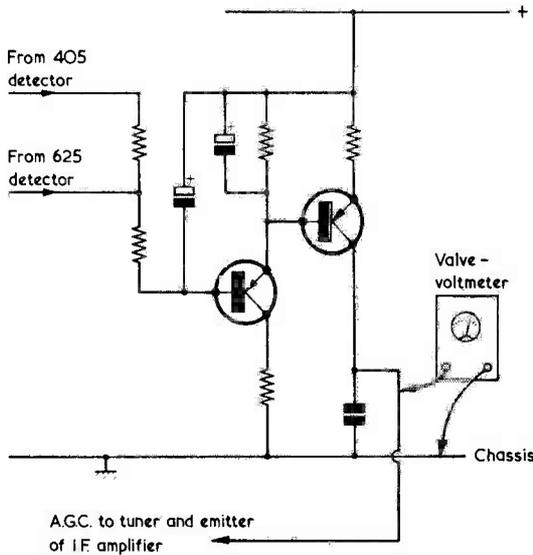


Fig. 4. The a.g.c. circuit in the Pye 40F receiver, with a valve voltmeter connected for signal strength measurement

to lift the signal sufficiently to work the set properly and to clear grain (noise effect) from the picture, but more is said about this later.

Aerial Choice

All aerials with more than nine elements in each array have produced usable signals. Stacked arrays, curiously, have given very little improvement over a single array of the same kind as used in the stacked formation. At maximum, doubling-up in this way gives a theoretical power lift of 3dB, this being yielded only if the matching to the downlead is optimised—not as easy in practice as theory appears to indicate! Possibly, a two-by-two box array would have assisted with the matching problems, giving a 6dB lift over a single, in-line array. However, such a system would have been too heavy for the support rig employed for these particular field tests.

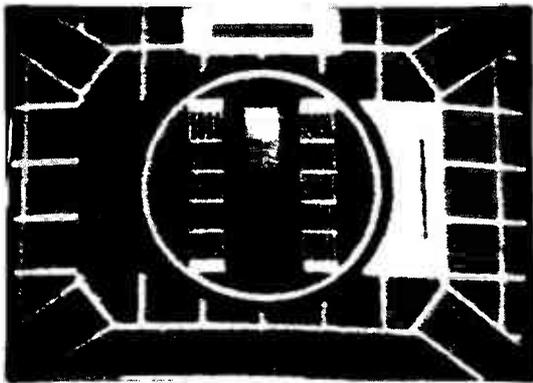


Fig. 5. Typical "average" reception

After tests extended over several months of changing propagation conditions using single in-line and double arrays, it was decided to work with a single in-line array; and eventually the latest J-Beam "Parabeam" array was chosen. This uses a modified slot-type dipole, a reflector of similar shape and sixteen directors, giving eighteen in-line elements in all.

The J-Beam array was fitted right at the top of the 16ft, 2in diameter alloy mast by means of a universal adjusting clamp, the latter allowing the array to be tilted skywards as well as horizontally to vary the plane of polarisation. The aerial was coupled to the set through really low-loss u.h.f. coaxial feeder. The feeder run to the set was only about 30ft but the author has found from previous experience that the better quality coaxial cable tends to "stabilise" a u.h.f. aerial installation, particularly where set-side signal boosting is required, even though "standard" cable over such a short length would offer very little direct attenuation.

Effects Of Aerial Tilt

Tests were then made during a period of settled signal (steady at about $50\mu\text{V}$) for skyward and horizontal tilt. Skyward tilt was adjusted at chimney level with the aid of two lengths of cord, one fastened at each end of the main boom so that the array could be swivelled up and down on the loosened clamping bracket.

Adjustments to skyward tilt certainly appeared to endow the system with extra effective height; the optimum was about 15° which gave an increase in signal strength at the feeder of almost 6dB (double). However, it is doubtful if the same result would be given with all installations, and it probably occurred at the test site because of the local rise in the land (point A in Fig. 1).

It is sometimes said that tilting an aerial towards the sky to gain effective height is undesirable because it then becomes unduly sensitive to reflections of signal from passing aircraft. At any event, the author's receiving site is almost directly below an air line route, and no bad trouble from aircraft flutter has so far been experienced. Indeed, there is often more on the v.h.f. channels. This does not imply that aircraft flutter is non-existent on u.h.f.; it has still manifested in the usual way when the aircraft have been particularly low-flying, as occurs with helicopters and off-sea planes.

Testing for horizontal tilt was much more tricky as this mean removing the array from the chimney lashings each time. A very slight off-horizontal tilt was found to give about 15% increase in signal strength, indicating that the plane of polarisation of the signal is altered a little during its journey over sea and cliff tops. A curious thing was observed when experimenting with polarisation tilt, and that was a change in the strength of the sound signal relative to the vision signal. On the face of it, this would appear to indicate that the plane of polarisation at the receiving site differs by a small amount between the vision and sound signals in the channel. Selective fading between the sound and vision

signals is not particularly uncommon over DX paths, but this is the first time that the author has encountered seemingly selective change in polarisation!

How The Weather Affects Reception

The "Parabeam" is now permanently erected and adjusted carefully to optimise all the factors discussed, and some sort of BBC2 signal is always present. However, there are times when it is very weak indeed, barely locking the field, while at other times it is as strong as the local BBC1 and ITV transmissions. Entertainment-value reception is possible for about 40 per cent of the time (up to date), and the "average" type of reception is depicted in the off-screen photo of Fig. 5. Reception like that shown in Figs. 3 and 6 occurs only during exceptional conditions.

It is well worth noting that the exceptionally good conditions on u.h.f. have not so far coincided with high ionospheric and tropospheric activity in the v.h.f. channels. VHF Continental interference is troublesome at the receiving site during early spring and summer months, and when this has



Fig. 6. Reception of a colour transmission under good conditions

been at its height u.h.f. reception has not been particularly brilliant. Conversely, during times of good u.h.f. reception, Continental interference has not been noticeably troublesome.

UHF reception is worst during periods when the barometric pressure is at a steady "low", is average at a steady "high" and is exceptionally good during a violent change in pressure from high to low or from low to high. Severe rain causes a steady signal drop of about 6dB (50%), while heavy cloud and thundery conditions have resulted in fairly rapid changes in signal strength, swinging from about $5\mu\text{V}$ to $150\mu\text{V}$ at times. Local thunder clouds have also caused bad multipath interference on both picture and sound. These have given a multiplicity of strong ghosts on the picture and a very high level of harmonic distortion on sound, just as though the clouds were acting as giant signal reflectors. This is probably what does happen anyway due to cloud ionisation, the clouds then acting rather like a dense local ionosphere.



Fig. 7. An example of the signal given without a booster amplifier

Signal Boosting

So far nothing has been said about signal boosting. All the off-screen photographs so far referred to were obtained from a boosted aerial signal, with the booster close to the set and not at the aerial. Several set-side boosters have been tried, including a two-transistor, low-noise Italian design, but the device currently in use is a version of the King u.h.f. Telebooster with a second-generation silicon, low-noise u.h.f. transistor. This uses a quarter-wave cavity resonator which gives very good electrical stability close to the set's u.h.f. tuner. Overall gain on Channel 24 is about four times (12dB), and one or two alterations have been tried at the front end of this to secure the best possible signal coupling from the download to the transistor emitter, including tuning.

The booster thus ensures that the set receives between about $300\mu\text{V}$ and $600\mu\text{V}$, depending on the signal conditions. Fig. 7 shows the kind of average picture obtained without a booster, the aerial being connected direct to the tuner with the signal approaching the $100\mu\text{V}$ mark. Signal boosting has been found to be essential, even though the set uses a transistorised tuner.

With a download of 50ft or less, no significant improvement is obtained by locating the booster

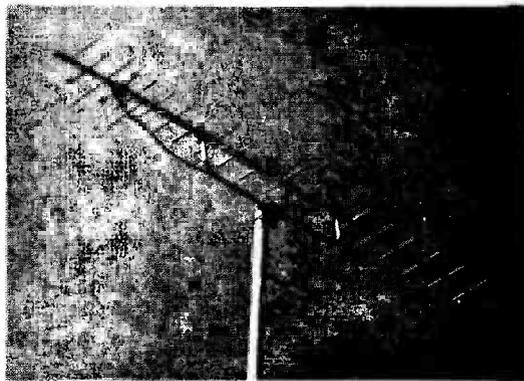


Fig. 8. The aerial installation used for the tests

at the aerial end. Such a location can, in fact, lead to problems in feeding power to the booster, and the power filters then required have been known to add attenuation to the aerial system.

Improving Noise Performance

The first stage noise factor is the most important, and for all practical purposes the following expression gives the noise figures. Where N_1 is the noise

$$\text{Total Noise Factor} = N_1 + \frac{N_2 - 1}{P_1}$$

figure of the first stage, N_2 the noise figure of the second stage and P_1 the power gain of the first stage. Thus, the total noise is kept low by using a low-noise first stage with a high power gain.

Let us suppose that the tuner in the receiver has a noise figure of 14dB and that a booster amplifier connected to it has a noise figure of 5dB and a power gain of 14dB. Then we get:

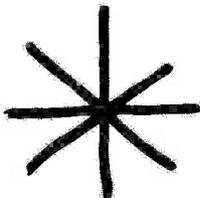
$$\text{Total Noise Factor} = 5 + \frac{14 - 1}{14}$$

which works out to 5.9dB, meaning that the noise performance has been improved by as much as 8.1dB. When the amplifier is at the aerial, its power gain is attenuated by the downlead attenuation factor, but the input signal/noise ratio tends to

improve because the transistor has a greater signal level passed to it than would occur at the bottom of the downlead. One effect more or less balances out the other. Even a transistorised tuner can be improved in terms of noise performance by the addition of a good low-noise amplifier. If the tuner has a noise factor of, say, 8dB, and the amplifier one of 5dB at 14dB power gain, a noise improvement of 2.5dB is secured.

This article has demonstrated, therefore, that u.h.f. reception—on Channel 24, at least—is influenced by the troposphere probably more than might have been realised. The normal range of a u.h.f. station is about 30 to 40 miles because the u.h.f. signals travel in a straight line, bent very slightly to hug the surface of the earth by diffraction in the local atmosphere. The reception distance is thus a little in excess of the line of sight distance between the transmitting and receiving aerials. Clearly, the greater the height of the aerials, the greater the reception distance.

Reception outside the normal service area is caused by the sky waves being bent more—to hug the surface of the earth over longer distances—than is normal. This abnormal bending is a function of the troposphere, and this in turn is obviously affected by local weather conditions, as has been, shown in this article.



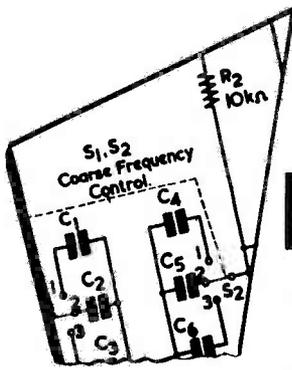
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Battery Voltage Indicators For Transistor Equipment

SUGGESTED CIRCUIT No. 206

by G. A. FRENCH

ONE OF THE MORE PREDOMINANT features in the field of electronics these days is given, of course, by the fact that battery-operated transistor equipment is very largely superseding the mains-driven valve equipment employed in earlier years. This point applies not only to such things as receivers and small record-players, but also to a wide range of test gear as well; and the transistor equipment has the obvious advantages of small size and low weight, together with negligible heat dissipation and absence of trailing mains wires.

A minor disadvantage with transistor equipment is that the power supply is given by a battery whose voltage drops continually with age and use, whereas the previous valve equipment obtained its power from the mains and thereby operated with a relatively constant supply voltage. A typical cause of irritation occurs, for instance, if it is found that the voltage of a transistor receiver battery has fallen below that needed for adequate functioning and a replacement is not immediately available. With test equipment the situation may be more serious, since low battery voltage can sometimes give rise to misleading results or incorrect readings. Again, the gram motor speed of a battery-operated record-player may be adversely affected if the battery voltage falls close to a specific level.

All these points argue the desirability of fitting transistor equipment with some form of meter to provide an indication of battery voltage. Thus, when the battery voltage approaches the lowest level at which

the equipment will reliably operate, a new battery may be purchased in good time for replacement. Also, a battery voltage indicator obviates the risk of deceptive readings with transistorised test equipment. Incidentally, the inclusion of battery meters in transistor radios is not a new feature, and the writer is interested to see that a recent British radio receiver (the Ferguson model 3158) is so fitted. In this particular receiver the meter is connected across the battery supply lines and gives a reading all the time the set is switched on.

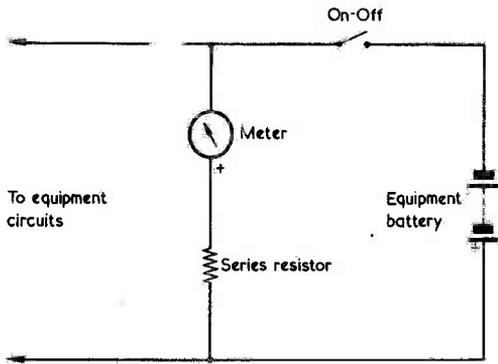
Since conventional transistor equipment cannot be used when the battery voltage has fallen to some two-thirds of its nominal value, a battery voltage meter will offer greatest usefulness if most of its scale can be calibrated from two-thirds of nominal battery voltage to full battery voltage, rather than from zero to full battery voltage. In practice, it is quite an easy matter to achieve this result with standard moving-coil meter movements, all that is required being the addition of a relatively inexpensive zener diode to the meter circuit. Such zener diodes are currently available at low cost, and have very small physical dimensions.

This month's "Suggested Circuit" article describes how expanded scale voltage indicating meters may be added to any transistor equipment employing 6-volt, 9-volt or 12-volt batteries, and which has sufficient panel space available to take the requisite meter. Also discussed are the pitfalls which need to be avoided when zener diodes are employed in

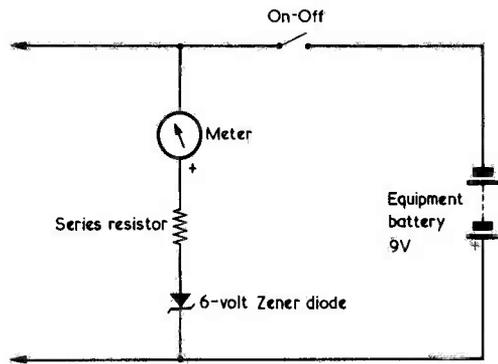
this manner.

Basic Operation

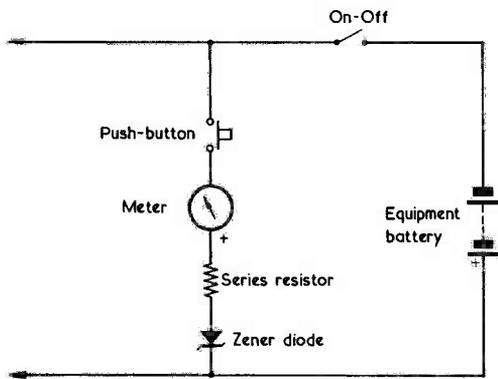
The simplest type of battery voltage indicator for transistor equipment is illustrated in Fig. 1 (a), where the on-off switch shown is that fitted to the equipment. The meter may be any moving-coil movement having a full-scale deflection in the range of, say, 100 μ A to 1mA, whilst the series resistor has a value which enables the meter to give a convenient indication of battery voltage. A typical home-constructor installation in a piece of equipment having a 9-volt battery could, for instance, consist of a 0-1mA meter with a series resistor which caused 1mA to be indicated for a supply voltage of 10. The 9-volt battery at its nominal voltage would then give a reading of 0.9mA, and so on. However, since the equipment could not normally be expected to function reliably at battery voltages below about 6 the meter scale from zero to the point corresponding to 6 volts offers no useful function and is wasted. In Fig. 1 (b) a 6-volt zener diode is inserted in the meter circuit, whereupon the range 6 to 9 volts appears across most of the meter scale. Assuming that the zener diode has a "perfect" characteristic, which causes it to exhibit infinite resistance at voltages below 6 and zero effective resistance above, the value of the series resistor may be made such that the meter needle just starts to be deflected from rest at voltages slightly exceeding 6 and achieves full-scale deflection at the voltage given by a brand new 9-volt battery. The scale may then



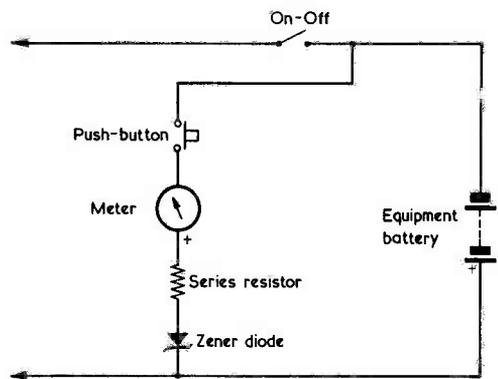
(a)



(b)



(c)



(d)

Fig. 1 (a). A simple indicator circuit to read battery voltage

(b). If a zener diode is added, the required range of voltage readings may be expanded to cover most of the meter scale. A 9-Volt battery is assumed in this diagram

(c). Adding a push-button to conserve battery drain

(d). An alternative circuit using a push-button

push-button may be added, as in Fig. 1 (c), this being pressed only when a reading of battery voltage is required. The inclusion of a push-button makes the circuit of Fig. 1 (d) attractive also, since this enables the battery voltage to be

be directly calibrated over all its length for this range, with the result that it offers maximum utility because it covers only the battery voltages at which the equipment may be employed. As we shall see shortly, it is not possible to obtain results as good as this with practical zener diodes, but the circuit description just given offers a useful introduction to the use of a zener diode for this particular application.

Some constructors may consider that the permanent connection of the meter, zener diode and series resistor across the battery supply lines is undesirable, because the current drawn by the meter could result in a significant shortening of the battery life. If this point is considered sufficiently important, a

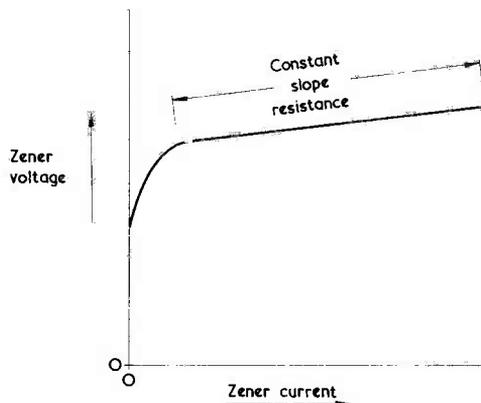


Fig. 2. A typical zener diode characteristic

read, off-load, when the equipment on-off switch is open. The arrangement of Fig. 1 (d) can give warning of a fault condition in the equipment which causes excessive current to be drawn from the battery, because it enables the drop in battery voltage which occurs when the on-off switch is closed to be readily observed.

Practical Versions

In practice, a zener diode does not have the perfect characteristic just assumed, and the zener voltage/zener current curve of a practical diode takes up the typical shape shown in Fig. 2. As, in this diagram, zener voltage increases from zero, no zener current flows until the zener voltage approaches a figure which is, normally, somewhat below the nominal zener voltage quoted for the device. Zener current then begins to flow, increasing with voltage in non-linear fashion until the region designated "Constant Slope Resistance" is reached. Over this region the diode carries out its function of stabilising the zener voltage most efficiently, and large changes in zener current correspond to small changes only in zener voltage. The fact that there is a slight increase in zener voltage with increase in zener current infers that the diode is exhibiting resistance.

When the zener voltage/zener current curve is a straight line this resistance is constant. The constant slope resistance for different zener diodes varies according to type and nominal zener voltage. As an example of what is to be expected, a typical slope resistance for a small 9-volt zener diode would be of the order of 15Ω . In our present application the zener diode is in series with a resistor and a meter and, over the zener current range which offers a constant slope resistance, will merely insert a constant amount of extra resistance in circuit. The circuit, operating as a voltmeter, will then be able to give linear voltage readings. If, on the other hand, the current flowing through the zener diode brings it back to the highly curved part of its characteristic the slope resistance inserted by the diode will vary by a relatively large amount, and voltmeter indications will be noticeably non-linear. Most small zener diodes with nominal voltages above 6 enter the constant slope resistance section of the characteristic at about 1mA or less, whilst with lower voltage diodes the curved section usually extends beyond 1mA.

The zener diode circuit checked by the writer for this article is shown in Fig. 3. This may be

employed in either of the arrangements shown in Figs. 1 (b), (c) or (d), according to the wishes of the constructor. For a 6-volt battery supply the zener diode may be a type Z4.7, for a 9-volt supply a type Z6.2 and for a 12-volt supply a type Z9.1. These three zener diode types are all listed in the Henry's Radio 1967 catalogue at 3s. 6d. each, and have the nominal zener voltage indicated by the type number at a tolerance of 5%. In each case the lead identified with a red spot connects to the positive side of the circuit. (If a zener diode is connected wrong way round it merely functions as a normal diode.)

The meter, M_1 , may be any moving-coil instrument having an f.s.d. between $100\mu\text{A}$ and 1mA. Should it be desired to have most of the scale calibrated in linear fashion the higher current meter is preferable, since it brings the zener diode on to (or adequately near to) the constant slope resistance section of its characteristic over the range of supply voltages it is intended to indicate. Fig. 4 (a) illustrates the results given with a 0-1mA meter, as obtained in practical tests with the

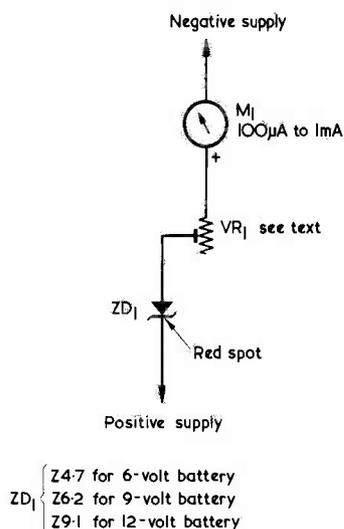


Fig. 3. The zener diode circuit checked by the author

Henry's Radio diodes employing 6-volt, 9-volt and 12-volt supplies, and using the circuit of Fig. 3. Meter reading is plotted against

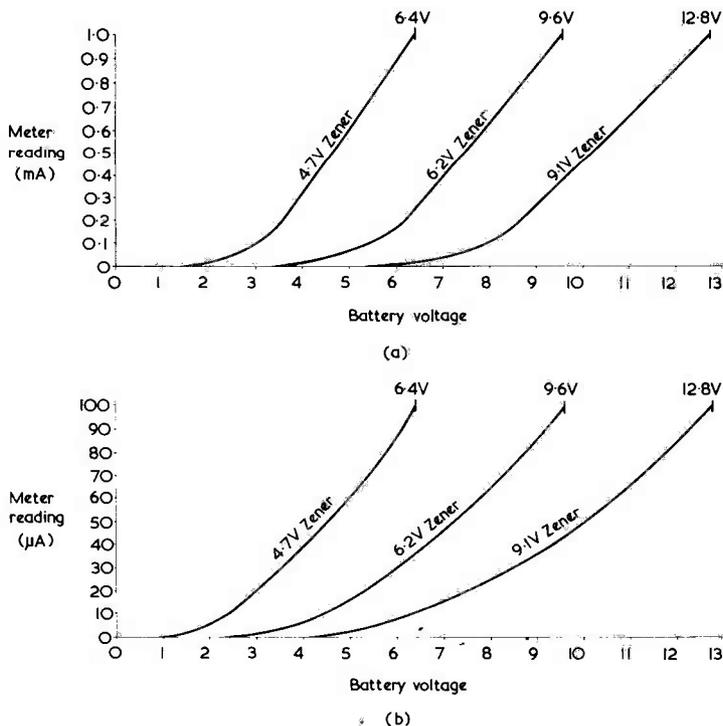


Fig. 4 (a). Meter readings versus battery voltage with a meter having an f.s.d. of 1mA and using the circuit of Fig. 3

(b). The results obtained with a 0-100 μA meter

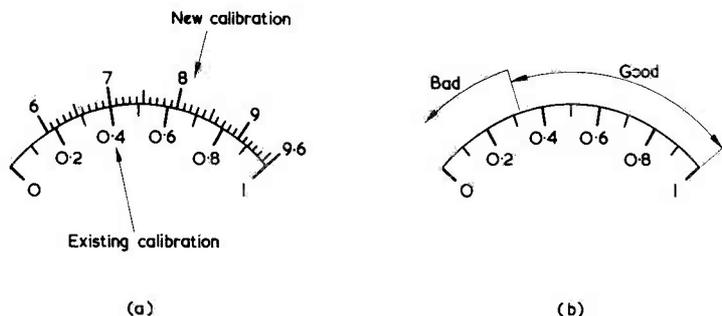


Fig. 5 (a). A re-calibrated meter scale corresponding to the central curve of Fig. 4 (a), and suitable for fitting in equipment with a 9-volt battery

(b). An alternative type of meter calibration

battery voltage. Since a new battery may exhibit a terminal voltage corresponding to nearly 1.6 volts per cell, f.s.d. reading in the meter was chosen (by adjustment of VR_1) to correspond to 6.4, 9.6 and 12.8 volts respectively. It will be seen that all the curves in Fig. 4 (a) are quite linear down to a reading of about 0.2mA in the meter, this reading corresponding to some 4 volts, 6 volts and 9 volts respectively. Thus, with the 1mA meter it is possible to obtain a wide linear expanded scale covering all the useful voltages which can be supplied by the associated battery, whereupon a new calibration similar to that shown in Fig. 5 (a) (which corresponds to the central 9.6 volt curve of Fig. 4 (a)) can be achieved. Below a meter reading of 0.2mA the curvature in the zener diode characteristic has a noticeable effect on the linearity of the readings, and all the curves of Fig. 4 (a) tail off to a zero current reading well below the nominal zener voltage of the diode concerned. It will be noted that, in Fig. 5 (a), no attempt is made to calibrate the scale below the 6 volt point.

