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Standardization of Components

WE do not propose to discuss the circumstances in which standardization can be regarded as being good or bad, but rather to consider a mild case of indifference.

It would seem that with notable exceptions the radio industry as a whole is not making anything like the use it might of the new series of component specifications issued by the Radio Industries Council since the war. One suggested explanation is that junior designers and draughtsmen, who presumably do all the work, have not seen or may not even have heard of them. If this is so we urge them to apply at once to their seniors or direct to the R.I.C., whichever may be the more discreet or convenient.

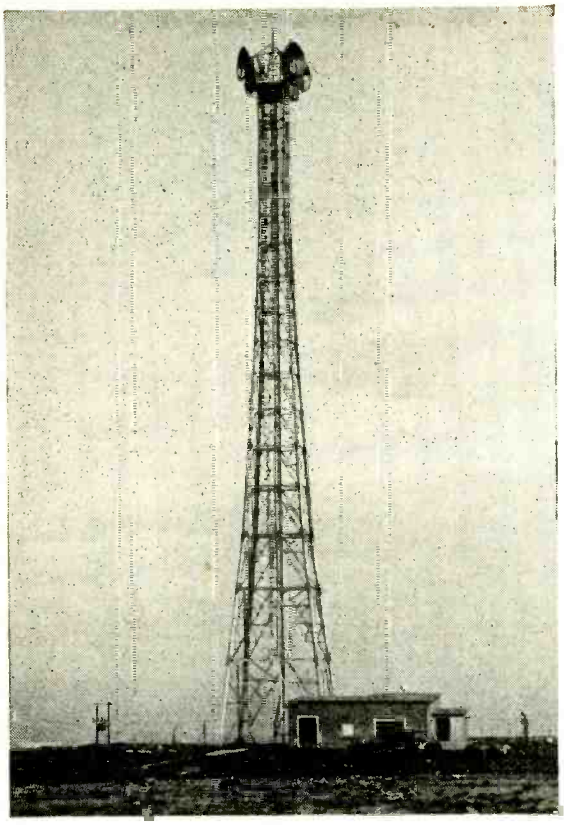
But is this the real reason? What are the root causes of success or failure in standardization? First and last, universal acceptance; and (in between) time, money and technical merit—probably in that order.

The element of time operates in a number of ways. Before the war many people thought that technical development in component design was becoming asymptotic, yet within a decade we have seen three major changes in components standards; first, the abandonment of pre-war civilian standards for the wartime I.S.C.T.C. specifications and now modified R.I.C. specifications drafted with an eye to the all-important export as well as the home market. Thus political and national-economic as well as technical factors can set a period to the useful life of a specification, and speed is the essence of the contract if sufficient quantities are to be made to justify standardization before circumstances change. There is truth in the cynical saying that standardization is the stepping stone from chaos to obsolescence.

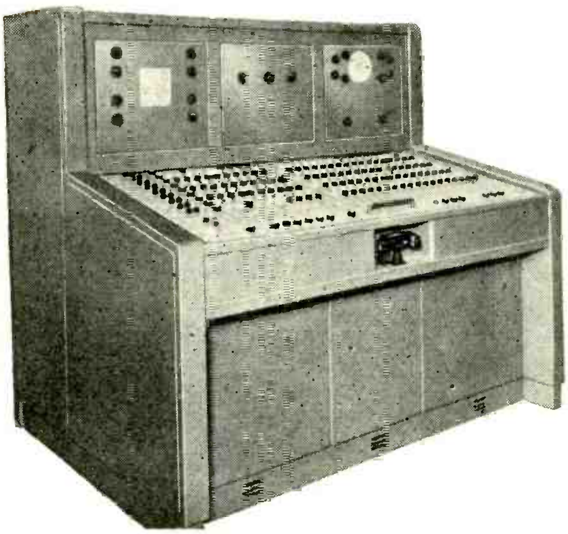
The most effective weapon for breaking down prejudice against standardized components is price, and the quantities made must be sufficient for the argument of money to be irrefutable. Your junior (or senior) designer will then have to produce evidence of a spectacular improvement of performance before he will get the approval of the costing and sales departments for a non-standard part. But how to ensure the quantities that will fix the irresistibly attractive price? It is unfair to ask the component manufacturer to shoulder the capital risk of a long production run without orders, and it is up to the customers, who also stand to gain, to take the much less hazardous step of ordering to standard specification wherever possible, even if it hurts their individual pride a little to do so. After all, the performance requirements have been laid down not only by component manufacturers but by competent representatives of the customers themselves, and such technical compromises as have been made are in the interest of wider acceptance of the standard. They are expressions of need rather than imaginative conceptions of what an ideal component should be, and the manufacturers already have components to meet them tooled ready for quantity production.

If there were more overlapping between the R.I.C. and R.C.S.C. specifications, one might hope that the rearmament programme would provide the pump priming necessary to start the economic processes of price reduction, but it seems likely that for commercial equipment even the lowest Services standards will be unnecessarily high, except, perhaps, for marine or extreme tropical conditions. If the industry wants to derive the full economic advantages of standardization it must find within itself the concerted drive necessary to implement the R.I.C. specifications. First, equipment manufacturers should agree among themselves to specify a minimum number of preferred standard types and then ask the component manufacturers to respond with a sufficiently attractive reduction in price for these standardized items.

In the meantime design staffs should be encouraged to familiarize themselves with the contents of R.I.C. specifications, which represent the pooling of considerable knowledge and experience of the desirable *and realizable* properties of good components. Putting their value no higher than this, they will have justified the time and thought which have gone to their compilation if they mark out a safe track for the tenderfoot designer, and help him to avoid the pitfalls which await the unwary in the overgrown jungle of commercial catalogues and sales literature.



Repeater station at Blackcastle Hill, near Dunbar. The 200-ft steel tower is the highest one along the whole route and was made necessary by the high ground to be spanned by the beam transmission southwards.



Remote control desk at Kirk O'Shotts. This controls the complete chain of repeater equipment along the incoming-signal channel and shows the condition of equipment at all the repeater stations.

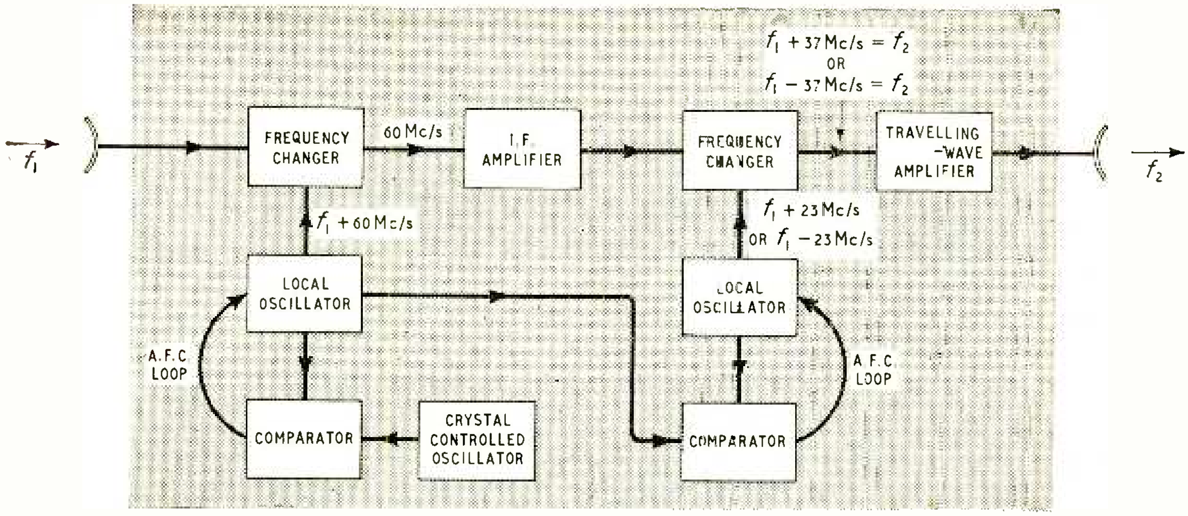
Centimetre-Wave Television Relay

Two-Way Radio Link Between Manchester and Kirk O'Shotts

VISION programmes for the new Scottish television station at Kirk O'Shotts are transmitted over the last 250 miles of their journey, from Manchester onwards, by a radio relay system. This is the latest section to be added to the national relay network that is being built by the Post Office to link up all B.B.C. television transmitters and studio centres; it has been designed and constructed to meet the Post Office technical requirements by Standard Telephones & Cables, Ltd. The rest of the network at present consists of coaxial cable links: one from London to Birmingham, with a radio relay as an alternative link, another from Birmingham to Manchester, and a third, still in the process of construction, from London to the new transmitter at Wenvoe near Cardiff.

A radio system has been used for the Manchester-Kirk O'Shotts link partly because the terrain is more suited to a radio system than a coaxial cable and partly because at the time of planning the link the Post Office had no other telecommunication requirements in view over this route and it would not have been worth while laying a single-tube coaxial cable for television alone. In addition to the two terminal stations at Manchester and Kirk O'Shotts, there are seven intermediate repeater stations spaced out at about 30-mile intervals up the east side of the Pennine Chain. This particular route was chosen so that it would pass fairly close to Newcastle, to permit a "tapping" to be made for the proposed new transmitter in that area, and close to Leeds and Edinburgh to enable programmes to be injected into the system from these towns. It will be possible, in fact, to inject local programmes at all the seven repeater stations.

The relay is a two-way system with two uni-directional channels working side by side, so programmes can be sent in both directions at once. It uses two carrier frequencies, both in in region of 4,000Mc/s (7.5cm wavelength) and a change from one to the other is made at each repeater station, the arrangement being such that in each section the "coming" and "going" channels working side by side are on different frequencies. The transmissions are beamed along optical paths between paraboloid aerials; these are mounted on masts and are connected to the radio equipment on the ground by waveguides. The paraboloids are 10ft in diameter and are fed by waveguide horns; they have a gain of about 40db relative to a

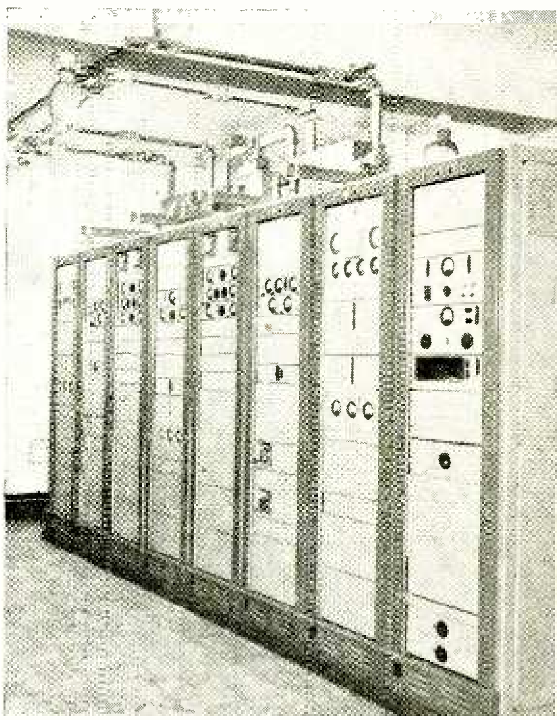


half-wave dipole and give an angular beam width of $\pm 1\frac{1}{2}°$ to the half-power points.

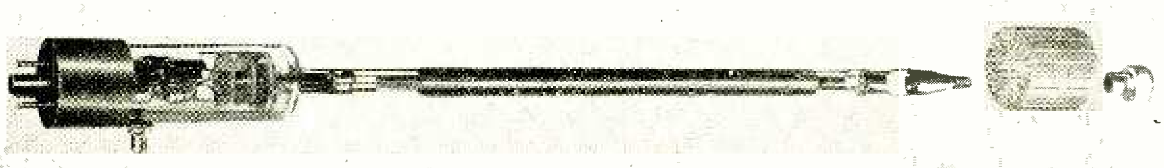
At the terminal stations the carrier frequency is generated by a reflex klystron, and this is frequency modulated by the incoming vision signal (of 3Mc/s bandwith), giving a maximum carrier deviation of ±3Mc/s. The output of the klystron is then fed by waveguides to a travelling-wave amplifier, which gives a gain of about 17db and delivers approximately 1 watt of r.f. power to the transmitting aerial. The carrier frequency is kept constant by an automatic frequency control system which works by comparing the klystron frequency with a reference frequency from a local crystal-controlled oscillator.

On arrival at a repeater station (see block diagram) the f.m. signal goes to a crystal frequency changer, where it is mixed with the output of a local coaxial-line oscillator to produce an i.f. centred on 60Mc/s. This goes through an i.f. amplifier fitted with a.g.c. and on to another crystal frequency changer for conversion back to a centimetre-wave signal. Here the local oscillator is arranged to work at such a frequency that one of the products of mixing is 37Mc/s above or below that of the incoming signal to the repeater. This product is selected by a filter, amplified by a travelling-wave amplifier to a power of 1 watt and passed to the transmitting aerial. Thus the transmitted signal is on a carrier frequency 37Mc/s removed from that of the received signal—whether it is 37Mc/s above or 37Mc/s below depends on the

Above: Block diagram of repeater system for one direction of transmission. Below: Complete set of receiving and transmitting equipment at a repeater for both directions of transmission. A duplicate set is mounted back-to-back to act as a standby. On top are the waveguide feeds to and from the aerials, and waveguide switches for switching between main and standby equipments.



Below: The S.T.C. travelling-wave amplifier used in the terminal and repeater stations. A notable feature of this tube is its ability to amplify signals over an extremely wide frequency band—of the order of 100 Mc/s. When in operation it is cooled by a forced air stream directed on to the radiator (shown removed at the right hand side).



position of the repeater in the chain.

As in the terminal stations there is an automatic frequency control system, but here it serves to stabilize the two local oscillators and maintain the necessary constant frequency difference between them. The output of the first one is compared with a reference frequency derived from a crystal-controlled oscillator; any frequency drift causes the output of the comparator (actually a frequency changer) to alter one way or the other and this change is used to bring the local oscillator back on to its correct frequency. The second local oscillator is controlled in a similar way, a comparison being made between its frequency and that of the already stabilized first oscillator.

Short aerial tower built into the side of the hill at Blackford Hill, near Edinburgh. The waveguide feeds pass down the centre of the tower.

All the repeater stations are designed to work unattended and can be remotely controlled from the terminal stations. Each terminal is able to control the entire chain of equipment along the channel bringing its incoming signals, and both terminals have an indicator system which shows the condition of the equipment at all the repeaters for both directions of transmission.

Elaborate precautions are taken to guard against possible interruption of the service. In each repeater all the equipment except the aerial system is duplicated, and if a breakdown occurs there is an automatic change-over from one set of equipment to the other. Similarly with the power supplies. If the local public mains supply fails, a standby generator consisting of a diesel engine and alternator starts up automatically and takes over within 15 seconds.

SCOTTISH TELEVISION STATION

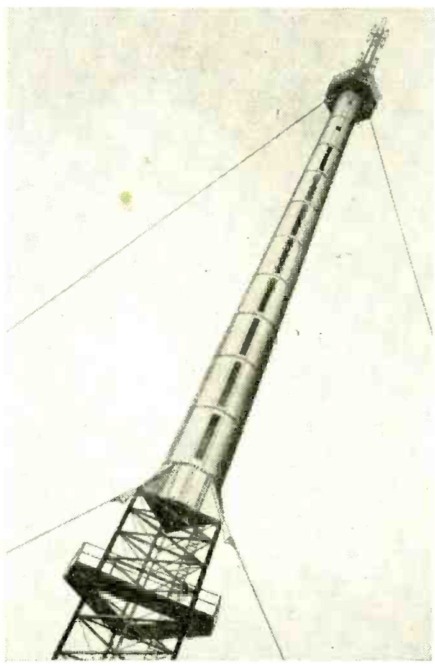
THE recent report in the lay Press that George Barnes, the director of television, B.B.C., had stated that the high-power transmitter for Kirk o'Shotts "cannot be made to work satisfactorily" brought forth an announcement from the manufacturers—Electric & Musical Industries. They stated on 1st April that 'although delays have been experienced due to the new design [it employs low-level modulation] and to labour and material shortages the transmitter is now operating [at the works] at a higher power and efficiency than any other known television transmitter."

Until this equipment is installed the low-power Marconi sound and vision transmitters have been providing a regular service since 14th March in Channel 3 (56.75 Mc/s vision, 53.25 Mc/s sound). These low-power transmitters, similar to those originally ordered for the secondary stations (Newcastle, Aberdeen, Belfast, Plymouth and Southampton) are being installed, together with a standby aerial system, in each of the high-power stations.

The standby vision transmitter is of the low-level modulated type with a peak white output power of 5 kW. Modulation is carried out at the 500-watt level and the signals are then amplified by two Class "B" wide-band linear r.f. amplifiers. The appropriate shaping of vestigial side-band signals radiated by the vision transmitter is carried out in its own circuits, and not by a separate vestigial side-band filter as in the case of the high-power transmitter.

The station is situated roughly midway between Glasgow and Edinburgh on a site 900ft above sea level so that the two tiers of four vertical dipoles atop the 750-ft mast are over 1,600-ft high.

At Kirk o'Shotts, as at Holme Moss, the outputs of the vision and sound transmitters are combined at ground level and a single transmission line is used to convey this combined output to the common aerial system at the top of the mast. The transmission line for Kirk o'Shotts, which was developed and built for the B.B.C. by E.M.I. is of novel construction. It is of the coaxial copper tube type but the inner tube has been replaced by a locked coil wire rope, the outer layer of wires being made of high-conductivity copper. This rope, together with the 5-inch diameter copper tube forming the outer conductor, is suspended from a support at the top of the mast. The wire rope is tensioned at the lower end by a loading mechanism designed to apply a force of approximately two tons. The rope is located coaxially with the outer conductor by small rod insulators, spaced at 120 deg., projecting at intervals from the inner surface of the tube.



Atop the triangular section lattice mast erected by B. I. Callender's at Kirk o'Shotts is the 100-ft. cylindrical v.h.f. slot aerial above which is the combined sound and vision radiators.

High-Quality Amplifier Modifications

By D. T. N. WILLIAMSON*

Correction for Long-playing Record Characteristics; Input Circuits for High-impedance Pickups

THE introduction of long-playing records in Great Britain, after the publication in November, 1949, of gramophone pre-amplifier circuits for the "High Quality Amplifier" which were suitable only for the 78-r.p.m. standards, has made it necessary to revise these designs.

The principle of recording with a rising frequency characteristic at high frequencies and reproducing with a correspondingly falling characteristic, in order to effect a reduction in the level of surface-noise from the material, is a well-established and useful one. In the case of long-playing records it results, in conjunction with the use of a homogeneous plastic for the record material, in an almost silent background.

There are, however, dangers attendant upon its use. The scheme is based on the hypothesis that the energy level of music decreases with increase of frequency above about 500 c/s. Thus it should be possible steadily to increase the gain of the recording channel above this frequency. This appears particularly attractive at first sight, since with the normally used constant-velocity characteristic the recorded amplitude for a constant recording level is inversely proportional to frequency and is therefore very small at high frequencies.

Initially, a rising frequency response characteristic producing practically constant amplitude at constant level was used, the energy level distribution being relied upon to restrict the amplitude at high frequencies. The effect of this was, in practice, to cancel the improvement in tracing, which the small-groove system offered, by producing, at high frequencies and high orchestral levels, recorded waveforms with radii of curvature too small to be traced accurately. The resulting distortion manifested itself as a tearing sound superimposed on the full orchestra.

There is additional evidence to suggest that the original hypothesis required revision, since it is demonstrable that it breaks down when such percussion instruments as cymbals and castanets are considered, particularly when the frequency range is wide. Indeed, the peak power level required to reproduce cymbals exceeds that normally required at medium frequencies.

This early experience has lead to the adoption of a characteristic which is a better compromise between these conflicting factors and gives much more satisfactory results in practice. Fig. 26 shows the provisional recording characteristic now in use by the Decca Record Company for L.P. records. The amount of treble boost is lower than the theoretical optimum, but the use of even this amount of compensation means that the first stages of the pre-amplifier must be capable of handling occasional high-frequency peaks which are greater than those experienced with standard records, unless the pickup is a constant amplitude one, or its output at high frequencies is attenuated before reaching the pre-amplifier.

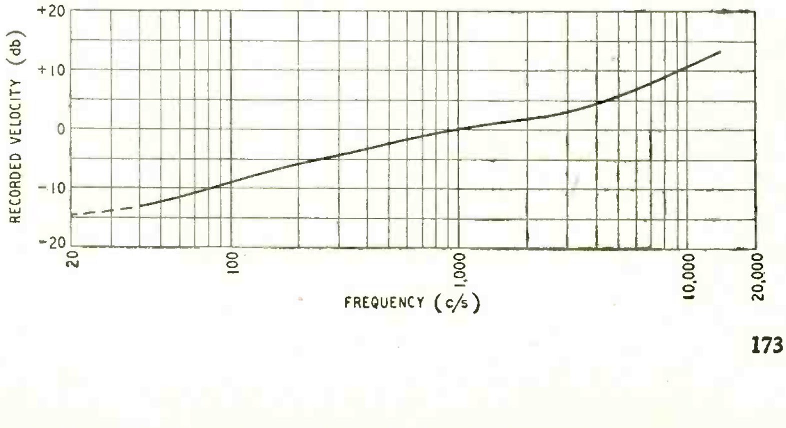
This article shows how the original circuit should be modified for use with long-playing records, and gives details of circuit changes necessary for the direct connection of high-impedance pickups. The figure numbers and circuit component suffixes have been chosen to run consecutively with previously published articles, all of which, together with the present article, will be reprinted in a revised edition of "The Williamson Amplifier" booklet to be issued soon by our Publishers.

The original designs of pre-amplifier employed negative-feedback methods of compensation, and hence are particularly suitable for a wide range of inputs. However, pickups are available with such a wide variety of output levels that no single circuit will cope adequately with them, and external attenuators may have to be used.

Modifications.—Dealing first with the single-valve pre-amplifier (original circuit *Wireless World*, Fig. 13, p. 423, November, 1949), the revised circuit of Fig. 27 shows the modifications necessary to provide alternative standard and long-playing characteristics. To sim-

* Ferranti Research Laboratories.

Fig. 26. Recording characteristic used for current Decca long-playing records.



plify the switching, by using a single-pole changeover switch, the capacitor C_{15} is left permanently in circuit, giving a Decca 78-r.p.m. characteristic in the "78" position. Alternatively, C_{15} may be removed to give the E.M.I. characteristic. In either case, correction for the other 78 r.p.m. characteristic may be made by means of the treble control on the tone compensation unit.

The advantage of this simplified switching is that it becomes practicable to gang the switch to the motor speed-change control to give automatic compensation. If this arrangement is not desired, a two-pole multi-position switch may be used, to give three or more combinations, as in Fig. 28.

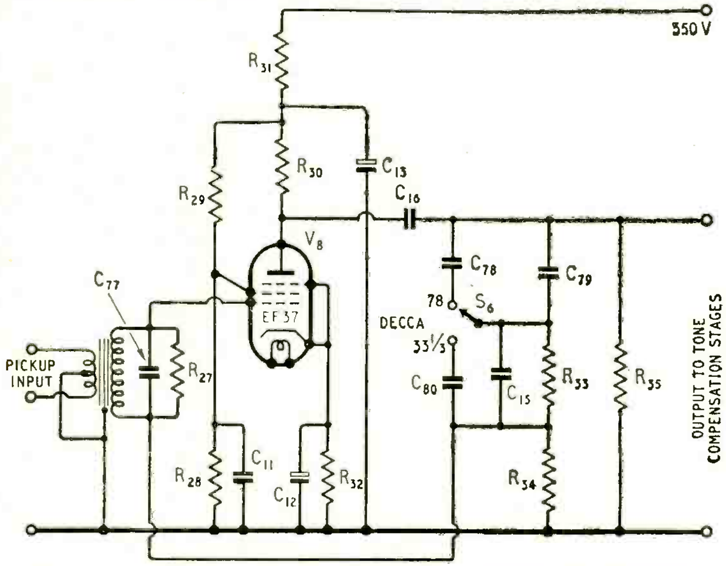
It should be noted that the position of C_{16} has been altered, so that the whole of the feedback network is at earth potential. This avoids switching transients which would otherwise occur, due to charging and discharging of capacitors as the switch is operated.

A small capacitor, C_{17}, has been connected across the input transformer secondary. This is to prevent any tendency to instability or peaking at high frequencies, caused by the presence in the feedback loop of the stray secondary reactances of the transformer. The necessity for this capacitor and its minimum value, will vary with the individual transformers. Its value should be kept as small as possible, consistent with stability.

Modifications to the three-stage high-pass pre-amplifier (original circuit *W.W.* Fig. 15, p.424, November, 1949) are on the same lines, and Fig. 29 shows the revised circuit.

With these pre-amplifier circuits, the wiring to the selector switch must be kept short, and the switch should, if possible, be mounted on the pre-amplifier. Should the position of the pre-amplifier render such a switch inaccessible, consideration should be given to the use of a relay in place of the selector switch, rather than the use of extension leads. This has the additional advantage that it could easily be operated from the speed-change lever by means of a micro-switch or from the additional switched pin which is a feature of some pickups with interchangeable heads.