Fig. 4 (b) shows the results obtained with a $100\mu\text{A}$ meter in the M_1 position. Here, we are working on the curved section of all the zener diode characteristics, this fact being reflected in the non-linear appearance of all the curves shown. Also, the 4 volt, 6 volt, and 9 volt points correspond to a meter reading of about $35\mu\text{A}$, which is relatively higher than occurs with the 1mA meter.

Calibration

If the constructor wishes to re-calibrate the meter employed to

For calibration, the zener diode meter circuit is set up in the manner shown in Fig. 6. The pre-set variable resistor, VR_1 , is necessary to take up zener voltage variations, within tolerance, of the particular zener diode employed, and it must always be adjusted to insert maximum resistance into circuit at the commencement of calibration. After VR_1 has been set up it may, if desired, be replaced by a fixed resistor of the appropriate value. For meters with an f.s.d. of $100\mu\text{A}$ VR_1 should have a value of $100\text{k}\Omega$. For an f.s.d. of $200\mu\text{A}$ to $400\mu\text{A}$, VR_1 should be $50\text{k}\Omega$; for an f.s.d. of $500\mu\text{A}$ to $750\mu\text{A}$, VR_1 should be $25\text{k}\Omega$; and for higher f.s.d. figures up to 1mA, VR_1 should be $10\text{k}\Omega$.

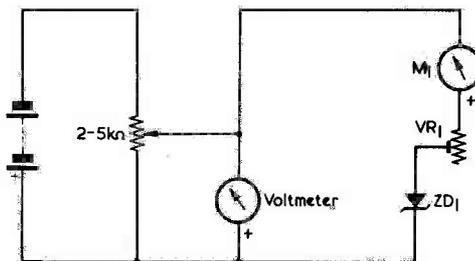


Fig. 6. The simple set-up required for calibrating the zener diode meter circuit

indicate battery voltage, the re-calibration make take the form shown in Fig. 5 (a). This re-calibration will be easier to carry out if a meter having an f.s.d. current of 1mA or slightly less is employed, because readings are linear over the range of voltages it is desired to cover. To avoid the rather delicate task of re-calibrating the meter scale itself, some constructors may prefer to mount a table alongside the meter, whereupon it will still, in general, be preferable to use a higher current meter.

Since the main function of the meter is to indicate when battery replacement is imminent, the alternative "Good-Bad" calibration of Fig. 5 (b) may be employed. The commencement of the "Bad" section is at the supply voltage at which the equipment ceases to function correctly and a meter of any sensitivity between $100\mu\text{A}$ and 1mA may be employed. As is evident from Figs. 4 (a) and (b), the "Good" section of the scale will be wider if the higher current meter is used.

The battery in Fig. 6 offers a voltage higher than that of the equipment battery with which the meter circuit is eventually intended to be used, and the voltmeter may be a multi-testmeter switched to the requisite voltage range. The potentiometer across the battery is first set up so that the voltmeter indicates a voltage corresponding to 1.6 volts per cell of the equipment battery. VR_1 is then adjusted so that M_1 gives full-scale deflection, if necessary re-adjusting the battery potentiometer to maintain the voltmeter reading. Lower voltages are then provided by the potentiometer to enable a calibration along the styles of Fig. 5 (a) or Fig. 5 (b) to be carried out. If the Fig. 5 (a) calibration style is employed with a 1mA movement, only a few calibration points down to two-thirds of nominal supply battery voltage are required, as the intervening graduations will have linear spacing.



TRADE REVIEW . . .

TRIO COMMUNICATIONS RECEIVER MODEL JR-500SE



Trio Communications Receiver Model JR-500SE

The Trio JR-500SE communications receiver has been designed as a high performance unit specifically to cover the amateur bands and the circuit consists of a crystal-controlled double superhet providing a high degree of sensitivity and stability. The manufacturer's specification is shown below and from this it will be noted that the 160 metre amateur band is not covered, although provision is made for reception of the 10 Mc/s WWV or MSF frequency standard transmissions.

Stability of performance is achieved by using a crystal controlled first local oscillator and a v.f.o. type second oscillator, frequency drift being practically nil since the v.f.o. has solid-state circuitry. The inclusion of two mechanical filters in the i.f. circuits ensure that a very high degree of selectivity is obtained.

The b.f.o. circuit operates as a crystal-controlled oscillator, and the v.f.o. is fitted with convenient output terminals in order that it may be used as a v.f.o. for the transmitter. A product detector is used for reception of c.w. and s.s.b. signals.

In addition to 8 Ω speaker terminals, the receiver is fitted with 500 Ω output terminals for recording purposes or for use as an output source for r.t.t.y. connections. Remote control terminals which facilitate connections to the transmitter are provided, and the receiver is also fitted with an on/off switch which may be used if it is desired to add a calibration circuit at a later date.

The design incorporates a.g.c., noise limiter and S-meter circuits. There is a total of 7 valves, 2 transistors, 5 diodes and 8 crystals in the overall design.

The dial mechanism includes an anti-backlash double-gear arrangement and gives direct readings down to 1 kc/s, the large tuning knob having a geared-down ratio of 28 to 1. The bands are covered in 7 separate ranges.

This receiver, recently released in this country, is available from Lasky's Radio Ltd., 3-15, Cavell Street, Tower Hamlets, London, E.1, and the price is 59 gns plus 12/6d carriage and packing.

Trio Communications Receiver Model JR-500SE

Manufacturer's Specification

Frequency Ranges: 3.5—4.0 Mc/s
7.0—7.3 Mc/s
14.0—14.35 Mc/s
21.0—21.45 Mc/s
28.0—28.5 Mc/s
28.5—29.1 Mc/s
29.1—29.7 Mc/s

Selectivity: ± 1.5 kc/s at -6 dB
 ± 6 kc/s at -60 dB

Sensitivity: 1.5μ V for 10dB s/n ratio at 14 Mc/s

Image Ratio and I.F. Rejection: More than 40dB at 14 Mc/s

Maximum Power Output: 1 watt

Power Consumption: 65 watts

Valve Line-up: V₁ 6BZ6 r.f. amplifier

V_{2(a)} $\frac{1}{2}$ 6BL8 first mixer

V_{2(b)} $\frac{1}{2}$ 6BL8 crystal oscillator

V₃ 6BE6 second mixer

V₄ 6BA6 i.f. amplifier

V₅ 6BA6 i.f. amplifier

V_{6(a)} $\frac{1}{2}$ 6AQ8 product detector

V_{6(b)} $\frac{1}{2}$ 6AQ8 crystal-controlled b.f.o.

V_{7(a)} $\frac{1}{2}$ 6BM8 a.f. output

V_{7(b)} $\frac{1}{2}$ 6BM8 a.f. voltage amplifier



World's Smallest Computer?

This compact computer is about the size of a standard building brick. Although it measures only 9 x 4 x 4 in, it has a memory capacity for 4,096 numerical "words", each 24 digits long, and carries its own battery power supply. Its manufacturers, Control Data Corporation, call it "the prototype of future home computers"

★ An Extra Feature for Our Readers

As a new service for our readers, we are commencing with this issue, a special feature entitled Radio Constructors Data Sheet. The sheet will appear in each issue on the inside back cover of the magazine, and will provide reference information on subjects which are of particular use to radio constructors. The information given each month will be complete in itself.

The advantages of publishing this material on the inside back cover, are; specific data may be quickly located; the material will be presented as an *extra* to the normal editorial text; for easy reference the sheets may be removed, without spoiling the remainder of the magazine, and filed or affixed to stiff card for use on the workshop bench.

By collecting these sheets regular readers will gradually build up a first rate source of reference. To avoid breaking the sequence readers are advised to order *The Radio Constructor* regularly as back issues are not always available.

The British Amateur Electronics Club

The British Amateur Electronics Club year started on January 1st, and all those interested in electronics as a hobby are invited to join. The Newsletter, which is now published quarterly, is sent to all members, and until supplies are exhausted past copies will be sent to new members to bring them up-to-date. Of particular interest in last year's Newsletters was a complete technical description of the Electronic Shooting Gallery which incorporated a binary counter converting to decimal. This is, of course, the basis of electronic counters and computers which are of particular interest at the present time.

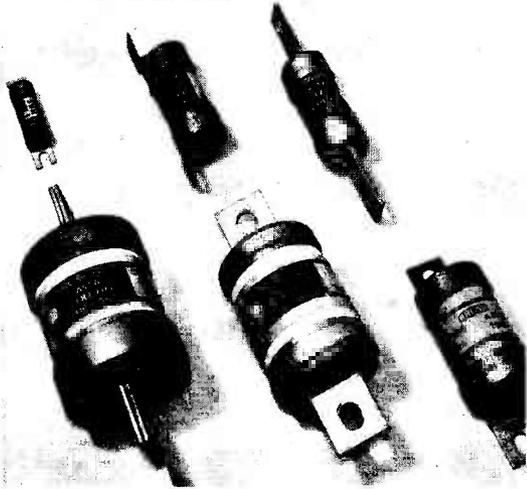
Members in all parts of the country

and overseas are now helping to design and make an Electronic Noughts and Crosses Computer. A series of articles on this ambitious B.A.E.C. Project starts in the January issue of the Newsletter, and reports will be given in future Newsletters, so that members will know how it is progressing.

For the benefit of those members who live near enough to Penarth, meetings are held at the Penarth Secondary School, St. Cyres Road (Off Redlands Road), Penarth, Glam, the new session starting on Thursday, January 11th, and thereafter every Thursday night at 7 p.m. until April 4th. At these meetings they experiment with modern electronic devices.

such as integrated circuits, dynaquads, light-activated silicon control rectifiers and so on. These experiments ultimately lead to incorporating the various devices in electronic games which are not only shown in an exhibition during the Penarth Holiday Week in aid of charity, but are also fully described in the Newsletters. If you would like to join the British Amateur Electronics Club (membership fee 10/-d per year), or require further information, please contact C. Bogod, "Dickens", 26, Forrest Road, Penarth Glam, who will be very pleased to forward you details of this new and exciting organisation.

COMMENT



The Fusegear Department of Brush Electrical Engineering Co. Ltd., a Hawker Siddeley Company, announce that their industrial range of HRC fuse links from 2 amps to 200 amps has now been certified in accordance with the requirements of BS.88 Part (1) 1967 for category of duty 415Q AC46 and AC80, Class Q1. These fuse links have a fusing factor of Class Q1 as defined by the specification.

More About The I.S.W.L.

In last month's issue we congratulated the International Short Wave League on its coming of age. There was only space then to refer to the origins of the league, the three main objects and the size of its membership. This month we complete the story by giving details of the services and activities provided for members.

Unlike most national radio societies, the League caters for members with interests in both the amateur and the broadcast bands and is able to provide a varied selection of services for both. Members interested in the amateur bands include both transmitting amateurs and short wave listeners and no distinction is made between the two. One of the League's main services to members is the provision of a monthly magazine, entitled "Monitor", which averages 34 quarto-sized pages per month. Large sections are devoted to reception conditions on both the amateur and the broadcast bands and members are encouraged to submit details of stations they hear. Several contests are held annually and the rules and results are also published in the magazine. Transmitting amateurs and V.H.F. enthusiasts have their own articles, and helpful advice for newcomers to the hobby

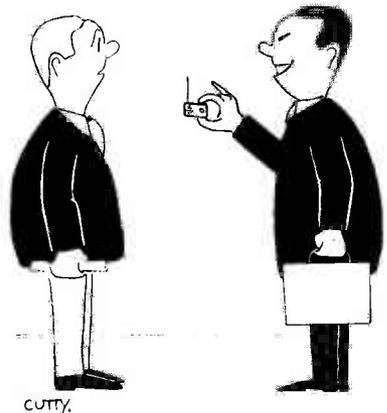
is given from time to time.

The I.S.W.L. QSL Bureau is well-known throughout the world as one of the fastest there is, all outgoing cards being cleared by the QSL Manager at intervals of never more than a fortnight even to the most remote countries. The Bureau is unusual in that it accepts reports to both amateur and broadcast stations and all cards received for members are sent to them free of charge, eliminating the nuisance of having to forward stamped envelopes to the Bureau at frequent intervals.

A series of awards, such as those for verifying 50 countries in the British Commonwealth of Nations and 50 European countries, is available free of charge to members only and a special "Anniversary Award" will be issued to members verifying 100 stations in 21 zones during the League's anniversary year. Amongst services available are the Translation Service, Tape section and Correspondence Bureau.

All I.S.W.L. Officers give their time voluntarily and receive no payments for their work other than out-of-pocket expenses. All subscriptions are therefore used to maintain and improve the facilities offered to members. The executive body of the League is the I.S.W.L. Council, which consists of seven

officers who are elected bi-annually. The Headquarters of the League is situated at 60 White Street, Derby, DE3 1HA, England, and the Secretary is Mr. B. J. C. Brown, C3JFD. The present annual subscription is £1 15s. 0d. sterling (U.S.A. \$5.00).



"Throw away like Biro refill"

Silicon Transistor Reflex T.R.F.

by G. SHORT

By taking advantage of the properties of silicon transistors this circuit offers a high performance with an extremely small quantity of components. The design is not critical and a number of modifications can be incorporated

THE TWO-TRANSISTOR REFLEX RECEIVER WHOSE circuit is given in Fig. 1 was designed with simplicity and component economy in mind, but performance has not been sacrificed. In fact, the sensitivity is much greater than that of most two-transistor receivers. The measured sensitivity of the prototype, *without using any reaction*, was about 20dB better than the sensitivity of a conventional two-transistor reflex receiver using an OC44 and an OC71. The current consumption is low—about 1.5mA.

Exploiting Silicon Transistors

This good performance is obtained by making use of the characteristics of modern high-frequency silicon planar transistors. These transistors work well as r.f. amplifiers at low collector currents.

In the usual type of reflex circuit, TR₁ feeds the detector, often of the double-diode type. The impedance presented by such a detector to low-level r.f. signals is typically about 1.5kΩ. This rather low impedance severely limits the gain of TR₁; and increasing the value of its collector resistor is of

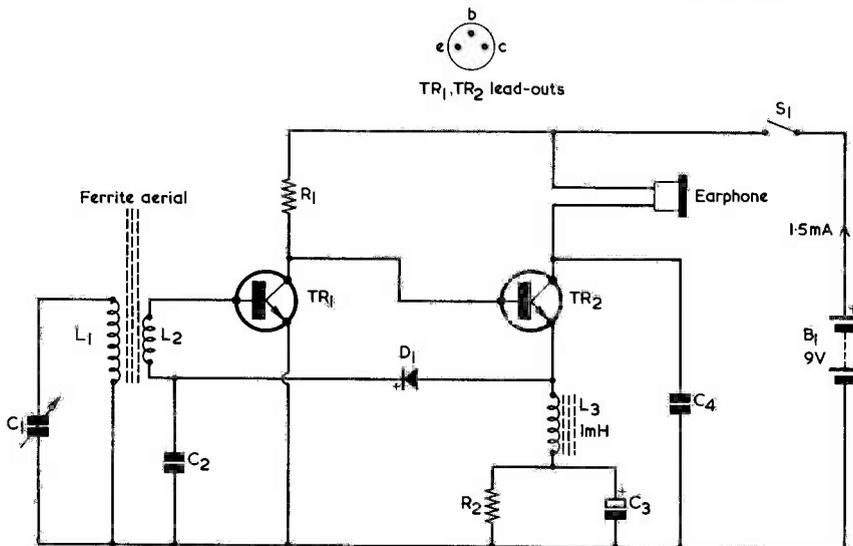


Fig. 1. The basic circuit of the reflex transistor receiver. A magnetic earphone is used. Note the economy in components

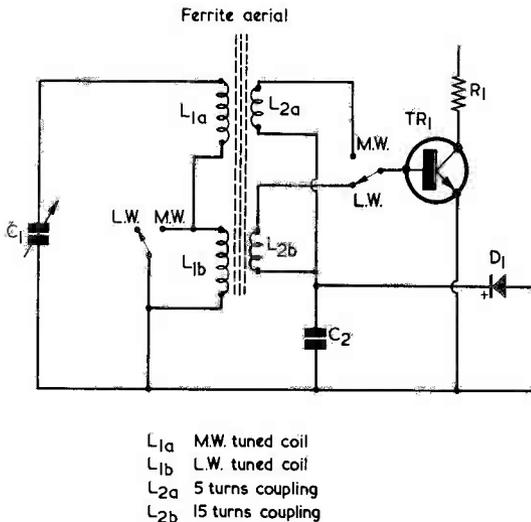


Fig. 2. Suggested modification for a medium and long wave version of the receiver

very little help. In the present circuit, however, TR₁ does not feed the detector directly. Instead,

COMPONENTS

(N.B. Some of the components listed below are altered if the modifications described in the text are made.)

Resistors

- R₁ 15kΩ, ¼ watt, 20%
- R₂ 680Ω, ¼ watt, 20%

Capacitors

- C₁ Tuning capacitor, to suit L₁
- C₂ 0.01μF
- C₃ 125μF electrolytic, 3V wkg.
- C₄ 0.01μF

Inductors

- L₁ Ferrite aerial for medium or long waves
- L₂ See text
- L₃ R.F. choke (see text)

Semiconductors

- TR₁ HK 301
- TR₂ HK 101, HK 301 or HK 601
- D₁ Any germanium diode

(The transistors are available from Amatronix, Ltd.)

Switch

- S₁ s.p.s.t. switch

Battery

- B₁ 9-volt battery

Earphone

- Magnetic earphone, resistance 250Ω to 4kΩ

TR₂ acts as a unity-gain buffer. TR₂ is an emitter-follower as far as the r.f. signals are concerned, and its input impedance is high. The full advantage of using a high value for R₁ (the collector resistor for TR₁) is thus obtained.

Direct Coupling

A further feature of silicon transistors which is put to good use in this circuit is their relatively high base-emitter voltage. This is about 0.65V in the present case. How this is useful can be seen by working out the collector emitter voltage of TR₁. This is made up of the sum of three voltages: the base-emitter voltage of TR₂ (0.65V), the drop across the forward-biased detector diode (0.1V), and the base-emitter voltage of TR₁ itself (0.65V). The total is 1.4V, and is well above the "bottoming" voltage of TR₁ which is about 0.5V in the present instance. If germanium transistors, with base-emitter voltages of about 0.2V had been used, the collector voltage of TR₁ would have been only 0.5V. Good r.f. germanium transistors such as the AF117 will not work well with such a low collector voltage, and in consequence the simple form of direct coupling from the detector used here is not practicable with germanium transistors.

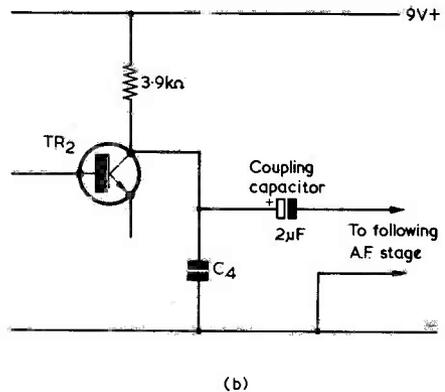
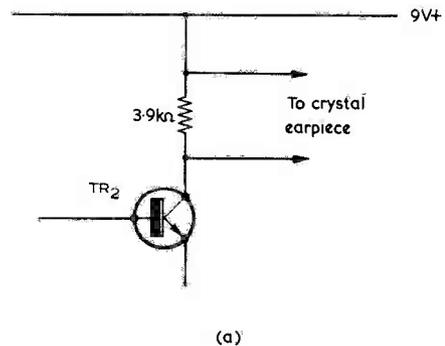
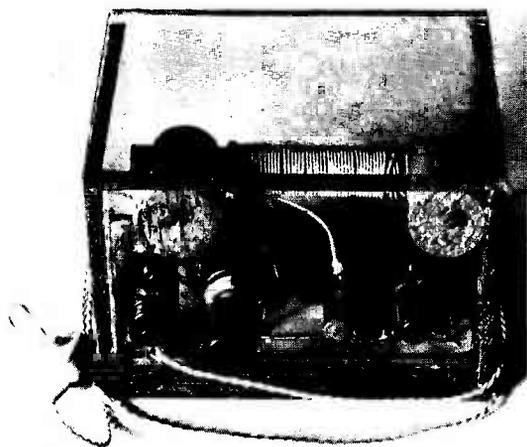


Fig. 3 (a). If a crystal earpiece is used, an additional 3.9kΩ resistor is fitted between the collector of TR₂ and the positive supply line
(b). An additional 3.9kΩ resistor is also required if the receiver is to feed a following a.f. amplifier



Front view of a receiver made up to the circuit of Fig. 1 and incorporating a volume control

Audio Circuit

The a.f. circuit is perfectly straightforward. The detector D_1 , which can be almost any type of germanium diode (a gold-bonded "computer diode" was used in the prototype) feeds the base of TR_1 , and TR_1 is direct coupled to TR_2 .

Adding Reaction

If L_3 is parallel to L_1 and close to it, positive r.f. feedback is produced, provided that the turns in L_1 , L_2 , and L_3 are in the appropriate direction. Alternatively—or additionally—reaction can be obtained by capacitive coupling between the collector of TR_1 and the "hot" end of the aerial tuned circuit. The best way of obtaining this is to connect a wire to the "hot" side of C_1 and wrap the other end of it round R_1 . This end should of course, be insulated. With correctly adjusted fixed reaction, quite weak stations can be received.*

Coil L_1 may be any ferrite aerial tuned coil intended for medium or long waves, and tuning capacitor C_1 should have a value to suit the particular ferrite aerial coil employed. With a medium wave ferrite aerial, L_2 consists of 5 turns of wire around

*For regeneration to occur with the capacitive coupling, the upper end of L_1 in Fig. 1 should be in anti-phase with the end of L_2 which connects to TR_1 base. This differs from the coil phase relationship apparent in the diagram, which is primarily intended to illustrate the basic operation of the receiver circuit. If satisfactory regeneration does not occur at the first attempt, try reversing the connections at L_2 . Editor.