Pickups without Transformers.—A number of pickups are available which do not normally require a transformer. It is possible to use the majority of these with the pre-amplifier circuits, by interposing a suitable 1:1 trans-



Left : Fig. 27. Simple two-position switching in single-valve pre-amplifier for playing Decca 78-r.p.m. standard and 33⅓-r.p.m. L.P. records. Compensation for the E.M.I. 78-r.p.m. standard characteristic should be applied separately by the treble tone control.

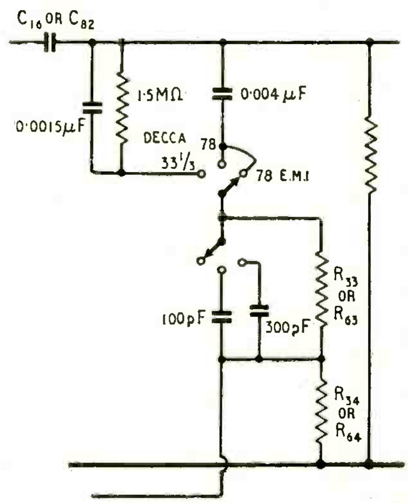
List of Components for Fig. 27

		Type	Rating	Tolerance
R_{27}	Value to suit transformer	High-stability carbon		
R_{28}	0.1MΩ	do.	½W	
R_{29}	0.68MΩ	do.	½W	
R_{30}	0.22MΩ	do.	½W	
R_{31}	47kΩ	do.	½W	
R_{32}	4.7kΩ	do.		
R_{33}	0.22MΩ	Composition		10 %
R_{34}	22kΩ	do.		10 %
R_{35}	2.2MΩ	do.		

All resistors may be ¼W rating, tolerance 20% unless otherwise specified.

		Type	Rating (V d.c. working)	Tolerance
C_{11}	0.5μF	Paper	250	
C_{12}	50μF	Electrolytic	12	
C_{13}	16μF	do.	450	
C_{15}	100pF	Silvered mica	250	10 %
C_{16}	0.05μF	Paper	500	
C_{77}	10–50pF	Silvered mica	250	
C_{78}	2500pF	do.	250	10 %
C_{79}	1500pF	do.	250	10 %
C_{80}	300pF	do.	250	10 %
S_6	Single-pole changeover switch			

Below : Fig. 28. Alternative circuit (applicable to Figs. 27, 29 and 30) with three-position switch giving compensation for Decca 33⅓, Decca 78 and E.M.I. 78-r.p.m. recording characteristics.



former. In other cases, when the connecting leads are short, it may be practicable to connect the pickup directly in place of the transformer secondary. The limiting factor will be the capacitance between the leads and their screening, which will be shunted across R_{34} or R_{64}, and which, if sufficiently large, would upset the treble compensation. The value of this stray capacitance should not be allowed to exceed 50 pF, and if C_{15} or C_{55} is switched out, should be compensated by a capacitance of one tenth of its value in parallel with R_{33} or R_{63}, to give a linear frequency-response characteristic at high frequencies.

Resistors R_{27} and R_{58} must be retained to provide a conducting path to the valve grid when the pickup heads are being interchanged.

There may be cases, where one side of the input must be earthed, in which it is impracticable to utilise

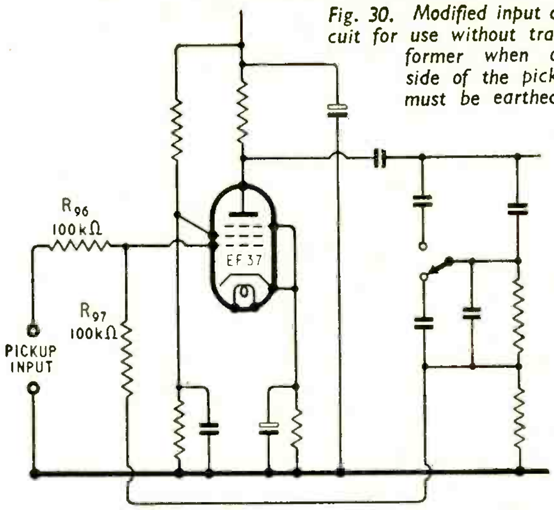
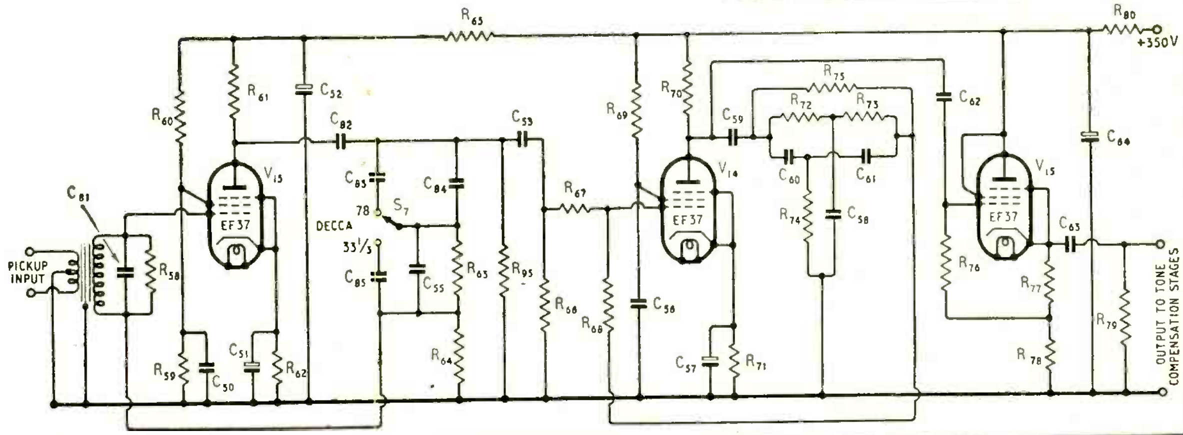


Fig. 30. Modified input circuit for use without transformer when one side of the pickup must be earthed.

Below : Fig. 29. Revised three-stage pre-amplifier circuit with high-pass filter, to play Decca 33⅓- and 78-r.p.m. records.



Component Values for Circuit of Fig. 29

	Value	Type	Rating	Tolerance
R_{58}	Value to suit Transformer	High-stability Carbon		
R_{59}	0.1MΩ	do.	½W	20 %
R_{60}	0.68MΩ	do.	½W	20 %
R_{61}	0.22MΩ	do.	½W	20 %
R_{62}	4.7kΩ	do.		20 %
R_{63}	0.22MΩ	Composition		10 %
R_{64}	20kΩ*	do.		
R_{65}	22kΩ	High-stability carbon	½W	20 %
R_{66}	0.22MΩ	Composition		10 %
R_{67}	0.20MΩ*	do.		
R_{68}	4.7MΩ	do.		5 %
R_{69}	1.0MΩ	do.	½W	20 %
R_{70}	0.22MΩ	do.	½W	20 %
R_{71}	2.2kΩ	do.		20 %
R_{72}	2.0MΩ	High-stability carbon		1 % or matched
R_{73}	2.0MΩ	do.		do.
R_{74}	1.0MΩ	do.		do.
R_{75}	10MΩ	Composition		5 %
R_{76}	47kΩ	do.		10 %
R_{77}	1kΩ	do.		20 %
R_{78}	47kΩ	do.	1W	20 %
R_{79}	0.22MΩ	do.		20 %
R_{80}	10kΩ	do.	1W	20 %
R_{95}	2.2MΩ	do.		20 %

* May require adjustment.

	Value	Type	Rating (V d.c. working)	Tolerance
C_{50}	0.5μF	Paper	250	20 %
C_{51}	50μF	Electrolytic	12	
C_{52}	16μF	do.	450	
C_{53}	0.02μF	Paper	350	10 %
C_{55}	100pF	Silvered mica	350	10 %
C_{56}	0.5μF	Paper	250	20 %
C_{57}	50μF	Electrolytic	12	
C_{58}	0.01μF	Silvered mica	350	1 % or matched
C_{59}	0.25μF	Paper	500	20 %
C_{60}	5000pF	Silvered	350	1 % or matched
C_{61}	5000pF	do.	350	do.
C_{62}	7000pF	do.	350	10 %
C_{63}	0.5μF	Paper	500	20 %
C_{64}	16μF	Electrolytic	450	
C_{81}	10–50pF	Silvered mica	250	
C_{82}	0.1μF	Paper	500	
C_{83}	2500pF	Silvered mica	250	10 %
C_{84}	1500pF	do.	250	10 %
C_{85}	300pF	do.	250	10 %
S_7	Single-pole changeover switch.			

All resistors may be ¼W rating, except where otherwise stated.

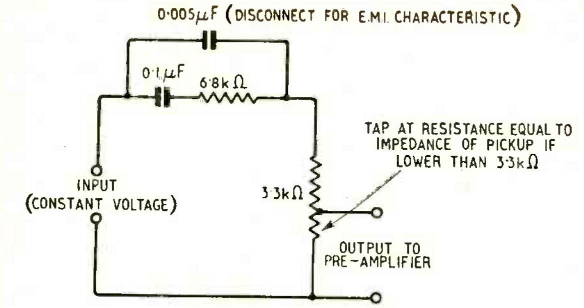
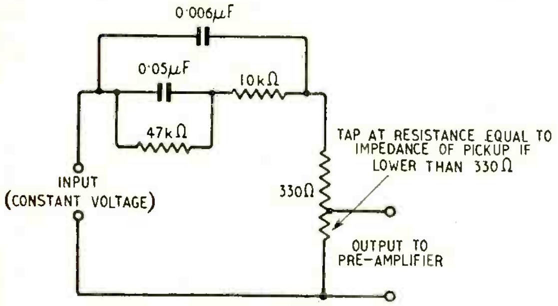


Fig. 31. Simulator for Decca and E.M.I. 78-r.p.m. recording characteristics.

Fig. 32. Simulator for Decca 33⅓ r.p.m. L.P. characteristic.



the pre-amplifiers in this way. In this event the circuit may be modified as shown in Fig. 30. This circuit applies to both pre-amplifiers. In it, the transformer had been replaced by a resistive network R_{96}, R_{97}, mixing the input and feedback voltages.

The input resistance of this circuit is approximately 0.1 MΩ, and its voltage gain at 1,000 c/s is 9. The frequency-response curve is almost identical with that of Fig. 14 (*W.W.* p.423, November, 1949). This circuit is suitable for most moving-iron variable-reluctance pickups, and can be used with piezoelectric pickups which have been loaded to give an output proportional to recorded velocity.

Danger of Overloading.—The input to the pre-amplifiers should be restricted to 200 mV in the case of the single-stage circuits and 50 mV for the three-stage circuit, and if necessary a potential divider should be used.

Piezoelectric Pickups.—Lightweight piezoelectric pickups have recently become popular, particularly for L.P. recordings. Since these give a relatively high output, no pre-amplifier is necessary and any correction required may be achieved by means of simple RC networks, details of which have already been published.[1]

Checking the Pre-amplifiers.—When a pre-amplifier has been constructed, it is advisable to measure its response curve over the audible frequency range and beyond, in order to ensure that nothing is amiss. This is particularly so in the case of the three-stage pre-amplifier.

To facilitate this measurement the networks of Figs. 31 and 32 have been devised. These circuits, when fed with constant-voltage variable-frequency input, produce outputs which are, respectively, replicas of the standard and L.P. characteristics.

To test a pre-amplifier, the appropriate network should be connected between an oscillator and the pre-amplifier input. The output from the pre-amplifier for a constant voltage to the network should then follow the response curve already published for the appropriate circuit (*W.W.* Figs. 14 and 17, pp. 423, 425, November, 1949).

Acknowledgment.—The writer is indebted to his colleagues for their help, and to Decca Radio and Television for information about their recording characteristic.

[1] West and Kelly, "Pickup Input Circuits," *Wireless World*, November, 1950, pp. 386-391.

STEERING BY RADIO

LEARNING to steer a vehicle, whether a bicycle, ship or aeroplane, is largely a matter of developing a set of instinctive reactions so that eventually the whole thing becomes automatic and requires no deliberate thought. Having mastered one vehicle it is easy enough to adapt the same set of reactions to another one—but not when it comes to steering a radio-controlled vehicle. Here one's acquired instincts are not only useless but definitely misleading, and many a confident aviator has made a fool of himself trying to pilot an aircraft from a control box on the ground.

The reason is, of course, that one is no longer moving with the vehicle and experiencing directly the effects of the steering movements. Moreover, when one's eyes are conditioned to being those of the vehicle, so to speak, it is extremely difficult to use them to gauge the effects of steering movements on a model that is some distance away, especially if it is moving across the line of gaze or actually coming towards one.

These problems, which must be quite peculiar to radio-controlled models, were discussed recently at an informal meeting on radio-controlled models at the I.E.E. The lecturer, P. A. Cummins, who opened the discussion, mentioned the difficulty he had had in steering a model car which was coming towards him, until he had learned to turn the controller steering-wheel in the right direction by instinct. Another speaker described an attempt to launch a model aircraft from a runway, with the operator stationed at the end of the runway behind the aircraft. When the model had become airborne it had started to climb; the operator immediately thought it was climbing too steeply and was about to stall, so he put it into a dive, with the result that it crashed. This difficulty, the speaker said, had been partly overcome by having another operator at right angles to the aircraft's point of take-off, but even so he thought there was a need for some kind of telemetering system to keep the operator informed of the aircraft's state of flight.

Demonstrations were given of a radio control system using six a.f. modulating signals to convey the orders, the mechanisms at the receiving end being moved by "step-by-step" actuators giving effectively continuous control.

Redesigned Government Hearing Aid

Features of the Mark IIA Instrument Designed by the Post Office

SINCE the original "Medresco" (Medical Research Council) hearing aid was described in this journal (January, 1948), responsibility for its development and production has passed from the Ministry of Supply to the Post Office. While retaining the basic recommendations of the Medical Research Council No. 261 report, advantage has been taken of improvements in valves and other components to increase the efficiency of the instrument, and details of the current Mark IIA have been given in a recent article.[1]

The advent of the CV2106 and CV2107 sub-miniature valves (which are equivalent to the Mullard DL66 and DF66 respectively) not only reduced the filament consumption from a total of 50 to 30 mA but enabled the standard gain to be achieved for an anode current of 0.57 mA, compared with the original figure of approximately 2.5 mA.

[1] "The Medresco Hearing Aid," by C. J. Cameron, A.M.I.E.E., and E. W. Ayers, B.Sc., A.M.I.E.E. *Post Office Electrical Engineers Journal*, January, 1952.

Fig. 1 is the revised circuit diagram. High values of anode load in the early stages give gains of 30 for anode currents of 15 or 20 microamperes. Approximately 2 volts bias for the output stage is derived from a resistor in the common h.t. lead; the loss of gain due to feedback from this resistor does not amount to more than 2 or 3 db. The switched capacitor C_3 adjusts the top response to conform to either of the recommended standard frequency characteristics. Response curves of the amplifier alone are shown in Fig. 2.

The overall frequency characteristic is determined by the characteristics of the earpiece and microphone as well as by the intervalve and decoupling components and the output transformer.

The new insert earpiece is of the magnetic type with a single centre pole associated with a ring magnet. The diaphragm is unclamped and a dished steel front plate relieves the diaphragm of excess magnetic flux. Fig. 3 shows the average frequency response characteristic and the permissible limits. All

Fig. 1. Circuit diagram of the "Medresco" Mark IIA hearing aid for use with insert earpiece.

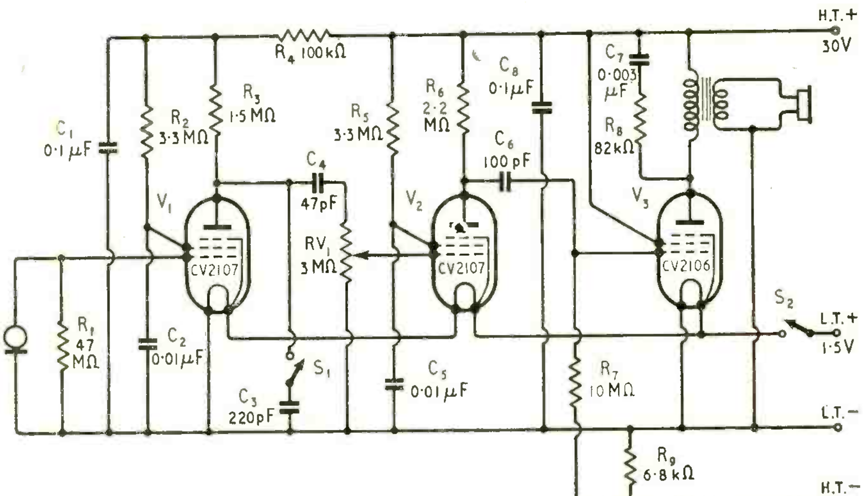


Fig. 1

Fig. 2. Frequency response curves of circuit of Fig. 1 for the two settings of the tone control switch.

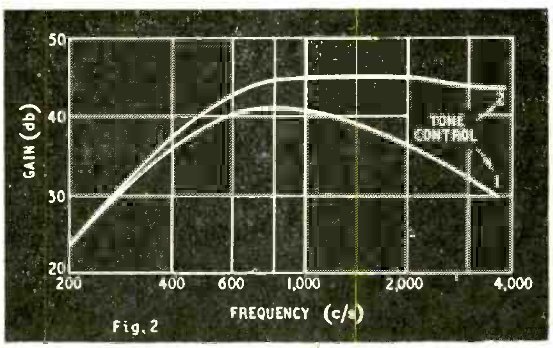
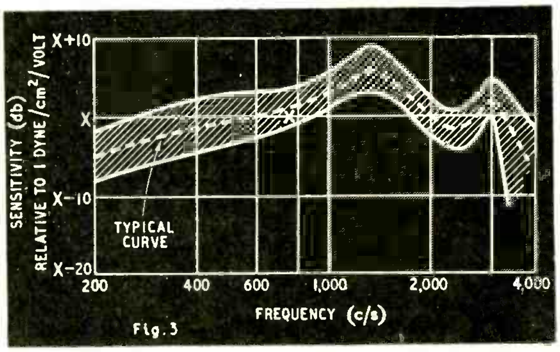


Fig. 3. Limits of frequency response characteristic of insert magnetic earpiece. At 750 c/s the level must not be less than +53db relative to 1 dyne/cm²/volt.



units are tested for sensitivity over the critical bands of 450-950, 1,200-1,700 and 2,700-3,200 c/s before acceptance.

As in the original hearing aid, a diaphragm-driven crystal microphone is employed and there are two types designed to match either the insert earpiece or the conventional external earphone which is supplied in special cases when the insert type cannot be used. It is relatively easy to modify the frequency response of the microphone to fit that of the earpiece and amplifier, and the variables available for this purpose are the weight of diaphragm, size of crystal element, and the grade of silk covering in front of the diaphragm.

Although the basic layout of the amplifier is substantially similar to that of the original, detail changes have been made to reduce manufacturing costs and improve accessibility. A combined volume control and switch has been substituted for the original mechanically coupled device.

It is reported that the p.v.c.-sheathed tinsel connectors have a service life of 6 to 12 months, and that improvements are being investigated to overcome failures due to migration of the plasticizer and discoloration by sweat acids.

Investigations of mercury, air-depolarized and rechargeable batteries have been made, but it is considered that at present the Leclanché layer-type h.t. and "dolly" l.t. cells should continue to be used either for technical, economic or administrative reasons.

Fundamental research is continuing into the problems of the minority who do not benefit from the standard hearing aid. Field trials of a bone-conduction aid are being carried out, and clinical investigations are being made of automatic level control and peak-limiting methods for the benefit of people with nerve or perceptive deafness, who require a high sound level of limited range.

Developments in printed circuit techniques and crystal triodes are being followed as possible future solutions of the ever-present problems of reduced weight and costs of production and maintenance.

WHAT IS A RECORDING CHARACTERISTIC?

Points from a B.S.R.A. Lecture and Discussion

MUCH thought has been given to the problem of selecting an optimum characteristic for direct disc recordings as a basis for the international exchange of recorded broadcast programmes, and an interesting lecture on this subject was given to the British Sound Recording Association on March 14 by P. E. A. R. Terry of the B.B.C.

A disc recording characteristic was defined as the relation between the r.m.s. electrical input to the recording chain and the r.m.s. lateral velocity of the groove cut in the disc. It was emphasized, both in the lecture and the subsequent discussion, that the publication of a recording characteristic did not necessarily define the content of a record or the setting of tone controls in the reproducing equipment that would give the most pleasing result. Experience had shown that in spite of the wide differences in the published characteristics of commercial recordings, the setting of tone controls for the best results on playback revealed no such wide deviations and tended to an average which implied an effective characteristic not very far from that used by the B.B.C. for direct disc recording. In the B.B.C. reproducing equipment a fixed equalizing circuit for the transcription discs is supplemented by a top-cut filter which can be switched to reduce surface noise when commercial pressings are used. No other tone correction is found to be necessary.

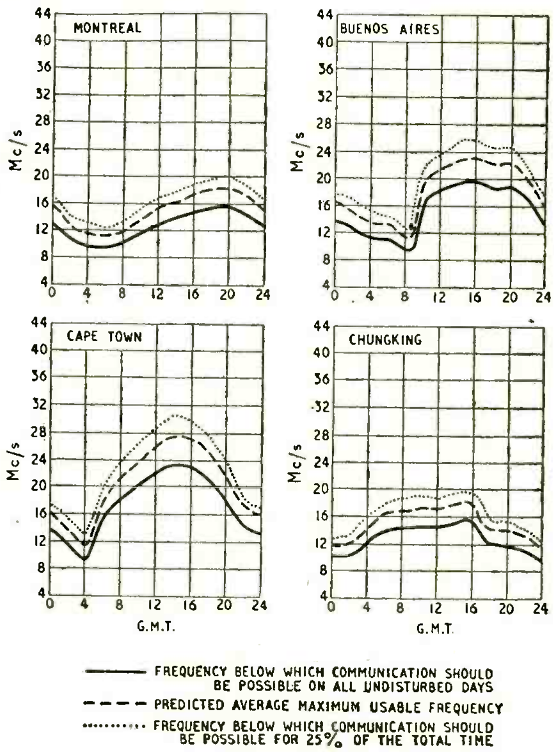
The interpretation of a recording characteristic clearly depended upon how one defined a recording chain. In practice it usually meant the recording machine and the amplifier immediately associated with it; the characteristics and placing of the microphone, studio acoustics and the judgment of the studio monitoring staff were not included. The justification for the search for an optimum recording characteristic was to be found in the limited but important matter of signal-to-noise ratio rather than in the quality of the recording as a whole, and the characteristic would ultimately be determined by the average distribution of energy with frequency in the programme material and in the inherent surface noise of the record. One of the chief difficulties in reaching an acceptable international standard had been the diversity of power levels in vowels and consonants met with in different languages.

Short-wave Conditions

Predictions for May

THE full-line curves given here indicate the highest frequencies likely to be usable at any time of the day or night for reliable communications over four long-distance paths from this country during May.

Broken-line curves give the highest frequencies that will sustain a partial service throughout the same period.



Developments in Components

Survey of the R.E.C.M.F. Exhibition

A private exhibition of the components and basic materials available to radio and electronic equipment manufacturers was held in London from 7th to 9th April. Notable items are described, and each section is followed by a list of exhibitors and their principal products.

CAPACITORS

WHILST miniaturization still continues to be the main trend in design of fixed capacitors, improvements in performance and in ratings have been effected in a number of cases. For example, the ceiling temperature without voltage derating for some T.C.C. electrolytics is now 85 deg C. This has been made possible by care in selection of materials and in the manufacturing process. Higher ripple currents are now permissible and the new technique is applied to the "Picopack" and "Multipicopack" ranges.

Widening of the working temperature range of the metallized paper capacitors made by Hunt has been made possible by a new impregnating and sealing method used for the new W97 type. A working range of —100 to +120 deg C is possible with only slight voltage derating above +100 deg C and they are fully tropicalized. This type is enclosed in a metal tube with very tough non-hygroscopic end-seals.

Suppression of television interference has been investigated by Dubilier with the result that a range of small units for including in, or on, various electrical appliances used in the home are now available. Some include a new design of lead-through capacitor and special miniature chokes wound on dust iron cores. Component parts can be obtained separately, a typical combination comprising two chokes and three capacitors.

Polystyrene is being used by T.M.C. in a new range of miniature capacitors. Known as "Syno" series, they are made in capacitances of from 0.002μF to 0.2μF for 150 V d.c. working.

Wingrove and Rogers ("Polar") have a new miniature tuning capacitor developed from a pre-set type and known as the C31-14. It takes just under 1 in × ¾ in of panel space and is made normally in 20- and 33-pF sizes.

Makers*: Bird (T, V); Daly (E); Dubilier (C, E, M, P, S, T); Erie (C, T); Hunt (E, M, MX, P); Jackson (T, V); London Electrical Manuf. (C, M); Mullard (T, V); Plessey (E, T, V); Stability Radio (M); Static Condenser (P); Telegraph Condenser (C, E, M, P, PL, S, T); Telephone Manuf. (M, P, PY); Walter Instr. (T); Wego (M, P); Welwyn (T); Wingrove and Rogers (T, V).