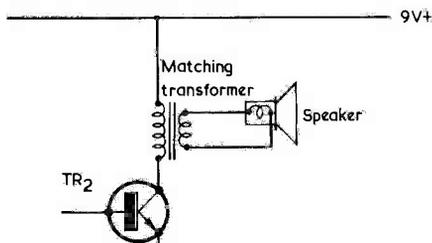


Fig. 4. Coupling a loudspeaker to the receiver

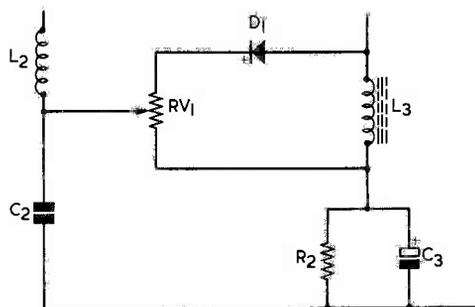


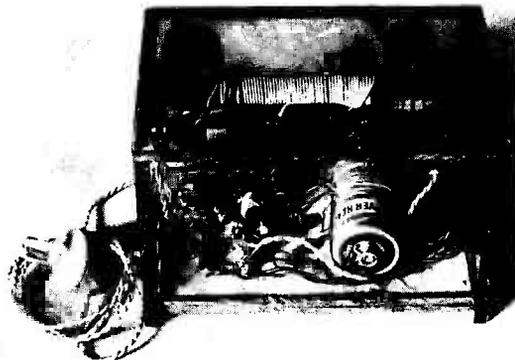
Fig. 5. Showing how a volume control may be added to the circuit

22 s.w.g. wound over the earthy end of L_1 or on the ferrite rod close to the earthy end of L_1 . The gauge of wire and its positioning are not critical. With a long wave ferrite aerial, L_2 should consist of 15 turns of the same wire wound on the ferrite rod close to the tuned coil. The prototype was made for single waveband working only. However, should the reader desire to use a medium and long wave ferrite rod aerial, two coupling coils may be fitted, with wave-change switching along the lines suggested in Fig. 2. In this diagram, $L_{2(a)}$ is the medium wave coupling coil and $L_{2(b)}$ the long wave coupling coil. The two switches in Fig. 2 are ganged.

The r.f. choke L_3 has an inductance of approximately 1mH. It may be made by scramble-winding 100 turns of 36 s.w.g. single silk covered wire on a $\frac{1}{2}$ in length of $\frac{1}{4}$ in diameter ferrite rod.

Modified Second Stage

As it stands, the receiver will operate a magnetic earpiece or headphone with a resistance between 250 Ω and 4k Ω . If it is desired to use a crystal earpiece, substitute a 3.9k Ω resistor for the magnetic earpiece and connect the crystal earpiece across it. See Fig. 3 (a). If it is desired to use the receiver as a radio feeder or as a "front end", to be followed by an audio power stage, similarly fit the 3.9k Ω resistor and couple to the following stage via a capacitor,



Rear view of the receiver. Component details are discussed in the text

as shown in Fig. 3 (b). If the following stage employs a transistor the coupling capacitor may have a value of $2\mu\text{F}$ electrolytic (as in the diagram); if it employs a valve the coupling capacitor may be $0.02\mu\text{F}$.

In favoured localities it may be possible to obtain enough power from TR_2 to drive a sensitive loud-speaker. To increase the power, the collector current of TR_2 may be increased, within reason, by using a lower value for R_2 . The voltage across R_2 is about 0.7V , and is more or less independent of the value of R_2 . Thus with $R_2 = 680\Omega$, the collector current of TR_2 is about 1mA . Reducing R_2 to 100Ω makes the current rise to about 7mA , and so on. If this modification is made, TR_2 should have a current amplification factor of 90 or more. With the ear-phone output, transistors from any of the available gain groups may be used, though the sensitivity of the receiver will, of course, be increased somewhat if high-gain transistors are employed in either or both stages. (The question of gain in available transistors is covered in the Note at the end of this article.)

For maximum output to the speaker a matching transformer is required. The optimum turns ratio is

$$\frac{V_{CE}}{I_C R_L}$$

where R_L is the loudspeaker impedance. For example, if $V_{CE} = 8\text{V}$, $I_C = 10\text{mA}$ and $R_L = 4\Omega$, the required turns ratio is 14:1. The maximum output is theoretically $\frac{V_{CE} I_C}{2}$, but in practice it is nearer

$\frac{V_{CE} I_C}{4}$, which in this case is 20mW . The speaker is connected as in Fig. 4.

Volume Control

There is no means of turning down the volume in the circuit of Fig. 1 except of course, by orienting the ferrite aerial so that less signal is picked up. A

volume control may be added as shown in Fig. 5. It is placed immediately after the detector. This is the best circuit position from the point of view of signal-handling capacity, since the a.f. input to the transistors can be minimised. The resistance of the volume control is not critical, but it should not be too high or the d.c. working conditions of the transistors will be disturbed at intermediate settings. On the other hand it should not be too low or sensitivity may be impaired. A potentiometer with a log track and a value of 5 or $10\text{k}\Omega$ is suitable, and it may, if desired, be combined with the on-off switch.

Built-Up Circuit

The accompanying photographs show two views of a receiver built up in a perspex case to the circuit of Fig. 1 (with the exceptions that a crystal earpiece is employed, as in Fig. 3 (a), together with a volume control, as in Fig. 5). Regeneration is obtained by way of an insulated lead from the "hot" side of C_1 to R_1 , as described earlier. The ferrite aerial covers the medium-wave band and is home-wound on a 4in length of $\frac{1}{8}$ in ferrite rod, and consists of 46 turns of 20 s.w.g. insulated wire close-wound. It is tuned by a variable capacitor of the type used in TV timebases, although any normal variable capacitor of around 300pF could be used instead. The battery is an Ever Ready PP4.

Note: Transistor Gain

The HK101 and HK301 transistors available from Amatronix Ltd. are in the following grades for h_{fe} . HK101: 30-60 (red); 50-100 (purple); 90-180 (blue); 150-450 (green). HK301: 20-60 (black); 50-100 (purple); 90-180 (orange); 150-450 (green). The HK601 is available with a minimum h_{fe} of 20 at 50mA.



CAN ANYONE HELP ?

Requests for information are inserted in this feature free of charge, subject to space being available. Users of this service undertake to acknowledge all letters, etc., received and to reimburse all reasonable expenses incurred by correspondents. Circuits, manuals, service sheets, etc., lent by readers must be returned in good condition within a reasonable period of time

Hallicrafter SX24 Receiver.—D. W. Davies, Pen-y-Maes, Halcog, Brymbo, Wrexham—any information, manuals, circuits, etc., both for this and the Mackay Marine Radio type 138-B.

* * * *

Delco Remy Car Radio.—D. Walsh, Ballylynch, Carrick-on-Suir, Co. Tipperary, Eire—service manual or circuit required on loan. Model No: 1252, valve line-up 6K7, 6K8, 6K7, 6Q7, 6V6 and vibrator supply.

* * * *

P58 Receiver (300-650 Mc/s).—R. G. Hayward, 'Sunnyfields', Lighthouse Road, St. Margaret's Bay, Nr. Dover, Kent—handbook or circuit diagram or any other details.

R1392E Receiver.—J. Cameron, 3 Eversley Court, Thundersley, Essex—circuit or manual or any details.

* * * *

R1392 VHF Receiver.—J. R. Keenan, 7 Parkmount, Bangor, Co. Down, N. Ireland—service manual required, loan or purchase.

* * * *

Taylor Valve Tester 45C.—T. Degnan, 4 Opie House, Allitsem Road, London, N.W.8—loan of the chart manual.

VERSATILE MULTIMETER

by

P. J. LE RICHE

Offering a d.c. sensitivity of $10k\Omega$ per volt, this simple multi-testmeter can provide all the measurements required in normal servicing and experimental work. The only expensive item is the basic $0-100\mu A$ meter movement, and the resistance of this component is unimportant since it is allowed for in the assembly of the current range shunt resistors

AS HAS OFTEN BEEN STATED before, one of the most useful pieces of test equipment a constructor can possess is a multimeter. Having for several years used a very simple meter of this type, the author felt the need for a second, more comprehensive, instrument and the result is the multimeter described in this article. Twenty-two ranges are provided covering quite a wide

range of d.c. voltages, a.c. voltages and d.c. currents, together with two resistance ranges giving a useful indication of resistance.

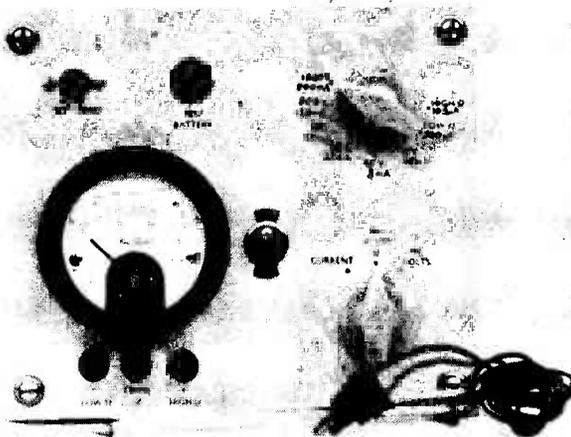
Circuit

The circuit is shown in Fig. 1. In this, two switches, S_1 and S_2 , are used to select the required range, S_1 switching in the appropriate shunt or multiplier and S_2 the appro-

priate function. The two resistance ranges share the same battery and the same zero set control; in one the unknown resistor is connected in parallel with the meter between the "Ohms" and the "Low Ohms" sockets, and in the other it is connected in series with the meter between the "Ohms" and the "High Ohms" sockets. In both cases the "Ohms" socket is positive with respect to the other. Provision is also made for testing the state of the battery by pressing the biased toggle switch S_4 , whereupon the battery voltage will be shown on a 50V range.

The other switch, S_3 , is simply an on-off switch, but with a slight difference. On voltage ranges only $S_3(a)$ plays a part, simply disconnecting the meter and leaving the input terminals open-circuit, but on the current ranges it disconnects the meter and also short-circuits the input terminals so that, if it is switched off while the instrument is in a circuit, the current may still continue to flow. $S_3(a)$ also short-circuits the meter terminals when it is in the "Off" position, thereby providing a useful degree of electrical damping and reducing considerably the amount by which the needle swings when the instrument is moved. It should be noted that this facility becomes inoperative when the function switch is in the "A.C. Volts" position, since the very low voltages generated by excursions of the pointer are insufficient to drive an appreciable current through the rectifier. S_3 should be in the "Off" position when the battery is tested, or no reading will be obtained.

Switching with the current ranges is, perhaps, slightly unusual in that the circuit combines the advantages of both the Ayrton-Mather universal shunt method and the simple shunt circuit without the disadvantages of either. In the simple shunt circuit shown in Fig. 2 (a) the switch contacts are in series with the shunts and can introduce an appreciable error, particularly on the higher current ranges. There is also a risk of damage to the meter when reading high currents if switch contact resistances are momentarily high. These difficulties are overcome in the Ayrton-Mather circuit (Fig. 2 (b)) but at the expense of a substantially larger voltage drop across the test terminals. The circuit used by the author is shown in Fig. 2 (c) and it will be seen that, although there are switch contacts in series with the meter and the input, neither of these will introduce serious errors. One set of switch contacts is between the meter and the shunts, but these



The completed instrument has a very neat and professional appearance

COMPONENTS

Resistors

(The values of R_1 to R_6 and R_{14} become altered if a meter with alternative scaling is employed. R_5 and R_6 should be made up from 2 or more resistors in series)

- R_1 50k Ω hi-stab, 2%, $\frac{1}{2}$ or $\frac{1}{4}$ watt
- R_2 150k Ω hi-stab, 2%, $\frac{1}{2}$ or $\frac{1}{4}$ watt
- R_3 500k Ω hi-stab, 2%, $\frac{1}{2}$ or $\frac{1}{4}$ watt
- R_4 1.5M Ω hi-stab, 2%, $\frac{1}{2}$ or $\frac{1}{4}$ watt
- R_5 5M Ω hi-stab, 2%, $\frac{1}{2}$ or $\frac{1}{4}$ watt
- R_6 15M Ω hi-stab, 2%, $\frac{1}{2}$ or $\frac{1}{4}$ watt
- R_7 - R_{13} Shunts (see text)
- R_{14} 500k Ω hi-stab, 2%, $\frac{1}{2}$ or $\frac{1}{4}$ watt
- R_{15} 100k Ω , 10%, $\frac{1}{2}$ or $\frac{1}{4}$ watt
- RV_1 250k Ω preset, Radiospares or similar

Meter

- M_1 Moving-coil meter, 100 μ A (see text for scaling)

Rectifier

- MR_1 1mA meter rectifier type REC.101 (Radiospares)

Battery

- B_1 22.5 volt battery type B122 (Every Ready)

Switches

- S_1 3-pole 8-way (see text)
- S_2 4-pole 3-way
- S_3 d.p.d.t. toggle
- S_4 d.p.d.t. biased toggle

Miscellaneous

- 3 wander plug sockets
- 2 pointer knobs
- Test prods, leads and plugs

N.B. Radiospares components may only be obtained through retailers.

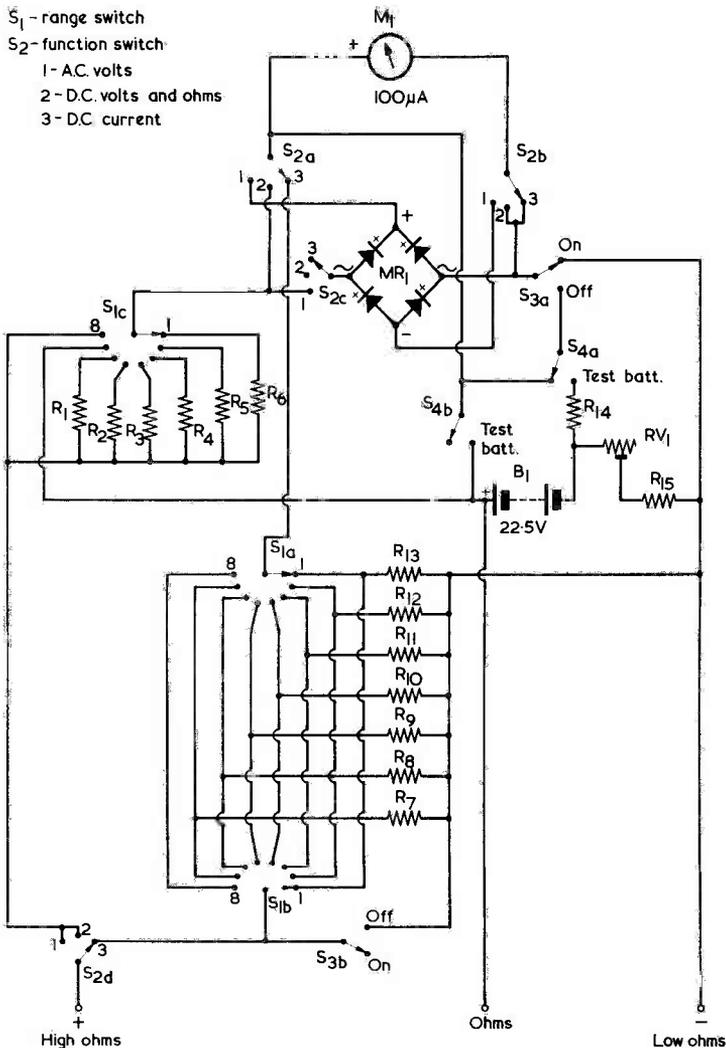


Fig. 1. The circuit of the multimeter. S_4 , which is operated to test the internal battery, is spring biased to the position illustrated. Voltages and currents to be measured are applied to the outside positive and negative sockets. The centre socket is used for resistance measurements

The meter incorporated in the instrument has a full-scale deflection of 100 μ A. The resistance of the meter is unimportant, as it is allowed for in the procedure used for obtaining the various current shunts. The voltage multipliers, R_1 to R_6 , are selected simply in terms of 10k Ω per volt, and no undue problems arise here.

The meter used in the prototype was scaled 0-15 and 0-50, this proving very convenient as it enabled the ranges to follow the progression 1:3:10:30, etc., thereby ensuring that most readings can be taken with a

good deflection of the needle. A meter with a single scale (e.g. 0-10) is not advised, as this does not readily lend itself to the range progression. Meters with the scales 0-15 and 0-50 may not be generally available through home-constructor retail sources and if an instrument of this type cannot be obtained, equally useful results will be given with a 100 μ A meter scaled 0-3 and 0-10, such as the Radiospares type MR31. In this case the voltage ranges may be 3V, 10V, 30V, and so on up to 1,000V, instead of those shown in Table 1, together with

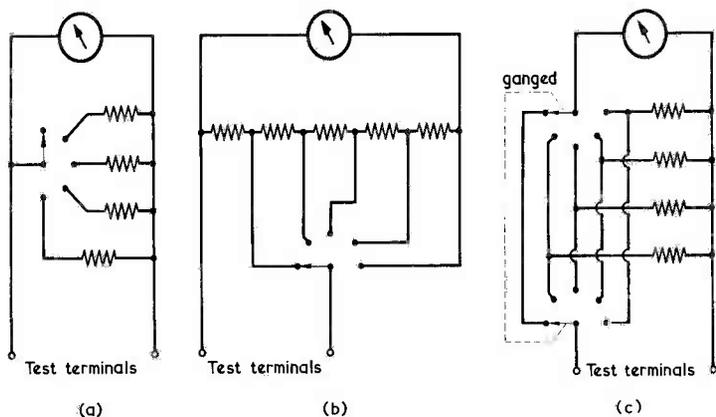


Fig. 2 (a). A simple shunt circuit

(b). The universal shunt circuit

(c). The shunt circuit employed by the writer. This has the advantages that only a low voltage is dropped across the test terminals, and that only the meter actuating current flows through the switch contacts between the shunts and the meter

corresponding current ranges. The only changes needed to the components are in the values of R_1 to R_6 , R_1 becoming $30k\Omega$, R_2 becoming $100k\Omega$, and so on up to R_6 becoming $10M\Omega$. The new values for R_1 to R_6 are still, of course, $10k\Omega$ per volt. If desired R_{14} could be changed to $300k\Omega$, whereupon the battery test reading is given on a 30V range.

Shunts

Resistance values for the shunts R_7 to R_{13} are not given as they will depend on the meter resistance. They may easily be calculated from the formula

$$R = \frac{I_m R_m}{I - I_m}$$

where R is the required shunt resistance (ohms), I_m and R_m are respectively the full-scale current of the unshunted meter (amps) and its resistance (ohms) and I is the required full-scale current (amps).

The meter resistance, if not known, may be found as follows. Having completed the instrument except for the shunts, put S_1 to "Low Ohms", S_2 to "D.C. Volts and Ohms", switch on S_3 and adjust RV_1 until the meter reads full-scale. Connect a resistance box or decade box between the "Ohms" and "Low Ohms" sockets and adjust it until the meter reads half scale. The resistance of the decade or resistance box is then equal to the meter resistance. If the reader does not possess or cannot borrow a resistance or decade box a 1% or 2% resistor of between 100 and $1,000\Omega$ may be used, and the meter resistance calculated from the equation for the

"Low Ohms" range which is given later.

When the meter resistance has been determined, the shunts may be made in the following manner. Select from wire gauge tables a resistance wire giving the required resistance in a convenient length of about a yard or so and cut somewhat more than will be finally needed. Connect this in series with a suitable current range, a variable resistor and a battery, and adjust the variable resistor until the second meter reads the full-scale current of the range for which the shunt is being made. Now connect the negative meter socket to the negative end of the shunt wire and connect a piece of fairly stout wire to the appropriate tag on $S_{1(b)}$. See Fig. 3. Switch S_1 to the appropriate range,

S_2 to "D.C. Current" and S_3 to "On", and touch the free end of the piece of copper wire on to bared points along the shunt wire until a point is found which gives full-scale deflection on the constructor's meter. The length of shunt wire between the two connections to the meter is now the required length, and may be wound on to a suitable former and soldered into place. Note that, on the more sensitive current ranges, one or more low value high stability resistors can be used to make up some of the shunt resistance required.

Alternatively, each shunt may be constructed by comparison with the next or next two more sensitive ranges, but this method is not likely to be very accurate by the time the higher ranges are reached.

Resistance wires are available from Post Radio Supplies, 33 Bourne Gardens, London, E.4, and Table II gives nominal resistance values per yard for the more common gauges likely to be used.

Other Components

The reader may have difficulty in obtaining a 3-pole 8-way switch for S_1 , in which case a 10 or 12-way component may be used. In some cases it will be possible to effectively remove the unwanted positions by passing a nut and bolt through the front plate of the switch to act as a stop. S_1 and S_2 should preferably be new components, but if they are not their contacts should be cleaned before use with carbon tetrachloride or a suitable switch cleaner.

The multipliers R_5 and R_6 should be made up of two or more resistors in series so that the voltage across each cannot rise above 350V, or 500V if the resistors are some 0.8in in length or longer. Too much

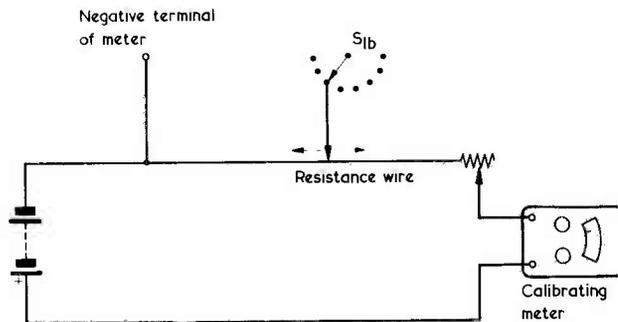


Fig. 3. The current shunts may be made up with the aid of a second, calibrating, meter. The negative terminal of the instrument described in this article is connected to the negative end of the resistance wire and a lead from the appropriate contact of $S_{1(b)}$ moved along the wire until the meter of the instrument being constructed indicates full-scale deflection

reliance should not be placed on the insulation of high stability resistors not covered with a ceramic sleeve, and it is advisable to prevent them touching each other.

Construction

The layout used by the author is shown in Figs. 4 and 5, but this is in no way critical and may be modified in any manner desired by the constructor. The prototype was housed in a hardboard box measuring approximately 7 x 6 x 2in. This was glued together with pieces of wood in the corners, whereupon the front panel was secured to these with chrome plated screws. The controls and sockets may be labelled with Data Publications Panel-Sign transfers to give a pleasing and professional appearance.

The rectifier, MR₁, is provided with a single 8BA clear fixing hole but it may also be quite readily supported by its leads. These are colour-coded as follows: green, a.c. input; red, positive output; black, negative output. Since the battery has quite a long life the connections to it may be soldered at its terminals. In the prototype the battery was held in position against the body of S₄ with a rubber band, but any other method of mounting can be employed.

A.C. And Resistance Ranges

Graphs should be drawn for the a.c. voltage and resistance ranges as these cannot be read directly off the scale.

Graphs for the a.c. voltage ranges may be made by comparison with the corresponding d.c. ranges in the following manner. Switch the meter to a d.c. voltage range, apply a voltage and note the reading, then turn S₂ to "A.C. Volts" and make a note of the corresponding reading in the meter. Repeat this process for a number of d.c. input voltages. Plot the points for a graph on which the vertical axis consists of the d.c. voltage readings, each multiplied by 1.11, and the horizontal axis consists of the corresponding a.c. voltage readings. Join the points by a smooth curve. When the instrument is later used to measure a.c. voltage, the actual r.m.s. voltage may be read off the vertical axis, working from the meter reading on the horizontal axis. It is necessary, when making up the graph, to multiply each d.c. voltage by 1.11 as just described, because the instrument responds to average voltage (which is equivalent to the d.c. voltage) and we wish to find the r.m.s. value of the alternating voltage being measured. For a full-wave rectified

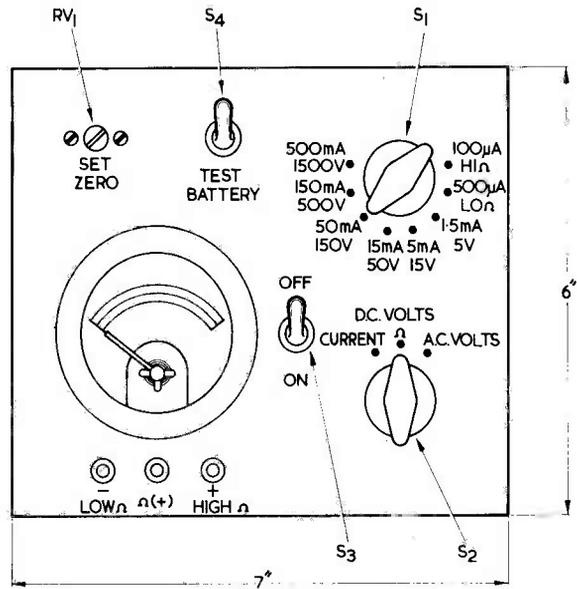


Fig. 4. The front panel of the author's meter. As may be seen, a neat layout in small space can be readily achieved

sine wave, r.m.s. voltage is 1.11 times average voltage. It will probably be found that the 50 and 150 volt graphs can also be used for the 500 and 1,500 volt ranges by simply multiplying by 10. (With the alternative meter scaling referred to earlier, the ranges concerned would be the 30, 100, 300 and 1,000 volt ranges respectively.) Non-linearity in the two lowest voltage ranges will normally make it necessary to use separate graphs for these.

Because of the wide range of resistances which may be measured on the resistance ranges, tables

might be more convenient than graphs for these. The author used a digital computer to calculate the resistances corresponding to 99 different meter readings on each range but few readers will be able to do the same and the quickest method other than this is undoubtedly to draw the graphs. Points for these, or values for the tables, may be calculated from the following equations.

For the high resistance range:

$$R = 225,000 \left(\frac{100}{I} - 1 \right)$$

TABLE I
Switch positions

		S ₂		
		Position 1 "A.C. Volts"	Position 2 "D.C. Volts & Ohms"	Position 3 "D.C. Current"
S ₁	1	1,500V A.C.	1,500V D.C.	500mA
	2	500V A.C.	500V D.C.	150mA
	3	150V A.C.	150 V.D.C.	50mA
	4	50V A.C.	50V D.C.	15mA
	5	15V A.C.	15V D.C.	5mA
	6	5V A.C.	5V D.C.	1.5mA
	7	—	Low Ohms	500µA
	8	—	High Ohms	100µA

N.B. The a.c. voltage figures for Position 1 of S₂ do not exactly correspond to f.s.d.—see text.

For the low resistance range:

$$R = \frac{IR_m}{100 - I}$$

In both cases, R is the unknown resistance (ohms), R_m is the meter resistance (ohms) and I is the meter reading (μA).

constructors will be able to tell of cases where their instruments have withstood a 10 times f.s.d. overload, or even more, with no apparent damage. A silicon diode connected across the movement as in Fig. 6 (a) is the simplest method of protection but is certainly not

TABLE II
Nominal resistance per yard of Eureka wire

S.W.G.	Resistance (Ω)
14	0.138
16	0.216
22	1.13
28	4.04
34	10.4
40	38.4

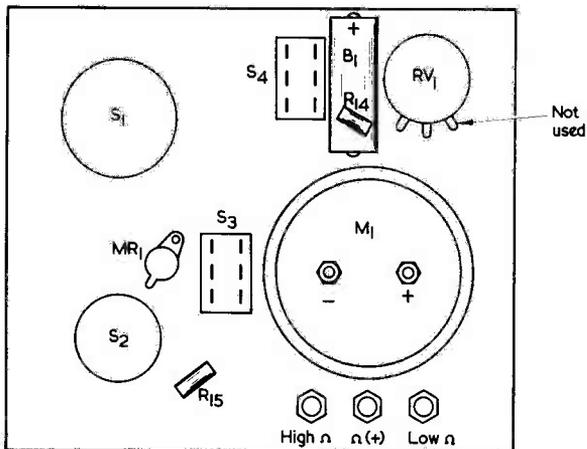


Fig. 5. The main components behind the front panel. The shunt and multiplier resistors are grouped around S₁. A small tagstrip to anchor the common ends of the shunts and multipliers may be mounted under one of the nuts of the switch which secures the wafer

Meter Protection

Before concluding, the writer feels that some notes on overload protection might be helpful. The electronic type of protection which will be referred to is not incorporated in the circuit of Fig. 1, but readers may care to add it to the completed instrument if they wish.

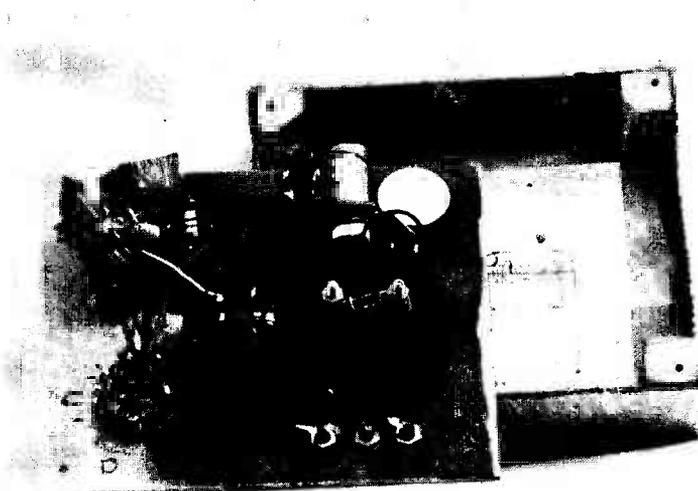
There are two main classes of meter protection devices, these being electro-mechanical and electronic. The former usually consists of a cut-out switch actuated by the impact of the needle on the end stop. This method of operation can have two disadvantages. Firstly, with a very heavy overload the needle could bend itself against the end stop before the cut-out operates. Secondly, if the meter was already reading near full-scale when the overload occurred, the pointer might not, in some cases, gain sufficient momentum by the time it struck the end stop to trip the cut-out.

A good electronic protection circuit would overcome both these disadvantages and furthermore would be instantaneous, but it is difficult to design a simple circuit which can fairly be described as better than reasonably good. Most meters have a maximum overload rating in the order of 4 times f.s.d. but many

perfect. A 100μA meter dropping 100mV at f.s.d. would suffer only a 10 times f.s.d. overload when protected by an OA200 if 100mA were put through the combination. This is a useful degree of protection

but is still some way removed from the 4 times f.s.d. rating. It has to be remembered also that the reader's meter could have a lower resistance than the one in the example just mentioned, in which case the degree of protection will be worse. A useful improvement over a silicon diode is a silicon transistor with its base strapped to its collector. For an n.p.n. transistor the collector and base are connected to the positive side of the meter, as shown in Fig. 6 (b). With a 2N2925 under the overload conditions of the previous example, 7.5 times f.s.d. would typically flow through the meter. The 2N2925 is available from L.S.T. Components, 23 New Road, Brentwood, Essex.

Germanium devices will not, in general, prove satisfactory for meter protection, except perhaps for particularly low resistance meters, because they will begin to conduct before the meter has reached f.s.d.



Very simple carpentry will provide a suitable housing for the meter. The case shown here is 2in deep

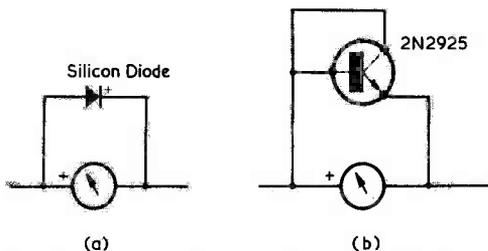


Fig. 6 (a). Overload protection by means of a silicon diode. When the voltage across the meter is sufficiently high the silicon diode conducts and passes forward current. (A second diode, connected the other way round, will give protection against overload voltages of opposite polarity)
 (b). Obtaining overload protection with a silicon transistor

Transistors and diodes may be very easily checked on this point with the

instrument described in this article. Switch the instrument to the "Low

Ohms" range and put the device across the meter; if the needle moves by more than $1\mu\text{A}$ from f.s.d. the device is unsatisfactory. It should be added that even if a germanium device is found that is good enough at room temperature, its leakage may well become too great at slightly elevated temperatures.

Conclusion

The writer would like to conclude by stating that the meter described in this article will carry out most of the measurements that are required of such an instrument about the workshop. If assembled and treated with care it will give many years of useful and reliable service.



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RADIO

CONTROL

FIELD

MONITOR

by **F. L. THURSTON**

A very valuable aid for the radio control enthusiast is a sensitive broadly tuned field monitor. In this article our contributor describes the circuit and operation of a neat wide-band pocket receiver which is capable of monitoring all local transmissions in the 27 Mc/s radio control band. Full constructional and setting-up instructions will be given in a concluding article next month

WHEN OPERATING ANY PIECE OF RADIO CONTROL equipment "in the field" there are a number of basic precautionary measures that must first be taken, and a number of simple rules of good behaviour and etiquette that have to be observed. To be specific, before operating the model one must make sure that the transmitter will not interfere with equipment being operated simultaneously by someone else, and that a transmitter operated by someone else will not interfere with one's own receiving gear. If interference does occur, the owner

of the offending equipment must then be located, before either party begins to operate a model, with a view to arriving at an amicable agreement as to who should take precedence in operating his equipment.

A valuable aid in meeting the above requirements is the Field Monitor. This is a sensitive pocket-sized receiver, with a built-in loudspeaker, which is pre-tuned to the 27 Mc/s radio control band and is so designed that it is simultaneously sensitive to the entire radio control band, rather than to a

single spot frequency. This type of receiver gives an audio output indication when any transmitter operates within its range and it enables any type of transmitter to be identified, including "carrier only" systems, i.e. transmitters that make no use of carrier modulation.

The Field Monitor described in this article employs a six transistor circuit. A complete kit of the electronic parts, including a telescopic antenna and 25Ω speaker, is available from Teleradio Electronics. The total current consumption of the unit is about 6mA, giving a normal field operating life of about one year.

The Circuit

The block diagram of the Field Monitor is shown in Fig. 1. The "heart" of the unit is a super-regenerative detector stage having a high sensitivity to r.f. signals, without being excessively frequency selective. When it is tuned to the centre of the 27 Mc/s radio control band signals within half a megacycle on either side of the centre frequency are detected at good strength, with the result that the super-regenerative detector stage effectively covers the entire band.

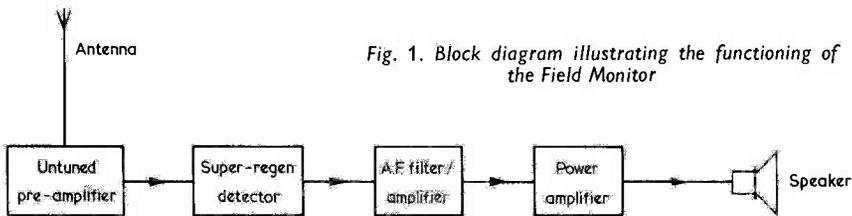


Fig. 1. Block diagram illustrating the functioning of the Field Monitor

The major snag of the super-regenerative detector stage is that, since it is in a constant state of oscillation, it tends to feed a 27 Mc/s signal into any circuitry to which it is connected. If connected directly to an antenna wire the circuit would tend to act as a very low power transmitter, and could cause interference to other receivers that are in moderately close proximity. To overcome this problem in the present Field Monitor design, the antenna is connected to the super-regenerative stage via a buffer pre-amplifier, which also improves the overall sensitivity of the unit. To prevent any unwanted increase in selectivity, the pre-amplifier stage is not tuned.

The output of the super-regenerative stage comprises, in the presence of a modulated carrier at the antenna, an unwanted strong high frequency signal at a few tens of kc/s, plus a weak but wanted component of the modulation signal. The output of the detector stage is therefore passed on to an a.f. filter/amplifier stage which rejects the unwanted high frequency signal and amplifies the wanted a.f. component. Finally, the amplified a.f. component is passed on to a power amplifier stage to eventually appear in audible form at the loudspeaker.

In the absence of a radio control carrier signal at the antenna, the Field Monitor emits a loud

rushing sound, this being the operating noise typical of a super-regenerative detector circuit. When a plain carrier wave is picked up at the antenna the operating condition of the super-regenerative circuit is changed, and the rushing sound is either diminished in volume or is completely eliminated, resulting in silence from the speaker. If the carrier signal is modulated in some way, the modulation signal will be amplified and emitted from the speaker at reasonable volume; because of the inherent a.g.c. action of the super-regenerative circuit no manual volume control is required in the Field Monitor.

When the Field Monitor responds to a transmitter signal, the type of transmitter can be identified by the type of signal heard at the speaker. For example, an intermittent single tone followed by silence indicates a single channel "constant carrier, keyed tone" system, and a continuous audio signal of

variable frequency which is also modulated with a "warbling" note indicates a dual-proportional system.

The full circuit diagram of the Field Monitor is shown in Fig. 2. Here the antenna is coupled to the base of the untuned TR₁ pre-amplifier stage, which has collector loads R₃ and L₂. The amplified signal is then passed on to the super-regenerative detector, TR₂, via C₆; TR₂ is tuned to the radio control band via the collector tank components C₈ and L₄.

The demodulated signal given by TR₂ is then taken from R₇ and fed to the filter circuit given by C₁₀, R₈ and C₁₁. This tends to reject any unwanted high frequency components and to accept a.f. signals, which are fed via C₁₂ to the direct-coupled two-stage audio amplifier given by TR₃ and TR₄. The amplifier further rejects any high frequency components via C₁₃ and C₁₄, while amplifying audio signals in the normal way. Finally, the amplified

Basic Radio Control (9)
by F. L. Thurston



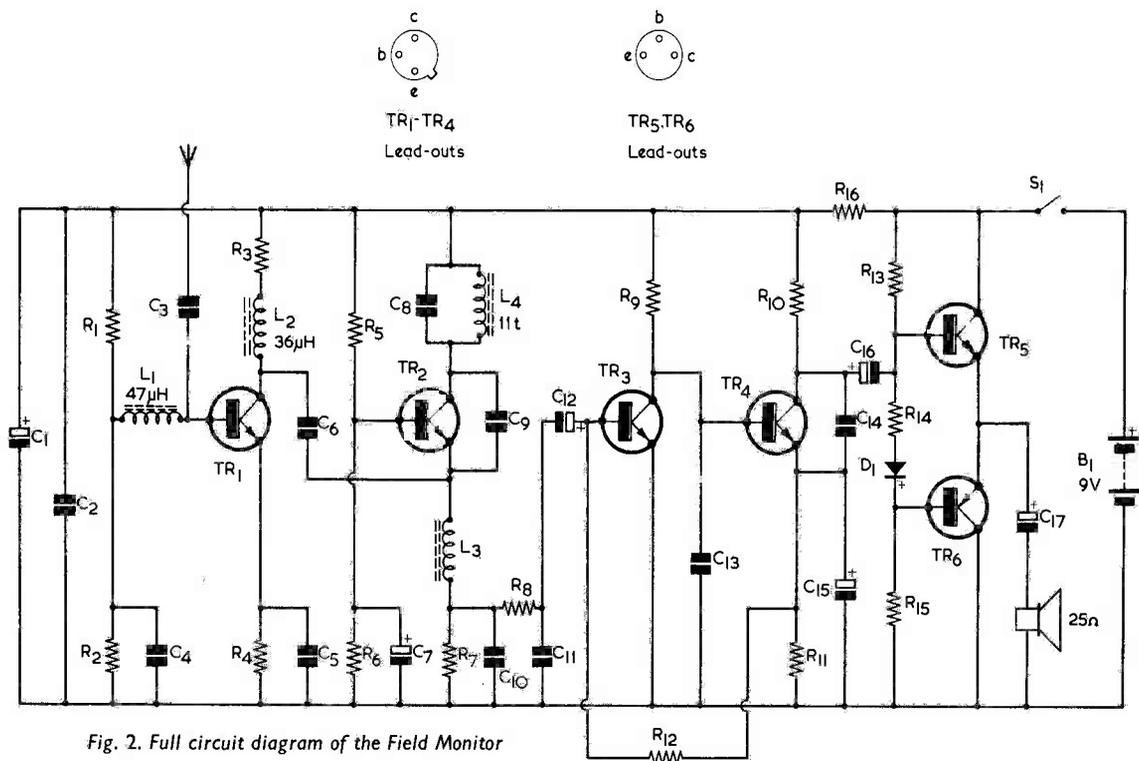


Fig. 2. Full circuit diagram of the Field Monitor

Resistors

(All values 10% $\frac{1}{4}$ watt. R₁₄ may require adjustment as described in next month's instalment.)

- R₁ 56k Ω
- R₂ 6.8k Ω
- R₃ 1k Ω
- R₄ 1k Ω
- R₅ 22k Ω
- R₆ 4.7k Ω
- R₇ 6.8k Ω
- R₈ 12k Ω
- R₉ 5.6k Ω
- R₁₀ 5.6k Ω
- R₁₁ 2.2k Ω
- R₁₂ 10k Ω
- R₁₃ 5.6k Ω
- R₁₄ 68 Ω
- R₁₅ 5.6k Ω
- R₁₆ 330 Ω

Capacitors

(All capacitors miniature types)

- C₁ 16 μ F electrolytic, 15V wkg.
- C₂ 0.05 μ F Mylar
- C₃ 0.1 μ F Mylar
- C₄ 0.01 μ F Mylar
- C₅ 0.02 μ F Mylar
- C₆ 27pF silver-mica
- C₇ 1 μ F electrolytic, 15V wkg.
- C₈ 33pF silver mica
- C₉ 12pF ceramic

C₁₀ 0.002 μ F Mylar

C₁₁ 0.01 μ F Mylar

C₁₂ 8 μ F electrolytic, 15V wkg.

C₁₃ 0.05 μ F Mylar

C₁₄ 0.005 μ F Mylar

C₁₅ 16 μ F electrolytic, 15V wkg.

C₁₆ 2 μ F electrolytic, 15V wkg.

C₁₇ 160 μ F electrolytic, 10V wkg.

Inductors

L₁ 47 μ H r.f. choke

L₂ 36 μ H r.f. choke

L₃ 1 Amp "TV choke" (Radiospares)

L₄ 11 turns of 28 s.w.g. enamelled wire on 5mm former with iron dust core

Semiconductors

TR₁ ST141 (Sinclair)

TR₂ ST141 (Sinclair)

TR₃ ST141 (Sinclair)

TR₄ ST141 (Sinclair)

TR₅ 2N1306 (Texas)

TR₆ 2N1307 (Texas)

D₁ OA90

Switch

S₁ On-off slide switch

Battery

B₁ 9-volt type PP3 (Ever Ready)

COSMOS

Aerial

Telescopic antenna type TA10 with socket (Teleradio Electronics)

Speaker

25Ω impedance, 2½ to 3in

Miscellaneous

Veroboard panel with 0.1in hole spacing (for dimensions see Figs. 3 and 5)

Wire, sleeving, battery clips, grommets, sheet aluminium, etc.

N.B. All the electronic components needed for the receiver are available in kit form from Teleradio Electronics, 325/7 Fore St., Edmonton, London, N.9.

audio signals from TR₄ collector are passed, via C₁₆, to the complementary emitter follower power amplifier stage incorporating TR₅ and TR₆, which has temperature compensation provided by D₁, and then on to the 25Ω speaker via C₁₇.

To prevent instability due to a.f. feedback in the circuit, decoupling network C₁ and R₁₆ is interposed between the output and the preceding stages, R₁₆ appearing in the positive supply line. To prevent r.f. instability, the earlier stages are also decoupled by C₂. It is necessary to employ a non-electrolytic capacitor across C₁ because, due to its form of construction, an electrolytic capacitor offers a relatively high impedance at radio frequencies. C₁ bypasses audio frequencies whilst C₂ bypasses radio frequencies.

(To be concluded)

Transformerless Code Practice Oscillator

by

W. KEMP

A simple little morse oscillator which can be built up on a piece of Veroboard measuring 1in by 1½in. This project will be particularly attractive for the beginner

A NUMBER OF MORSE CODE PRACTICE OSCILLATOR circuits have appeared in technical publications in recent years, but many of these have suffered from the disadvantages of requiring an expensive and possibly difficult-to-obtain transformer in their construction. The unit presented in this article is intended to overcome this difficulty, and to this end employs two low cost transistors in a transformerless circuit. The complete unit is built on a piece of Veroboard measuring 1 x 1½in, and can be built for some fifteen shillings.

The Circuit

The full circuit diagram of the unit is shown in Fig. 1. Here, TR₁ is wired in modified common base mode, with base-bias resistors R₁ and R₂, emitter bias resistor R₄, and collector load resistor R₃. In this mode of operation an input signal is fed to the emitter of the transistor and an amplified version of this signal then appears at the collector. It is important to note that the input and output signals are both in phase.

TR₂ is wired as an emitter follower, with emitter load RV₁, and with its base direct coupled to TR₁ collector. This circuit gives near-unity voltage gain between base and emitter, and has a high input impedance and low output impedance. Also, there



A view of the completed oscillator, with C₁ and C₂ at the left

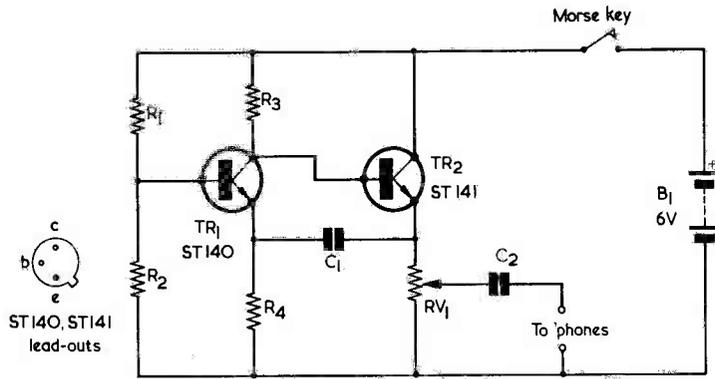


Fig. 1. The full circuit of the transformerless code practice oscillator

is zero phase shift between the input signal at the base and the output signal at the emitter. Thus, it can be seen that if an input signal is applied at TR₁ emitter, an amplified and in-phase version of this signal will be made available at TR₂ emitter.

The basic requirements for oscillation in an electronic circuit are that the output signal of the amplifier should be fed back to the input terminals with zero overall phase shift, and that the overall gain of the system should be greater than unity.

A - drill 6BA clear

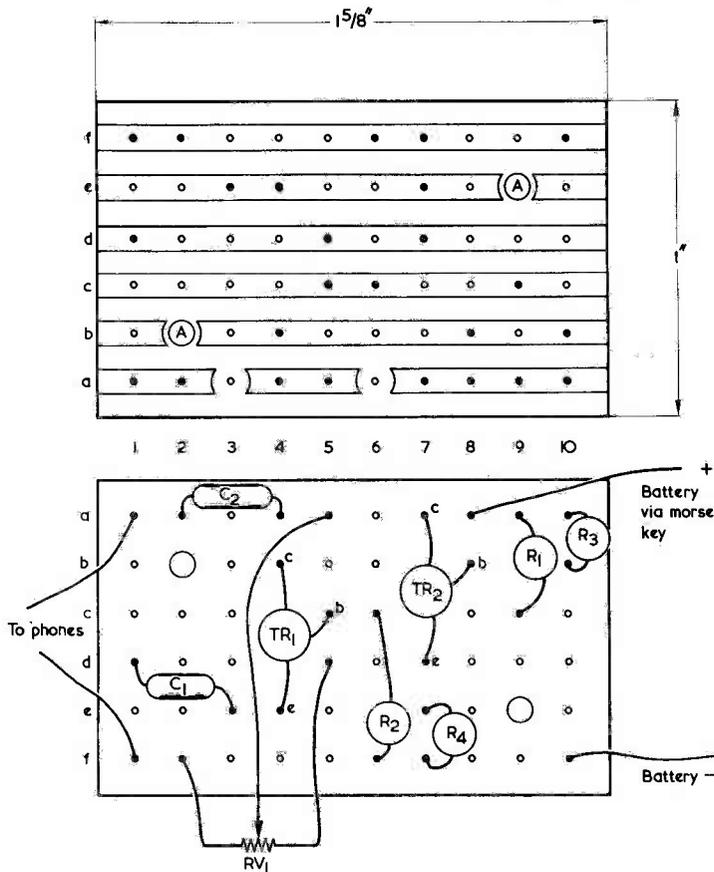


Fig. 2. Assembling the components on the Veroboard. The copper side of the board is shown above, and the component side below

Resistors

(All fixed values ½ watt 10%)

- R₁ 56kΩ
- R₂ 12kΩ
- R₃ 4.7kΩ
- R₄ 1kΩ
- VR₁ 2.5kΩ potentiometer, log track

Capacitors

- C₁ 0.1μF
- C₂ 0.1μF

Transistors

- TR₁ ST140 (Sinclair)
- TR₂ ST141 (Sinclair)

Battery

- B₁ 6-volt battery

Miscellaneous

- Morse key
- Phones (See text)
- Veroboard, 0.15in matrix, dimensions as in Fig. 2
- Solder, wire, etc.

These conditions are met in Fig. 1 by connecting feedback capacitor C₁ between the emitters of TR₁ and TR₂, whereupon the circuit functions as an oscillator.