**Abbreviations:* C, ceramic; E, electrolytic; M, mica; MX, mycalex; P, paper; PL, plastic; PY, polystyrene; S, suppressor; T, trimmer; V, air-dielectric variable.

COILS AND TRANSFORMERS

R.F. Coils.—A wide range of miniature coils, both screened and unscreened, both air and dust-core, and both signal and i.f. types, was shown by Weymouth. Coil-pack units, including a bandspread type, were also shown. There are nine wavebands using dust-iron cored coils wound on bakelite formers and with air-dielectric trimmers.

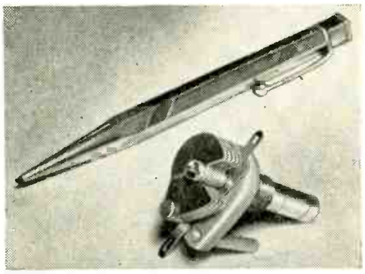
As in previous years, the general tendency is towards the use of dust-iron cores in the majority of tuning coils.

Makers: Advance, Bulgin, Igranic, Mullard, Plessey, Salford, Weymouth, Wireless Telephone.

Mains and A.F.—The use of C-cores for high-grade transformers continues, and examples were shown by many firms. No outstanding developments were evident, but the tendency noticed for some years towards improved workmanship and better sealing continues.

Partridge Transformers have produced an output transformer (Type P1292) rated for 15 W. It is of the push-pull type and is stated to be specially designed for use in negative-feedback circuits.

Transductors for use in magnetic amplifiers were shown by Parmeko. These are in the "Saturn" series and are mainly intended for use with low-impedance sources. Models are avail-



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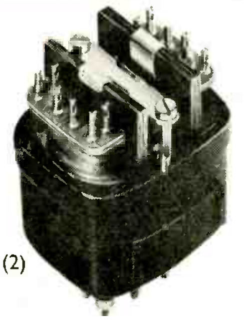

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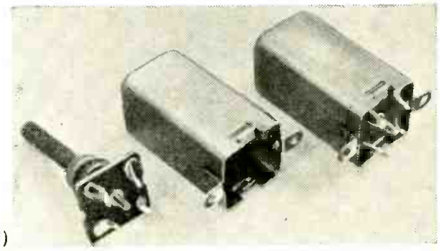

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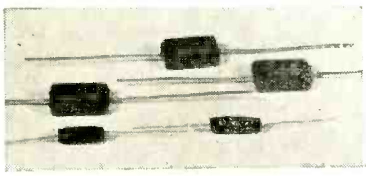

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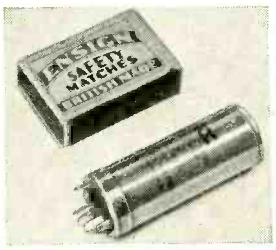

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(1) "Polar" miniature variable capacitor, model C31-14, developed from a pre-set trimmer. (2) Parmeko "Saturn" transductor. (3) Weymouth K-type coils, screened and unscreened. (4) Small capacitors and chokes (Dubilier) for a typical television interference suppressor. (5) T.C.C. high-temperature electrolytic capacitor. Size of a 32μF can be judged by comparison with the matchbox.

able for operation on supply frequencies of 50 c/s, 400 c/s or 1,600 c/s, and are suitable for the amplification of very small d.c. signals and, among other things, for converting d.c. information into a.c.

Makers: Acoustic Products, Advance, Bulgin, Electro Acoustic Industries (Elac), English Electric, Ferranti, Goodmans, Igranic, Parmeko, Partridge Transformers, Plessey, Rola Celestion, Vitavox, Weymouth, Woden.

RESISTORS

INTENDED for developing voltages from extremely small current pulses, the new "Megistors" shown by Morganite have values ranging from 10 to 10 million megohms! To obtain the necessary stability the carbon-film element is sealed in an evacuated glass envelope which is coated with water-repellant silicone lacquer. The temperature coefficient is approximately +0.3% change per deg C and the voltage coefficient is −0.2% change per volt. Working voltage is up to 300V, while the self capacitance is 0.2pF.

Welwyn were showing high-stability sub-miniature resistors of the cracked-carbon type with values up to 1MΩ. Miniaturization was also the main feature of the Electronic Components wire-wound resistors. Available in vitreous and lacquer with values up to 2MΩ, they have slots cut in the ends to enable the leads to be bent out at right angles to the body without doing damage. The latest thing from Erie was a 1-watt range of ceramic-insulated resistors.

Probably the smallest potentiometer in the show was the Egen Electric 3-MΩ hearing-aid volume control, with a diameter of $\frac{5}{8}$in and depth of $\frac{1}{4}$in. Going to the other extreme in size, Colvern were showing a large potentiometer for use in computing circuits with four wipers which give sine and cosine functions of the applied voltage.

Makers: British Electric Resistance, Bulgin, Colvern, Dubilier, Egen Electric, Electronic Components, Erie, Morganite, N.S.F., Painton, Welwyn.

TELEVISION COMPONENTS

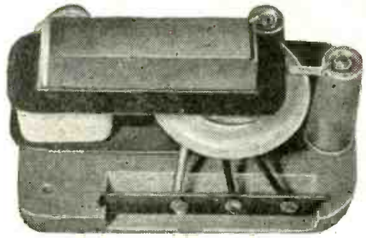
A GANGED tuner for television frequencies covering 40-70 Mc/s is being made by Plessey. It has three coils for the signal and oscillator circuits and each has a composite core of dust iron and aluminium. The three cores are mechanically coupled and adjustable by a single screw-type control. Padding inductors are included to secure tracking.

Present models are for intermediate frequencies of 10.5 Mc/s (sound) and 14 Mc/s (vision), but there are designs for frequencies of 37.5-38.5 Mc/s (sound) and 34-35 Mc/s (vision).

This firm also showed a range of television r.f. and i.f. coils in small screens, while Weymouth exhibited complete i.f. strips.

Igranic exhibited a range of deflector coils and transformers among which the types for 70 deg tubes are of major interest. The line coils are of 33.7 mH inductance and the frame of 77 mH. The auto-transformer for the line scan is designed to give 14 kV e.h.t. and the components in a suitable circuit will operate from a 190V h.t. line.

Plessey line-scan transformers have Caslam core material and the general form of construction is a centre core with end cheeks but no outer sur-



Igranic line-scan transformer.

round of magnetic material. Deflector coils are of two patterns, one having a plain Caslam ring for the iron circuit and the other having a slotted ring with the coils fitting into the slots.

Permanent-magnet focus units were shown by Plessey and by Elac—the later firm also exhibited ion-trap magnets—while Igranic had an electromagnetic type.

Projection-television units were shown by Mullard, c.r. tube masks by Long & Hambly and magnifiers by Thermo-Plastics.

Makers: Electro Acoustic Industries (Elac), Igranic, Long & Hambly, Mullard, Plessey, Thermo-Plastics, Weymouth, Wireless Telephone.

SWITCHES

TWO rather unusual switches were on view this year. The first was in effect a lever action, but the lever was arranged to move the rotor of a wafer switch backwards and forwards; both A.B. Metal Products and N.S.F. were showing two- and three-position types. The second, shown by Walter Instruments, was a miniature slide-action switch with a spring-loaded throw. Also very small in size were the latest Bulgin minia-

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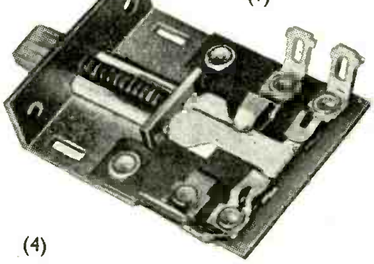

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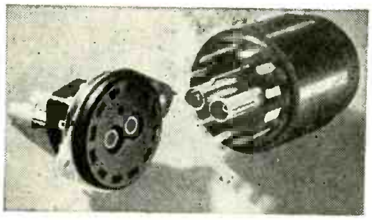

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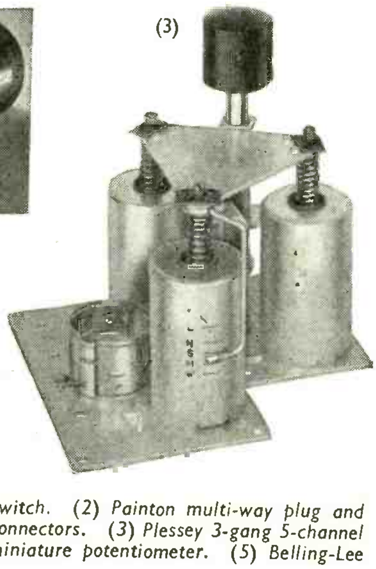

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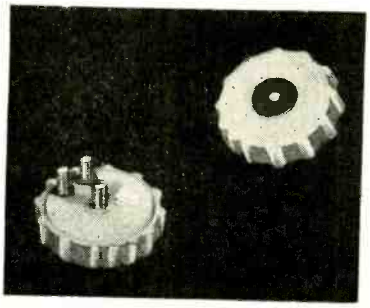

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(1) Walter miniature slide switch. (2) Painton multi-way plug and socket including two coaxial connectors. (3) Plessey 3-gang 5-channel television tuner. (4) Egen miniature potentiometer. (5) Belling-Lee flexible terminal block.

ture microswitches, which are made so that they can be ganged together; they have an extremely light action with operating pressures ranging from 20 to 60 grammes.

Makers: A.B. Metals Products, British Electric Resistance, Belling & Lee, Bulgin, Diamond H Switches, Electronic Components, Electrothermal Engineering, Erie Resistor, N.S.F., Painton, Plessey, Walter Instruments.

CHASSIS FITTINGS

THE potentialities of resilient plastic materials were demonstrated very effectively by two ingenious connecting devices. One was a flexible 12-way terminal block by Belling & Lee which can be fixed down to irregular or curved surfaces. Moulded in P.V.C., it is flexible in both planes, mechanically shock-proof, and can be cut into sections with a knife. The terminal screws are gripped securely by the moulding and cannot be shaken out even when it is mounted upside down. The other device was a simple wander plug by Carr Fastener in which the wire is gripped firmly by a push fit of one insulated part over the other.

A composite plug and socket designed for television and radar equipment, shown by Painton, has two Post Office type coaxial connectors surrounded by a circle of twelve ordinary contacts. Another well-designed multi-way plug and socket, displayed by Electronic Components, has a neoprene gasket which seals off the contacts against atmospheric conditions when the two halves are united.

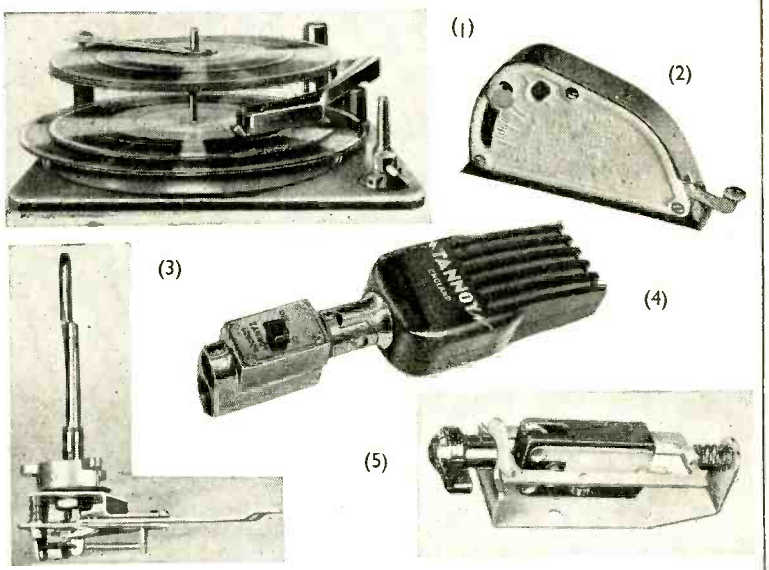
Makers: Antiference, Belling & Lee, Bray & Co., British Electric Resistance Co., British Mechanical Productions, Bulgin, Bullers, Carr Fastener, Clarke & Co., Colvern, Cosmocord, De La Rue, Electronic Components, Electrothermal Engineering, Erwin Scharf, Guest, Keen & Nettlefold, Hallam, Sleigh & Cheston, Hassett & Harper, Hellermann, Igranic, Jackson Bros., Long & Hambly, McMurdo, Micanite, Mullard, Mycalex, N.S.F., Painton, Plessey, Reliance, Reslosound, Salford, Simmonds Aerocessories, Steatite and Porcelain Products, Symons, T.C.M., Telcon, Thermo-Plastics, Tucker Eyelet, Walter Instruments, J. & H. Walter, Weymouth, Wingrove & Rogers, Wireless Telephone Co.

AERIALS

IT is rare indeed that improvements can be found in the design of the ubiquitous broadcast aerial, but this year Belling and Lee have fitted a new miniature transformer to the "Eliminoise" anti-interference aerial. The container is watertight and can be used in the most exposed positions and in any climate.

A new transformer is included also in the "Extat" aerial made by Antiference. It is much lighter than the original, has a "Ferroxcube" core and is said to give a good performance from 10 to 2,000 metres.

No new types of television aerial were seen for home use, but Antiference had a few models of horizontal "Antex" arrays for overseas and



(1) B.S.R. "Monarch" record changer with automatic selection of 7in, 10in or 12in mixed records. (2) Garrard stylus pressure gauge for lightweight pickups. (3) Spindle and record release mechanism in the Collaro 521 record changer. (4) Tannoy miniature ribbon microphone (Type MR425). (5) Cosmocord GP29 turnover crystal pickup.

having wide-band characteristics. The Belling-Lee contribution in this field includes *inter alia* several new indoor aerial distribution boxes, one being a six-way box taking coaxial connectors for operating six television receivers simultaneously without interaction.

Makers*: A.B. Metal Products (T); Antiference (B, C, F, T); B.I. Callenders (B, C); Belling & Lee (B, C, F, T,); Reliance Electrical (C); Telegraph Construction & Maintenance (C).

**Abbreviations:* B, broadcast including anti-interference; C, cables and feeders; F, aerial fittings; T, television.

SOUND REPRODUCTION

NEW record changers shown all make use of centre-spindle release mechanisms, and will play records at 33⅓, 45 and 78 r.p.m. The Plessey multi-speed record changer is automatic in discriminating between 10in and 12in mixed records at 33⅓ or 78 r.p.m., but manual selection is required when playing 7in records at either 33⅓ or 45 r.p.m. In the Collaro 521 series of record changers a new spindle mechanism with a simple and robust lever release passing through the barrel of the spindle takes the place of the conventional small pawl. Complete automatic selection of 7in, 10in and 12in records, mixed in any order, has been achieved in the new "Monarch" record changer introduced by Birmingham Sound Reproducers. This unit is light in weight and of simple and strong construction.

Turnover pickup cartridges with cantilever stylus mountings are employed in the Plessey and B.S.R. record changers, and in the Collaro model there is automatic weight compensation with change of stylus, operated by a single lever at the side of the arm. Cosmocord have introduced a new cantilever turnover pickup (GP29), for manufacturers, designed for a stylus pressure of 10gm for all records, and frequency correction is inherent in the mechanical design of the crystal drive. Automatic compensation is also a feature of the B.S.R. turnover head. Erwin Scharf (Goldring) have introduced a cantilever-driven magnetic head of the turnover type with an output comparable with the crystal types.

To ensure correct stylus pressures, Garrard have produced a neat gauge working on the spring-balance principle which can be used to test any pick-up *in situ*. It has a range of 0 to 15gm and costs 15s.

The Tannoy range of high-grade microphones has been extended by the addition of a miniature ribbon microphone (MR425) and a pressure type (MC424) with sockets designed to fit American stands. Cosmocord have added to their list a neat general-purpose hand microphone (MIC30) with integral desk stand and a top suspension loop. The response is flat from 50 to 5,000 c/s and the sensitivity is −55db referred to 1V/dyne/cm^2.

In addition to their dual concentric high-quality loudspeakers, Tannoy now make a direct-radiator type with a dissipative edge termination for the main diaphragm and a convex aluminium centre dome integral with the voice-coil former. Goodmans have introduced a Mark II version of their Axiom 150 twin diaphragm speaker in which the high-frequency cone has been modified to reduce the effects of surface noise from gramophone records.

The loudspeaker manufacturers are turning their attention to vibration generators for the physical testing of components, and Goodmans were showing two types for light and heavy duties, together with drive oscillators and auxiliary equipment. Electro Acoustic Industries, in conjunction with G.E.C. Laboratories, have developed a special high-frequency vibrator, for investigating valve microphony, in which special care has been taken to reduce stray fields in the vicinity of the work table.

Makers*: Acoustic Products (D, LS); Birmingham Sound Reproducers (GM, GU, RC, PU); Collaro (GM, GU, RC, PU); Cosmocord (E, M, PU); Edison Swan Electric (LS, PU); Electro Acoustic Industries (LS, V); Garrard (GM, GU, RC, PU); Goodmans Industries (LS, V); Plessey (GM, GU, RC, LS, PU); Reslosound (LS, M); Rola Celestion (LS); Erwin Scharf (PU); Tannoy (LS, M); Truvox (LS, M); Vitavox (LS, M).

**Abbreviations:* D, diaphragms; E, earphones, headphones; GM, gramophone motors; GU, gramophone units; RC, record changers; LS, loudspeakers; M, microphones; PU, pickups; V, vibration generators.

MATERIALS

A NON-METALLIC permanent-magnet material ("Ferroxdure") of a ceramic nature has been developed by Mullard, which shows remarkable resistance to demagnetizing fields up to strengths of 2,000-3,000 gauss. It is very suitable for focusing in television tubes and for small multi-polar generators. Its high resistivity (of the order of 10^6 ohm-cm) makes it suitable for use in h.f. fields and as a bias source in pulse transformers. An energy content of 800,000 gauss-oersteds is obtainable (about 1/7th that of Ticonal G) and the coercivity is 1,600 oersteds (about twice that of the best magnet steels).

Instrument winding wires insulated with polytetrafluorethylene (PTFE) to a standard thickness of 1 mil are now being made by B.I. Callender's Cables. The stable temperature range is $-75°$ to $+250°$C.

Further improvements in cored solder have been introduced by Multicore in the form of *five*-cored wires, available down to 22 s.w.g., in which the flux is brought very close to the surface to ensure rapid flow to the work.

Makers*: Associated Technical Manufacturers (B, C, IM, IS, W); Geo. Bray (CE); B.I. Callender's Cables (C, CO, IS, W); British Moulded Plastics (IM); Bullers (CE); H. Clarke (Manchester) (CF, IM, IS); De La Rue (IM); Du Bois (S); Duratube & Wire (C, IS, W); Electrothermal Engineering (C); H. J. Enthoven (S); Fine Wires (W); Hellerman Electric (IM, IS); London Electric Wire (C, IS, W); Long & Hambly (RP); Magnetic & Electrical Alloys (M, L); Micanite & Insulators (CF, IM, IS); Mullard (DC, M); Multicore (S); Murex (M); Mycalex (IM); Permanent Magnet Assoc. (M); Reliance Electrical Wire (B, C, CO, IS, W); Salford Electrical Instruments (CF, DC, MT); Geo. L. Scott (L); Standard Telephones (M); Steatite & Porcelain (CE); Suflex (B, CO, IM, IS, W); H. D. Symons (CF, IM, IS); Telegraph Construction & Maintenance (C, DC, IM, IS, M, L, W); Thermo-Plastics Ltd. (CF, IM); Vactite Wire Co. (W).

**Abbreviations:* B, braiding; C, cables; CE, ceramics; CF, coil formers, bobbins; CO, cords; DC, dust cores; IM, insulating materials; IS, insulating sleeving; L, laminations; M, magnets and magnetic alloys; MT, magnetic recording tape; RP, rubber products; S, solder; W, bare or covered wires.

VALVES AND CATHODE-RAY TUBES

New "Glassware" and Contact Rectifiers

As in the case of test and measuring equipment this section of the report covers items seen either at the Physical Society or R.E.C.M.F. Exhibition.

AMONGST the many special-purpose valves on show this year, probably the most interesting was the Ericsson "Dekatron," a cold-cathode gas discharge tube suitable for counting or working as an electronic selector. It has a circle of ten cathodes arranged round a common anode, and the glow is passed round from cathode to cathode by applying negative pulses to guide-electrodes between them; thus the number of pulses applied is indicated by the position of the glow round the circle. Another new gas discharge tube was the Mullard ME1503 thyratron, which is hydrogen-filled and has very low ionization and de-ionization times.

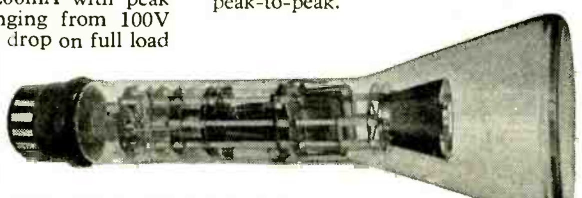
The versatile germanium crystal is now beginning to show its paces as a power rectifier, in which role it has the advantages of small size and high efficiency. B.T-H. were showing their GJ types using the new p-n junction; these allow a maximum d.c. output current of 200mA with peak inverse voltages ranging from 100V to 200V, the voltage drop on full load being about 0.7V. On more familiar ground, Brimar displayed two germanium diodes for use in television receivers, the GD3 as a vision detector and the GD4 as a noise limiter. An experimental transistor was shown by S.T.C. This firm also had some small selenium rectifiers which can be wired direct into circuits, one range having soldering tags and the other (known as "Unistors") being mounted in ceramic tubes with colour-code bands and wire ends just like resistors. Intended for similar applications was a small, high-impedance selenium rectifier by Westinghouse with a reverse resistance of about 50MΩ

"Dekatron" tube by Ericsson.

Westinghouse also had metal rectifiers designed to work at ambient temperatures of up to 70°C, and hermetically sealed versions of their 36EHT tubular rectifiers.

Many of the new receiving valves on view were types designed specifically for television circuits—some specifically for use with wide-angle c.r. tubes. In line-scan output valves there were the Osram N339 pentode, the Brimar 50CD6 beam tetrode and the Ediswan V646 beam tetrode. New efficiency diodes were the Osram U329, with a peak heater-cathode rating of 7.5kV, the Brimar 25U4GT with a h-k rating of 3.8kV and the Ediswan U283.

As for cathode-ray tubes, a number of rectangular-screen types were shown, the largest being the 17-in (diagonal) Brimar C17B and Ferranti TR17. The latest circular tubes on view were the 16-in type 6901A by G.E.C. and the Ediswan 15-in wide-angle tube CRM 152a. Notable amongst oscilloscope tubes was the 20th Century Electronics S6BA, which has three post-deflection accelerators—these produce an extremely bright spot without impairing the deflection sensitivity. Also designed for giving a very bright trace was the Ferranti 06/2P which uses magnetic focusing to obtain a fine spot, the anode voltage being as high as 15kV. Representing the other end of things was the Cintel monoscope—a pick-up tube which scans a test card permanently fixed inside it, giving out a video signal of 0.5μA peak-to-peak.



20th Century Electronics polar co-ordinate c.r. tube.

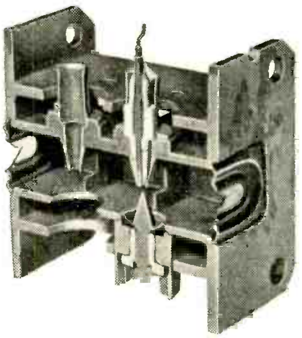
Physical Society's Exhibition

Electronic Techniques in Research and Measurement

A survey of apparatus and methods of radio and electronic interest shown at the 36th Exhibition of the Physical Society held in London from 3rd to 8th April

RESEARCH

MICROWAVE technique generally is still a field in which research is being vigorously pressed forward, and there is now considerable emphasis on measuring apparatus. Ferranti showed an interesting attenuator for use at 9,250 ± 250 Mc/s



Section through Ferranti electronic attenuator.

which gives an attenuation of 0-50 db for a standing-wave ratio of 1.2. It comprises a cavity filled with krypton and provided with two insulated electrodes from which a discharge to the case can be maintained. The intensity of the discharge is regulated by the applied voltage and controls the amount of attenuation.

The G.E.C. Research Laboratories demonstrated coaxial filters with the aid of a swept-frequency oscillator and a c.r. display. At 2,000 Mc/s, remarkably square pass-bands of 100 Mc/s are obtained from a line provided with three stubs, each consisting of several $\lambda/4$ sections in series having alternately different impedances. The different impedances are obtained by placing lengths of polythene tube on the centre conductor at intervals.

The Radar Research and Development Establishment exhibited apparatus for measuring the frequency characteristics of waveguide components. A standing-wave detector is used with a directional coupler to determine the ratio between incident and reflected waves and so obtain the reflection coefficient. A swept-frequency oscillator is used and the output is displayed on a c.r. tube.

An interesting magnetic device was shown by the Signals Research and Development Establishment. It comprises a stack of mu-metal laminations of the usual EI form with a normal-type winding on the centre limb. There are, however, a few only of the I laminations and these are widely spaced; these individual laminations carry subsidiary windings. There is also a further winding which encircles in a complex manner the centre limb and also individual laminations extending from it to meet the I laminations. The main winding saturates the I laminations. An individual lamination can be unsaturated by a bucking flux generated by current in a control winding and the coupling between coils on that lamination can thus be altered. The device can thus be used as a switch. In addition, it can be used to give a memory, because of the remanance of the core.

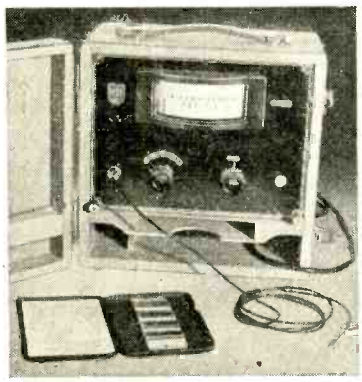
A recurrent-surge oscilloscope was exhibited by B.T.-H. It is intended for transient-response testing and develops a recurrent pulse of the form cos ωt**1**. The frequency of the cosine term is lower than any frequency in the circuit response, so that the wave approximates to a unit step. The front rise time of the output voltage is 0.01 μsec, and sweep times of 1 μsec to 50 μsec are obtainable.

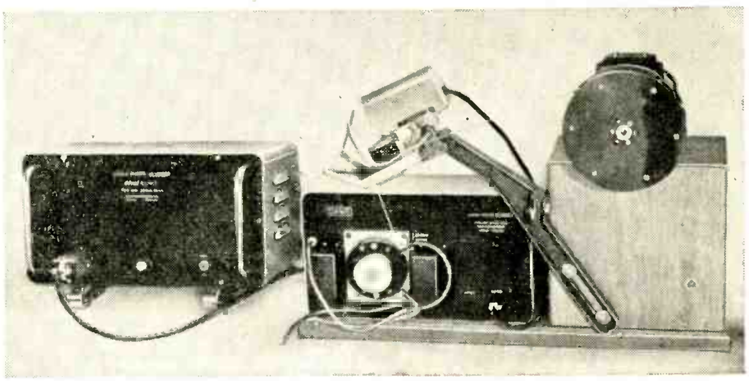
INDUSTRIAL ELECTRONICS

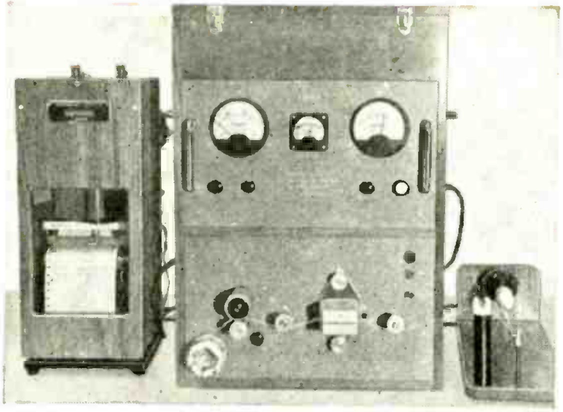
ONE of the most important services of electronics to mechanical engineering is the non-destructive testing of metals by supersonic waves to determine not only flaws, but thickness. This is particularly important in the pressure vessels used in oil refining, and Dawe Instruments were showing a special battery-driven instrument (Type 1101) operating on the standing-wave, variable-frequency principle and small enough to pass through the usual inspection manholes. Developments in ultrasonic techniques were also shown by the N.P.L. and included barium titanate transmitter-receiver probes of low impedance.

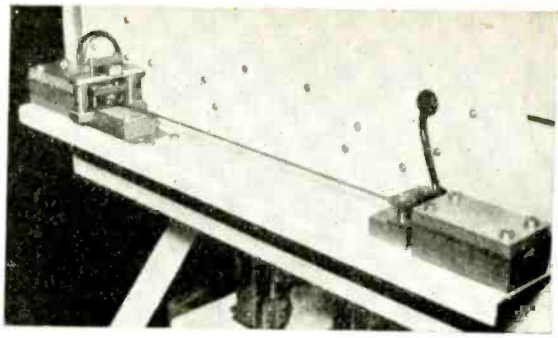
The evaluation of machined finishes by electronic magnification of the surface profile has been reduced to an exact science in the equipment developed by Taylor, Taylor and Hobson, which is designed for permanent installation in the gauge and tool room. Simple portable apparatus (Type PR9150) was shown by Philips in which a crystal pickup with sapphire stylus is preceded by a larger-diameter ball to give the reference level and is

Left: Philips surface roughness comparator with standards. Right: "Linra" photo-slubber (Dawe Instruments).









Left: Fielden-Walker yarn weight recorder and integrator. Above: Elliott magneto-striction delay line.

drawn manually across the surface. An amplifier and integrating meter records the e.m.f. developed which may be compared with a set of roughness standards provided.

Electronics in the textile industry were well represented. Kelvin and Hughes were showing a yarn tension pickup making use of a differential transformer type of transducer which can be rapidly applied to a running yarn to detect and, if necessary, record fluctuations of tension. Irregularities in the weight per unit length of yarn are recorded in the Fielden-Walker Type WL1A equipment by passing the yarn through a condenser which forms one arm of a bridge. A similar end is achieved in the Dawe Instruments "Linra" irregularity gauge (Type 1103) by measuring the thickness photoelectrically, and in the automatic "slubber"—shown by the same firm and operating on the same principle—a thyratron-operated cutter prevents thickness faults passing to the finished work.

Electronic control is widely used in the chemical industry for the regulation of temperature and hydrogen-ion concentration (pH). In a new automatic titrimeter shown by Electronic Instruments the neutralizing reagent is dispensed in small measured quantities by a magnetically operated pump, the pulses being registered by a counter. A relay associated with a pH meter stops the machine at the end point, and the volume of liquid used can be read off the boldly figured counter scale. Photoelectric assessment of flame coloration is used in the Evans Electroselenium flame photometer for the accurate estimation of sodium and potassium salts in solution.

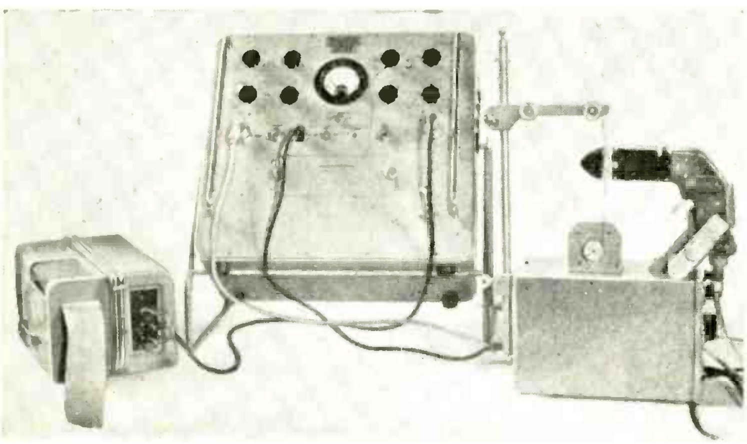
NON-INDUSTRIAL ELECTRONICS

UNDOUBTEDLY one of the highlights of this year's exhibition was the flying-spot television microscope shown by Avimo. The specimen to be examined is put in an ordinary microscope and scanned through the optical system by a c.r.t. flying-spot generator placed at the eye-piece end—in this way the scanning raster is focused down to the right sort of dimensions for the specimen. Light transmitted through the specimen is then collected by a photo-multiplier tube, and the output of this is amplified and used to modulate the spot intensity of a viewing c.r. tube (the scanning system of the two tubes being synchronized of course). Apart from its obvious advantages for demonstration purposes, the instrument gives a magnification greater than that of any optical microscope and, unlike the electron microscope, can be used for examining living cellular structures.

Another somewhat unusual instrument was a high-speed recorder (Ferranti) with no moving parts and consequently no mechanical inertia to limit the frequency response. Instead of a pen, it uses a fixed "comb" of separate styli, each of which responds to a particular voltage level on the input waveform and makes a dot on the voltage-sensitive recording paper. Thus the record is not a continuous line but built up from a series of these dots. The input waveform is arranged to frequency modulate an oscillator so that different voltage levels produce different frequencies; these are selected by a bank of tuned circuits each one of which energizes a stylus in the "comb."

Among the various pieces of computing apparatus on show was a regenerative-loop digital storage system (Elliott) using a new kind of delay line. Working on the magnetostriction effect, it consists of a length of nickel-iron tape with an input coil at one end and an output coil at the other. When a pulse is applied to the input coil the tape undergoes a change of length (the magnetostriction effect) and this causes a constriction to travel along to the far end where it generates a pulse in the output coil. The delay obtained is about 5 microseconds per inch of tape.

Kelvin and Hughes yarn tension pickup unit and auxiliary apparatus for recording.



OSCILLOSCOPES

THERE are no signs that the oscilloscope is being in any way displaced by other methods, but there are certainly fewer new designs than in previous years. To a large extent this is due to the requirements of a general-purpose oscilloscope having become largely standardized.

In one case, the scope of the instrument has been broadened by increasing its flexibility for the measurement of non-electrical quantities. This is the Southern Instruments M950 universal oscilloscope for which auxiliary units, usually powered from the oscilloscope itself, are available. It has a 5-in tube operating at 2 kV or 5 kV as required and a Y-amplifier with a gain of 1,200 times. A calibrator is provided. The time-base covers 0.5 c/s to 100 kc/s and can be used free-running or triggered. Stabilized power supplies are used.

A. E. Cawkell have an unusual oscilloscope in that the time-base has a maximum recurrence frequency of 50 c/s, and a minimum of 0.25 c/s. A 6-in tube with a 5-sec afterglow screen is used and the instrument is expressly designed for the investigation of very low-frequency phenomena. An electronic switch, which operates in both X and Y circuits, is provided to give a double-beam effect. The amplifiers are direct-coupled.

The Nagard wide-range calibrated oscilloscope, type 103, is unusual in having an interchangeable amplifier—there are several different models.

Of a different type, the J. Langham Thompson high-speed triggered oscilloscope, type 252, has a sweep speed of 10 μsec to 20 msec, and the trigger can be delayed from 150 μsec to 10.4 msec.

COMPONENTS

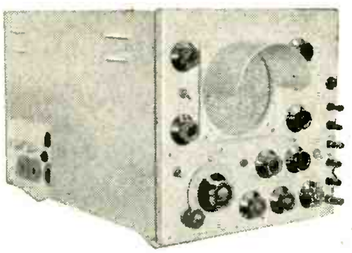
SOME further developments of the miniature "Castanet" tantalum electrolytic capacitors have been made by Plessey. By series and parallel connection of the basic unit—a disc of $\frac{7}{8}$in dia and $\frac{1}{4}$in thick giving 55 μF at 80 V working—a wide range of capacitances for different voltages can be produced. New miniature ceramics—the "Cascap" for 500 V d.c. or 265 V a.c. working—were shown in a wide range of values.

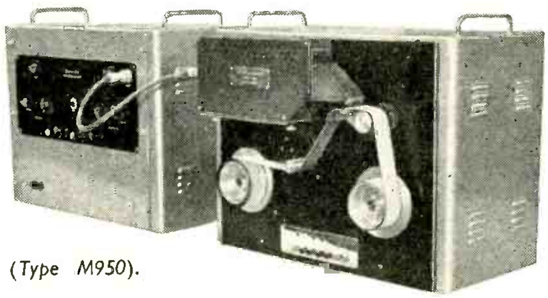
New wire-wound resistors in high ohmic values have been developed by British Electric Resistance. A ceramic tube is used on which is space-wound a very fine gauge resistance wire, but as it will not withstand high firing temperatures it is embedded in a special low-temperature setting enamel, which after setting hard can be operated at much higher temperatures. Resistors up to 250 kΩ are made in this type.

Ericsson have developed some new miniature relays. One, a polarized type, operates with less than 1 mW input and has double-pole contacts, the other (non-polarized) is about the same size as a miniature valve, operates with 0.7 to 0.8 mA and is a single-pole type.

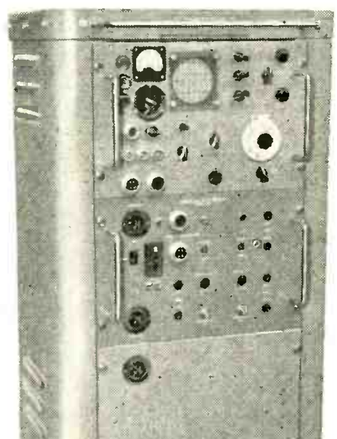
MATERIALS

SEVERAL new developments were noted in magnetic and electrical resistance alloys. Standard Telephones were demonstrating the properties of Permalloy "F," a high permeability "rectangular" hysteresis loop type of alloy designed for saturable reactors and magnetic amplifiers, and Telegraph Construction and Maintenance showed Mumetal tape 0.0003in thick which is suitable for reactors working up to 40 Mc/s. The same firm have developed a resistance alloy, "Telconal," having properties similar to "Constantan," but containing no nickel. They have also succeeded in producing the high-saturation alloy "Permendur" in wire as well as sheet form and were showing a vanadium cobalt iron permanent-magnet material, "Vicalloy," which is malleable before heat treatment for magnetization. It has a rententivity of 9,000 gauss and coercivity of 300 oersteds.





Left: Southern Instruments general-purpose oscilloscope (Type M950). Right: Ferranti high-speed recorder with fixed style.



Left: Avimo television microscope. Right: Langham Thompson delayed triggered oscilloscope (Type 252).

TEST AND MEASURING GEAR

For Routine Laboratory and Workshop Use

Under this heading are collected notes on commercially-available test equipment shown either at the Physical Society's Exhibition or at the R.E.C.M.F. Exhibition in London. No distinction as to the origin has been made as some items appeared at both shows.

SIGNAL SOURCES

A PRECISION standard signal generator covering television frequencies which provides a wide variety of video patterns is produced by Philips. It embodies crystal-controlled sound and vision oscillators (changeable for different channels) sync and blanking pulses and 13 different video patterns made up of lines, bars and dots. There is a built-in c.r. tube for monitoring the patterns.

Tuning forks as standard of audio-frequency still serve many purposes and a new electrically driven model is included in the Muirhead range. It is available either as a self-contained mains-operated unit (Model D630) or as a chassis for use in larger equipments (Model D639). Operating frequencies range from 480 to 2,000 c/s with a stability of ± 20 parts in a million.

A frequency standard fitted with a crystal-controlled oscillator, frequency dividers and multipliers and giving either a pulse or a sine wave output in decade steps from 100 c/s to 1 Mc/s is a new Airmec product. Its short-period stability is better than 1 part in 10^6 and a 2½-in c.r. tube is incorporated for visual comparison of internal and external frequencies. Comparison by heterodyne beat is allowed for also. A clock driven from a 50-c/s division of the oscillator is used for frequency checks.

Nucleonic and Radiological Development have a new crystal-controlled pulse generator embodying a chain of decade dividers giving variable width pulse outputs from 100 kc/s down to 0.5 c/s.

MISCELLANEOUS TEST EQUIPMENT

HIGH-VOLTAGE equipments for resistance, leakage and breakdown tests are more in evidence this year and some are quite versatile in the facilities provided. Panax have a portable set operating up to 10 kV and giving aural indication of ionization on approach to the breakdown voltage as well as providing for resistance measurements up to 10^6 ohms. One made by Airmec gives test voltages variable from 3.5 kV to 20 kV with resistance-measuring facilities, while Hivolt have an elaborate set with a d.c. output continuously variable from 300 V to 30 kV. Qualitative measurements of ionization current are made and it is equipped with an automatic cut-out which operates when insulation breakdown occurs; there is also a clock for registering the exact time of breakdown after initiating a test. The clock stops when the cut-out operates.

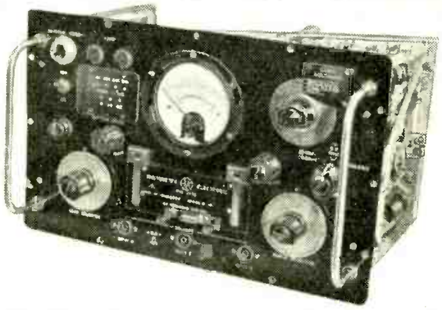
The Avo "Electronic Multimeter" is a wide-range general-purpose test set for use under arduous conditions which was developed originally for the armed forces. Basically a millivoltmeter of 250 mV full scale deflection, it includes shunts and multipliers for some 97 ranges of a.c. and d.c. current, voltage and resistance. There is an r.f. probe for measurements up to 250 Mc/s.

Direct measurement of very small a.f. and r.f. voltages is provided by the British Physical Laboratories' "Probe Millivoltmeter" which in three ranges covers 0-150 mV, 0-500 mV and 0-2 V respectively. The smallest readable indication is 10 mV and it is usable from 10 c/s to 150 Mc/s.

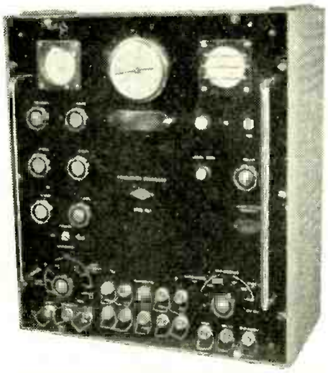
For r.f. power measurements on small transmitters, particularly of the mobile type, Marconi Instruments have a compact power output meter covering 80 to 160 Mc/s and giving direct readings over the ranges 0-5 W and 0-25 W.

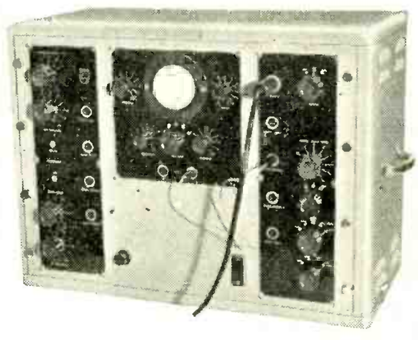
Sifam have a blind-man's milliammeter with an embossed scale and a buzzer to indicate alignment between the external hand-moved pointer and the internal instrument pointer, also a portable quick-acting low-temperature indicator for use over the range −80 deg C to +200 deg C. An open scale of limited coverage, or one of wide coverage, can be provided as required. It is known as the "Thermaster" and is basically a bridge with a special Thermistor in one arm which is an exploring probe.

An electromagnetic system which causes an inductance to oscillate about a dust-iron core was shown by Electro Acoustic Industries. Inductance variation is 1.6 to 4.8 μH and the unit can be used for producing the sweep in a television signal generator.



Left: Marconi Instruments transmitter power output meter, Type TF912/1, and (right) Avo 95-range "Electronic Multimeter," Type CT38.





Airmec crystal-controlled frequency standard, Type 861, and (right) Philips television standard signal generator, Type GM2657, giving choice of 13 test patterns.

LETTERS TO THE EDITOR

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

Ionospheric History

I WOULD like to add a few comments to Prof. E. W. Marchant's article, "Pre-Heaviside Propagation Theories," which appeared in the April issue.

The so-called "Heaviside" layer is more accurately known as the "Kennelly-Heaviside" layer. Heaviside's article in the *Encyclopædia Britannica*, wherein he suggested that long-distance radio wave propagation may take place via an ionized region in the upper atmosphere, did not appear until shortly after Kennelly's paper in *Electrical World and Engineer*[1] in which Kennelly put forward the same hypothesis.

Concerning the first published suggestions of the existence of an ionized region in the upper atmosphere, it is important to note the contributions of the geomagneticians, Gauss and Stewart. In 1838, Gauss stated, at the conclusion of paper on the origin of the earth's magnetic field that "another part of our theory, on which there may rest a doubt, is the assumption that the causes of the terrestrial magnetic force are confined to the interior of the earth. If we look for the direct causes, partly or wholly, outside the earth and confine ourselves to known scientific principles, we can only think of galvanic currents. The atmosphere is no conductor of such currents, neither is the void. However, the enigmatical phenomenon of the aurora, in which electricity in motion seems to play the main part, forbids us to deny the possibility of such currents."[2] In the ninth edition of the *Encyclopædia Britannica* (1882), Stewart discussed four theories which had been proposed to explain the solar diurnal variation of the earth's magnetic field and he discarded three of them.[3] The fourth, his own suggestion, was that this particular geomagnetic variation was due to the dynamo-action of a body of ionized air in the upper atmosphere moving across the earth's permanent magnetic field. The magnetic field associated with these dynamo-induced electric currents was the cause of the solar diurnal geomagnetic variation.

Finally, it is interesting to note that Professor Chapman had put forward the hypothesis[4] that the ionized region of the earth's atmosphere was stratified shortly before the experimental verification of this fact by Appleton. Chapman's evidence was based on geomagnetic observations. C. G. McCUE.

Datchet.

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[2] K. F. Gauss. "Allgemeine Theorie des Erdmagnetisimsus." Resultate aus den Beobachtungen der Magnetischen Vereins im Jahre 1838, pp 1-57, Leipzig, 1838.

[3] B. Stewart. "Hypothetical Views Regarding the Connection Between the State of the Sun and Terrestrial Magnetism." *Encyclopaedia Britannica*, 9th Edition, Volume 16, p 181.

[4] S. Chapman. "The Evidence of Terrestrial Magnetism for the Existence of Highly Ionised Regions in the Upper Atmosphere." *Proc. Phys. Soc.*, Vol. 37, p 38D, 1925.

"Odd" Resistors

IN a recent article ("Why 47," February issue) "Cathode Ray" shows the advantages of "preferred value" resistors. Readers may be interested in an additional advantage (at least for some values!) indicated by this passage from a well-known serviceman's guide.

"Some of the larger radio manufacturers . . . employ mercury-vapour lamp lighting in their assembly plants. Certain colours are difficult to distinguish under the bluish-green light of these lamps. To overcome this difficulty, in such cases, these manufacturers employ odd-values of resistors. For example, the "black" in the green-black-orange colour coding of a 50,000-ohm resistor is not clearly distinguishable under this light. Therefore, instead of using 50,000-ohm resistors, 51,000-ohm units are used instead, since each of the code colours (green-brown-orange) for this value of resistance show up sufficiently well. Likewise 99,000-ohm resistors are used instead of 100,000-ohm units, etc." E. N. MEAKIN.

Carlisle.

Colour Coding

MAY I suggest an idea which I have found most useful? The colour code for resistors is firmly established, and directly one sees a green spot one's mind automatically says "5." I mark all B.A. taps and dies with a paint spot, so I can pick a 2B.A. tap out of dozens simply by its red spot. Also, drills can be marked with three significant figures, so that a ½in drill has brown and red whilst a 5/64in drill has green, blue and yellow. A 1/16in drill would normally be difficult to distinguish from the last-mentioned in a pile of drills, but painted brown, brown blue it looks quite different.

This system is much quicker than looking at the drill shank and also serves to put a personal mark on the tools. LEONARD W. GENTRY.

Fakenham, Norfolk.

Units of Capacitance

THE plea of V. Mayes (January issue) in favour of billion instead of milliard for 10^9, leaves us on the Continent with the problem of what to call 10^{12} (now billion = bi-million).

Compare 10^{18} = tri-million or trillion, 10^{24} = quadruple-million or quadrillion, 10^{30} = quintillion, sextillion, septillion, etc.

Though more used in astronomy than radio, the logic of these names seems so clear that I recommend them strongly.

Incidentally, the prefixes "pico" and "nano" became popular in this country fifteen or twenty years ago, mostly through the technical publications of Philips and others, with "pico" as favourite.

Zwolle, Holland. E. J. F. THIERENS.

Picture Quality

APROPOS the remarks recently made by correspondents in your columns regarding the "lininess" apparent on the larger television screens, I thoroughly agree that this spoils the general pleasure (?) of viewing, and cannot easily be overlooked.

Spot wobbulation has been suggested and tried as a cure with encouraging results, although few manufacturers fit this as a standard feature. There are disadvantages in its use, such as the necessity for careful screening to keep the signal from passing through the video amplifier, or from interfering with neighbouring receivers.

I would like to suggest an alternative scheme which does not have the above disadvantages, though no doubt it will have its own difficulties.

The scheme could be termed "Frame Lift" and its action is to lift the whole picture by half the distance between the centres of adjacent lines, the result being, to the eye, a picture of 910 lines instead of 405 lines. The light output should be increased since more of the screen is used, and since the signal required is a square wave of 12½ pulse repetition frequency synchronized with the frame, there can be little r.f. interference.

The overall effect is really that of two pictures displaced vertically by half a line width, that is, say in the case of a 9in screen, never greater than 0.01in.

Thus any defocusing effect will be negligible, but "lininess" will disappear.

I am in no position to experiment with this matter, but mayhap some of your correspondents will do so and report. C. E. S. R.

Telegraph Tempo

YOUR Editorial (April 1952 issue) complains of the speed of transit of messages over the inland telegraphic network. Although there are no doubt numerous examples of troublesome delays on these services, it can be said that very positive steps are being taken to reduce the transit time to a minimum, the most important step being the introduction of an automatic switching scheme for the inland network.