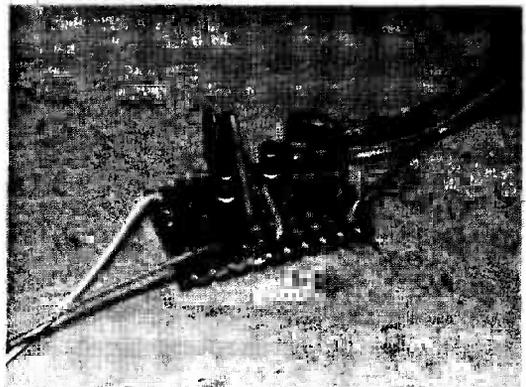
In practice it is found that the circuit generates a sawtooth type of waveform which is very rich in harmonics, and it lends itself readily for use as a code practice oscillator. With the component values shown the circuit operates at a frequency of approximately 2 kc/s. The frequency of operation can be altered, if required, by simply changing the value of C₁, this value being increased to lower the frequency and vice versa.

The output of the circuit is taken from the slider of RV₁, which acts as a volume control, and is fed to the phones or an earpiece via C₂. The phones should have an impedance of 5kΩ or greater, and may be a crystal earpiece, if preferred. Phones with an impedance somewhat below 5kΩ may also be employed quite satisfactorily, the only alteration to circuit operation being that the lower impedance causes the frequency of oscillation to increase above the designed figure. This is of little importance for normal practical work. The oscillator will continue to function even if coupled to phones having an impedance of a few ohms only. The output is not sufficient, incidentally, to drive a speaker adequately.

The morse key is wired in the positive supply line between the battery and the oscillator, so that no current is consumed when the key is not pressed, and a separate on-off switch is thus not required. Battery B₁ is a 6 volt type, and the circuit consumes between 2 and 3mA when operating.

Construction

The major part of the circuit is wired up on a



An alternative view of the oscillator, with R₁ and R₃ at the left

small piece of Veroboard panel with 0.15in hole spacing, and construction should be started by cutting this panel to size and drilling the two small mounting holes, to clear 6BA screws, as shown in Fig. 2. Now break the copper strips, with the aid of a small drill or the special cutting tool that is available, where indicated.

All components and leads should now be soldered in place on the plain side of the panel, as shown in Fig. 2. All the components are mounted vertically, and insulated sleeving should be used where there is any danger of lead-outs short-circuiting against one another. Variable resistor RV₁ is connected to the panel via three flexible leads.

When assembly is complete, connect the phones to the output leads, and the 6 volt battery to the supply lines via the morse key. Press the key, and check that a tone signal is heard. The volume of the tone can be adjusted via RV₁. The unit is now complete and ready for use.

If required, the panel can be mounted on a chassis by drilling two holes in the chassis to line up with the mounting holes in the panel, and then securing the two parts together with the aid of 6BA screws. Two small rubber or p.v.c. grommets should be interposed between the panel and the chassis, under the Veroboard mounting holes, to act as shock-absorbing spacers and insulators. An advantage given by fitting the unit to a small chassis is that the latter offers a convenient mounting for RV₁. If the board is mounted in this fashion, care should be taken to ensure that copper strips E1 to E8 and B3 to B10 do not short-circuit against the securing screws; this possibility may be obviated by removing the copper immediately adjacent to the screw holes.

Using The Unit

When attempting to learn the morse code, the novice should try to learn to recognise the sound of each letter and number, rather than remember it as so many dots and so many dashes. For example, the letter V should be remembered as "di-di-didah", rather than as "dot-dot-dot-dash".

Full information on the morse code and allied subjects will be found in *The Radio Amateur Operator's Handbook*, available from Data Publications, Ltd. at 5s. plus 5d. postage.



The 'Spontaflex' Transistor Short Wave Receiver

by Sir Douglas Hall, K.C.M.G., M.A. (Oxon)

Although this short wave receiver employs few components and its construction is relatively simple, it offers outstanding results from 1.25 to 15 Mc/s (or higher if a high-gain transistor is employed in the second stage). The design is based on the author's "Spontaflex" circuit and reflexing takes place over all stages to obtain maximum gain from a minimum number of transistors. An idea of the ingenious reflex operation employed is given by the fact that the headphone output is taken from the same emitter that the aerial is applied to!

SOME TIME AGO THE AUTHOR described a short wave receiver which used the "Spontaflex" circuit and provided 6 stages with 3 transistors.* Some readers have obtained remarkable results with this receiver, but several have asked for modifications to allow the 80 and 160 metre bands to be received,

and it has also appeared from correspondence that many prefer to use headphones for short wave listening, rather than a loudspeaker for which the earlier circuit was designed. The receiver to be described is a considerably modified version of the first five stages of the earlier receiver. It covers from well below 20 metres to the lower part of the medium wave band without coil changing, a simple switch

*The Radio Constructor, March 1966, page 493. — Editor.

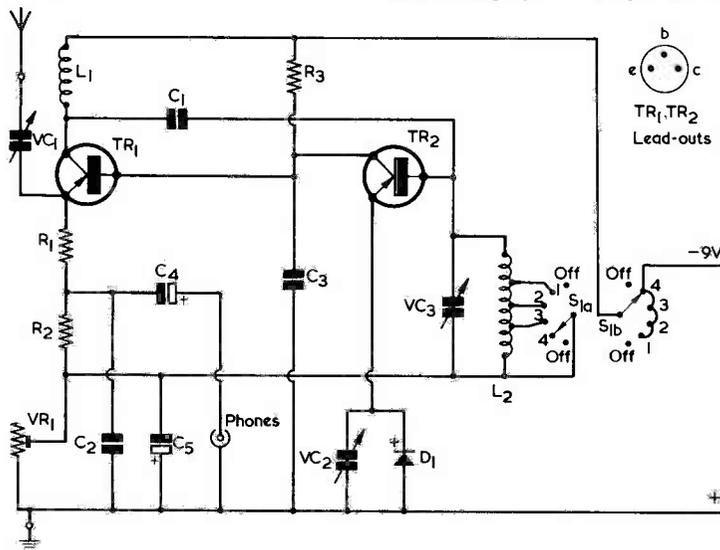


Fig. 1. Circuit diagram of the DRC2 reflex 4-band short-wave receiver

COMPONENTS

Resistors

(All fixed values $\frac{1}{4}$ watt 10%)

- R₁ 330 Ω
- R₂ 3.9k Ω
- R₃ 22k Ω
- VR₁ 500 Ω potentiometer, preset

Capacitors

- C₁ 22pF
- C₂ 0.1 μ F
- C₃ 0.0015 μ F
- C₄ 100 μ F electrolytic, 9V wkg.
- C₅ 100 μ F electrolytic, 3V wkg.
- VC₁ 100pF variable, solid dielectric (Wavemaster)
- VC₂ 100pF variable,

"Dilecon", Cat. No. 3006 (Jackson Brothers)
 VC₃ 100pF variable, air-spaced, Eddystone, Cat. No. E585 (Home Radio)

Inductors

- L₁ 2.5mH r.f. choke (Repanco)
- L₂ See text

Semiconductors

- TR₁ MAT101 or MAT121
- TR₂ MAT101 or MAT121
- D₁ OA81

Switch

- S₁ 2-pole, 6-way, miniature rotary

Phones

- Headset type DLR5 (Henry's Radio)

Dial Drive

- Vernier dial, Model T501 (Henry's Radio)

Plugs, Sockets

- Phone jack plug (see text) and socket
- Aerial socket
- Earth socket
- Battery connector clips

Battery

- 9-volt battery type PP7 (Ever Ready)

Miscellaneous

- 3 pointer knobs
- Tagboard
- Plywood, Paxolin, connecting wire, etc.

providing 4 wavebands. The output is suitable for DLR5 headphones, which are cheap, good, and readily available. These will be found to give excellent results—far better than are provided by a small magnetic ear plug which can, however, be used as an alternative. The name DRC2, incidentally, stands for “Double Reflex Colpitts 2”.

Colpitts Reaction

The use of a Colpitts reaction circuit has two advantages. First, it makes the coil unit and switching very simple as there is only one winding; second, it automatically provides the exact degree of coupling which is most efficient for reaction purposes at high frequencies for any transistor which may be used, a far simpler process than trying out different sizes of reaction winding in a 4-band unit.

However, this form of reaction with the “Spontaflex” circuit is not suitable for wavelengths greater than about 240 metres as the internal self-capacitances at longer wavelengths do not allow for efficient regeneration. Also, with this particular circuit avoidance of positive feedback at audio frequencies depends on L_2 having a very low impedance at such frequencies, and any attempt to cover the rest of the medium waveband with a larger inductance will probably result in audio frequency instability.

The high frequency limit is determined by the characteristics of TR_2 as a common collector amplifier, and the 16 metre band (18.7 Mc/s) is somewhere near the limit. In other words, the wavebands offered represent the maximum capabilities of the circuit.

If we examine the passage of a signal through the circuit shown in Fig. 1 we see that the aerial is coupled through VC_1 to the emitter of TR_1 which acts as a common base high frequency amplifier. The amplified output at the collector of TR_1 is applied to the base of TR_2 through C_1 , and TR_2 , which is a “Spontaflex” amplifier, provides radio frequency amplification by the common collector mode. Demodulation takes place by means of D_1 , and TR_2 then acts as a common base audio frequency amplifier, the amplified signal being taken from the collector of TR_2 straight to the base of TR_1 , R_3 forming the collector load. Finally, TR_1 provides low frequency amplification in the common collector configuration, the output being at the emitter and applied across a pair of comparatively low impedance headphones. Reaction is provided by VC_2 . At first it might

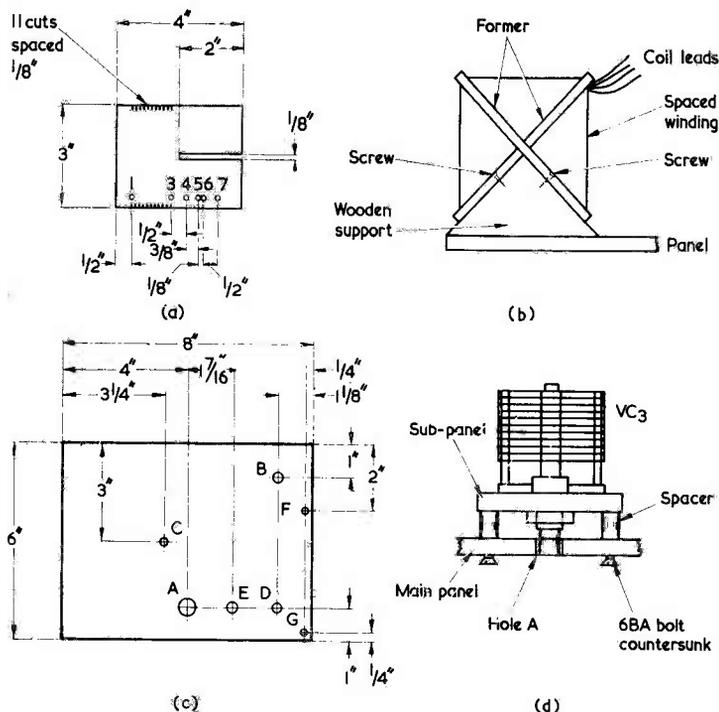


Fig. 2 (a). Detail showing one of the two pieces of Paxolin which make up the coil former
 (b). The former assembled and mounted on its triangular wooden supports
 (c). The front panel, seen from the rear
 (d). Tuning capacitor VC_3 is mounted on a small sub-panel, spaced back from the front panel

appear that this component would tend to bypass high frequency signals to earth, but in fact it provides a capacitive tap into the tuned circuit in conjunction with internal self-capacitance in TR_2 . Reaction is increased as the capacitance of VC_2 is increased.

The behaviour of TR_1 as the first stage—as a common base high frequency amplifier—is interesting. It is generally assumed that common base amplification is less efficient than common emitter amplification and in most practical cases this is undoubtedly true. But common base amplification depends on a number of factors, amongst which are the impedance offered by the output load, and the impedance of the input source. Amplification increases with an increase in load impedance and with a decrease of source impedance. In practice the ideal load conditions are impossible to realise. One cannot design a source to have negligible impedance, and in any case the output impedance of the transistor is lowered as the source impedance is reduced and consequently there is a damping

effect on the output load. What is gained by lowering the impedance of the source can be offset, to some extent, by a resultant lowering of the impedance of the output load.

In Fig. 1, the source impedance is R_1 in parallel with that offered by the aerial, and at the fairly high frequencies which this circuit is designed to receive, this impedance is low if VC_1 is near its maximum capacitance. The output load of TR_1 which is the tuned circuit, has its impedance artificially raised by the application of reaction, so that the damping of the output load, due to the small source impedance, is cancelled out. In these conditions—tight coupling of the aerial and critical setting of reaction—the amplification given by TR_1 is extremely high. A practical indication of what has been described is given by the need to slacken off reaction as VC_1 is adjusted for greater capacitance, (at all frequencies lower than about 15 Mc/s). This is because the increased amplification provided by TR_1 produces some additional reaction effects due to capacitances in the wiring, etc.

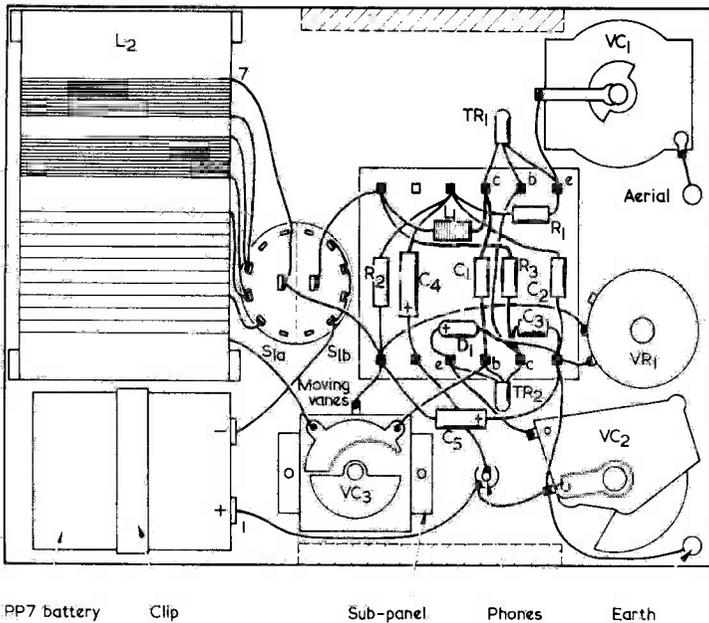


Fig. 3. All components are mounted on the front panel, the layout and wiring being as shown here

It may even happen, on certain wavebands where the natural frequency of the aerial is such as to produce a very low impedance at the frequency to which the receiver is tuned, and especially if an earth is used, that the receiver will oscillate with the vanes of VC₁ fully enmeshed, even if the vanes of VC₂ are fully open. In this event, matters can be put right by opening the vanes of VC₁ a little.

An earth connection has not been found essential with the prototype, which has proved to be free from hand and body capacitance effects with several different aerials even when no earth is used. However, it is always possible that these effects will prove troublesome in some cases, and an earth will improve efficiency considerably, particularly at frequencies below 5 Mc/s. If an earth is used it will often be found necessary to turn VC₁ a long way anti-clockwise towards minimum capacitance—sometimes, possibly, fully anti-clockwise—in the interests of selectivity.

VR₁ is a preset control adjusted so that the current passing through TR₂ is such as to provide maximum efficiency at the highest frequencies for which the circuit is designed. It should be adjusted for best results on the 16 or 19 metre bands, and then forgotten.

Construction

It is suggested that construction

should start with the coil. First, a piece of 1/4 in Paxolin, or similar, is cut out as in Fig. 2 (a). A second piece of Paxolin is also required, this having the same dimensions and the same cuts made in the edges, but holes 1 and 3 to 7 (there is no

hole 2) are not required, and the 2 by 1/4 in slot should be made from the opposite end. These two pieces are then fitted together to make a former with an X section. Two pieces of 1/4 in wood, triangular in shape, are next formed by cutting a 1 1/4 in square across a diagonal. These are screwed into position as shown in Fig. 2 (b), appearing at opposite ends of the former. The position of these two pieces of wood should be such, that, looking at one end of the former, hole 1 is at the top right hand side, and looking at the other end, hole 7 is at the top left, the coil standing on the two long sides of the triangular pieces of wood. Fig. 2 (b) is a view from the end nearest hole 1, and shows the edge from which the coil leads are taken (these being anchored at the holes already drilled). Four new holes in the Paxolin are needed for the wood screws which secure the former to the triangular wooden pieces, and the latter should be fitted flush with the ends of the former. The long ends of the two triangular wooden pieces are later fitted to the receiver panel by adhesive (or any other convenient method).

Enamelled 32 s.w.g. wire is used for the coil, and 11 turns are first wound on (with a tap after the fourth turn), starting at hole 1 and ending at hole 3. The windings are held in position by the shallow cuts on the former, which provide 1/4 in

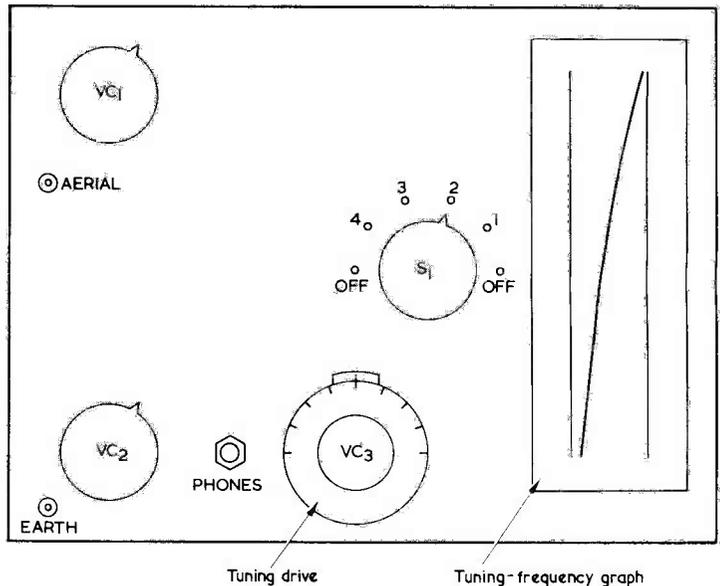


Fig. 4. Front view of the panel, showing the controls and the tuning-frequency graph

spacing. A few inches of wire should be left at each end for connections, and the ends may be locked in the holes using shortened match sticks as plugs. At the end of the fourth turn, counting from hole 1, the wire is bared and a lead soldered to it. This is lead No. 2. Next, starting at hole 4 and ending at hole 5, 12 turns are wound on with the turns touching (close-wound) and, starting at hole 6 and ending at hole 7, 15 turns are wound on, similarly close-wound. The leads are identified by the numbers of the holes through which they pass. The coil is now complete.

A panel should be cut as in Fig. 2 (c) using $\frac{1}{4}$ in plywood. Hole A should be $\frac{1}{2}$ in; holes B, C and D, $\frac{3}{8}$ in; hole E of a size suitable for the phone socket; and holes F and G to take sockets chosen for the aerial and earth connections. Components should then be mounted as shown in Fig. 3, L_2 and VR_1 being secured in position with adhesive or any other suitable means. VC_3 is not mounted directly to the panel, but on a small plywood sub-panel as in Fig. 2 (d) so that the spindle just passes through the hole A in the main panel. This will allow for the fitting of the slow motion drive specified. In the prototype the tag-board is home-made using a small piece of Paxolin and individual solder tags. But its dimensions, $2\frac{1}{2}$ by $2\frac{1}{4}$ in, are approximately the same as those of the Radiospares Standard 6-way tagboard which may, of course, be used instead. A tin plate clip should be devised to hold the battery in position. As the receiver takes less than 2mA a smaller battery may be used, but the PP7 specified fits neatly in the position available for it.

Although they both have the same value and are solid dielectric types, the Components List quotes two different makes for VC_1 and VC_2 , the capacitors specified having terminal positions which allow short wiring to be given. Apart from the question of terminal positioning it is essential in any case to use a Jackson "Dilecon" capacitor in the VC_2 position, because the law of its plates eases reaction adjustments. Although the spindle and mounting bush of VC_1 are at r.f. aerial potential, no harm results from mounting this component direct to the wooden panel. Some constructors may prefer to isolate its bush with insulated mounting washers, but this was not found to be necessary with the prototype.

The plug fitted to DLR5 phones is rather large, and most constructors will prefer to fit a smaller one. The

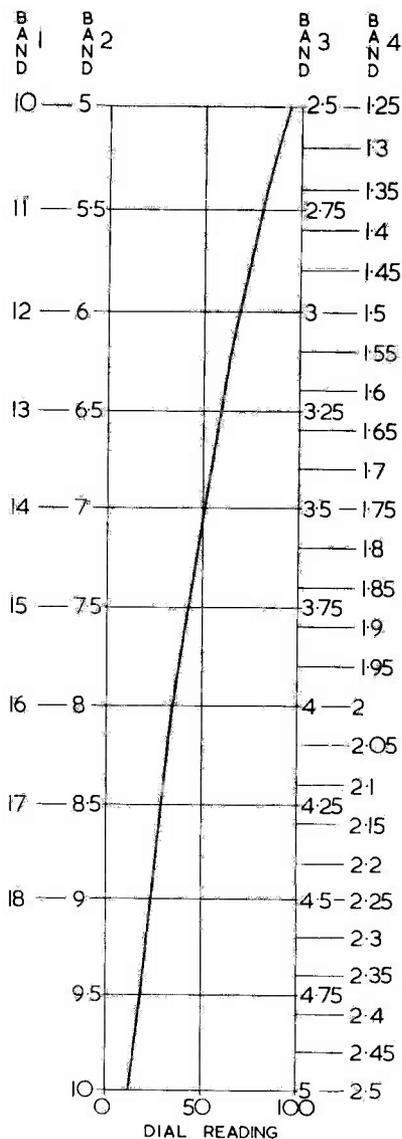


Fig. 5. Graph showing VC_3 dial readings at different frequencies (in Mc/s) in the four wavebands covered. This is reproduced full size and may be cut out or traced

matching socket is fitted to hole E (Fig. 2 (c)).

As will be seen, all components are mounted direct to the panel. A front view of the panel is given in Fig. 4. The shaded rectangular sections in Fig. 3 are 3 in long and it will be found helpful to fit small $3 \times 2\frac{3}{4}$ in pieces of plywood, $\frac{1}{4}$ in thick, to these points. The receiver can then be stood, panel upwards, on these pieces of wood during testing and similar work. However, since the coil can be damaged quite easily the set should be finally fitted

in a simple box. Internal dimensions of the box will need to be about $8 \times 6 \times 3$ in.

Operation

The receiver can be used on any aerial, though a few yards of wire across the room is all that is needed and is, indeed, recommended. The aerial should approach the receiver from the side on which its socket is placed. It should not pass near the coil.

With S_1 fully clockwise, the receiver is switched off. Turning the

switch anti-clockwise brings in Bands 1 to 4, in that order, with a further off position when the switch is fully anti-clockwise. With the vanes of VC₃ nearly open oscillation will start with VC₂ turned only a short way clockwise. Enmeshing the vanes of VC₃ to increase wavelength may require a gradual increase in the capacitance of VC₂ to produce oscillation, though on Band 4 (1.25 to 2.5 Mc/s) the reverse may hold. It is advisable, when searching a band, to turn VC₁ to the half-way position and, starting with VC₂ fully open, turn it clockwise gradually until a slight hiss, or a whistle if a signal is present, signifies the oscillation point. Reaction is so smooth that it is easy to pass the oscillation point and wonder why no signals can be received. On receipt of a signal, VC₁ can be opened, if interference is present,

or closed if the signal is weak but without interference. In either event, some adjustment of VC₂ may then be necessary, as already described, and perhaps a touch on the tuning control. C.W. signals are best received with the receiver just oscillating.

In order for best results to be obtained at the high frequency end of Band 1, TR₂ should be a high amplification specimen. Experiments showed that transistors near the minimum amplification tolerated by the makers would not oscillate at frequencies higher than about 15 Mc/s though any with an amplification factor of 120 or over would give good results up to 18 Mc/s. If reception is poor at the high frequency end of Band 1 it is worth while trying the effect of changing TR₁ and TR₂ over, the better transistor being used for TR₂.

It is possible that slightly improved results will be given if MAT121's are used instead of MAT101's, but with the prototype it appeared that gain was the more important parameter.