Between 1935-1938 a complete survey was carried out into the possibilities of automatic telegraphy and field trials were in progress at the outbreak of hostilities in 1939. The whole scheme was shelved because of the war, but in 1943 a manual switching scheme was introduced. The earlier point-to-point method required numerous retransmissions of most messages and the greater flexibility of manual switching largely overcame this, greatly decreasing the transit time. Time was still lost, however, in the process of setting up and clearing switchboard connections, and this difficulty will be overcome by the automatic switching scheme. Automatic switching centres are already installed in various parts of the country and the scheme should be completed by 1955 with a total of 24 switching points.

Indeed, on completion, any teleprinter operator will be able to set up a connection with any other telegraph office in the country by merely dialling a six-digit code; the total setting-up time taking less than 10 seconds!

If then, in a year or so, an air passenger arrives at his destination ahead of the telegram announcing his departure, it does not appear that the fault will lie in a lack of foresight in the *technical* field.

Bletchley. E. M. GLASSCOCK.

WINDS IN THE IONOSPHERE

WINDS in the lower atmosphere are caused by temperature or pressure gradients, which result in bodily movements of the air tending to produce more uniform conditions. But in the stratosphere it was supposed that they would not exist, because the temperature has hitherto been thought not to vary with height. Similarly, at higher levels in the atmosphere, i.e., the ionosphere, it was considered that the air would be stratified into layers of uniform intensity, and not subject to wind-like movement.

Details of investigations made both in the U.S.A. and in this country, which have recently been published, indicate that these ideas about the stratosphere and ionosphere may not be correct and that horizontal movements of air, as well as local turbulences, may occur. Most of this work has been done in this country by the Cavendish Laboratory, Cambridge, the University of Manchester, and the D.S.I.R. Radio Research Station, and, in the U.S.A., by the National Bureau of Standards.

The ionospheric investigations are mainly based on the fact that when a probing radio wave of constant amplitude is sent up to the ionosphere it usually returns with an amplitude which varies with time. This indicates the presence of an irregularity in the ionization of the reflecting layer, and it is then necessary to examine the nature of the fading in order to determine whether any movement exists at the point of reflection. One method of doing this is to observe the fading on two spaced receiving aerials. It is then found that the fading observed at the different receivers is of a similar pattern, but is displaced in time. This means that the ionospheric irregularities are reflecting the waves in a varying manner so as to produce a pattern of varying field strengths on the ground, and, furthermore, that the varying field strength pattern is moving past the receiving aerials in accordance with the movement of the reflecting irregularities. The fading pattern on the ground will, in fact, move twice as fast as the irregularity in the ionosphere overhead.

In this country (and also in the U.S.A.) three receivers spaced about 100m apart in the form of a triangle have been used to measure the movement of irregularities in the E region at a height of 100km. The irregularities have been found to have a size of about 200m and to move horizontally at a speed of about 80m/sec, besides having a random or turbulent movement. Similar wind-like movements have been observed in the F layer, the drift velocities being of the order of 100m/sec, and the turbulent velocities of the order of 1m/sec.

Results obtained in the U.S.A. have been compared with those obtained here, and the directions of drift were found to be in many ways similar. This may indicate that a world-wide circulatory system exists in the high atmosphere. In the winter the wind direction is principally towards the east and in the summer months generally south-westerly.

Some observers have, however, noted diurnal changes in the drift, and in some cases complete reversals have occurred within 30 minutes. Meteorological opinion is that if bodily movements of air occur in the high atmosphere they are most likely to be caused by temperature differences, but that the temperature differences necessary for the drift velocities observed are unlikely to exist. Furthermore, the reversals in direction which have been noted are difficult to explain on the basis of temperature changes. The present conclusion seems to be that, whilst the observed phenomena *may* be due to actual wind-like movements of air in the ionosphere, movements of electron-density do not necessarily imply such bodily movement. And the moving fading pattern on the ground could therefore be produced by movements in the electron density overhead, without there being bodily movement of the air.—T. W. B.

WORLD OF WIRELESS

Earls Court Plans ✦ Interference Investigation Continues ✦ Record Exports ✦ Future of Telekinema

National Show

PLANS for the 19th National Radio Show, to be held at Earls Court, London, S.W.5, from 26th August to 6th September, have now been announced by the organizers, the Radio Industry Council.

Advantage is being taken of the experience gained at last year's show (the first at Earls Court) and, as a result, a considerable amount of rearranging of stands and the inclusion of special exhibits is planned. Some of the wide open spaces, which last year produced what our correspondent, "Free Grid," called "an air of sepulchral gloom," will be filled. The B.B.C. studio will be bigger than last year and will have seating for 2,000.

The spirit of the exhibition, which is planned to be representative of the whole radio industry, is "show how it works."

V.H.F.: a Promise?

THE north-east is to have a v.h.f. broadcasting transmitter and the first of the low-power television stations to be erected. This was stated by the P.M.G., Earl De La Warr, when he received a deputation recently to discuss the delay in establishing a television service in the area and the possibility of improving the sound service.

It will be recalled that in the original plan for a nation-wide television service there was to be a station on Pontop Pike, Co. Durham, but, like the other four secondary stations, its erection has been postponed. It has been suggested that the 5-kW transmitters being used initially at Kirk o' Shotts and Wenvoe were originally intended for the low-power stations, but the P.M.G. will not be drawn into confirming this.

Interference Suppression

IN response to a number of questions in the House recently, the Asst. P.M.G. has made known the progress made in investigating interference. He announced that an advisory committee had been appointed by the P.M.G. to consider the requirements which might be prescribed in regulations dealing with interference caused by small electric motors. Among the twenty-one members—selected from the panel nominated by the I.E.E.—are three members of the I.E.E. Radio Section, N. R. Bligh, W. A. H. Parker and E. L. E. Pawley. The director of the Electrical Research Association (Dr. S. Whitehead) and W. A. Scarr, past-president of the R.S.G.B., are also members of the Committee, of which J. R. Beard, C.B.E., is chairman.

A regulation is now being prepared regarding the fitting of suppressors to new cars, and the committee investigating interference caused by refrigerators has submitted a report to the P.M.G. and the question of making regulations is being considered.

Another Radio Jubilee

WILLIAM DAVIES, recently awarded the M.B.E., completes his 50th year with the Marconi Marine Company in June. It is claimed he was the first official sea-going wireless operator, having joined in 1902. After training at the Lizard Station "Billy" Davies went to sea in the Allan Liner *Parisian*. Earlier marine wireless had been on what we should now call an experimental basis. Marconi's success in spanning the Atlantic in 1901 had convinced shipowners that useful ranges of communication could be attained, and Mr. Davies may be said to have inaugurated the regular marine service.

The first voyage was not arduous; there was only one coast station with which the *Parisian* could communicate—Malin Head, Northern Ireland. There were then no stations on the other side of the Atlantic. Fairly obviously, jamming was no problem, but atmospherics were. The coherer detector then in use was an "on-off" device, offering no means of discriminating between atmospheric discharge and signal. Mr. Davies, who is still at sea, served through both World Wars, and was off Arromanches on D-Day.

WILLIAM DAVIES outside Buckingham Palace after receiving the M.B.E.

Amateurs at Sea

AS a result of negotiations between the Radio Society of Great Britain and the G.P.O., it is announced that the P.M.G. is prepared to authorize qualified persons to operate amateur stations on board ship. It is, however, stressed that these maritime mobile licences, costing £4 p.a., will be issued for the sole purpose of undertaking constructive experiments with nominated amateurs in the 144, 420, 1215, 2300 and 5600 Mc/s bands.

Communications regarding these facilities should be addressed to the Overseas Telecommunications Dept., (B.B.), Headquarters Building, G.P.O., London, E.C.1.

B.S.R.A. Exhibition

THE sixth annual convention and exhibition of sound recording and reproducing equipment, organized by the British Sound Recording Association, will be held at the Waldorf Hotel, Aldwych, London, W.C.2, on 17th and 18th May. Twenty-three exhibitors will be taking part and a number of them will demonstrate disc, tape and wire reproducers and audio-frequency equipment in the demonstration rooms provided.

Admission to the show, which will be open both days from 10.30 to 6.0, will be by catalogue, price 1s 6d.

Exports Still Rising

IN spite of the demands of the defence programme, substantial increases in exports were recorded by each of the four sections of the industry during the first two months of the year compared with January and February 1951. The comparative figures (1951 in brackets) are:—components £1,615,000 (£1,013,000), transmitters, communications gear and navigational aids £1,064,000 (£687,000), broadcast receivers £956,000 (£634,000) and valves £658,000 (£470,000).

Industrial Electronics

THE application of electronics in handling and processing materials is to be dealt with in one of the eleven papers at the Convention organized in connection with the Mechanical Handling Exhibition (Olympia, 4th-14th June). The paper "Electronics in Materials Handling," by L. Landon Goodman, B.Sc.(Eng.), will deal *inter alia* with electronic speed control of power drives, the use of light-sensitive cells for counting, sorting, batching, etc., and remote radio control.

Tickets for admission to the exhibition are obtainable from the organizers, *Mechanical Handling*, Dorset House, Stamford Street, London, S.E.1. Separate tickets are required for the Convention; these are obtainable on the day at the exhibition.

"*The Marriage Arranged*"

NO mention was made in the announcement by Lord Woolton on the future of the Telekinema on the Festival of Britain South Bank site to the continuance of large-screen television demonstrations.

The Telekinema, which is being taken over by the British Film Institute, provided the ideal setting for the marriage of television and films, and it is to be regretted that the plans so far announced make no mention of television.

It is announced that the auditorium, which has accommodation for about 400 people, will be maintained by B.F.I. as a national repertory cinema and for the showing of stereoscopic films. It will not be open to the public before the autumn.

"*Trader Year Book*"

A NEW feature in the recently published twenty-third edition of the "Wireless and Electrical Trader Year Book" is a list of the intermediate frequencies of receivers marketed during the past five years. First published in 1925, the "Trader Year Book" has become the vademecum of the radio and electrical industries. The 1952 edition, which comprises 264 pages, gives condensed specifications of current broadcast and television receivers, 200 valve base diagrams, legal and general information and directory sections (printed on distinctively coloured papers) of manufacturers' addresses, proprietary names and classified buyers' guide.

It is published by the Trader Publishing Co., Dorset House, Stamford Street, London, S.E.1, price 10s 6d.

B.I.F.

THE radio industry's display at the British Industries Fair, which opens in London (Olympia and Earls Court) and Castle Bromwich on 5th May, can hardly be called representative. While in the Midland section the industrial applications of electronics will be well represented and a number of instrument makers are exhibiting at both centres, there is almost a complete absence of domestic receivers. Sound recording and reproducing equipment for both commercial and domestic use and intercom equipment constitute the major part of the industry's contribution at Olympia.

Admission to each section of the Fair, which will remain open until 16th May, is 2s 6d.

PERSONALITIES

A. J. Brunker, B.Sc. (Eng.), A.M.I.E.E., general export manager of E. K. Cole, Ltd., who recently returned from a business visit to South America, has now been made additionally responsible for the commercial activities of the company's Electronics Division of which Lord Waleran is commercial manager.

D. T. Hollingsworth has been appointed chief engineer of British Insulated Callender's Cables, Ltd., and, as such, will be responsible for applied research and the design and engineering application of all products manufactured by the company. He joined Callender's in 1925 and, following the merger between Callender's Cables and British Insulated Cables, he was appointed cable research manager.

W. H. Stevens, who, in 1946, left the Research Dept. of A. C. Cossor, Ltd., after fifteen years in the company's employ, to join R.F. Equipment, Ltd., has rejoined Cossor's as manager of works design. He will be responsible for the production engineering of the company's products.

Hector V. Slade, M.B.E., T.D., deputy managing director of the Garrard Engineering and Manufacturing Co., has been elected chairman of the Radio and Electronic Component Manufacturers' Federation in succession to W. F. Taylor (T.C.C.).

H. V. SLADE, M.B.E.,

P. D. Canning, who is re-elected vice-chairman of the R.E.C.M.F., was in charge of Plessey's transmitter test and installation dept. until 1945 when he became responsible for components development for the company. He is chairman of the R.I.C. Technical Specification Committee (he jointly opened the recent I.E.E. discussion on component standardization) and of the Federation's Technical Committee.

Maurice Taylor, the chief engineer of the recently formed Cyprus Broadcasting Service, was with the B.B.C. until 1948, when he was appointed Chief Technical Officer to the Forces Broadcasting Service in the Middle East. Whilst with the B.B.C. he was concerned with the installation of the medium-wave station at Ottringham and the building of the high-power mobile transmitters which were set up in France soon after D-Day.

OUR AUTHORS

D. T. N. Williamson, who writes on modifications to the Williamson amplifier in this issue, studied engineering at the University of Edinburgh, joining the M.O. Valve Co. in 1943, where he was

RECENTLY-ELECTED OFFICERS OF THE INDUSTRY

G. DARNLEY SMITH, chairman, R.I. Council.

G. A. MARRIOTT, B.A., vice-chairman, R.I.C.

P. H. SPAGNOLETTI, B.A., chairman, B.R.E.M.A.

K. S. DAVIS, B.Sc., chairman, R.C.E.E.A.

concerned mainly with circuit techniques. It was while he was there that he designed the amplifier which is now known universally by his name. Since 1946 he has been with Ferranti at Edinburgh, engaged on research projects of a diverse nature, including instrumentation and the visual recording of data, pickup development and the design of electro-mechanical devices. He is, at present, in charge of a department investigating problems of precision measurement and control.

H. V. Sims, contributor of the article "Experimenter's R.F. Bridge" in this issue, joined the Radio Gramophone Development Co. in 1934, subsequently taking charge of the Service Dept. In 1940 he went to the B.B.C. Operations and Maintenance Dept. and for three years worked on transmitters at Westerglen and the Daventry Empire station, followed by three and a half years' experience of aerial measurements at Daventry. He joined the Engineering Training Dept. of the Corporation in 1946 and was appointed senior lecturer (radio frequency) in 1949.

IN BRIEF

Receiving Licences.—For the second month in succession, the number of television licences in Great Britain increased by more than 100,000 in February, bringing the total to 1,386,000. Approximately 12,687,000 broadcast receiving licences, both sound and television, were current in the U.K. at the end of February.

Another Caravan transmitter was brought into service by the B.B.C. in March (on a site between Barnstaple and Bideford, Devon) to expedite the implementation of the plan to provide twelve low-power stations to improve reception of the Home Service. Two 250-watt transmitters, capable of being paralleled, are installed in the caravan. The aerial for the 2-kW permanent station is being used. The station—the eighth to be brought into use—operates on 1,052kc/s.

Television in Ireland.—Ekco advise us that during the opening of the Kirk o' Shotts television station a dealer in Belfast—117 miles from the Scottish transmitter—reported reception of this 5-kW transmitter "incomparably better" than from the 45-kW Holme Moss station.

Development of C.R.Ts.—Charts and lecture notes covering the development of the cathode-ray tube from the original observation of "cathode radiation" by Plücker in 1859 to the present time have been produced by Ediswan. They are obtainable gratis by lecturers, schoolmasters, etc., from the Publicity Dept., The Edison Swan Electric Co., Ltd., 155, Charing Cross Road, London, W.C.2.

Television Lectures.—A series of five lectures on the application of modern television transmitting techniques, by members of the B.B.C. technical staff, are to be given at 7.0 on Mondays (beginning 12th May) at the Norwood Technical College, Knight's Hill, London, S.E.27. They will be preceded on 5th May by a lecture on large-screen television by T. M. C. Lance (Cinema Television). Particulars of the lectures are obtainable from the principal, Dr. W. J. Thomas. The fees are: individual lectures, 4s; whole series, 17s 6d.

Durham Bursary.—The Junior Institution of Engineers offers the award of the Durham Bursary (£20) to young men between the ages of 19 and 25 who are "in course of training for the engineering or an allied profession." Entrants must submit a thesis by 1st August on an "engineering, technical or scientific" subject written specially for the competition. Entry forms and particulars are available from the J.I.E., 39, Victoria Street, Westminster, London, S.W.1.

Gramophiles.—We have received a programme of the next three months' meetings of the City of London Phonograph and Gramophone Society (previously C. of L. Phonograph and Radio Soc.) in which is listed a number of recorded recitals including cylinders, lateral cut discs and hill and dale recordings. On 6th May, Lynton Fletcher, who was for some years director of the B.B.C.'s Recorded Programme Dept., will talk on "The Future of Sound Recording" (with recorded illustrations). Particulars of the Society, which mainly caters for those technically interested in the recording and reproduction of sound, are obtainable from R. H. Clarke, 12, Grove Road, North Finchley, N.12. Meetings are held fortnightly at 6.30 at the "Cock and Magpie," 72, Wilson Street, London, E.C.2.

Electronics Exhibition.—The seventh annual exhibition of electronic devices, organized by the North West Branch of the Institution of Electronics, will be held at the College of Technology, Manchester, from 15th to 18th July. Admission to the exhibition, which will include, in addition to the commercial section, one devoted to scientific and industrial research, will be by ticket available from W. Birtwistle, 17, Blackwater Street, Rochdale, Lancs.

Telearchics.—During the week-end of 16th-17th August two international contests for radio-controlled models are being held at Stanley Park, Blackpool, Lancs, under the auspices of the International Radio-Controlled Models Society. On the 16th model power and sailing boats will be competing, and on the 17th model aircraft. Details of the contests, which are open to any competitor, can be obtained from C. H. Lindsey, 292, Bramhall Lane South, Bramhall, Stockport, Cheshire.

CONSUMING THEIR OWN NOISE. Designed by N. D. N. Belham, science master at the Mid-Essex County Technical School, Chelmsford, this multi-keyboard electronic organ permits as many as 24 students to practise without mutual interference. The teacher can listen to any or all players, interject instructions and connect the output from individual keyboards for duets, quartets, etc.

R.E.C.M.F. Council.—The annual general meeting of the Radio and Electronic Component Manufacturers' Federation—which now has 137 members—was held a few days before the opening of the components show (reported elsewhere in this issue). The following member firms—with (in brackets) the representative—were elected to the Council:—Garrard (H. V. Slade), N.S.F. (S. Wilding Cole), Painton (C. M. Benham), Plessey (P. D. Canning), Reliance Electrical Wire (C. H. Davis), T.C.C. (W. F. Taylor), T.C.M.C. (W. F. Randall), and T.M.C. (W. A. Jackson), with Hassett & Harper (J B. Hassett, Jnr.) as representatives of the associate members. The Council subsequently co-opted Automatic Coil Winder (R. E. Hill), B.I. Callender's (G. B. Wetton) and Hunt (S. H. Brewell).

Patent Office Library.—It has been decided to continue the extended hours of opening of the Patent Office Library at 25, Southampton Buildings, Chancery Lane, London, W.C.2, introduced in May last year. It will continue to open at 10 a.m. each weekday and close at 9 p.m. Monday to Friday and 5 p.m. on Saturday.

Australian Television.—The introduction of a television service in the Dominion has been postponed indefinitely in view of the economic situation. It was announced over a year ago that a 5-kW experimental station, working on 625 lines in the band 181.5-204Mc/s, would be opened in Sydney preparatory to stations being erected in the six State capitals.

Great Lakes R/T.—A treaty was recently signed between Canada and the United States, providing for a uniform system of marine radiotelephony on the Great Lakes. It also makes compulsory the fitting of radiotelephone equipment in all lake shipping of 500 gross tons and over, and in all passenger-carrying vessels over 65 feet in length.

German Television Sets.—The radio industry in Western Germany—which, according to figures given in the radio edition of *The Export Market*, comprises 39 companies—is now producing a large number of 625-line television receivers. Most of them cover the six channels in the 174-216Mc/s band, some being continuously tunable, while others are switch controlled.

"The Cat's Whisker," the name given to the radio shop in the model village at the recent *Daily Mail* Ideal Home Exhibition, was organized by the Radio and Television Retailers' Association (R.T.R.A.) and manned by the staffs of member-retailers.

"Sporadic E. Clouds".—The following corrections should be made to the note by D. W. Heightman in our April issue. Page 136, col. 2, line 8: for "temperature" read *temperate*; line 18: for "maximum" read *minimum*.

PUBLICATIONS

R.S.G.B. Call Book.—A revised edition of the R.S.G.B. Amateur Radio Call Book, which will contain details of approximately 6,750 amateurs in the British Isles and Ireland (an increase of 750 on the previous edition), is being published by the Society. It can be obtained from the headquarters, New Ruskin House, Little Russell Street, London, W.C.1, price 3s 6d.

Electronic Music.—A bibliography covering all traceable information on electronic musical instruments has been compiled by the Tottenham Public Libraries and Museum. The 31-page booklet covers books and patents as well as articles published in periodicals (both British and foreign) since 1900. It is obtainable from the Tottenham Corporation, London, N.15.

Sixth Edition of O. Lund-Johansen's annual "World-Radio Handbook for Listeners," published last November, gives details of long- and medium-wave broadcasting stations in most countries of the world in addition to particulars of the world's short-wave stations. Printed in English, although published in Denmark, it is obtainable in this country from Surridge Dawson & Co., Ltd., 136, New Kent Road, London, S.E.1, price 8s 6d.

NEW ADDRESSES

Acru Electric Tool Manufacturing Co., makers of "Pyrobit" soldering irons, have moved to Chapel Street, Stockport Road, Levenshulme, Manchester.

Aluminium Wire and Cable Co., Ltd., whose head office and works are at Port Tennant, Swansea, have opened a branch office at 6, Livery Street, Birmingham, 3 (Tel.: CEN 5370).

Lustraphone, Ltd., manufacturers of sound equipment, announce that they have acquired new factory and office premises at St. George's Works, Regent's Park Road, London, N.W.1. (Tel.: Primrose 0630.)

N.R.D.—Nucleonic and Radiological Developments, Ltd., who recently moved from Chelsea to 22, Marshgate Lane, London, E.15, advise us that their telephone number is Maryland 4577.

Television Society.—The London office of the society is now at 164, Shaftesbury Avenue, W.C.2 (Tel.: Temple Bar 3330).

BUSINESS NOTES

D.S.R.—The delayed sound reinforcement system (D.S.R.) installed experimentally in St. Paul's Cathedral by Pamphonic Reproducers, Ltd., and described in our February and March issues, has now been approved by the Dean and Chapter of the Cathedral and a permanent installation has been ordered.

Ship-Shore V.H.F. radio-communication equipment has been installed by Marconi's at a number of pilot stations around the Swedish coast. In addition to the 10-watt transmitter, the Bramo lighthouse off Sundsvall has been equipped with radar to facilitate the work of the pilot cutters. Ships fitted with equipment covering 156.8Mc/s will be able to secure piloting information from the shore stations.

Aeradio.—International Aeradio announces that twelve of their prefabricated aeradio stations have now been installed and are in operation in Burma. I.A.L. also announces that they have installed a synthetic air traffic control trainer for the Belgian Air Force.

Mexican Enquiry.—British television receiver chassis, operating on American standards, are required by Statex (Trading), Ltd., exporters, of 11-13, Southampton Row, London, W.C.1. They are for use in Mexico City where the supply is 110/120V, 50c/s, and should have 17in or 20in tubes.

Murphy television receivers and electronic gear are to be made in Italy under an agreement recently concluded between Murphy Radio, Ltd., and Societa Anonima Fimi.

Sound installation recently fitted by G.E.C. at the "up" marshalling yard at Toton, Notts, one of the largest in the country, consists of 25 microphone control positions (some outdoors), 15 amplifiers (varying in power up to 60W) and 40 loudspeakers (mostly outdoors). Two-way communication is maintained between the control room (overlooking the "hump" down which the wagons run to 37 sidings) and the signal boxes and ground staff.

E. K. Cole, chairman and managing director of Ekco, opened the third All-India Conference of National-Ekco dealers in March. While in India he conferred with Indian principals of National-Ekco Radio and Engineering Co. on future developments.

Elliott Brothers advise us that L. Bagrit, their managing director, is visiting the United States and whilst there is going into the question of the manufacture of some of the company's electronic apparatus in the U.S. We are also advised of the appointment of W. P. Rowley, M.B.E., M.Brit.I.R.E., as sales manager of the Electronics Division of the Elliott organization. He was formerly with the Edison Swan Electric Company. His office will be at Century Works, Lewisham, London, S.E.13 (Tel.: Tideway 3232).

Rees-Mace Marine, Ltd., announce that J. M. Wardle, who was for twenty years with the Marconi International Marine Communication Co. (ten years at sea), has joined the company to take charge of all its depots in Great Britain. J. A. Gordon has also joined Rees-Mace as travelling consultant and will be mainly concerned with acquainting yachtsmen with the possibilities of radio-telephone equipment.

Pye radio-telephone gear has been fitted by Rees-Mace in the 26-ton yacht *Marabu* which will take part in the 600-mile Newport-Bermuda race in June.

Alsheath, Ltd., is the name of the new company formed jointly by British Insulated Callender's Cables and The Loewy Engineering Co. to utilize their knowledge, patents and development work in the field of aluminium-sheathed cables. The offices are at Norfolk House, Norfolk Street, London, W.C.2.

MEETINGS

Institution of Electrical Engineers

Radio Section.—"A Phototelegraphy Transmitter-Receiver Utilizing Sub-Carrier Frequency Modulation" by R. O. Carter, M.Sc.(Eng.), and L. K. Wheeler, B.Sc.(Eng.), at 5.30 on 14th May at the I.E.E., Savoy Place, London, W.C.2.