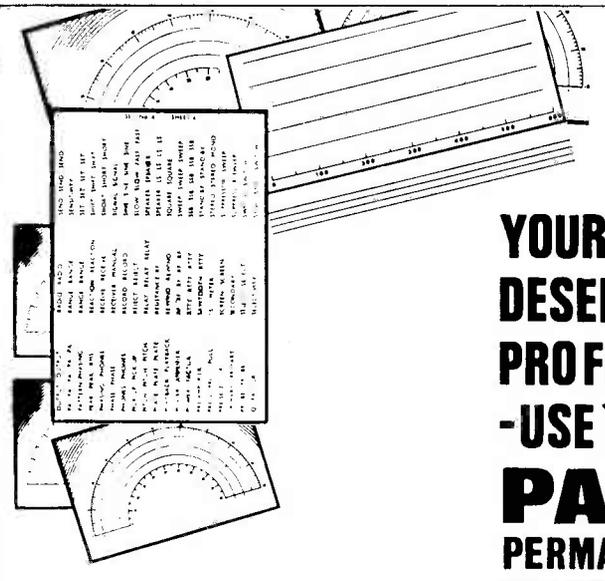
The coil is so designed that the frequency tuned at any dial setting on Band 3 is twice that at the same setting on Band 4. On Band 2 it is twice that at the same setting on Band 3 and, similarly, on Band 1 it is twice that on Band 2. There are, of course, small errors, which are bound to creep in, but a single graph with four scales, as shown in Fig. 5, provides accuracy to within 4% on all bands with the prototype. It is suggested that Fig. 4 be traced off and the result pasted on the blank space on the panel above the coil. The graph will only be accurate, of course, if the specified tuning capacitor and tuning drive are used.



Winner of Eddystone Prize Announced

Bruce Taylor, a 25-year-old student at Edinburgh University, is winner of the Eddystone Radio essay competition, which the firm organised earlier this year, among radio enthusiasts all over Britain. Mr. Taylor, who is currently engaged on PhD work, is an active radio 'ham' and wins a high performance EA12 Eddystone communications receiver, worth £185. He received from the judges high praise for an essay describing a new approach to radio receiver design. Each competitor was asked to write an essay of not more than 1,500 words on one of four subjects.

One of the three judges was Professor Roger Jennison, Director of the Electronics Laboratories at the University of Kent, winner of a similar Eddystone competition when he was a student at Manchester University. The receiver was handed to Bruce Taylor, GM3NZI, at a presentation at Eddystone works, when the Company marked the occasion by announcing a new v.h.f. receiver. Also present were the other judges, T. P. Douglas (G3BA) and H. A. Bartlett (G5QA).



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IN LAST MONTH'S ARTICLE WE INTRODUCED THE subject of negative feedback and saw how this may be applied to an audio frequency amplifier by connecting a fraction of the output signal voltage in series with the input signal voltage. We now continue with this subject. In the present article we shall be referring to the application of negative feedback to a.f. amplifiers, but it should not be forgotten that negative feedback may also be applied, with equally beneficial results, to other classes of amplifier working at the lower frequencies.

Gain Reduction

It will be helpful, before proceeding further, to briefly recapitulate the points which were made last month. It will be recalled that we first introduced a simple a.f. amplifier, represented here in block form by Fig. 1 (a). In this diagram, the plus and minus signs at the input and output terminals indicate signal polarity during one half-cycle of the input signal. In Fig. 1 (b), resistors R_1 and R_2 are introduced across the output terminals, the fraction of the output voltage appearing across

the overall gain with feedback tends towards a constant figure despite the fact that the gain of the amplifier without feedback may vary considerably. The tendency towards a constant overall gain figure is most pronounced when the gain without feedback is high and a relatively large fraction of the output voltage is fed back to the input.

A typical form of distortion in an a.f. amplifier occurs when some frequencies are given greater amplification than others. Applying negative feedback to such an amplifier causes the overall gain at all frequencies to tend towards a constant figure, with the result that the amplifier exhibits a smoother frequency response characteristic. That is to say, whereas a curve showing amplifier gain at various frequencies might exhibit pronounced peaks or troughs before feedback was applied, the overall gain curve after feedback has been added would be smoother and "flatter".

Harmonic Reduction

In addition to improving the frequency response of an a.f. amplifier, negative feedback may also

UNDERSTANDING RADIO

Negative Feedback

$$f = \frac{1}{2\pi\sqrt{LC}}$$



by W. G. Morley

R_1 being inserted, in anti-phase, in series with the input signal voltage. To achieve the same output voltage, the input signal has now to be increased by an amount equal to the amplitude of the fraction of the output signal which is developed across R_1 . If the fraction of the output voltage appearing across R_1 is n , and the voltage gain of the amplifier on its own (as in Fig. 1 (a)) is A , then the overall gain in Fig. 1 (b) is A divided by $(1 + nA)$. We referred to $(1 + nA)$ as the *feedback factor*.

We were next able to deduce that, if the product of n and A is large, the overall gain in Fig. 1 (b) is always nearly equal to $\frac{1}{n}$ regardless of the actual gain of the amplifier without feedback. As an example we assumed n to be $\frac{1}{20}$ and showed that for $A=2,000$ we have, with negative feedback, an overall gain of 19.8. With $A=1,000$ and 500, the overall gain figures with negative feedback were 19.6 and 19.2 respectively.

It follows from this that one of the results of applying negative feedback to an amplifier is that

reduce the effects of distortion introduced by the amplifier itself.

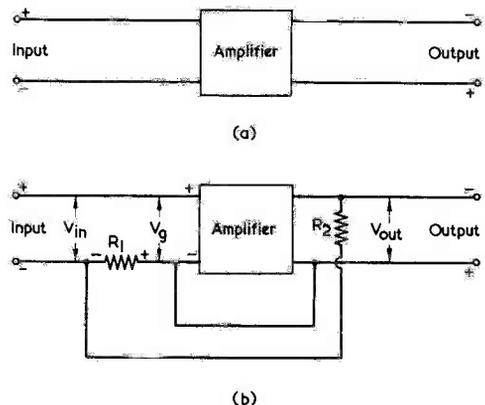


Fig. 1 (a). A simple amplifier, illustrated in block form (b). The amplifier of (a) with negative feedback added

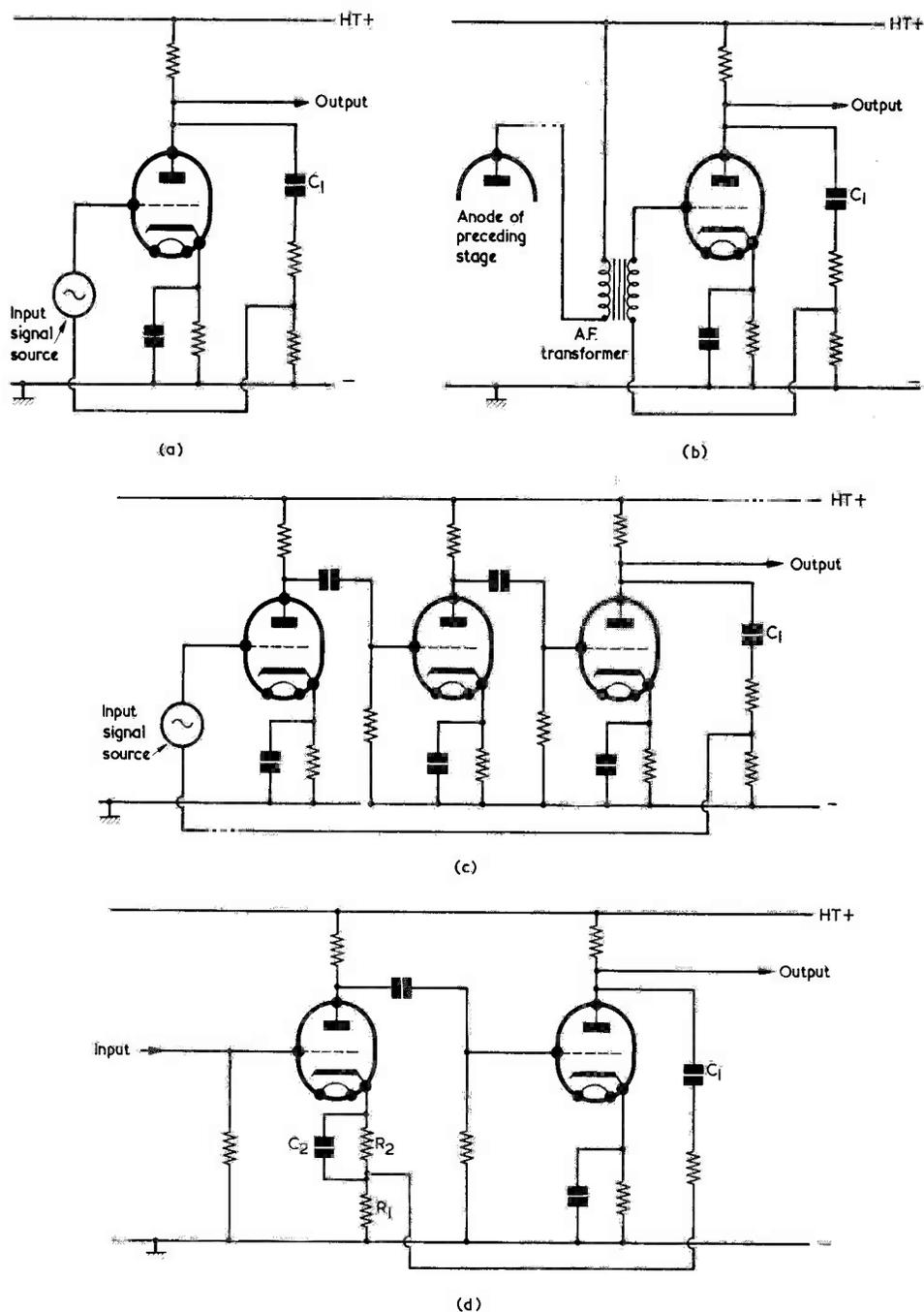


Fig. 2 (a). Applying negative feedback over a single amplifying stage

(b). For the circuit of (a) to be practicable, the preceding valve has to be coupled to it via an a.f. transformer

(c). Feedback from an anode to a preceding grid may also be applied over three valves

(d). When feedback is from anode to cathode, an even number of valves should appear in the loop

Let us assume that the amplifier of Fig. 1 (a) introduces a certain amount of distortion and that we apply a sine wave signal to its input terminals. We will then obtain an amplified, but distorted, sine wave at the output terminals. The distorted output will, in fact, consist of the original pure sine wave plus a number of harmonics of that sine wave.

In Fig. 1 (b) we introduce negative feedback and apply a fraction of the output signal in series with the input signal. The sine wave fed back to the input circuit is in anti-phase with the input signal, and there is a reduction in the overall gain of the sine wave following the lines we have already described. With the harmonics introduced by the amplifier, however, the effect is somewhat different because such harmonics were not present in the original signal. What the negative feedback circuit is, in effect, doing here is to inject into the input of the amplifier a series of harmonics which are opposite in phase to the harmonics created in the amplifier itself. The result is that the harmonics resulting from distortion in the amplifier tend to be very nearly cancelled out, and the amplifier output consists of the original pure sine wave together with a lower harmonic level than was evident before negative feedback was applied. It can be shown that the harmonic level is reduced due to negative feedback by the same ratio as is the amplifier gain. Thus, if the amplifier without feedback has a gain of 1,000, and the feedback has resulted in an overall gain of 20, the harmonics introduced by distortion will be reduced 50 times. If the harmonic distortion was 5% before feedback was added, after feedback it becomes 0.1%. It is important to note that this ratio of reduction in harmonic distortion applies for the case where the same output voltage is given with feedback as was previously given without feedback.

By the same reasoning, it may be seen that other spurious signals generated in the amplifier are also reduced by the application of negative feedback. The spurious signals normally encountered are hum (due to inefficient mains supply filtering circuits and unwanted couplings between the amplifier circuits and mains power supply wiring and components) and noise. Noise is mainly generated in valves and resistors, and appears as a hiss in the output of the amplifier.¹ Negative feedback reduces hum and noise generated in the amplifier by the same amount as it reduces harmonic distortion due to the amplifier. As with harmonic distortion, this relation holds true when the output voltage is the same after the application of feedback as it was before.

Yet a further advantage provided by negative feedback is that it helps to stabilise the performance of an amplifier. Since the gain given with feedback tends towards a constant figure regardless of the

gain offered without feedback, it follows that variations in performance due to valve ageing, different component values within tolerance, and the like, will have less effect on overall performance when negative feedback is applied.

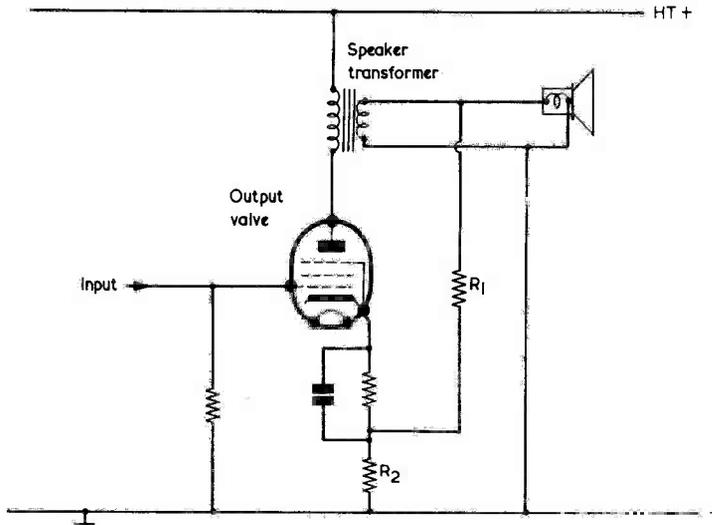
Output Power

Negative feedback confers a number of important advantages, and these are of particular value in a.f. amplifiers which are intended for good quality or high fidelity reproduction. The main disadvantage of negative feedback is that the overall amplification is reduced. Indeed, negative feedback offers the greatest improvements in performance when the gain without feedback is considerably higher than the gain with feedback. For best results, negative feedback has to cause a *large* reduction in overall gain.

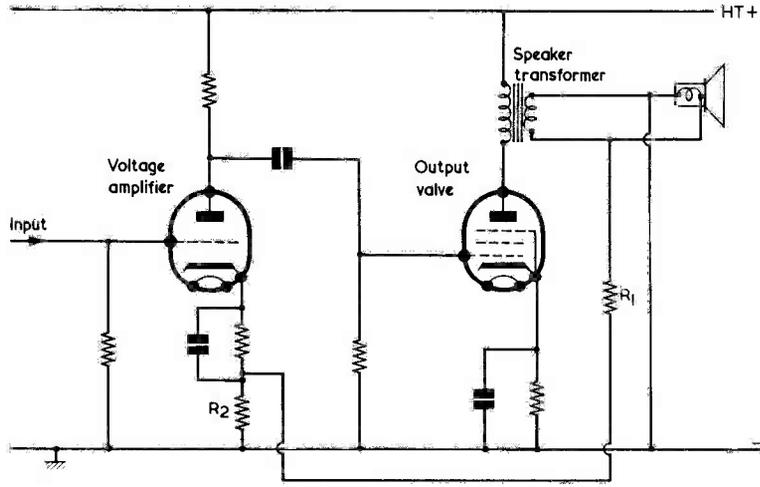
In practice, this loss in gain is not a great inconvenience because it is possible to obtain a high level of gain before feedback is applied by means of voltage amplifier stages, and voltage amplifier stages are relatively inexpensive in terms of valves, components and h.t. supply requirements. The most expensive stage in an a.f. amplifier is normally the output stage, which requires a power valve (or valves), the output transformer and a high h.t. supply current. An output stage offering an output power approaching the maximum of which it is economically capable introduces considerably more distortion than does a voltage amplifier stage. Also, as we have seen in recent articles, the distortion introduced by an a.f. output stage increases with output power. If we were to avoid the use of negative feedback, one method of obtaining a low distortion output would consist of employing an output stage capable of providing considerably more output power than we actually intend to use. Such an output stage would, however, be very uneconomical in terms of valves, components and h.t. supply requirements. A much cheaper method of obtaining a low distortion output at the required power would consist of using an output stage working near its economic maximum and applying negative feedback from the output back to a preceding voltage amplifier. We would then obtain the same output power as without feedback but at a much reduced distortion level, and all we would lose would be the gain provided by a low-cost voltage amplifier stage.

Domestic valve radios and television receivers either have no negative feedback circuits or, at best, provide only a low level of negative feedback in their a.f. amplifying stages. This is because equipment of this nature is manufactured at highly competitive prices which do not permit the inclusion of voltage amplifier stages whose gain is to be largely cancelled out by negative feedback. For most people, the standard of reproduction without feedback given by equipment of this nature is considered to be acceptable. On the other hand, high quality and high fidelity reproducing equipment, which is not subject to quite the same stringent price limitations, may incorporate a number of

¹Noise due to valves and resistors is mainly troublesome if they appear in an early stage of the amplifier, whereupon there is a high level of subsequent amplification. To help in reducing noise, special low-noise valves are available, as also are high-stability resistors. The latter offer a lower noise level than do the normal composition types.



(a)



(b)

Fig. 3 (a). A feedback loop which includes the speaker transformer. As in Fig. 2 (d), the feedback is applied to a cathode circuit

(b). Negative feedback applied to the cathode of a voltage amplifier preceding the output stage

voltage amplifying stages whose gain, due to the use of negative feedback, is partly or completely nullified.

Feedback Circuits

In Fig. 1 (b) we applied negative feedback from the output to the input of an amplifier, the latter being shown in block form. This diagram demonstrates *voltage feedback* because it is a signal voltage which is fed back. An alternative type of negative feedback involves the feeding back of an output current, and is known as *current feedback*. Current

feedback is not employed in quite the same way as is voltage feedback, and we shall discuss it in more detail in a later article.

Another term which needs to be introduced at this stage is *feedback loop*. This term applies to the composite amplifier from the input terminals to the output terminals and then back to the input again via the feedback circuit.

Some voltage feedback circuits appear in Fig. 2. Fig. 2 (a) shows a circuit following the same basic principles as Fig. 1 (b). Here, a fraction of the signal voltage at the anode of the valve is fed

back via capacitor C_1 (assumed to have negligible reactance at a.f.) so that it is in series with the source of input voltage, which is depicted as an a.c. generator. Since the voltage at the anode is out of phase with the input signal, the circuit gives negative feedback. This circuit suffers from the practical shortcoming that neither side of the source of input signal is at chassis potential. It would be impossible to precede the circuit with a voltage amplifier stage having a common chassis connection unless an a.f. transformer were used for coupling, as in Fig. 2 (b). Since an a.f. transformer is liable to introduce more distortion than resistance-capacitance coupling, the circuit of Fig. 2 (b) is not very attractive. Nevertheless, it has the merit of illustrating basic principles, and we shall give it a little further consideration before passing on to other feedback circuits.

The circuit of Fig. 2 (a) is useful if one amplifying valve appears in the feedback loop, as occurs in the diagram, or if three valves in cascade appear in the loop, as in Fig. 2 (c). With three valves the feedback would still be negative since each valve provides 180° phase reversal of the signal. If feedback of this type was attempted with two valves, however, the feedback would be positive. Thus, feedback of the type shown in Figs. 2 (a) and (c) may only be applied over an odd number of valve amplifying stages.²

In Fig. 2 (d) there are two valves with resistance-capacitance coupling, and feedback is provided via C_1 (which has negligible reactance at a.f.) from the anode of the second valve to the *cathode* of the first. R_1 , in this diagram, has a value lower than the normal cathode bias resistance required by the first valve, this resistance now being given by R_1 plus R_2 . C_2 is a normal cathode bypass capacitor. The fact that the feedback in Fig. 2 (d) is negative may be ascertained by seeing what occurs when, for instance, the grid of the first valve goes positive. This causes its anode to go negative and the anode of the second valve to go positive. The cathode of the first valve then goes positive also, reducing the grid-cathode voltage change due to the initial positive-going input signal and thereby providing negative feedback. A feedback circuit of the type

shown in Fig. 2 (d), where the anode signal is fed back to a preceding *cathode*, may only be employed with an even number of valves. If an odd number of valves were used, the feedback would become positive. It will be noted that the circuit of Fig. 2 (d) allows the preceding amplifying stage to share a common chassis connection.

Fig. 3 shows voltage feedback circuits in which the speaker transformer appears in the feedback loop. A single valve output stage is assumed.

A great advantage conferred by having the speaker transformer in the feedback loop is that the phase of feedback may be reversed, if required, by merely transposing the connections to the speaker transformer secondary. The feedback loop can then accommodate either an even or an odd number of stages. A further advantage is that the output voltage at the transformer secondary is available at a low impedance and can be readily applied back to an earlier cathode circuit, which will exhibit a much higher impedance. Also, the negative feedback will reduce distortion due to the output transformer itself, which now enters the feedback loop.

In the simple feedback circuit shown in Fig. 3 (a) the feedback is applied, by way of R_1 and R_2 , over the output stage only. This circuit offers some improvement over the performance without feedback, but the full benefits which can be given by negative feedback are not realised due to the relatively low gain available in the single stage before feedback is applied.

In Fig. 3 (b) the feedback is applied over the output stage and a preceding voltage amplifier stage. This circuit is capable of offering a much better performance than that of Fig. 3 (a) because the gain without feedback is considerably higher.

Feedback from the speaker transformer secondary to the cathode circuit of an earlier voltage amplifier stage represents a very commonly used technique in valve high fidelity amplifiers. In such amplifiers the output stage will normally be push-pull, whereupon the feedback is applied to the cathode of a voltage amplifier preceding the phase-splitter. The number of stages in the loop may be catered for by connecting the speaker transformer secondary into the circuit with appropriate polarity.

Next Month

In next month's article we shall continue with the subject of negative feedback.



New International Technical Exhibition For London

Modern manufacturing techniques developed for the production of all kinds of electronic equipment will be featured at a new international exhibition in London.

The International Electronic Production Equipment Exhibition—ELPEX—is to be held at Earls Court, London, in March 1969, presented by Industrial Exhibitions Limited, leading European organisers of international technological shows.

New electronic assemblies, such as integrated and monolithic circuits, have brought into being entirely new methods of manufacture. These include cryogenic and high-vacuum equipment as well as complex chemical processing plant.

International ELPEX will pinpoint the plant, machinery, equipment, tools, materials and services needed in modern electronic manufacture. At the present time, many of the production techniques are in a state of rapidly changing development which will give an urgent sense of topicality to the 1969 show.

In your work -shop



Dick and Smithy are confronted, this month, by a Workshop in which all the repair jobs were cleared out over Christmas. However, the lack of work proves to be a blessing in disguise because it enables our pair to devote their time to the latest batch of hints received from readers.

ADDING INSULT TO INJURY," muttered Dick moodily, "that's what it is!"

"What is?"

"Starting the New Year on a Monday," replied Dick bitterly. "It was bad enough when they moved the Bank Holiday to the end of August. Now, they've started having New Year's Day on Mondays."

"You great buffoon," snorted Smithy irritably, "it's only *this* year that the New Year starts on a Monday. Next year it will start on quite a different day."

Nothing To Do

But Dick's gloom was not to be dispelled by a mere statement of the obvious.

"I don't care," he replied complainingly. "It was New Year's Eve last night, which means that I've had hardly any time at all in the pit. After which not only do I have to make an appearance this morning, but the morning happens to be Monday morning as well. What a way to start a year!"

Smithy sighed.

It was only on infrequent occasions that the effervescent Dick indulged in a mood of gloom, but when such an event took place the cloud of melancholy which enveloped him caused the entire Workshop to be pervaded with a black atmosphere of Stygian impenetrability. Smithy knew from past experience that the only way to dispel Dick's present disposition was to find some constructive activity.

"Well, now," he offered brightly. "Perhaps there's a nice little repair job outstanding that won't cause you too much effort."

"No, there isn't," grunted Dick despondently. "We cleared out all the sets that needed fixing before Christmas."

"Aren't there," persisted Smithy hopefully, "any odd bits of maintenance to do on the test gear?"

"That's been all done, too," replied Dick dejectedly. "Things were quiet in the few days after Christmas and so we got all the outstanding maintenance jobs finished up then. And now there just isn't anything to do at all, mate!"

Suddenly, inspiration came to Smithy.

"Tell you what," he remarked. "How would it be if we started off the New Year with a selection of hints sent in by readers?"

The Serviceman was delighted to see that this suggestion caused a gleam of animation to appear in Dick's eyes.

"Now that," conceded Dick, "isn't a bad idea at all. It seems *ages* since we last had a readers' hints session."

"It is rather a long time," agreed Smithy, opening a drawer in his bench. "Quite a few hints have arrived since the last time, too, so we should have a good selection to deal with."