Northern Ireland Centre.—"Modern Telegraph Practice" by Major E. H. Wilkinson, M.C., at 6.45 on 13th May at the Presbyterian Hostel, Howard Street, Belfast.

South Midland Radio Group.—Visit to the Meteorological Station at Dunstable on 24th May.

Southern Centre.—"Technical Colleges and Education for the Electrical Industry" by H. L. Haslegrave, M.A., Ph.D., M.Sc.(Eng.), at 6.30 on 7th May at the Royal Beach Hotel, Portsmouth.

British Institution of Radio Engineers

London Section.—"An Aerial Analogue Computer" by W. Saraga, Dr.Phil., D. T. Hadley and F. Moss, B.Sc., at 6.30 on 7th May at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

Merseyside Section.—Annual General Meeting, followed by a programme of technical films, at 7.0 on 1st May at the Electricity Service Centre, Whitechapel, Liverpool.

North Eastern Section.—Annual General Meeting, followed by a programme of technical films, at 6.0 on 14th May at Neville Hall, Westgate Road, Newcastle-upon-Tyne.

British Sound Recording Association

London.—Discussion "Musicians *v.* Technicians" at 7.0 on 16th May at the Waldorf Hotel, Aldwych, W.C.2, where the annual convention and exhibition will be held on the following two days.

Television Society

London.—A Discourse by Richard Dimbleby on "London Town" at 6.30 on 1st May in the Lecture Theatre, I.E.E., Savoy Place, London, W.C.2.

"Image Orthicon Camera Tubes" by Baldwin Banks, B.Sc., and K. Frank, Ph.D. (English Electric), on 8th May.

"The H.M.V. 21in-tube Receiver" by J. J. Billin (E.M.I., Eng. Development) on 23rd May.

Both meetings will be held at 7.0 at the Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, London, W.C.2.

Institution of P.O. Electrical Engineers

London Centre.—"A General Introduction to Communication Theory" by J. E. Flood, Ph.D., L. R. F. Harris, B.A., and A. D. V. Ridlington, M.A., at 5.0 on 6th May at the I.E.E., Savoy Place, London, W.C.2.

Institute of Navigation

"Radar Chart-Matching Devices" by J. Home Dixon at 5.0 on 16th May at the Royal Geographical Society, 1, Kensington Gore, London, S.W.7.

Component Colour Coding

Summarizing the Standard Systems Now in Operation

By D. F. URQUHART*

THE colour coding of radio components for value and identification was originated by individual manufacturers, but has now been standardized by trade associations and Government departments working co-operatively. Coding of resistors and capacitors has also received international attention by the International Electrotechnical Commission.

In Great Britain the two bodies concerned with coding of radio components are the Inter-Service Radio Components Standardization Committee (R.C.S.C.), Castlewood House, New Oxford Street, London, W.C.1, which represents the Navy, Army, Air Force and Post Office; and the Radio Industry Council (R.I.C.), 59, Russell Square, London, W.C.1, which comprises representatives of the Radio and Electronic Component Manufacturers' Federation, the British Radio Equipment Manufacturers' Association and the Radio Communication and Electronic Engineering Association.

The colour shades used for radio component colour coding are laid down in British Standard 381-C: 1948, and in all specifications the shade numbers from 381-C are quoted. Where one colour is put over another the final result may be slightly different from the shades given in the British Standard but the shades have been chosen such that under all normal conditions of use they are distinct and are not liable to be confused by people of normal vision.

Resistor coding.—The information conveyed by the colour coding of resistors is resistance value, tolerance and identification. This applies to both wire-wound resistors and to composition resistors of both grades. The standard resistance ranges for composition resistors are 10 ohms to 10 megohms. The resistance range for wire-wound resistors is not definitely stated in any existing specification. In RCS/111, part numbers are given covering certain ranges, but these are in process of modification.

With wire-wound resistors colour coding is allowed as an alternative to other marking, but with composition resistors colour coding is preferred for Grade 1 and obligatory for Grade 2.

Preferred-value tables are laid down for both wire-wound and composition resistors. For wire-wound resistors the preferred values are the same for all tolerances. This is also the case for Grade 1 composition resistors, but with Grade 2 composition resistors the preferred values differ with tolerance. The standard tolerances for wire-wound resistors are ±1%, ±2%, ±5% and ±10%. With composition resistors the standard tolerances for Grade 1 are: ±1%, ±2% and ±5%. For Grade 2: ±5%, ±10% and ±20%.

For wire-wound resistors, Grade 1 composition resistors, and Grade 2 composition resistors of ±5% tolerance, the preferred value series is:—

10; 11; 12; 13; 15; 16; 18; 20; 22; 24; 27; 30; 33; 36; 39; 43; 47; 51; 56; 62; 68; 75; 82; 91; 100, with the addition of a nought to each decade up to the maximum value.

For composition resistors Grade 2 of ±10% tolerance the preferred value series is:—

10; 12; 15; 18; 22; 27; 33; 39; 47; 56; 68; 82; 100, with the addition of a nought in each decade up to the maximum value.

For composition resistors Grade 2 of ±20%

* Erie Resistor, Ltd.

Fig. 1. System of colour-code marking used for wire-wound and composition resistors.

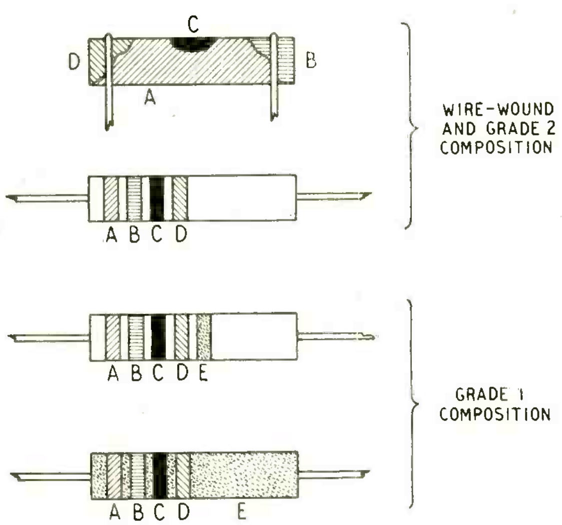


TABLE I

Standard Colour Code Chart for Resistors

Colour	B.S.381-C Number	1st Figure "A"	2nd Figure "B"	Multiplying Value "C"	Tolerance "D"
Silver	—	—	—	10^{-2}	±10%
Gold	—	—	—	10^{-1}	±5%
Black	—	—	0	1	—
Brown	412	1	1	10	±1%
Red	538	2	2	10^2	±2%
Orange	557	3	3	10^3	—
Yellow	355	4	4	10^4	—
Green	221	5	5	10^5	—
Blue	166	6	6	10^6	—
Violet	796	7	7	10^7	—
Grey	632	8	8	10^8	—
White	—	9	9	10^9	—
Salmon Pink	443	—	—	—	—

Where no colour is used to denote tolerance, the tolerance is ±20%.

tolerance, the preferred value series is as follows:—

10; 15; 22; 33; 47; 68; 100, with the addition of a nought in each decade up to the maximum value.

Value and tolerance of resistors is indicated by the following general scheme which refers to Table I and Fig. 1.

First colour, "A," denotes first digit of resistance.
Second colour, "B," denotes second digit of resistance.
Third colour, "C," denotes multiplier of resistance.
Fourth colour, "D," denotes tolerance.
Fifth colour, "E," identifies Grade 1 composition resistor and is Salmon Pink.

The specifications concerned with this resistor colour coding are:— (R.C.S.C.) RCS.111, RCL.112, Issue 1 and (R.I.C.) RIC/111, Issue 1, July, 1950, RIC/112, Issue 1, May, 1950, RIC/113, Issue 1, June, 1950. It will be appreciated that work on specifications of this nature is continuous and that new issues of the specifications will be necessary from time to time; nevertheless, the specification numbers will remain the same.

Capacitor coding.—Colour coding of capacitors is rather more complicated than resistor coding as there is extra information to be conveyed. Therefore the various types of capacitors concerned and their specifications are each dealt with separately.

Mica dielectric, stacked foil (*specification* D/RIC/132).—The use of colour coding under this specification is for indentification and is dealt with in clause 1.8.15, which lays down that "capacitors designed for 750-volt working shall be suitably marked or have a green fleck in the moulding material."

Ceramic dielectric (*specifications* RCL/133 *and* D/RIC/133).—Both these specifications permit a colour code to be used as an alternative marking and in practice this is very largely used. A five-colour code is necessary because in addition to capacitance and tolerance the temperature coefficient must be indicated. At the time of writing the R.C.S.C. have not officially adopted any colour code. The colour code set out in D/RIC/133 is given in Table II and Fig. 2 shows how it is applied.

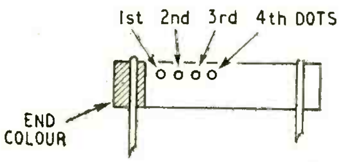


Fig. 2. Colour-code system for ceramic-dielectric capacitors.

TABLE II

Standard Colour Code Chart for Capacitors

Colour	End Colour (temp. coeff.)	1st dot. 1st sig. figure	2nd dot. 2nd sig. figure	3rd dot. Multi-plier	4th dot tolerance: 10 pF or less	4th dot tolerance: More than 10 pF
Black	NPO	0	0	1	±2.0pF	±20%
Brown	N030	1	1	10	±0.1pF	±1%
Red	N080	2	2	100	—	±2%
Orange	N150	3	3	1,000	—	±2.5%
Yellow	N220	4	4	10,000	—	—
Green	N330	5	5	—	±0.5pF	±5%
Blue	N470	6	6	—	—	—
Violet	N750	7	7	—	—	—
Grey	P030	8	8	0.01	±0.25pF	—
White	P100	9	9	0.1	±1.0pF	±10%

This code is accepted by the R.C.S.C. in actual practice, and it is expected that it will appear in future issues of their specification.

Electrolytics (*specification* D/RIC/134).—Here again colour coding is merely used for identification and the specification says "Where two or more capacitors are included in one can, the anode of the capacitor occurring on the outside of the combined winding shall be connected to a tag coded RED."

Tubular, metallized paper dielectric (*specification* D/RIC/136).—Here colour coding is an alternative method of marking capacitance because there is only one standard tolerance. The colour coding scheme is shown by Table III below.

It should be noted that in every case where colour coding is used to indicate a number the colours always have the same numerical value.

Transformers.—Some years ago a standard colour code for transformer leads was laid down by the R.E.C.M.F., but this has gone out of use and at the present time manufacturers who do use coloured leads each have their own system of coding. It would seem that a standard colour code for transformer leads no longer exists in this country.

Pick-up styli.—An identification colour code for styli has recently been adopted by the R.E.C.M.F. The case is either self-coloured or has a colour spot as follows, according to the shade numbers laid down in B.S.S. 381-C:—

Red (538)	..	long playing
Green (216)	..	standard 78 (r.p.m.)
Violet (796)	..	universal

The stylus itself is marked on the tip as follows:—

Red (538)	0.001in
Lemon (355)	0.002in
Green (216)	0.0025in
French Blue (166) ..	0.003in
Orange (557)	0.0035in
Violet (796)	universal

The material is indicated by a colour band on the shaft:—

Black	hard metal
White	diamond
No colour	sapphire
Special Sky Blue ..	oval tip

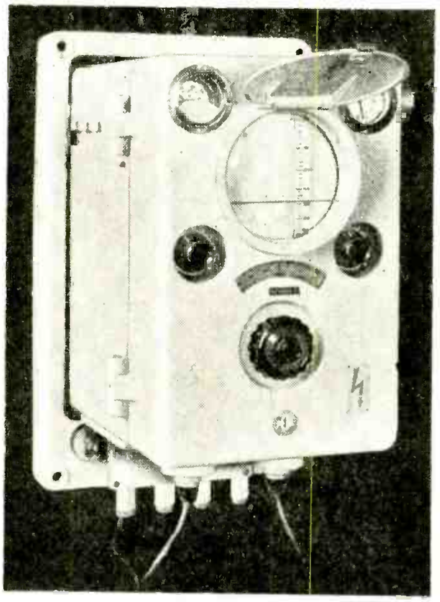
TABLE III

Colour Code for Metallized-paper Capacitors

Colour	1st Dot 1st Fig.	2nd Dot 2nd Fig.	3rd Dot Multiplier
Black ..	0	0	1
Brown ..	1	1	10
Red ..	2	2	100
Orange ..	3	3	1,000
Yellow ..	4	4	10,000
Green ..	5	5	—
Blue ..	6	6	—
Violet ..	7	7	—
Grey ..	8	8	0.01
White ..	9	9	0.1

ECHO FISHING

Ultrasonic Depth Sounder Indicating Different Kinds of Fish



Indicator unit of the "Fischlupe" sounder

ALTHOUGH fishermen have the reputation of being somewhat conservative in their approach to new technical aids and devices, it seems they have been completely won over to the advantages offered by radio and electronics. Radio pure and simple they have accepted almost universally, radar is well on the way, and now they are going in for ultrasonics as a means of sounding the depth of fish shoals.

Depth sounders, of course, work on essentially the same principle as radar, though there is very little resemblance elsewhere. The latest piece of echo fishing equipment, however, actually looks like radar, for in place of the more conventional display system it uses a cathode-ray tube. Moreover, it has the special feature, not possessed by ordinary echo sounders, of being able to "focus" on to a shoal of fish, and because of this the makers (Electroacustic G.m.b.H., a German firm) have called it the "Fischlupe," or fish lens.

This facility is particularly useful, for it enables an operator to estimate the size and density of a shoal and to find its centre where the fish are thickest. Furthermore, it magnifies the echo responses to such an extent that he can distinguish between different kinds of fish by the different traces they produce. Responses from herring, for example, are fine and closely packed while those from larger fish, like cod, are bold and widely spaced. It is even possible to see single traces from individual fish.

The "Fischlupe" uses pulses of ultrasonic energy to make the soundings, projecting them down towards the sea bed at a rate of 78 per minute. These pulses are generated by shock-exciting the energizing coil of a nickel magnetostriction element, which produces trains of damped oscillations at its natural frequency of about 30kc/s. The element is fitted flush with the bottom of the boat on one side of the keel. A short distance away, on the other side of the keel, is the receiver — another magnetostriction element but working in reverse and converting the received echoes into electrical signals. After these signals are amplified they are displayed by the cathode-ray tube on a time base which is locked to the initial transmitted pulse and arranged vertically to represent the depth of water below the keel. Thus echoes from the sea bed and any intervening fish shoals appear as horizontal deflections, and the distances from the top at which they occur represent the actual depths.

Once the presence of fish has been detected, the "focusing" device is brought into action. By means of a control knob the time-base is speeded up so that the length of the sweep no longer represents the complete echo path but a small section of it 45ft deep—this being the approximate width of a net opening. Turning the control knob moves this section up or down so that it "scans" the echo-path, the effect on the cathode-ray tube being rather like looking out of the window of a diving bell that is being raised or lowered through the water. When the fish shoal appears on the screen again, now with the echoes well spaced out, the exact depth, accurate to within a few inches, can be read off direct from a scale on the control knob in terms of fathoms.

Ultrasonic waves are used for the sounding because of their directivity and ability to penetrate to great depths. Because of the directivity, the transmitter and receiver can be placed quite close together on the bottom of the vessel and it is possible to detect fish very near to the surface. Another advantage is the freedom from engine-noise interference.

Altogether the "Fischlupe" consists of four units: an indicator (see picture), a control box, a pulse generator unit and a rotary converter. Although it is made in Germany, the Marconi International Marine Communication Company have acquired the sole rights for the U.K. and Commonwealth countries, and maintenance facilities will be available at all their home and overseas depots.

INDUCTION HEATERS

SO far there has been no uniformity in the power rating of high-frequency induction heating equipment, some manufacturers preferring to state the power taken from the supply mains while others give a figure for the output determined under arbitrary conditions.

A British Standard (B.S.1799), "Power rating of valve-driven high-frequency induction heating equipment," has therefore been published specifying the method of expressing the power rating of such equipment operating from single or polyphase mains supplies. The appendices explain the significance of output voltage and current in relation to power ratings and give examples of methods of output power measurement.

Copies of the Standard may be obtained from the British Standards Institution, 24, Victoria Street, London, S.W.1, price 2s 6d.

Experimenter's R.F. Bridge

Simple Design Using Fixed Inductive Ratio Arms

By H. V. SIMS,* Assoc.I.E.E., A.M.Brit.I.R.E.

IN addition to the ordinary r.f. measurements of inductance, capacitance, resistance (or conductance) and Q of components and tuned circuits, this simple and robust bridge, developed by the B.B.C. Engineering Training Department, can be used for measuring the constants of aerials and transmission lines, the input and output impedances of r.f. and video frequency amplifiers, the a.c. slope resistance of valves, for the tuning and adjustment of transmitters and receivers and for many other purposes. In its simplest form it is suitable only for measuring unbalanced impedances, but it can be modified for balanced measurements as well and then can be used on such things as twin-wire transmission lines and push-pull circuits. The bridge measures parallel values, and does so with a short-term accuracy which depends on the care taken in calibration and a long-term accuracy which depends on wear of the moving parts.

The usual arrangement of modulated r.f. oscillator, bridge and receiver is shown in Fig. 1. The receiver is tuned to the frequency at which measurement is required and this frequency may be the fundamental or a harmonic of the modulated oscillator frequency. In general it should be the fundamental, unless the harmonics provided by the oscillator are particularly strong.

The basic circuit of the bridge is given in Fig. 2 and consists of an input transformer with a centre-tapped secondary which provides two arms of the bridge; the other arms consist of the balance controls R_1 and C_1 across which the unknown is connected, and a calibrated resistor R_2 and capacitor C_2 in parallel. The detector is connected between centre tap and earth. When the currents in the two arms are equal in magnitude and phase the detector will not be energized and the bridge is balanced.

With the "unknown" terminals open circuited, capacitor C_2 at half capacitance and resistor R_2 fully in circuit, balancing controls R_1 and C_1 are adjusted for null at the detector. An impedance placed across the "unknown" terminals will unbalance the bridge until a movement of the calibrated controls R_2 and C_2 restores the balanced condition. The parallel aspect impedance of the unknown can then be read directly from the calibrated controls. The scale of the calibrated resistor R_2 may be marked in ohms or millimhos and that of the capacitor C_2 in pF with a centre- or half-scale zero. If the unknown impedance is capacitive an increase of capacitance will be required on the calibrated capacitor C_2 and if it is inductive a decrease will be necessary. The unknown reactance or susceptance is then obtained by conversion from positive or negative pF; positive pF representing capacitance and negative pF representing inductance.

The practical circuit is shown in Fig. 3. The input transformer is specially wound to obtain an accurate unbalance-to-balance connection and to maintain the closest possible coupling between the two halves of the secondary.

Great care is necessary in winding the input transformer; it is particularly important that the interwound windings should be identical and that the spaces between each end of the secondary and the primary windings should be equal. Details are given in Fig. 4. No screening of this transformer is necessary nor is any kind of screen required between the primary and secondary windings.

The variable capacitors C_1 and C_2 may each be of the order of 500 pF and the mechanical layout is simplified if they are identical, but this is not an absolute necessity.

The variable resistors R_1 and R_2 are each 1,000 Ω and must be non-inductive and possess little self-capacitance. The solid carbon-track type of variable resistor is most satisfactory and the actual type used is Morganite MNAP 10210. The law of this resistor is very suitable, 10% of the resistance being inserted at 50% traverse, resulting in a comparatively open

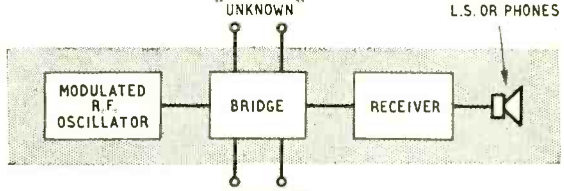


Fig. 1. Set-up of the equipment required for measurement.

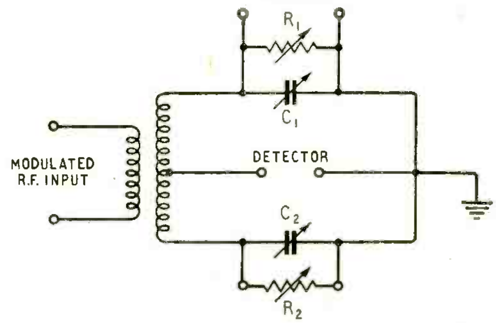


Fig. 2. Basic circuit showing the principle of operation.

* B.B.C. Engineering Training Department.

resistance scale for low values. The series resistor R_3 of 500 Ω (¼-watt carbon) is included to enable balance to be obtained on R_1 at a convenient point on its traverse. The 100-Ω resistor R_4 establishes the output impedance at a low value so that variations of receiver tuning do not affect bridge balance in the presence of slight inaccuracies.

Terminals are provided for the measurement of negative resistance (referred to again later) and for the connection of additional capacitance standards to extend the range of measurement beyond the scale of the calibrated capacitor.

The connecting leads inside the bridge should be made of wide brass or copper strip to reduce inductance, the capacitance between the leads being unimportant; the layout should be compact and as symmetrical as possible.

The provision of dials for R_2 and C_2 fixes the spacing of these components, and R_1 and C_1 should be symmetrically arranged with respect to them. All the components are assembled on a metal sheet (aluminium or tinplate being quite suitable) which forms the lid or panel of a metal cabinet. The unknown and additional standards connections may be ordinary terminals, one of each being earthed to the metal sheet and the others taken to the appropriate points in the circuit. The r.f. input and detector output connections may be concentric plug (or socket) fixings to enable concentric external leads to be used.

The approximate frequency range of the bridge using the input transformer described in Fig. 4 is from 100kc/s to 3Mc/s. This range may be altered in either direction by variation of the number of turns on the input transformer (a decrease in turns moving the range to a higher frequency) but accuracy in the high-frequency region tends to deteriorate with frequency unless a radically different construction is adopted. The maximum useful frequency using the proposed layout and a modified transformer is in the region of 15Mc/s.

Calibration is carried out at 1Mc/s, in the following manner. The apparatus is connected as shown in Fig. 1. Capacitor C_2 is set at half capacitance with resistor R_2 fully in circuit, and at these positions the scale of C_2 is marked zero and that of R_2 is marked infinite resistance. The bridge is now balanced by adjusting capacitor C_1 and resistor R_1. Known non-inductive resistors are placed across the "unknown" terminals and R_2 is calibrated accordingly. These resistors may conveniently be ¼-watt carbon types ranging in value from about 25 Ω to 100,000 Ω, and may be checked for accuracy by a d.c. measurement; the requisite values may be obtained by series and parallel combinations. It will be found that resistance measurements below about 50 Ω are rather difficult to make partly because of discontinuity in R_2 and partly because of the inherent ineffectiveness of parallel bridges in dealing with very low values. C_2 may be adjusted with each resistor change to obtain a true null at the detector and this takes into account any stray capacitance across the resistors. Having calibrated R_2 from about 25 Ω to 100,000 Ω in the required steps, the dial may be suitably inscribed; it should be noted that R_2 may equally well be calibrated in millimhos by the choice of the correct calibrating resistors.

C_2 may be calibrated by connecting known capacitances directly across the "unknown" terminals for scale readings in pF greater than zero (i.e. positive), and across the additional standards terminals for readings less than zero (i.e. negative pF). The calibrating capacitance may consist of separate capacitors or a non-inductive standard variable of about 250pF.

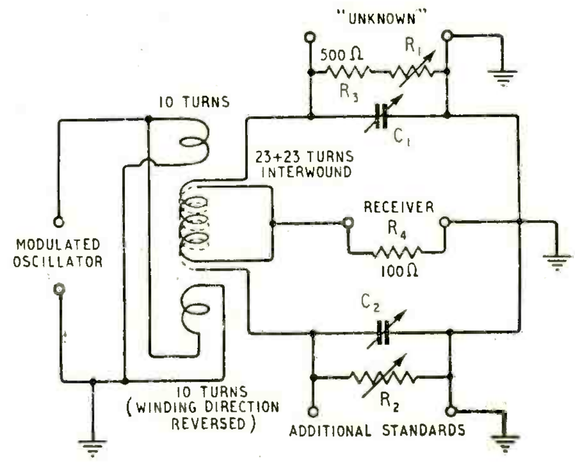


Fig. 3. Practical circuit diagram of the bridge.

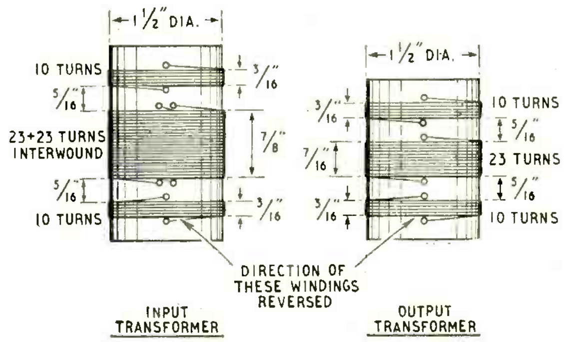


Fig. 4. Details of the input transformer (left) and of the output transformer (right) used when the bridge is modified for balanced measurements.