The Serviceman extracted a sheaf of letters from the drawer and studied them carefully.

"Here's a good one to commence with," he remarked. "It's one of those neat little devices which, at virtually no cost, can offer very reliable service indeed. There's a sketch in the letter, so you'd better come over here and have a look at it."

Dick's low spirits were obviously beginning to dissipate, and it was with some of his normal alacrity that he carried his stool over to Smithy's bench and sat alongside him. He looked with interest at the sketch Smithy showed him. (Fig. 1).

"This," remarked Smithy, "is a very inexpensive fuse alarm which gives an indication immediately the fuse has blown. A medium-sized

safety pin is stretched to a wide-open position and is fixed to an insulated panel with a nut and bolt, using a second nut as a spacer in between. Fuse wire of the required current rating is fastened around the pointed end of the pin and is then taken to the nearby terminal, where it is secured under tension. The circuit to the load is then completed. If the load current rises to too high a level the fuse wire burns out and the pin then springs over to touch a bolt on its other side. This connects the supply to an alarm circuit which can consist of a light bulb, or a bell or buzzer as desired. Incidentally, it doesn't greatly matter if the fuse wire should happen to touch the fixed arm of the safety pin before burning out as this simply reduces its effective length."

"That's crafty, I must say," commended Dick. "You couldn't get a fuse alarm much simpler than that!"

It was quite manifest that Dick had by now completely forgotten his previous depression.

"And here," continued Smithy cheerfully, "is a letter with two hints in it. The first of these will particularly appeal to the experimenter who likes to try out unusual ideas. It makes use of one of those old TV width controls in which the position of the core was varied by a coarse-thread screw and spindle."

"I know the width controls you mean," broke in Dick. "Every now and again the sliding bit which engaged with the thread would stick. You then used to turn the knob like billy-oh and get nowhere!"

"That's the type," chuckled Smithy. "Well, our contributor has found that these old width controls make quite effective hash limiters if they are inserted in series with low impedance a.f. circuits. When connected in series with the speaker leads of a CR100 receiver, for instance, a width control of this type gives better protection against ignition interference on the 21 and 28 Mc/s amateur bands than does the noise limiter built into the set. Its effect can also be varied by adjusting the position of the core. Three separate types of width control of the same basic construction have been tried in this application, and they have all given the same hash suppression effect."

"I suppose," remarked Dick, "that the fairly high inductance of the width control coil offers a high impedance to the pulses given by impulsive interference."

"That would seem to explain how it works," agreed Smithy. "At any

event, the idea of using a width control of this nature for noise suppression is certainly one which is worth experimenting with. I said just now that there were two hints in this letter, so I'll press on now to the second one."

"Is that to do with noise suppression as well?"

"Oh no," replied Smithy. "This second hint falls into quite a different category. Our correspondent discovered, one Sunday morning, that he was out of Rawlplugs on a job which had to be completed without delay. Luckily, he found that standard coaxial cable was a snug fit in a No. 12 Rawlplug hole and so he cut suitable lengths of cable with side cutters and used these instead of the Rawlplugs. He says they made a very sound job indeed. So, if you run out of Rawlplugs, try using some lengths of coaxial cable instead!"

Awkward Nuts

"That's one for the book," grinned Dick. "Our readers certainly have some ingenious ideas for getting out of trouble."

"They have, indeed," said Smithy, looking through the letters. "Here's another letter with two hints in it. The first of these is a simple approach towards the perennial problem of fitting nuts in awkward corners in a chassis. What you do is to initially solder a short length of 18 s.w.g. tinned copper wire to the nut, and then use the wire to manoeuvre the nut on to the screw so that the latter can be tightened up. (Fig. 2). After the nut is in place and tightened up, the wire may then be ripped off or snipped off short. If the wire is soldered on lightly it should pull away pretty easily from the nut. You can use the same idea with a plain washer as well. With steel nuts and washers the wire and solder should pull off completely, leaving a clean surface. This idea can also be used with bolts, the tinned copper wire being lightly soldered to the side of the bolt head before fitting."

"I think," remarked Dick, "that this hint will be of use to me for my next bit of home-constructed gear. Whenever I make up something to my own design, there's inevitably one nut, or one bolt, which turns out to be completely out of reach!"

"You aren't the only one," grinned Smithy. "It happens to the best of us at times. Anyway, the second hint in this letter is also aimed at helping the home-constructor. The idea is to initially make up front panels for new equipment with $\frac{1}{4}$ inch plywood,

which is discarded later. The plywood readily takes ball-pen markings, and the components can be easily mounted on it and checked for position, mutual interference, symmetry, and all the other things which have to be catered for if the finished equipment is to have a truly professional appearance. It doesn't matter at this stage if the mounting holes for some of the panel components have to be re-positioned, and the plywood is easy to drill and cut out. An incidental point mentioned by the reader is that the chips resulting from hole-drilling at this stage have the advantage of being non-conductive! The spindles of potentiometers and other controls can be sawn to length whilst in position on the plywood without fear of damaging paint work or any other finish. Once a satisfactory layout is achieved with the plywood panel, the panel components can then be wired up. Their fixing nuts are next removed and the plywood panel taken off, leaving the components hanging in the wiring. The plywood panel is then used as a template for the metal panel that will finally be employed, all the holes on the metal panel being marked out from the plywood. In this case, best accuracy is given if each hole centre on the plywood is identified by vertical and horizontal lines (Fig. 3), since this eliminates guesswork when marking up the centre of the corresponding hole on the metal panel. Using vertical and horizontal lines in this manner is particularly desirable if some of the holes in the plywood have been elongated in one direction or the other and the correct component mounting bush centre is not immediately obvious from the hole outline. After the metal panel has been marked out from the plywood panel, it is next drilled and painted, after which any transfers or other markings may be applied. The metal panel is then ready for fitting to the equipment and it will have a really immaculate finish."

"Blimey," commented Dick. "Now that really is a useful idea. Particularly when you have a panel on which a lot of components are going to be mounted."

"I couldn't agree more," said Smithy. "Incidentally, there seems to be something missing in this New Year that's just started."

"What's that?"

"Tea, mate," replied Smithy firmly. "My tongue is just about hanging out with all this nattering. I'm beginning to feel a bit peckish, too."

"Are you?" asked Dick, as he

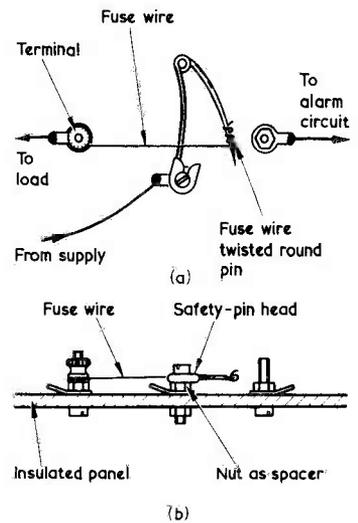


Fig. 1 (a). Top view of the simple fuse alarm. When the fuse wire breaks, the safety pin leg springs to the right and completes the alarm circuit

(b). Side view of the fuse alarm, giving mounting details

walked over to the assortment of cracked and battered utensils which formed the culinary effects of the Workshop, and filled the kettle. "You can have some of my lunch sandwiches if you like."

An avid expression appeared on Smithy's face.

"What sort of sandwiches are they?"

"Turkey sandwiches."

The avid expression failed, to be followed by one of gloom.

"I've brought turkey sandwiches, too," pronounced Smithy resignedly. "So far as I can make out, we've got enough turkey in our house to see us through to the middle of February. I seem to have been eating nothing else since Christmas Day."

"It's the same at my place," commiserated Dick, as he walked back from the sink. "I think our

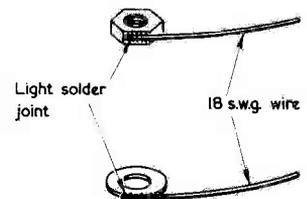


Fig. 2. When a nut or washer has to be fitted in an awkward corner it is often helpful to initially solder a piece of wire to it, this being removed later

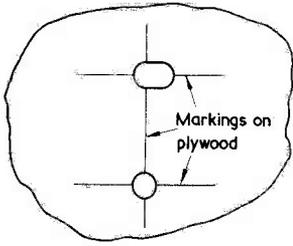


Fig. 3. When using a plywood panel as a template for marking out a metal panel, individual hole centres should be identified by vertical and horizontal lines, as shown here. This eliminates guesswork, particularly if the hole in the plywood has an irregular outline

butcher must have worked a flaming great albatross on to us this year. No domestic bird could possibly keep providing meat three times a day for ever and ever like the one we've got does."

"Breakfast, even?"

"With toast."

Smithy shuddered.

"The trouble with Christmas," he remarked, "is that it goes on for such a long time, both before and after. Oh well, let's have a look at the next hint."

Smithy turned his attention once more to his sheaf of letters.

"Here's a novel idea," he announced, after a moment's examination. "This letter describes a device for bypassing a stage of amplification in valve equipment during servicing. What you do is to insert a valve-holder plug in place of the valve, a capacitor coupling the control grid pin to the anode pin. (Fig. 4 (a)). If the valve you're bypassing is an i.f. amplifier, the capacitor between control grid and anode pins can be of the order of 3 to 5pF. To avoid excessive detuning effects, another capacitor, say 10pF, can be connected between the control grid and the suppressor grid or cathode pin. These values, says our correspondent, give more or less equal results to an EF80 so far as i.f. tuning in the grid and anode circuits is concerned. If the i.f. valve has its heater in a series string then a suitable resistor can be wired between the heater pins of the plug to maintain heater chain continuity. For an EF80, which has a heater voltage of 6.3 at 300mA, the resistor could be a 2 watt wire-wound component of 22Ω. A 'stage-jumper' plug of this type can be very useful for locating a stage which is out of action due to component faults or to overloading

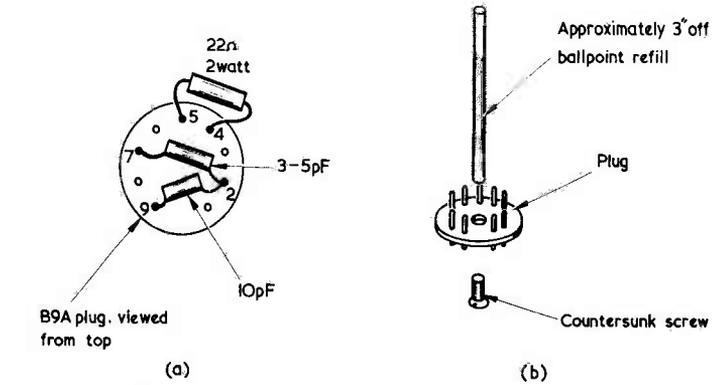


Fig. 4 (a). Wiring up a "stage-jumper" plug assembly. The assembly shown here can replace an EF80 valve, or similar types, in a TV i.f. strip (b). A small handle added to the plug makes it easy to fit and remove

because of a.g.c. trouble. By keeping the cover off the plug, and fitting it with a short handle (Fig. 4 (b)), the

assembly is easy to fit in the valve-holder. A further advantage is that all the potentials on the valve socket

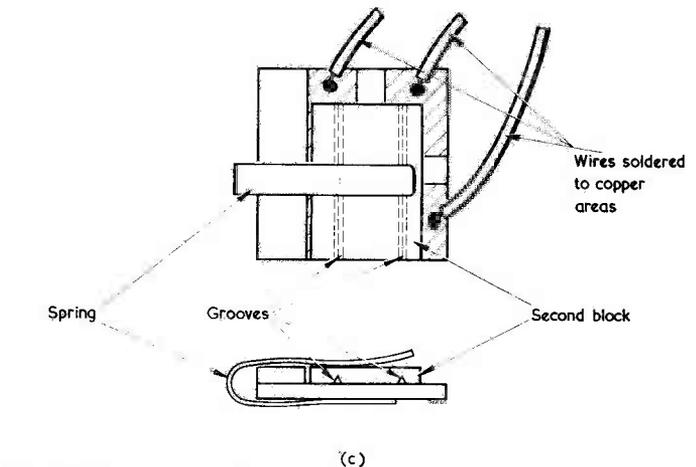
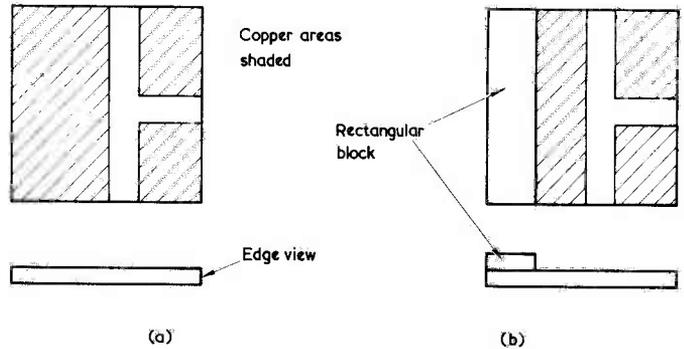


Fig. 5 (a). First step in making up the micro-miniature socket described in the text

(b). A small rectangular block of plastic material is glued to the base (c). A second block, with grooves to accept plug pins, is finally secured to the base with the aid of a spring

then become readily available for checking with the testmeter prods."

"That is an unusual approach," remarked Dick, "and it sounds like a very practical servicing aid, too. I suppose it's necessary to make up a different plug assembly for each valve type you want to bypass in this manner."

"With TV i.f. valves," said Smithy in reply, "you probably wouldn't need a great deal of plug assemblies. For instance, a plug assembly made up for an EF80 would cope with an EF85, EF183 or EF184 stage as well, since all four valves have the same pinning and, so far as rough and ready testing is concerned, fairly similar inter-electrode capacitances as well. Also, all four valves have the same heater voltage and current."

"Perhaps," said Dick thoughtfully, "you could make up replacement plug assemblies for a.f. valves as well."

"Oh, definitely," confirmed Smithy, studying the letter in his hand. "In this case, all you need is an $0.01\mu\text{F}$ capacitor of about 400 working volts between grid and anode pins, together with a suitable resistor across the heater pins. The presence of the resistor across the heater pins won't, of course, cause any trouble with parallel operated heaters, as it will merely draw the same heater current as that of the valve it replaces."

"What about a.f. valves," asked Dick, "which are combined with diodes?"

"You fit a germanium diode to the plug," replied Smithy, "to take the place of each valve diode. A germanium diode might not give exactly the same results in the circuit as the valve diode did, but they will be near enough for checking purposes."

Micro-Miniature Socket

"I must say," remarked Dick warmly, "that we do get some very ingenious wheezes sent in to us."

"We always do," replied Smithy, picking out another letter. "Now, here's a suggestion for making up a micro-miniature socket for an ear-phone output from a receiver. The advantages of the socket are that it is extremely small and flat, and that it can be integral with a printed circuit board or piece of Veroboard. If you're making up the socket as a separate component you would start off with a piece of circuit board having a copper pattern like this."

Smithy indicated to Dick the sketch accompanying the hint. (Fig. 5 (a)).

"You next," continued Smithy,

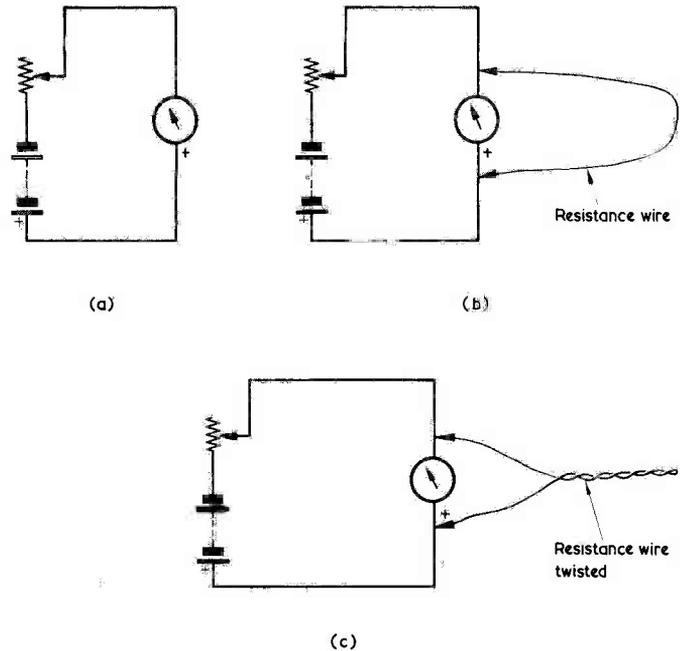


Fig. 6 (a). To make a current-reading meter read 10 to 20 times its present maximum, it is first connected as here. The variable resistor, which should initially insert maximum resistance, is adjusted for an f.s.d. reading

(b). A length of bare resistance wire is next connected across the meter terminals

(c). The resistance wire is then twisted at the mid-point until the desired new meter reading is obtained

"glue a rectangular block of thin plastic to one edge (Fig. 5 (b)), and make up a second block of the same thickness which leaves about $\frac{1}{16}$ in of the base edge and side uncovered for wire connections. (Fig. 5 (c)). The second block has two grooves cut in it to accept plug pins and is held in place by a small spring. To connect to the 'socket' you then simply press two pins along these grooves, whereupon contact is made to the copper sections on the base part."

"I'm a bit puzzled here," said Dick. "There are two bits of copper under one of the grooves instead of one."

"Those two bits of copper," explained Smithy, "form a switch. If you have the correct circuitry, inserting the plug can then switch on the receiver as well."

"Blow me," exclaimed Dick, "that's a knobby scheme! What sort of plug does the socket take?"

"The actual dimensions of the socket and plug," said Smithy, "are left to the constructor. A good approach, for instance, would consist of having two separate plug-pins which would be inserted individually."

Smithy returned the letter to his

bench and picked up another.

"Ah!" he remarked. "Here's another letter with two good hints in it. The first of these is an ingenious method of making up a shunt to cause a current-reading meter to indicate ten or twenty times its existing f.s.d. You start by connecting the meter in series with a variable resistor and a battery, the variable resistor being adjusted so that the meter gives full-scale deflection. (Fig. 6 (a)). You then connect a length of bare resistance wire across the meter terminals, this length being greater than will be needed for the eventual shunt. (Fig. 6 (b)). The next thing to do is to start twisting the resistance wire back on itself at the mid-point. This will reduce the effective length of resistance wire which is in circuit and you keep on twisting until the meter reads one-tenth or one-twentieth of f.s.d., as desired. (Fig. 6 (c)). Solder the twisted section at the end nearer the meter, cut off the excess, and you have a meter shunt—all complete and ready to use—that will multiply meter readings by ten or twenty, exactly as intended."

"That twisting business," said Dick, "is a neat idea. I haven't

heard of reducing the length of resistance wire in that way before."

"Neither had I up till now," admitted Smithy. "Although, like most other things, it's dead obvious once you're told about it! I think I should mention one or two minor points, incidentally. For most accurate results, the battery voltage should be such that the resistance inserted by the series variable resistor is much higher than the resistance of the meter on its own. Also, you're relying on the calibration of the meter at one-tenth or one-twentieth of f.s.d. to indicate when you've got the correct length of resistance wire in circuit. For more accurate results you'll need a second meter in series with the one to which you're adding the shunt, both giving readings near f.s.d. for the desired new current. Nevertheless, the idea as described is more than good enough for most applications and, of course, you only need the single meter which will eventually be used at the new current."

"What's the other hint in that letter?"

"It's an idea for removing components with a large number of tags from printed circuit boards," replied Smithy. "Things like i.f. transformers and so on. The general idea is to make up a tinned copper wire 'octopus' arrangement out of lin

lengths of wire around 24 s.w.g. One end of each length of wire has a small-diameter loop, which is tacked lightly with solder to a tag of the component as it protrudes through on the copper side of the board. The free ends of the lin wires are then all bound and joined together in the form of a large flat 'button' having as much surface area as possible. You next hold the circuit board, component side uppermost, so that this 'button' rests on the bit of a heavy soldering iron, the bit being well-tinned at the area of contact with the 'button'. After a few seconds, the heat passing through the lin wires radiating from the 'button' should make it possible for the component to be lifted clear of the board."

A Good Start

As Smithy stopped speaking, a series of indignant splutterings from the direction of the sink indicated that the Workshop kettle was about to give voice for the first time in 1968. Smithy put his letters away, and the kettle abruptly produced an ear-splitting whistle.

Dick hurried over and filled the tea-pot.

"Any more hints?" he called out through the steam.

"Not for the time being," replied

Smithy, closing his drawer, "but, as I've still got a few in hand, it looks as though we'll have to have another session pretty soon."

"Good show," replied Dick appreciatively, walking back with the disgraceful tin mug from which Smithy always drank his tea. "I'll look forward to that."

"So will I," said Smithy, sipping at his mug. "And seeing that there's nothing else to do here except eat turkey sandwiches, I would suggest that, after we've both had a spot of tea, we close up the Workshop for the day and wander down to Joe's Caff. We can then celebrate the New Year with some good old ordinary non-Christmas scoff."

Dick licked his lips in anticipation.

"Pie and chips?"

"The same."

"With beans?"

"And," confirmed Smithy gravely, "H.P. sauce."

Editor's Note

The hints described in this episode of "In Your Workshop" were submitted, in the order in which they appear, by E. Swift, N. G. Dunbar, R. A. Jackson, A. J. Thorn-dyke, R. Kreuzer, and W. M. Stratton.

Further hints for this feature are welcomed, and payment is made for all that are published. 

Radio Topics

By Recorder

AS REGULAR READERS WILL KNOW we have published quite a large number of articles on the subject of modulated light communication in *The Radio Constructor* over recent years, the latest of these being the three articles by D. Bollen on the "Wide-Band

Photophone" which appeared in the last January, March and May issues.

The basic operating principle of all the modulated light systems described up to the present time has consisted of modulating the intensity of light radiated from the

transmitter. This modulated light is then picked up by a photosensitive device at the receiver, where the modulation signal is extracted and amplified by a conventional a.f. amplifier. To obtain a useful range, reflectors and/or lenses may be employed at both the transmitter

and receiver ends to concentrate the radiated beam into a narrow angle and to ensure that maximum light intensity falls on the photo-sensitive device.

Frequency Modulation

All the systems discussed so far have employed what may be described as amplitude modulated light, because it is the "amplitude" of the light which is modulated by the a.f. signal at the transmitter. We have now, however, received details of an alternative system from an enthusiastic worker in this field, Mr.

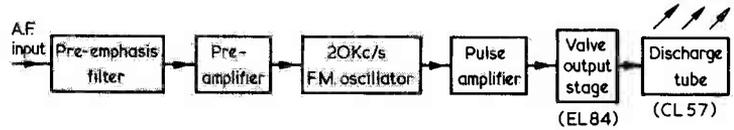


Fig. 1. Block diagram showing the stages in the frequency modulated light beam transmitter

may, therefore, swing on either side of the 20 kc/s subcarrier frequency to maxima of 10 kc/s and 30 kc/s. All frequencies within this range are capable of being handled by the transmitting lamp.

maximum light (at a current of 90mA) when the signal at the EL94 grid is positive-going, and minimum light (at a current of 10mA) when the signal at the EL94 grid is negative-going.

Thus, the output of the transmitter is given by a tube which offers pulses of bright light at a repetition frequency equal to the frequency of the f.m. oscillator. These light pulses may exhibit slight rounding at the corners due to the time needed for the ions in the tube to dissipate their energy as light, but they otherwise correspond fully to the discrete pulses generated by the f.m. oscillator.

The Receiver

The receiver block diagram appears in Fig. 3. Here the transmitted light pulses are applied to an OCP71 phototransistor, which tends to introduce further rounding of the corners, and are then fed to a pulse amplifier having a substantially constant gain from 5 to 300 kc/s. The output of the pulse amplifier is passed to a Schmitt trigger having a "backlash" potential of about 300mV. Positive input signals to the Schmitt trigger above 300mV give a trigger output of one value, whilst negative input signals (i.e. signals below zero volts) cause the trigger to revert to its previous state and give an output of the alternative value. Provided that the input signals to the Schmitt trigger are well in excess of the "backlash" potential, the output from the trigger consists of rectangular pulses having the same square corners as were originally generated by the f.m. oscillator at the transmitter. In other words, the Schmitt trigger "squares up" the pulses to their original form and gives them a constant amplitude.

The square-cornered pulses from the Schmitt trigger are next applied to a differentiator network which

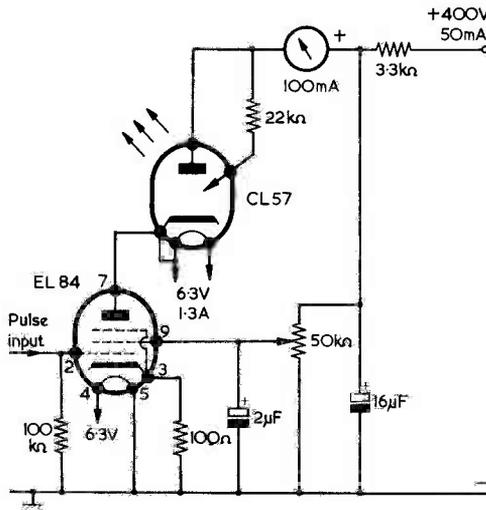


Fig. 2. Employing an EL84 to drive a Ferranti CL57 neon discharge tube

R. J. Ward, this alternative system employing a form of *frequency* modulation of the light from the transmitter. Mr. Ward states that this new process gives the same advantages of noise reduction and good quality reproduction as is evident in f.m. radio communication as opposed to a.m. radio communication. This f.m. light system, which has been designed and developed by Mr. Ward, offers considerable scope for experimenters working on modulated light communication, and I am devoting all my space this month to a description of its operation, and to circuits of a practical transmitter and receiver suitable for home-construction which have been passed on to us by Mr. Ward.

In the f.m. system the signal handled by the transmitting bulb, which is of the neon discharge type, consists of a 20 kc/s subcarrier frequency modulated up to ± 10 kc/s by the a.f. signal it is desired to transmit. The transmitter output

Fig. 1 shows a block diagram of the transmitter used by Mr. Ward for long range communication. An input from a microphone or any other a.f. signal source is fed through a high frequency pre-emphasis filter to a pre-amplifier, the latter providing the signal with sufficient amplitude to frequency modulate the 20 kc/s f.m. oscillator. The output of the oscillator consists of rectangular pulses (not a sine wave) and these are applied to a pulse amplifier and thence to an EL84 output stage. The output stage controls a Ferranti CL57 gas discharge tube using the circuit shown in Fig. 2. When the discharge tube is struck, it gives

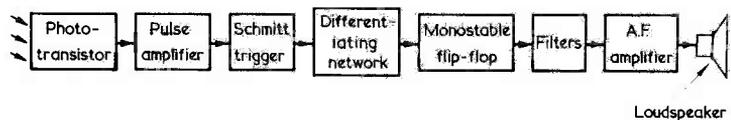
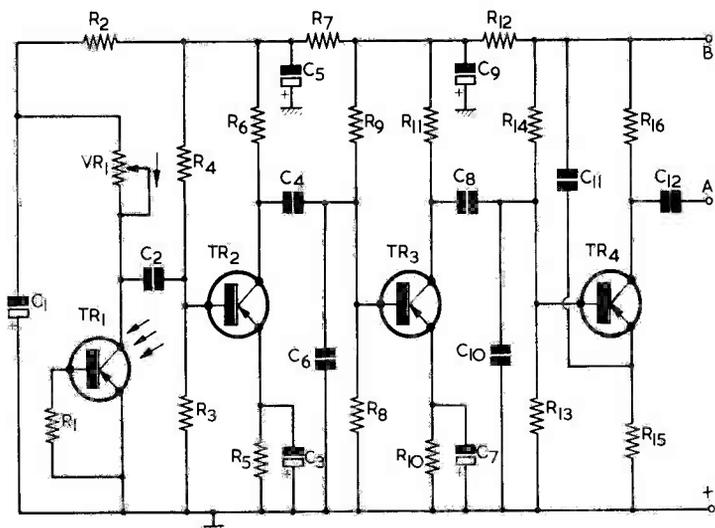
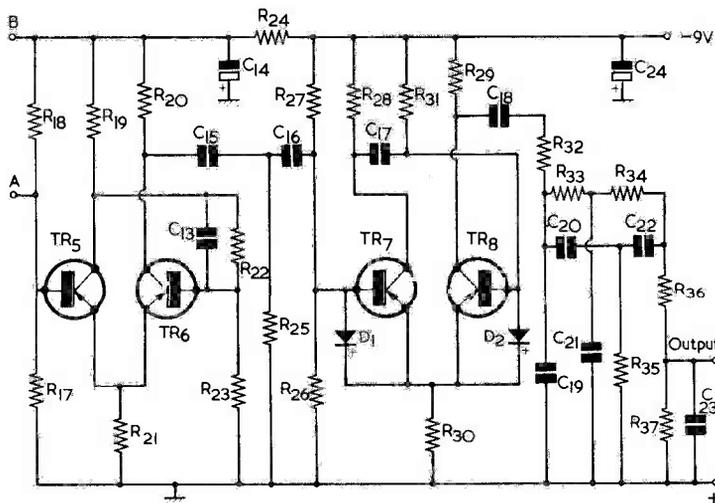


Fig. 3. Block diagram for the modulated light beam receiver



(a)



(b)

Fig. 4 (a). Pulse amplifier section of a receiver suitable for amateur construction. The arrow alongside VR₁ indicates the direction of clockwise rotation
(b). The pulse discriminator de-emphasis and filter sections of the receiver. Points A and B connect to the similarly identified points in (a)

COMPONENTS

Resistors

(All fixed values 10% $\frac{1}{2}$ watt unless otherwise stated)

R ₁	47k Ω	R ₈	6.8k Ω
R ₂	3.3k Ω	R ₉	27k Ω
R ₃	6.8k Ω	R ₁₀	1k Ω
R ₄	27k Ω	R ₁₁	2.7k Ω
R ₅	1k Ω	R ₁₂	100 Ω
R ₆	2.7k Ω	R ₁₃	6.8k Ω
R ₇	100 Ω	R ₁₄	27k Ω
		R ₁₅	1k Ω
		R ₁₆	2.7k Ω
		R ₁₇	33k Ω

R ₁₈	56k Ω
R ₁₉	2.2k Ω
R ₂₀	2.2k Ω
R ₂₁	2.2k Ω
R ₂₂	47k Ω 5%
R ₂₃	47k Ω 5%
R ₂₄	4.7k Ω
R ₂₅	12k Ω
R ₂₆	33k Ω
R ₂₇	56k Ω
R ₂₈	3.3k Ω
R ₂₉	3.3k Ω
R ₃₀	1.5k Ω
R ₃₁	100k Ω
R ₃₂	47k Ω 5%
R ₃₃	12k Ω
R ₃₄	12k Ω
R ₃₅	4.7k Ω
R ₃₆	56k Ω
R ₃₇	56k Ω
VR ₁	250k Ω potentiometer, log

Capacitors

C ₁	10 μ F 15V wkg. sub-miniature electrolytic
C ₂	0.1 μ F 30V wkg. miniature foil
C ₃	10 μ F 15V wkg. sub-miniature electrolytic
C ₄	0.047 μ F 30V wkg. miniature foil
C ₅	32 μ F 15V wkg. sub-miniature electrolytic
C ₆	500pF 10% ceramic
C ₇	10 μ F 15V wkg. sub-miniature electrolytic
C ₈	0.047 μ F 30V wkg. miniature foil
C ₉	32 μ F 15V wkg. sub-miniature electrolytic
C ₁₀	500pF 10% ceramic
C ₁₁	0.01 μ F 30V wkg. miniature foil
C ₁₂	0.047 μ F 30V wkg. miniature foil
C ₁₃	150pF 10% ceramic
C ₁₄	32 μ F 15V wkg. sub-miniature electrolytic
C ₁₅	150pF 10% ceramic
C ₁₆	5,000pF 10% ceramic or foil
C ₁₇	500pF 10% ceramic or silver-mica
C ₁₈	0.47 μ F polyester or miniature foil
C ₁₉	270pF 20% ceramic
C ₂₀	680pF 1% silver-mica
C ₂₁	1,500pF 1% silver-mica
C ₂₂	680pF 1% silver-mica
C ₂₃	470pF 20% ceramic
C ₂₄	100 μ F 12V wkg. electrolytic

Semiconductors

TR ₁	OCP71
TR ₂ -TR ₈	OC44
D ₁ , D ₂	OA81

converts them to one positive-going and one negative-going spike per cycle, and these spikes are passed to a monostable flip-flop. The flip-flop triggers to its unstable state on receipt of a negative-going spike then, after a fixed interval (which is always shorter than the time between negative-going spikes), reverts to its stable state. It is not affected by positive-going spikes. Consequent to this mode of operation it may be seen that, if the pulse repetition frequency increases, the monostable flip-flop will occupy, over a period, more time in the unstable state than in the stable state because, once initiated, each unstable state lasts for a constant length of time. As a result, the mean output from the flip-flop corresponds in linear fashion to the pulse repetition frequency from the transmitter, and it thereby functions as a discriminator. It gives an output consisting of the subcarrier and harmonics, plus the original modulating a.f. at the transmitter.

Referring again to Fig. 3, the output from the flip-flop is passed through a bridged-T filter to remove the subcarrier frequency and a de-emphasis filter to remove the higher audio frequencies. Some noise may be given by the phototransistor at the receiver input. If this should appear at the Schmitt trigger within its "backlash" range, it will cause a noise output to be present after the flip-flop. The de-emphasis network attenuates any noise which may be present due to this effect and it has a curve which complements that of the pre-emphasis network at the transmitter, whereupon the whole overall system has a response which is flat up to 5 kc/s. After the de-emphasis network, the a.f. signal is applied to a conventional a.f. amplifier and loudspeaker.

In Mr. Ward's installation employing the CL57 tube the OCP71 phototransistor was mounted behind an ex-Government lens having a diameter of 7.5cm and a focal length of 12cm, it being adjusted in position so that maximum transmitted light fell on the photo-sensitive area. This assembly was then covered, apart from the front and rear, with a cylindrical housing 30cms long, and painted black on the inside to avoid reflection of stray light.

The system was first tried out with no lens or reflector at the discharge tube. The receiver reproduced the signal with no noticeable noise at 20yds from the transmitter; at greater distances the noise increased rapidly. (This will be due to the peak-to-peak signal

applied to the Schmitt trigger becoming sufficiently low to be comparable with its "backlash" potential). The range was then increased by mounting the tube in a head-lamp reflector. Although the beam produced was not particularly narrow, reproduction with no noticeable noise was easily obtained at a distance of 100yds. The adjustment of the voltage drive to the EL84 had to be carried out carefully to avoid spurious oscillations, but when these had been avoided the quality was very good, both on speech and music. Indeed, several people to whom musical reproduction by way of the system was demonstrated expressed surprise that there was any equipment at all between the gramophone pick-up at the transmitter and the loudspeaker at the receiver. The quality most certainly exceeded that of many of the cheaper record-players.

Mr. Ward concludes that this f.m. system would appear to be capable of transmitting high quality sound over a beam of light.

Home Constructor Circuits

Circuits suitable for amateur construction, and using a smaller transmitting lamp, appear in Figs. 4 and 5.

Fig. 4 illustrates the receiver circuit and may be studied in conjunction with the block diagram of Fig. 3. Fig. 4 (a) shows the phototransistor and pulse amplifier stages, the output at A being applied to the similarly identified point in Fig. 4 (b). In Fig. 4 (b), TR₅ and TR₆ form the Schmitt trigger, and TR₇ and TR₈ the monostable flip-flop. The bridged-T and de-emphasis filters appear after C₁₈.

Fig. 5 shows the transmitter circuitry. In Fig. 5 (a) an a.f. input is applied to C₂₅, with TR₉ providing a.f. amplification. The pre-emphasis components are in the emitter circuit of this transistor. The output from TR₉ is applied to TR₁₂ and TR₁₃, which control the frequency of the multi-vibrator given by TR₁₀ and TR₁₁. Mean multivibrator frequency is controlled by VR₂.

The output, at point C, is passed to the pulse amplifier and output stage, TR₁₄ and TR₁₅ of Fig. 5 (b), and thence to the neon lamp V₁. This can be a Radiospares miniature panel neon with the integral resistor removed. If it is desired to use a larger neon tube such as the 5 watt variety, again with the integral resistor removed, R₅₂ should be changed to 2.2k Ω , R₅₅ to 1k Ω 5 watt, VR₃ to 5k Ω wirewound 3 watts, and C₃₄ to 1 μ F miniature foil. It should be noted that the

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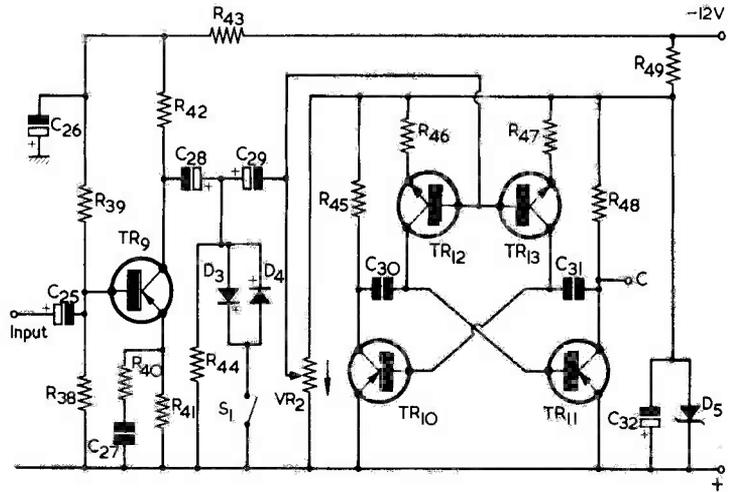
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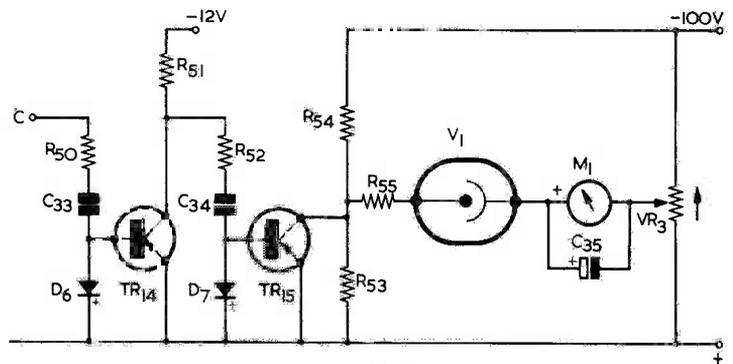
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(a)



(b)

Fig. 5 (a). The pre-emphasis amplifier and f.m. oscillator in the transmitter
(b). The transmitter output stages

Resistors

(All fixed values 10% ½ watt
unless otherwise stated)

R ₃₈	1.5kΩ
R ₃₉	5.6kΩ
R ₄₀	100Ω
R ₄₁	560Ω
R ₄₂	1kΩ
R ₄₃	1kΩ
R ₄₄	33kΩ
R ₄₅	2.2kΩ
R ₄₆	12kΩ
R ₄₇	12kΩ
R ₄₈	2.2kΩ
R ₄₉	330Ω
R ₅₀	27kΩ
R ₅₁	2.2kΩ
R ₅₂	8.2kΩ
R ₅₃	8.2kΩ 1 watt
R ₅₄	8.2kΩ 1 watt
R ₅₅	2.2kΩ 2 watt

VR₂ 25kΩ potentiometer,
carbon track, linear

VR₃ 25kΩ potentiometer,
wirewound 3 watts,
linear

Capacitors

C ₂₅	10μF 15V wkg. sub- miniature electrolytic
C ₂₆	100μF 15V wkg. sub- miniature electrolytic
C ₂₇	0.2μF polyester or miniature foil
C ₂₈	10μF 15V wkg. sub- miniature electrolytic
C ₂₉	25μF 15V wkg. sub- miniature electrolytic
C ₃₀	500pF 1% silver-mica
C ₃₁	300pF 1% silver-mica
C ₃₂	25μF 15V wkg. sub- miniature electrolytic
C ₃₃	0.022μF miniature foil
C ₃₄	0.22μF polyester or miniature foil
C ₃₅	25μF 15V wkg. sub- miniature electrolytic

COMPONENTS

Semiconductors

TR ₉	OC71
TR ₁₀	OC42
TR ₁₁	OC42
TR ₁₂	Any n.p.n. silicon with H_{fe} greater than than 10 (e.g. BSY27)
TR ₁₃	As TR ₁₂
TR ₁₄	OC42
TR ₁₅	ACY17
D ₃	HS3130 (Hughes)
D ₄	HS3130 (Hughes)
D ₅	6 volt 250mW zener diode
D ₆	OA5
D ₇	OA5

Tube

V ₁	Mains indicator neon (see text)
----------------	------------------------------------

Meter

M ₁	100mA f.s.d.
----------------	--------------

Switch

S ₁	s.p.s.t. switch
----------------	-----------------

ACY17 in the TR₁₅ position is operated at around its maximum collector voltage rating, but no trouble due to transistor breakdown has been experienced with the prototype transmitter.

Not yet discussed is the function of switch S₁ in Fig. 5 (a). When closed, this switch connects D₃ and D₄ across the output from TR₉. These diodes limit the signal to just below the level which produces over-modulation, with its attendant severe distortion. The clipping distortion deliberately produced on occasional speech peaks by closing S₁ is greatly preferable to that produced by overloading the system. With music, however, better quality is obtained with S₁ open.

The input impedance at the transmitter is of the order of 1k Ω , a peak-to-peak signal of 0.5 volt producing full modulation. A signal of this amplitude can be obtained very conveniently from the extension speaker terminals of the modulating equipment.

The output from the receiver is approximately 50mV r.m.s. when feeding into an open-circuit and, as such, is suitable for applying to the "high gain" or "high impedance microphone" input of a valve amplifier.

Setting Up

After construction, the transmitter and receiver are set up in the following manner.

First disconnect the phototransistor and turn VR₁ fully clockwise (in the direction of the arrow in Fig. 4 (a)). Connect together the

positive lines of the 12 volt and 9 volt supplies.

Take an insulated lead from the junction of VR₁ and C₂ and wrap it three or four times around the insulated lead at point C (Figs. 5 (a) and (b)) of the transmitter. Connect a signal source to the transmitter input and an a.f. amplifier to the receiver output.

Switch on the 12 volt supply to the transmitter (not the 100 volt supply) and the 9 volt supply to the receiver. Turn up the amplifier gain control carefully.

As VR₂ is adjusted it will be found that, over a region of about 40° of rotation, the signal is reproduced clearly, and that severe distortion occurs outside this region. VR₂ should be set to the middle of this region.

Disconnect the power supplies and remove the temporary link between the transmitter and the receiver. Reconnect the phototransistor.

Arrange the optics (reflector, lens, etc.) of the phototransistor and the neon tube so that a light beam from the tube will be focused on to the transistor. Set VR₃ fully anticlockwise. Connect the 12 volt and 100 volt supplies to the transmitter and rotate VR₃ clockwise until the neon glows and a current is indicated by the meter.

Adjust the optics to provide maximum neon light on to the phototransistor and then switch on the receiver power supply.

Adjust VR₁ for minimum receiver noise and VR₃ likewise, having regard for the neon current, as indicated by the meter. This is 10mA maximum for the miniature neon specified.

The system is then ready for use.

January Again

It is pleasant, in this January issue, to be able to pass on a description of a new *amateur* development, as it enables the New Year to start off with yet another exciting project. It seems only yesterday that I was writing last year's January contribution, and yet there have since been 12 issues of *The Radio Constructor* which have all been packed with new approaches and developments for the home-constructor. We at Maida Vale are keeping up the good work and you can rest assured that there is plenty of exceptional interest to come in the remaining issues for 1968.

And, of course, I mustn't finish this month without wishing you all a really Happy and Prosperous New Year. See you in February!

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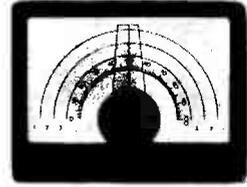
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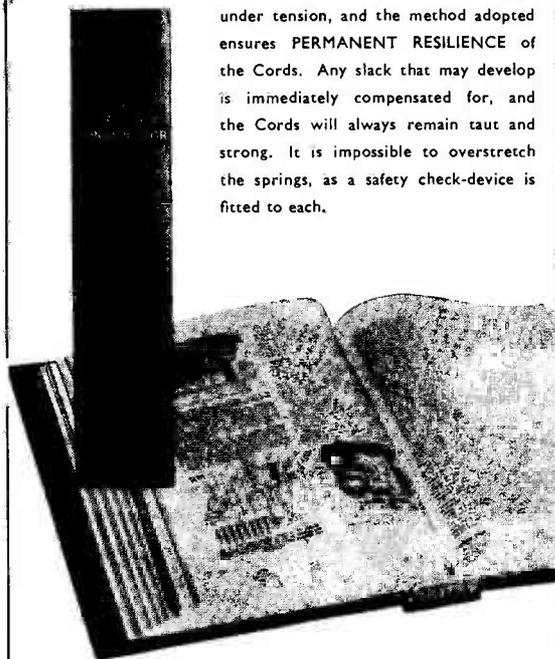
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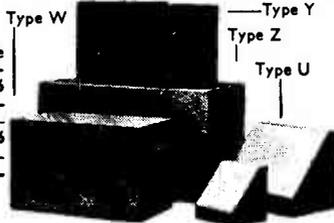
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1

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$$R = \frac{E}{I}$$

$$I = \frac{E}{R}$$

$$E = IR$$

where R is resistance in ohms, E is potential difference in volts and I is current in amps. Or, where R is in kilohms, E is in volts and I is in milliamps.

Capacitive Reactance

$$X_c = \frac{1}{2\pi fC}$$

where X_c is capacitive reactance in ohms, f is frequency in cycles per second and C is capacitance in farads. Or, where X_c is in ohms, f is in megacycles and C is in microfarads. The reactance of a given capacitor decreases as frequency increases.

Inductive Reactance

$$X_L = 2\pi fL$$

where X_L is inductive reactance in ohms, f is frequency in cycles per second and L is inductance in henrys. Or, where X_L is in ohms, f is in megacycles and L is in microhenrys. The reactance of a given inductor increases as frequency increases.

Resonance

$$f = \frac{1}{2\pi\sqrt{LC}}$$

where f is resonant frequency in cycles per second, L is inductance in henrys and C is capacitance in farads.

$$\text{Or, } f = \frac{1,000,000}{2\pi\sqrt{LC}}$$

where f is in kilocycles, L is in microhenrys and C is in picofarads.

These formulae are true for series tuned circuits and have negligible inaccuracy for parallel tuned circuits with Q above 20.

REFERENCE FORMULAE

Resistors Or Inductors In Series

$$R_{\text{total}} = R_1 + R_2 + R_3 \dots$$

$$L_{\text{total}} = L_1 + L_2 + L_3 \dots$$

Capacitors In Parallel

$$C_{\text{total}} = C_1 + C_2 + C_3 \dots$$

Resistors Or Inductors In Parallel

$$\frac{1}{R_{\text{total}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \dots$$

$$\frac{1}{L_{\text{total}}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} \dots$$

For two components in parallel,

$$R_{\text{total}} = \frac{R_1 \times R_2}{R_1 + R_2}$$

$$L_{\text{total}} = \frac{L_1 \times L_2}{L_1 + L_2}$$

Capacitors In Series

$$\frac{1}{C_{\text{total}}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \dots$$

For two capacitors in series,

$$C_{\text{total}} = \frac{C_1 \times C_2}{C_1 + C_2}$$

D.C. Power Equations

$$W = EI,$$

$$W = \frac{E^2}{R},$$

$$W = I^2R$$

where W is in watts, E is in volts and R is in ohms.

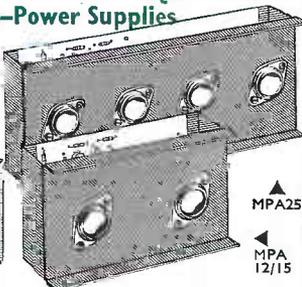
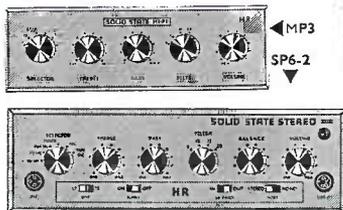
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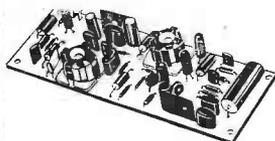


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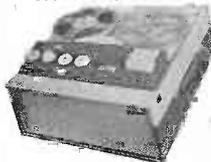


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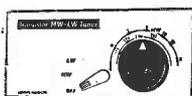
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