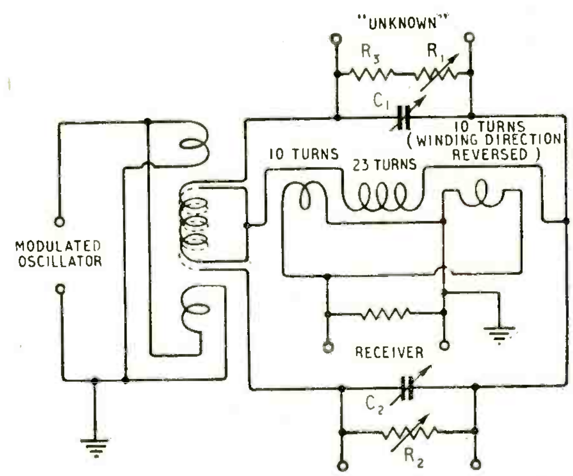


Fig. 5. Practical circuit diagram of the bridge modified to permit balanced measurements as well.

The overall accuracy may now be checked by connecting known values of combined resistance and reactance across the "unknown" terminals. If the secondary winding of the input transformer is slightly unbalanced, or if the effective leakage reactances are unbalanced, reactance readings may be inaccurate when accompanied by parallel resistance of about 200 Ω or less. An improvement may be effected by changing over the secondary connections, but if this increases the inaccuracy the symmetry of the circuit should be checked and also, if necessary, the transformer should be rewound.

The bridge circuit described and shown in Fig. 3 is unsuitable for the measurement of balanced loads because one unknown terminal is connected to earth. A modification may be carried out which will permit the measurement of balanced or unbalanced loads but the frequency range of the bridge will be further restricted and symmetry is slightly more difficult to maintain. The modified circuit is shown in Fig. 5 and it will be seen that the detector is connected *via* a further balance-to-unbalance transformer and no part of the actual bridge circuit is earthed. Details of the output transformer are given in Fig. 4.

If the bridges are in constant use, considerable wear takes place on the variable resistors R_1 and R_2, and it will be necessary to replace R_2 periodically; this will necessitate re-calibration of the R_2 scale as it is generally impossible to match these resistors exactly. When R_1 wears, R_3 may be replaced by a slightly different value which will move the balance position on R_1 away from the worn part of the track.

The modulated r.f. oscillator should provide an output of approximately one volt. If the receiver is particularly sensitive about a tenth of a volt will suffice, although noise will probably be troublesome. The oscillator should be adjusted to give maximum output, and gain adjustments should be made at the receiver and not at the output attenuator of the oscillator; under these conditions there is less danger of the stray radiation from the oscillator being picked up by the receiver and masking the balance for null.

The receiver should be fitted with an r.f. gain control, and automatic gain control should be switched off. Care must be taken not to overload the receiver, otherwise balancing will be very difficult or even impossible. In certain cases where delayed a.g.c. is incorporated, an ordinary receiver with only an audio frequency gain control may be satisfactory; it may be necessary, however, to adjust the output of the oscillator as well as receiver gain. It is essential that the outer conductors of the coaxial leads used for connecting the bridge to the receiver and oscillator should be properly earthed to the cases of all the instruments, otherwise false results will be obtained; coaxial connectors are generally quite satisfactory for this purpose.

When attempting to balance, it must be remembered that balance is obtained by the correct setting of both calibrated controls, and alternate adjustment for minimum should be made with each control until null is obtained.

When measuring pure capacitance of low value, the bridge should first be balanced for null with the necessary leads to the unknown open-circuited and the calibrated capacitance control at zero. For all other measurements the leads should be disconnected from the bridge during the preliminary balance for null, and if extreme accuracy is required in the final measurement due allowance must be made for the effect of the connecting leads. In general, however, if the leads are reasonably short no allowance need be made. For any load other than pure low capacitance it is unwise to connect leads for the preliminary balance as a double error may be incurred, depending on the value of the load.

Negative resistance measurements may be made by using the additional standards terminals instead of the "unknown" terminals. The normal resistance scale will now read negative values and the reactance scales will be reversed. Susceptance calculations are particularly useful inasmuch that graphs show values through zero, whereas parallel reactance values go through infinity and are often unmanageable.

Convenient approximate formulae for finding reactance and susceptance may be derived as follows:—

$$\text{Reactance of a capacitor} = \frac{1}{2\pi f C}$$

$$\text{Reactance in ohms} \simeq \frac{10^6 \times 0.318}{2 \times f(\text{Mc/s}) \times C(\text{pF})}$$

$$\simeq \frac{159{,}000}{f(\text{Mc/s}) \times C(\text{pF})}$$

Susceptance in millimhos is found by multiplying the reciprocal of reactance by 1,000. Hence susceptance in millimhos

$$\simeq \frac{f(\text{Mc/s}) \times C(\text{pF}) \times 1000}{159{,}000} \simeq \frac{f(\text{Mc/s}) \times C(\text{pF})}{159}$$

NEWS FROM THE CLUBS

Birmingham.—The May meetings of the Slade Radio Society are to be devoted to talks and demonstrations on "The use of v.h.f. in mobile radio schemes" by J. Collett (G3BUR) and M. A. Brett (G3HBD) of the Midland Amateur Radio Society on the 9th, and on "Frequency-modulated equipment for amateur practice" by E. G. H. Brown (G5BJ) on the 23rd. Meetings are held on alternate Fridays at 7.45 in the Parochial Hall, Broomfield Road, Erdington, Birmingham. Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23.

Cleckheaton.—At the meeting of the Spen Valley Radio & Television Society on 7th May, E. M. Price will give an introduction to frequency modulation. The subject at the meeting on 21st May will be "Sound reproduction" by D. A. Newbold. The Spen Valley Society meets on alternate Wednesdays at 7.30 in the Temperance Hall, Cleckheaton. Sec.: N. Pride, 100, Raikes Lane, Birstall, Nr. Leeds.

Leicester.—A lecture on "Frequency modulation" will be given by C. L. Wright, B.Sc., to members of the Leicester Radio Society on 5th May. The Society's contests officer (M. Storey, G4BB) will outline plans for participation in the R.S.G.B. National Field Day at the meeting on 19th May. The club meets on the first and third Mondays of each month at 7.30 in the Holly Bush Hotel, Belgrave Gate, Leicester. Sec.: A. L. Milnthorpe, G2FMO, 3, Winster Drive, Thurmaston, Nr. Leicester.

London Group of the International Radio-Controlled Models Society meets at 2.0 on 11th May at the Horseshoe Hotel, Tottenham Court Road, W.C.2, when J. C. Hogg will speak on "Radio Controlled Sailing Boats." Particulars regarding the Society, which also has branches in Birmingham, Manchester and Newcastle-upon-Tyne, are obtainable from the secretary, C. H. Lindsey, 292, Bramhall Lane South, Bramhall, Stockport, Cheshire.

Manchester.—Meetings of the Manchester & District Radio Society are held on the first Monday of each month at 7.30 at the Manchester College of Technology, Sackville Street. Sec.: P. Dean, G3FNT, "Fairfield," Park Lane, Whitefield.

NOISE

By "CATHODE RAY"

1—*Explaining Its Nature and Origin*

BEING fond of terse, laconic titles I couldn't resist this one, but I really have no intention of saying anything about noise in general; only "noise" in its electronic sense. And a very silly sense too, non-technical people probably sniff, when they are told that it can be perfectly silent. "*Look* at all that noise!" says the television engineer, pointing to the screen—not the loud speaker.

And since "electronic" is another of those rather elastic words it had better be clear that I mean noise due to the electronic nature of matter—*not* noise caused by loose valve electrodes or bad contacts or vacuum cleaners or sparking plugs or thunder storms.

Noise and confusion often go together, and that seems to be true even of the subject of noise, which for some reason or other seems to be particularly difficult to put across. It may be too much to hope that the following attempt will succeed, but there is no harm in trying. Perhaps it will be all right if we take it one step at a time, including some steps that usually seem to be taken for granted. Those are generally the ones that trip people up.

Happy-go-Lucky Electrons

First let us take a molecule's eye view of the inside of a piece of wire—or in fact any stuff that could form part of a circuit, though at the moment there is no e.m.f. Like any other stuff, when looked at so closely it is seen to be mostly empty space. The only thing that distinguishes it as solid material is the fact that the main structure keeps formation, like a body of troops standing in extended order. But being conducting material it has also a lot of little urchins (called electrons) roaming around aimlessly in between the stationary men. Real urchins, however, could never be so perfectly and ideally aimless as these loose electrons. Their motion is quite random, in accordance with the laws of chance. Averaged over any considerable fraction of a second there are as many movements in any one direction as in the opposite direction. But it is one of the features of random motion that *at any given instant* there may quite well be a slight balance one way or the other. If you were to get thousands of children to keep on throwing balls up into the air, on the average there would be as many coming down as going up. If U were the number going up at any instant and D the number coming down, U−D would average zero. But it is not zero all the time. It fluctuates between positive and negative. Most of the time it is very small compared with U or D, but it fluctuates in amplitude too. If you were prepared to wait a very long time indeed, and the children kept on being replaced as they died off, you might even witness one of those rare occasions when all the balls were moving in the same direction at the same time.

That is a very rare event with a few thousands of random units, but with trillions of them, as in our piece of wire, it is so unlikely as to be quite negligible. In any case it would be over in less time than a flash. But the number of electrons moving in any direction does fluctuate. And since movement of these electrons in any direction is what we call an electric current in that direction, everything has a fluctuating electric current in it all the time, even though no e.m.f. is acting. There is nothing we can do to stop it. The fluctuations can be increased by heating the material, or reduced by cooling it; but the starting point is the absolute zero, about −273°C, so even cooling it down to zero Fahrenheit (−18°C) from room temperature (say 60°F or 15°C) reduces the fluctuation by less than 12%.

Not being a learned physicist, I am not going to attempt a more scientific account of the actual nature of this fluctuation, but will pass straight on to one of the radio engineer's favourite dodges—the equivalent generator (Fig. 1). The fluctuation currents in the wire or whatnot can be regarded as due to an imaginary generator producing a fluctuating e.m.f., E_N, in series with the resistance of the wire (or whatnot), R. The justification for this is that it enables one to predict quite correctly the fluctuation voltage and current set up in any circuit connected to R. If a very high load resistance is connected to any generator, almost the full generator e.m.f. appears at the terminals, but very little current, so the power is small. With a very low-resistance load, there is nearly maximum current but little voltage, so again little power. The maximum power is delivered when the load resistance is equal to the generator resistance. The e.m.f. is then divided equally between generator and load, so the terminal voltage is E/2. Power into the load is voltage-squared divided by load resistance, so is $(E/2)^2 \div R$, or $E^2/4R$. (Remember this for use later on.)

Power and Frequency

This well-known general principle of generator and load applies equally to the fluctuation generator. But before one can make much use of this knowledge one has to know what the voltage E_N is. Actually it is slightly simpler to consider the maximum fluctuation power that it stirs up in a load resistance

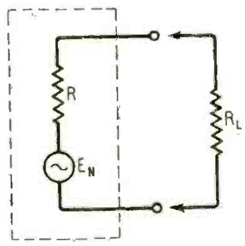


Fig. 1. For calculating the noise due to electron fluctuation in any resistance R, imagine it to be coming from an internal generator giving a r.m.s. e.m.f. E_N. R_L is any load into which noise power is flowing from R. (Noise power would also flow from R_L into R, but the power due to each element in a circuit can be found separately and added up.)

D 9

connected to it. Surprisingly, that power does not depend in the least on the number of electrons that are fluctuating. The whole world, connected to a load of the same resistance, would generate no more power than a ¼-watt resistor. The value of resistance, even, makes no difference, so long as the load resistance is equal. What, then, does the power depend on?

One thing has already been mentioned—temperature. The fluctuation power is directly proportional to absolute or Kelvin temperature (°K) which is centigrade temperature plus 273. It is denoted by T. Room temperature is generally taken to be 290°K (=63°F); and ordinary variations of temperature, since they are only a few per cent of 290, can generally be neglected.

The next thing to consider is the frequency of E_N. It is a truly alternating voltage, because it fluctuates just as much negatively as positively. But it differs from man-made a.c. in having no definite frequency, or rather it has all frequencies at once. This may be a difficult idea to grasp. Perhaps it can be understood better by considering the effect of an ordinary gramophone record on the pick-up. One of the main aims in pick-up design is to prevent it from resonating at any audible frequency. But suppose we went to the opposite extreme and designed one to resonate very sharply indeed, say at 1,000 c/s. Then if we put it on a variable-frequency test record it would respond very little until the recorded signal came to 1,000 c/s, when the pick-up output would peak sharply. Now, suppose we changed the record for an unrecorded disk made of rather rough material. The needle would stumble over the millions of granules at entirely random and irregular intervals. There would be so many granules that one of them would almost be bound to hit the needle every thousandth of a second, making it vibrate at that rate, so that the pick-up would put out a 1,000-c/s e.m.f. All the other millions of granules would be hitting the needle at different intervals, and the response of such a sharply tuned system to these would be almost negligible.

This is a slight exaggeration of what used to happen with certain early types of pick-up that had a sharp resonance peak at a few thousand c/s; when they played an unrecorded groove the "scratch" was more like a whistle. Although the fluctuation of the record surface was quite random the resonant pick-up responded to is own particular frequency. Another pick-up, resonating at a different frequency, would pick out that frequency from the continuous frequency band present on the disk. But a really good pick-up with no noticeable resonance responds to everything, and the result has no definite frequency—it is that entirely characterless sound called scratch or hiss or "rushing."

White Noise

"A sound with no definite frequency" is the usual definition of noise, so this particular type of sound has the best right to that name. Most of what are called noises in everyday life are not uniformly spread over the whole frequency range—the noise of a passing car is closely related to the frequency of firing, for example—but we, being scientifically minded, are ignoring these pseudo-noises. To make quite sure that "noise" is understood to mean the perfectly random kind, occurring with complete equality at every frequency, one sometimes calls it "white noise." This term probably strikes the layman as either whimsically poetical or quite unintelligible, according to his temperament; but of course it is based on the analogy of light. White or colourless light, as we were assured at school, is made up of light of every colour (i.e., frequency) and the separate colours can be picked out by a suitable optical device, such as a shower of rain.

White noise, or what we are calling just noise, is therefore the particular kind of sound that contains every frequency equally. If our fluctuation generator, Fig. 1, were applied to the input of a perfectly "flat" amplifier and loud speaker, the resulting sound would be white noise. It might of course be applied to a perfectly flat amplifier and cathode-ray tube, and the resulting visible fluctuation (Fig. 2) could hardly be noise in the dictionary sense, but one understands what is meant. In the same way, fluctuations that could by means of suitable equipment cause noise are themselves rather absurdly but very conveniently called noise. From now on I am going to give way to convenience.

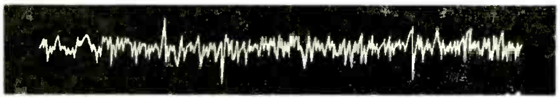


Fig. 2. Typical appearance of noise on the screen of a cathode-ray tube.

Boltzmann's Constant

One reason why the word "noise" is used perhaps more often of the cause than the effect is that the equipment necessary to make it audible never is perfectly flat, so audible noise has the frequency characteristic of the equipment stamped on it. In fact this is one very good method of determining the frequency characteristic of equipment—to apply white noise to the input and measure the output at all frequencies.

A simple way to demonstrate how white noise usually becomes coloured by whatever it comes to us through is to open your mouth and blow through it. The blowing sound is basically fairly white, but becomes coloured by the resonance of the mouth cavity. By suitably varying the size of this cavity you can easily play a recognizable tune, even when the blowing is kept below the intensity necessary to provoke actual oscillation (whistling).

In the same way, if the noise generator of Fig. 1 (which may be a resistor, circuit, aerial, or anything else having electrical resistance) is applied to an amplifier, the output (reckoned as *power*) at any particular frequency is proportional to the amplification at that frequency. A high-gain high-fidelity amplifier and loud speaker gives a close approximation to pure white noise—a rushing sound, like the patter of raindrops on the ground or the stirring of leaves in a breeze, and for the same reason. A tuned amplifier responds to a more or less narrow band of frequency, all the rest being unamplified and inaudible. If an r.f. amplifier is given a band-pass characteristic, say 10 kc/s to cover broadcast sound up to 5 kc/s, then noise is let in over this frequency band. A high fidelity receiver having the same gain but covering 30 kc/s would let in just three times as much noise power. And so on in proportion.

Now the voltage E_N is, very fortunately, much too small to measure directly with a voltmeter. It was not until amplifiers were made with a voltage magnification of the order of a million—power gain of a billion (10^{12})—that one really came up against it. So actual measurement of noise power cannot be made without very considerable amplification. Amplification—and particularly the very considerable amplification needed for this purpose—cannot be done at all frequencies at once. But there is no need to, when it is known that the noise power is directly proportional to the frequency band amplified. We are, of course, not so much interested in the noise power coming out of a particular amplifier used for measurement, because obviously that would depend on the amount of amplification. But dividing the measured noise power at the output of the amplifier by the power amplification would give the noise power at the input to the amplifier, or rather that part of the input power occurring within the frequency bandwidth of the amplifier. To make the figure so obtained more general we could divide by the bandwidth in cycles per second, giving noise power per unit bandwidth. To make it more general still we could divide it again, this time by the absolute temperature. The result, which is the noise power per cycle-per-second per degree absolute, turns out to be a constant, called Boltzmann's constant, usually denoted by k. It is a very small number, as you might guess. If the power is reckoned in watts, it is 1.38×10^{-23}.

The fact that it is a constant means that the amount of noise power varies with nothing but temperature. Seeing that only the power within a specified bandwidth is of practical interest, however, it is convenient to treat it as if the generated power were proportional to bandwidth as well as temperature; but the bandwidth has nothing to do with the noise generator itself (provided that it is always working under matched-load conditions) but only with the amplifier that renders the noise audible or at least detectable.

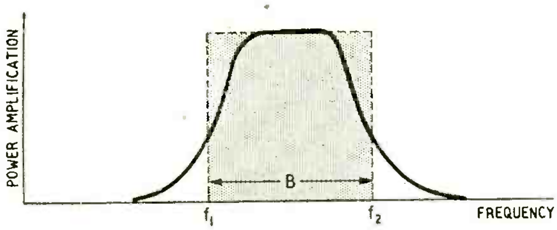


Fig. 3. How the frequency bandwidth B ($= f_2 - f_1$) of an amplifier is reckoned for purposes of noise calculation. It is the width (in frequency) of the rectangle having the same height and area below as the actual power-amplification frequency characteristic of the amplifier.

Now let us sum up what we have found, because it is the heart of the whole matter. It can be put in the form of an equation:

$$\frac{\text{Noise power (W) from matched load connected to noise generator}}{\text{Temperature (°K)} \times \text{Bandwidth (c/s)}} = 1.38 \times 10^{-23}$$

or in conventional symbols:

$$\frac{P_N}{TB} = k \qquad \text{So} \quad P_N = kTB$$

P_N is called the "available" noise power, meaning that it is the maximum that can be drawn by any load; obtained, as we know, when the load resistance is equal to the noise generator resistance. And, as I have emphasized, it is not the whole available noise power but only that part of it which falls within the frequency band B c/s wide. We have reached this fundamental result by a practical approach—measuring the noise with an amplifier and output meter. It is in fact quite an easy matter to demonstrate this kind of noise with any sensitive receiver by disconnecting the aerial and turning the gain control to maximum. Or you could make up a simple 3-stage resistance-coupled pentode amplifier that would enable you to hear the noise made by a resistor connected across the input terminals. With a little more trouble you might even have a shot at finding for yourself the value of k. But there are at least three questions that would probably arise when you started to do this.

Measuring the Noise

You may remember that I said the noise fluctuates according to how many electrons happen to be moving in the same direction at any one moment. So the instantaneous noise power *could* be absolutely anything! How, then, can a definite figure be measured? Well, there was the possibility that everyone in the world who died last year might have done so on the same day. But the possibility was so remote that undertakers were safe in ignoring it. When happenings, such as deaths or electron movements, are more or less random in their timing, they are very unlikely to vary much from the average rate. If noise is examined by some very quick-acting type of apparatus, occasional peaks are seen that are several times the mean (Fig. 2). But averaged over even as short a period as one tenth of a second the mean is quite steady enough to read definitely.

Next, how is the bandwidth B reckoned? Amplifiers don't have square frequency characteristics, perfectly flat between two limiting frequencies and down to zero everywhere else. Suppose an actual characteristic, plotted as power gain against frequency, is the curve in Fig. 3. The equivalent perfect characteristic is the dotted rectangular one that has the same area under it (shaded), and the equivalent bandwidth is represented by the distance between its vertical sides.

Those two problems are easily disposed of, but the third is not. Although I explained at the start that everything is full of fluctuating electrons, so that all are noise generators, I have been describing the measurement as if the amplifier itself were an exception, the only noise coming out from it being due to whatever was connected to its input terminals. Actually, of course, what comes out includes the noise generated in every part of the amplifier, amplified to an extent depending on the position of that part. Practically it is not nearly so complicated as this, because most of the noise is not amplified enough to have any significant effect on the result. Suppose for example that there are four stages, each with a voltage gain of 20 times, which is a power gain of 20^2 or 400 times. Then, assuming that each stage is identical, the output power due to noise generated at the input to the second stage, being amplified 400 times less than that due to the first stage, is negligible. Noise due to third and fourth stages is even more negligible. In fact, unless the gain of the first stage is rather low, the noise contributions of all other stages can be neglected. An advantage of reckoning in power is that power contributions from different parts of the circuit can, as we saw recently,* be simply added together. The main contribution to first-stage noise is usually the resistance between grid and cathode. Now so far we have been considering the noise generator in terms of "available noise power." But a valve is operated by input voltage, not power. Since Fig. 1 is equivalent for purposes of calculation to any noise-generating resistance R, the open-circuit noise voltage E_N is, as we have already seen, related to the available noise power P_N thus:

$$E_N^2 = P_N \times 4R$$

Since P_N is mean power, E_N^2 is mean square voltage and E_N is r.m.s. We already know that $P_N = k\text{TB}$, so putting these together we get:

$$E_N^2 = 4k\text{TBR}$$

and

$$E_N = 2\sqrt{k\text{TBR}}$$

For example, if T is the usual 290, what is the noise voltage within a 10-kc/s bandwidth across the terminals of a 0.1-MΩ resistor? $E_N = 2\sqrt{(1.38 \times 10^{-23} \times 290 \times 10{,}000 \times 100{,}000)} = 4 \times 10^{-6}$ volts or 4μV. Followed by four stages of noiseless $\times$ 20 voltage gain, this would yield an output of $4 \times 10^{-6} \times 20^4 = 0.64$V. If the noise were accepted over a band 100 times wider (1 Mc/s), the output would be 6.4V. But in practice the resistances and amplification in a wide-band amplifier are lower, offsetting such an increase.

One other noise source is likely to make an appreciable contribution to the output—the first valve itself. Although this noise is also electronic in origin, it is caused differently, because a valve is quite different from an ordinary resistor, however much we may use the Fig. 1 dodge to calculate its performance. To revert to our original molecule's eye view, all the troops have been dismissed (by means of a vacuum pump) and when anode voltage is applied there is a stream of urchins from cathode to anode. There is no fluctuating to and fro, but since the anode current is made up of separate packets (electrons) it cannot be perfectly continuous and steady. It is not like the silent stream from a tap turned on just far enough to make the separate drips coalesce, but more like rain, which arrives with a slight audible pattering of separate drops, even though these fluctuations may be very slight compared with the average rate of fall reckoned over several acres. This minute fluctuation in the anode current of a valve is called shot effect, to distinguish it from the other kind of fluctuation noise we have been discussing, which is called thermal or Johnson noise.

There is one condition under which it can be calculated simply and accurately. That is when the valve is a diode, with sufficient anode voltage to attract all the electrons being emitted by the cathode, so that the anode current is limited by the temperature of the cathode and not by unemployed electrons hanging around it—the "space charge." In this special case

$$I_N^2 = 2eI_aB$$

where I_N is the r.m.s. value of the noise component of anode current—the anode current fluctuation; I_a is the anode current itself; e is the charge of one electron (1.59×10^{-19} coulombs), and B is the bandwidth as before. For example, if I_a were 0.005 (5mA) and B were 10 kc/s, I_N would be $\sqrt{(2 \times 1.59 \times 10^{-19} \times 0.005 \times 10{,}000)} = 1.26 \times 10^{-10}$amps or one forty-millionth of the anode current.

Amplifying valves cannot be worked under these conditions, for the variations in grid voltage would have no effect on the anode current; and it is found that the space charge that collects in an amplifying valve somewhat reduces shot effect. In pentodes and other multi-electrode valves it is increased by random allocation of electrons between screen, anode, etc. (This is sometimes referred to as a separate phenomenon—partition effect.) But the above formula can be used to get a *rough* idea of the magnitude of the first-stage contribution of valve noise in our 4-stage amplifier. We multiply the current fluctuation, 1.26×10^{-10}, by the anode coupling resistance it flows through, say 10,000Ω, to get the valve noise voltage passed to the second stage, 1.26μV. This compares with the 4μV from the first grid resistance multiplied by 20 (first stage gain) making 80μV to the second stage. So in this case the Johnson noise would swamp the valve noise. A convenient way of specifying shot noise so that it can be directly compared with Johnson noise is as the resistance which, connected to the input of the valve concerned, would cause the same noise current in the anode circuit by Johnson effect. So if the equivalent noise resistance of a valve is, for example, 5,000Ω, it means that when used with an actual 5,000-Ω input resistance the Johnson and shot noise would be equal.

There is quite a lot to be said about how these kinds of noise affect the practical working of receivers and things, but it will have to wait until next month.

* "Total Power," March, 1952.

WIRE CAPACITORS

MINIATURIZATION is having such an effect on component design these days that one can no longer be sure of recognizing things by their external appearance. One would never guess, for example, that a piece of 18 or 20 s.w.g. copper wire about 2in long, with two leads soldered on, could in reality be a 100-pF capacitor. But that is exactly what the latest kind of miniature capacitor looks like. The Philips organization at Eindhoven have produced it, primarily for use in miniature i.f. transformers, although, of course, it has many other applications as well. For a given capacitance and working voltage, it is claimed to be the smallest capacitor ever made, its volume being less than one-third of that of an equivalent ceramic type. The dielectric loss and temperature coefficient (about $+1 \times 10^{-4}$ per °C) are comparable with those of a mica capacitor.

The two plates are formed by an outer cylinder and a concentric inner core, the narrow space between them being filled with compressed insulating material. This type of construction is obtained by a wire-drawing technique. The outer cylinder starts off as a piece of ¾-in diameter tube about 8in long and the inner core as a rod of about ⅓-in diameter. After the dielectric material, in powder form, is packed between them, the complete assembly is drawn out to a length of about 40 yards. The drawn "wire" is then chopped up into pieces of the required length, and at one end of each piece the "outer" is removed so that the core is left bare and connecting leads can be soldered on to both plates.

A complete description of the capacitors is given in the *Philips Technical Review* for December, 1951.

"Single-Ended" Push-Pull Amplifier

Overcoming Effects of Output Transformer Primary Leakage Inductance

AN interesting push-pull output stage has recently been developed and described[1] by A. G. P. Peterson and D. B. Sinclair of the General Radio Company (Cambridge, Massachusetts). The basic circuit is shown in Fig. 1 and it will be seen that the output valves are connected in series as far as the d.c. supply is concerned, but that the a.c. load is effectively shared by the two valves in parallel.

Several advantages accrue from this arrangement. With an output impedance one-half instead of twice the optimum load required by one of the output valves, the output transformer is easier to design, or it may be eliminated altogether if a valve such as the 6AS7 is used. This double-triode power valve has an a.c. resistance per section of only 280 ohms, and it should be possible to wind a loudspeaker speech coil to provide the optimum load for two sections in parallel without increasing unduly the mass of the coil.

If required, the output stage can be driven from a balanced phase-splitter with direct grid coupling, the anode load resistor of the phase-splitter being connected to the mid-point of the output stage. Bias for the top valve can then be obtained in the correct polarity by tapping off the volt drop in this resistor. Unfortunately the drop in the cathode circuit of the phase-splitter is of the wrong polarity and must be backed off in order to supply the lower valve with correct bias.

The chief advantage claimed for the circuit is that it provides an alternative solution to the use of bifilar-wound transformers[2] for eliminating the switching transients often experienced with normal push-pull stages when swinging from one valve to the other under Class B or Class AB conditions, when there is leakage inductance between the two halves of the primary.[3]

Against these advantages must be set the practical difficulties of working with twice the normal h.t. voltage (or of using a parallel d.c. feed circuit involving the use of large bypass capacitors), and of obtaining an adequate driving voltage from the phase-splitter, since there is inherent negative feedback between the output and the anode supply to the driver stage. Another limitation is the capacitance to earth of the anode of the driver stage, which sets an upper limit on the frequency response of the system; while this can be controlled as far as the range of audio frequencies is concerned, it seems unlikely that the circuit will be suitable for video frequencies.

For the practical realization of an audio amplifier using this principle, an output transformer with a split primary is convenient. In some conventional push-pull transformers the two halves of the primary are brought out to separate terminals, and can be used to carry the screen currents (in opposition) if beam tetrode output valves are employed, or to feed the d.c. to the anodes in parallel in order to halve the h.t. supply voltage required (Fig. 2). Leakage

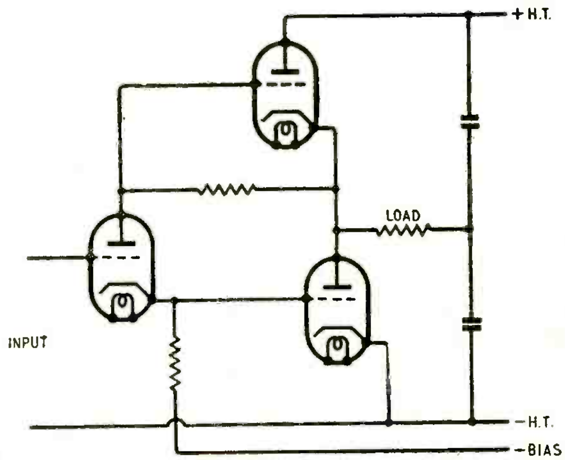
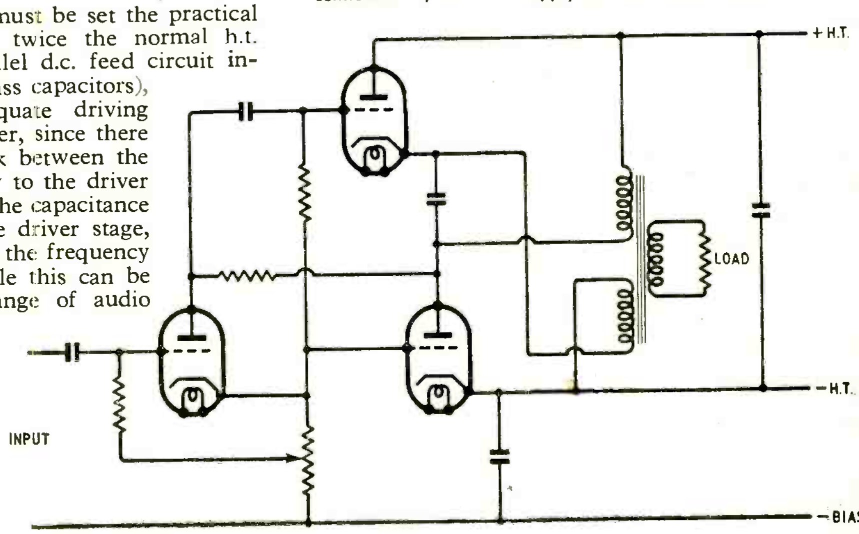


Fig. 1. Basic circuit of output stage with phase-splitter driver.

Fig. 2. The use of a split primary winding for parallel connection of the h.t. supply to the output anodes.



[1] "A Single-ended Push-Pull Audio Amplifier" by A. Peterson and D. B. Sinclair, *Proc. I.R.E.*, Vol. 40, p. 7, Jan. 1952.
[2] "New 50-watt Amplifier Circuit" by F. H. McIntosh and G. J. Gow, *Audio Engineering*, Dec. 1949.
[3] "Quasi Transients in Class B Audio-frequency Push-Pull Amplifiers" by A. Pen-Tung Sah, *Proc. I.R.E.*, Vol. 24, p. 1522, Nov. 1936.

inductance between the two halves of the primary does not affect the output since, as far as the signal is concerned, they are in parallel.

Amplifiers elaborating these basic ideas have been built and tested and are described in the October, 1951, issue of *The General Radio Experimenter*. With feedback, frequency response is shown to be level within 0.5db from 20c/s to 20,000c/s and harmonic distortion is less than 0.2 per cent above 50c/s and below 40 watts output in a nominal 50-watt amplifier.

F.M. RECEIVER MODIFICATION

Fitting an X79 Frequency Changer in Place of the X81

By J. G. SPENCER*

AFTER publication of the design of the f.m. receiver in the November and December issues of the *Wireless World* it was learnt that the valve used for the frequency changer, the X81, although still available, is now becoming obsolete, and will be superseded by the X79, a similar type of valve on the miniature noval base (9 pin). An X79 has accordingly been fitted in the prototype receiver and the performance checked in respect of sensitivity, oscillator drift and a.g.c. characteristic.

* Research Department, B.B.C.

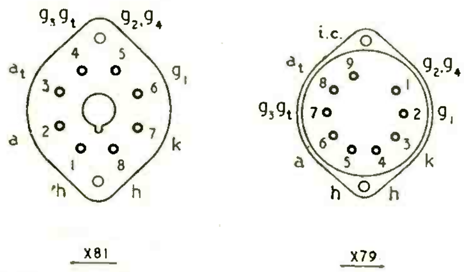


Fig. 1. Base connections of X81 and X79 frequency changers compared. Sequence of connections are largely the same although bases are of quite different type.

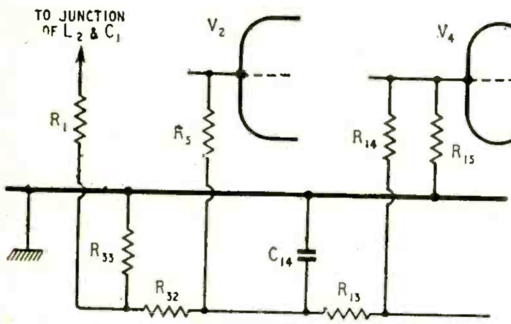


Fig. 2. Modifications to a.g.c. circuit to enable the r.f. stage to be controlled as well as the frequency changer.

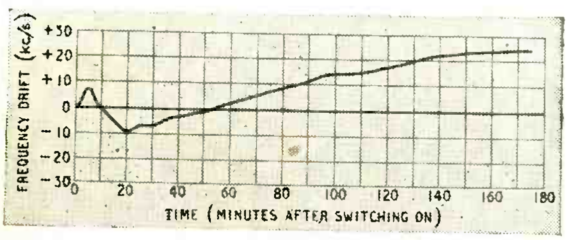


Fig. 3. Curve showing combined effect on signal frequency of drif in local oscillator and discriminator circuits.

Apart from the change of valveholder, no alterations in component layout are required to accommodate the new valve. As can be seen from the base diagrams in Fig. 1, the electrode connections are brought out in the same order in both types, with the exception of the pins for the triode grid and anode, which are transposed. The pin markings are, however, different. If the noval valveholder is suitably orientated the change involves practically no disturbance to the original wiring and the change of oscillator circuit capacitance is well within the range of the trimmer capacitor C_{18}.

Two minor modifications to the circuit have been found necessary. Resistor R_{17} is decreased from 10 kΩ to 8.2 kΩ to reduce the frequency changer screen voltage to a value within the valve rating, and a.g.c. is now applied to the r.f. amplifier as well as the mixer, since the control obtainable with the X79 alone was found to be insufficient.

The value of 8.2 kΩ specified for R_{17} gives 95 V at the junction of R_{17} and R_{18} with an h.t. line voltage of 220. Should the h.t. voltage differ appreciably from 220 V, R_{18} should be adjusted appropriately, since a low screen voltage will reduce the conversion gain of the mixer; conversely, the maximum rating of 100 V applicable both to the valve and to C_{25} must not be exceeded.

The alteration to the a.g.c. circuit is shown in Fig. 2. R_{13} is changed from 1.5 MΩ to 1.0 MΩ and two additional resistors, R_{32} of 1 MΩ and R_{33} of 1.5 MΩ are connected in series from the junction of R_5 and R_{13} to earth. The low potential end of R_1, which originally was returned to chassis, is now connected to the junction of R_{32} and R_{33}. Using the X79 with these circuit modifications the a.g.c. is quite satisfactory and there is no audible deterioration in the signal to noise ratio, while the sensitivity of the receiver is substantially unchanged.

The curve of frequency drift which is shown in Fig. 3 was taken in a different manner from that published with the original test results. The latter was obtained by measuring the actual local oscillator frequency, whereas the curve given here is of the input carrier frequency required to produce zero d.c. output from the discriminator. It thus takes account of both oscillator and discriminator drift and is of more practical value. As can be seen from Fig. 3, the performance of the X79 in this respect also is practically identical with that of the X81.

UNDERWATER TELEVISION

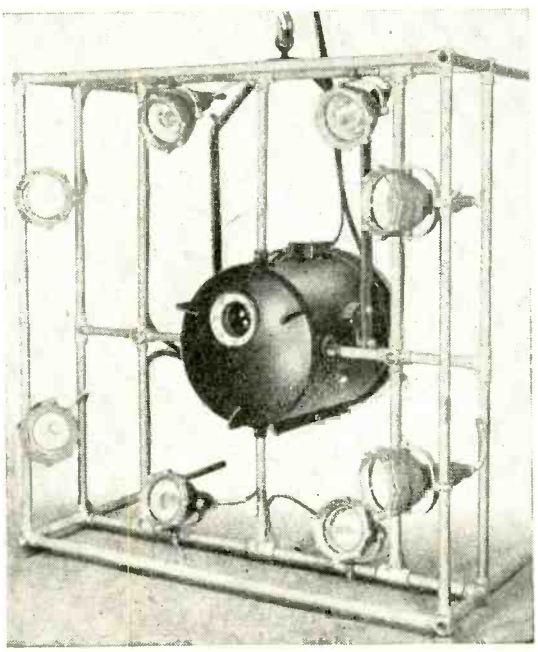
IT will be recalled how that television was successfully brought into use a year ago in the search for the lost submarine *Affray* which sank during exercises in the English Channel. The equipment used at the time was very much a lash-up, for, although the sensitivity of the Marconi image-orthicon camera for underwater investigation had been demonstrated at the Admiralty Research Establishment some months previously, it was not until the initial search for the *Affray* had proved unsuccessful that Marconi's were asked by the Admiralty to provide a camera and associated equipment to assist in identifying the many wrecks located by Asdic.

The installation in the deep-diving vessel H.M.S. *Reclaim* was, with the exception of the camera housing, standard 405-line portable O.B. gear such as is used by the B.B.C.

The success of the search opened up a new field in the application of television and, whilst electronically the equipment is unmodified, a number of additions have now been made to facilitate the operation of the camera at considerable depth—the *Affray* was 280 feet below the surface.

The additions which have been found necessary to give remote control and "indication of behaviour" on board ship are: remote focus control (as indication of setting is shown at the control point, it is possible to estimate the size of an object and its distance away with reasonable accuracy), remote iris control, inclinometer (giving remote indication of the unit's angle when submerged), and moisture indicator. It is also intended to include a compass to show the orientation of the unit.

The 32-core cable linking the camera with the control equipment was provided by B. I. Callender's.



Television camera in pressure case and adjustable lighting gantry provided by Siebe, Gorman. For downward "shots" the gantry and camera can be swung through 90° on the trunnion

NORTHERN SHOW

BY the time this issue appears the first Northern Radio Show to be held since 1938 will be in full swing in the City Hall, Manchester. The ten-day show closes on 3rd May.

Arrangements, similar to those made at the National Show at Earls Court last year, provide for the demonstration of more than 200 television receivers almost continuously whilst the show is open (11 a.m. to 10 p.m.). In addition to the receivers in the communal viewing avenue, many exhibitors are demonstrating television sets on their stands without having to resort to enclosed viewing rooms. The distribution is on television Channel 4 (61.75 Mc/s and 58.25 Mc/s).

Instead of installing a separate public address system, the sound channel feeding the television receivers is being used for general announcements.

RANDOM RADIATIONS

By "DIALLIST"

Resistor Coding

WHAT IS THERE to recommend the colour-coding system and why has it become so firmly established? I just do not know. Not a few readers are of the same opinion, to judge by the letters I have received from old and valued correspondents. Apart from the matter of colour blindness, mentioned by L. G. Wollet in a recent letter to the Editor, it must always take some training to make newcomers to the radio factory so conversant with the bands and dots of the code that they can read the value of a resistor instantly—and correctly. They have, in fact, to learn an entirely new set of numerical symbols and to use them instead of the figures with which they have been familiar since their earliest schooldays. One understands that the "wastage" amongst women in factories is heavy (queer that marriage should be classed as wastage!), which means that there is a continual stream of new employees to be trained. Nor is the factory operative the only person to be considered: very important users of resistors are the experimenters, both professional and amateur, upon whose work radio progress depends. I defy anyone to prove that the code markings can be read as quickly as plain figures; they waste time and that is never good. It is surprising, too, how quickly you get out of practice with the code unless you are frequently making use of it.

A Plain-Figure Scheme

The colour printing needed for code-marking resistor covers must add to production costs. Here's an idea for doing without it which would make values instantly readable by anyone and would be as nearly foolproof as anything in this world can be. Mark resistors from 1 megohm upwards in good clear print 1M, 2M and so on. From 100,000 to 900,000 ohms mark 0.1M, 0.2M . . . 0.9M; from 1,000 to 90,000 ohms mark 1k, 2k . . . 90k; and from 1 ohm to 900 ohms mark 1Ω, 2Ω . . . 900Ω. It would be difficult to make a mistake with resistors bearing clear markings of that kind and they would waste no one's time. I would suggest the use of colour for indicating the watt-rating. But not dabs or dots or rings of colour: the *whole* of the case would be of the colour standardized for any particular rating, say:

Under $\frac{1}{8}$-watt	medium grey
$\frac{1}{8}$-watt	bright blue
$\frac{1}{4}$-watt	olive green
$\frac{1}{2}$-watt	salmon pink
1 watt	white

Tolerances could be indicated in this simple way: 20 per cent, no mark; 15 per cent, one star; 10 per cent, two stars; 5 per cent, three stars. Thus a salmon pink resistor marked 47k ** would be instantly recognizable as having a resistance of 47,000Ω with a tolerance of 10 per cent and a current-carrying capacity of 0.5 watt.

Neglected Opportunity?

ONLY ONE of the new television receivers with 12-in or 15-in tubes makes use of spot-wobble; or, perhaps, I have missed the announcements of others which do. Why spot-wobble is not much more widely used in sets with 12-in or larger tubes beats me. It is not an expensive addition for it means no more than one extra valve and a pair of vertical deflector coils containing only one or two turns apiece. The valve oscillates at about 10 Mc/s and the coils give the spot a very small up-and-down movement as it performs the line scan. The spaces between the lines are thus filled in and the image loses all trace of lininess. Having had some experience of spot-wobbled reception, I am prepared to maintain that, installed in a good 405-line receiver, it provides a picture as detailed and as pleasing as anyone could want.

Queer Habit

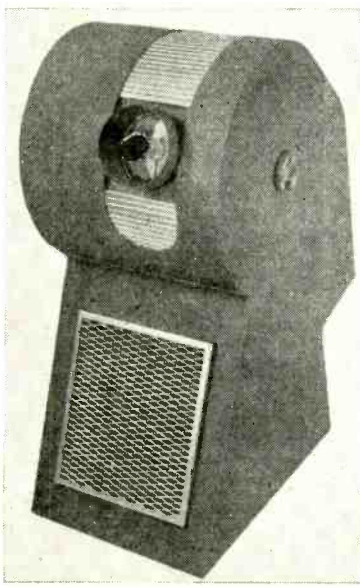
CALLED TO THE TELEPHONE the other evening, I found at the other end of the line an old friend who had floundered into deep water and was crying urgently for help. "I'm trying to read a French television article," he said, "and I've come up against a snag: what on earth does *le blocking images* mean?" Blocking is the English word all right; but "the blocking" is not an English term for any part of a television receiver. Looks more like a bit of printers' technical jargon, doesn't it? My friend's very natural perplexity was due to the queer French habit of retaining only the adjective when they assimilate a term, technical or otherwise, of ours. Believe it or not, *un rocking* is perfectly good French for rocking chair. By this time you will no doubt have realized that *un blocking* is just a blocking oscillator and that *le blocking images* is the frame oscillator!

A.R.R.L. HANDBOOK FOR 1952

REVISED and brought thoroughly up to date, the 1952 Radio Amateur's Handbook retains its emphasis on the practical problems of amateur communications. As the accepted standard manual of amateur radio its greatest appeal is in the broadness of its scope. Every aspect of the subject is covered, from a history of amateur radio and basic electrical theory to construction of transmitters, receivers and test apparatus of various kinds.

There is a vast amount of compressed information in its numerous charts and tables, while the enlarged valve section forms a useful reference to all old and new transmitting and receiving valves and c.r. tubes. American types only are included, but many are now either made in this country or have near equivalents.

Copies of the handbook are obtainable from the Modern Book Co., 19-23, Praed Street, London, W.2, at 30/- (31/- by post), or it can be ordered through the Radio Society of Great Britain, New Ruskin House, Little Russell Street, London, W.1, for delivery from the U.S.A., the price being 30/- including postage.



NEW IDEA IN OUTWARD FORM.—*A front-projection television receiver (Rainbow Radio Manufacturing Company) with the case contoured to fit round the optical system. The set, designed for use in clubs, hotels, schools, etc., projects a 4ft × 3ft picture on an external screen.*

UNBIASED

By FREE GRID

A Cry from the Heart

WHEN is some radio manufacturer going to co-operate with a furniture maker to produce an armchair designed specially for comfortable carpet-slipper listening? I want something which will give me the intimacy

An upholsterer's nightmare

of headphones without the attendant physical discomfort they bring. The sort of thing I have in mind is one of those armchairs with what I would call winged headrests. These padded headrests could so easily accommodate concealed low-intensity reproducers. My own attempts to carry out my ideas on an existing chair of this type have led to nothing but an upholsterer's nightmare. Two chairs of this type in each home would do much to lessen the strain on the Divorce Court, as few things are so marriage-wrecking as having to listen to a programme you dislike.

Cybernetics

WITHOUT doubt, one of the most interesting but at the same time most depressing articles in the April issue was that dealing with cybernetics. Few of us care to think of ourselves as a sort of glorified servo-mechanism. Personally, I do not like to think of my brain as a mere bulb perched on the top of my spine like a toffee-apple on its stick. It is also very hard for me to accept that when the poet wrote of:—

"Sweet ecstasies of long ago,
And old remembered things too sad for tears."

he was merely using a lot of unnecessary words to describe something which could have been more accurately expressed as an equation, and that the forlorn and rejected lover in the poem could have easily got rid of his well-nigh unbearable burden of sorrow by getting his memory-storage loops cut at the same time as his tonsils.

But I have to confess that the effect on me of this earnest cybernetician's words is only to be measured in megalogons. The greatest effect was produced by that part of the article which dealt with maladies afflicting the nervous system. Some of these are stated to be due to "certain feedback loops which should give negative feedback but have changed round to positive feedback." The result is the same sort of instability and tendency to violent oscillation as we had to put up with in our amplifiers before the development of the screen-grid valve and decoupling technique.

All we did then—and indeed all we could do—to improve matters was to apply palliatives such as direct aerial coupling, grid current, reversed a.f. transformer connections and many other things of a like nature which we, in the dark ages of the mid-'twenties, used to call "applying a little 'dampo.'" In so doing, we inevitably damped out a large part of the useful properties of our valves.

Now that biologists are turning more and more to communications engineering to help them solve their problems, those of them who are also medical men cannot fail to realize that they are still living in the dark "dampo" age which we radio men passed through in the pre-1927 era. Let them take heart, therefore, from our experience and when the physiological screen-grid valve eventually arrives, be prepared to throw their bromides, barbiturates and other forms of sedative "dampo" into the medical dustbin to join the leeches. When that day dawns it will no longer be necessary to manhandle the feedback loops as we did our triodes in 1925, so that in checking their undesirable properties their useful and normal ones become enfeebled.

Car Radio and the Law

IT is very difficult in these days to go through life without breaking one of the thousand and one regulations and restrictions by which we are beset. Until recently, however, I did not realize that every time I venture out in my austerity limousine and use my car radio to while away the tedium of the three-hour intermittent crawl from the Bank to Marble Arch I am turning myself into a common felon; perhaps felon is hardly the right word for I believe that I am correct in saying, technically, it is not a felony but an offence that I commit.

I do not mean, of course, that I am making Mr. Butler's task harder by failing to take out a wireless licence for my car radio. But of using my car radio in a manner not covered by my wireless licence.

Morally, the P.M.G. is to blame, for he takes my money with callous indifference to the fact that the licence does not grant me that freedom of the air which I thought it did when I bought it. There is no warning printed on the back of the licence to point out to me that I am statute-barred from using my car radio when stuck in a traffic jam or at a standstill for other reasons.

Yet such is actually the case, for what other conclusion can I draw from a recent court case in which a driver was fined for using an "audible instrument" upon his taxi-cab while it was stationary. True, the instrument in this case was a horn, but it is obvious that a radio set bellowing through the open windows of a car, which one so often hears in a traffic jam, is also an "audible instrument." The fact that the offender in this case was a taxi driver does not alter matters.

If I were to use headphones or make my car soundproof in order to make the set inaudible to outsiders, I should be unable to hear when I was gonged and so would lay myself open to a charge of "failing to stop when called upon to do so." There is, therefore, nothing for it but to use more of the country's scarce materials and manpower hours in connecting my car radio to the stop light so that when the latter goes on the former goes off.

Unconvicted felon ?