CONTENTS

Wireless World

ELECTRONICS, RADIO, TELEVISION

JANUARY 1964

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MULLARD ELECTROLYTIC CAPACITORS

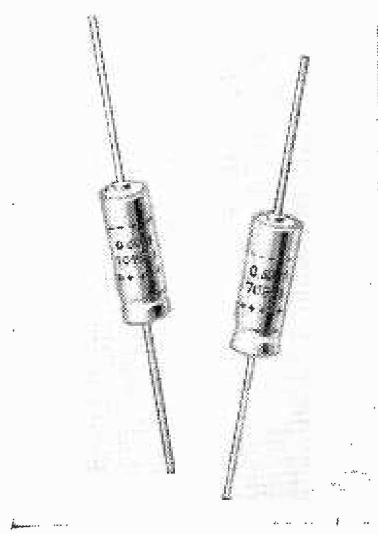
Standard Series provides economy and reliability

STANDARD electrolytic capacitors of the Mullard C425 series form a notable supplement to the established C426 series of miniature electrolytics, and are frequently encountered in domestic entertainment equipment.

Although the imagination can be fired by descriptions of miniature equipment and components, space in present-day domestic equipment is not always at a premium. Reduction in cost without loss of performance is sometimes a more important factor. In applications where the smallness of can sizes 1 and 2 of the C426 series is not required, use of the standard C425 range will afford a more economical solution.

The standard capacitors are 18·7mm long and have a diameter of 6·8mm. Eleven different combinations of capacitance and working voltage are available in the series, ranging from 0·64μF, 64V to 40μF, 4V. As with the C426 series, the tolerances on these capacitances are −10, +50%, and the power factor of the components is extremely low, indicating the high quality of the capacitors.

With the lower values of capacitance in the standard series, it may be necessary to choose a voltage rating higher than that dictated by circuit conditions, but this will simply add to the long service life that is a characteristic of Mullard electrolytic capacitors.



PCF802 TRIODE PENTODE FOR LINE OSCILLATORS

LINE oscillator circuits incorporating the Mullard PCF802 are being used in the dual-standard receivers that are now appearing in readiness for BBC-2.

Because negative vision modulation will be used in the new 625-line service instead of the positive modulation of the present 405-line service, line oscillators operating on the flywheel principle are attractive. The Mullard PCF802 has been designed for use as a sine-wave oscillator whose frequency is controlled by the triode section of the valve functioning as a reactance valve.

A notable feature of this type of circuit is that only one switch is needed to change the frequency of the oscillator from that required for the 405-line standard — 10·125kc/s — to that required for the 625-line standard 15·625 kc/s.

WHAT'S NEW IN THE NEW SETS

These articles describe the latest Mullard developments for entertainment equipment

Special attention has been paid in development of the new valve to minimising hum and microphonic interference. Furthermore, the amplification factor of the triode section of the valve is high, thus making the section particularly suitable for operation as a reactance valve.

CAR RADIO TRANSISTOR PACKAGE

The Mullard LCR2 car radio audio package comprises the OC82DM miniature driver transistor and the AD140 output transistor. The AD140 has a high current gain and possesses good linearity and frequency characteristics.

The package forms a two-stage class A amplifier capable of delivering 3W when driven directly from the detector of an all-transistor receiver. The sensitivity of the amplifier with respect to a 1kΩ source is typically 25mV for full output. The LCR2 is thus meeting the need for high audio gain in car radios, ensuring an excellent standard of performance while offering an economic design. (Replacements for maintenance should be ordered by the individual type number.)

MVE 1566

4WW—090 FOR FURTHER DETAILS.

Wireless World

VOL 70 NO 1 JANUARY 1964

Hi Fi by Numbers

LETTERS from Mr. C. C. V. Hodgson and from the B.B.C. in this month's correspondence columns revive a topic which has been and probably always will be a source of controversy as long as there is interest in high-quality sound reproduction.

No one denies that the ideal sound reproducing system should have a frequency response extending to the upper limit of audibility of the youngest listener; otherwise the occasional but nevertheless important transients in sound will show differences from the original. An illustrated lecture, for instance, on the influence of the country of origin on the tonal quality of triangles would be pointless without frequencies up to or beyond 15 kc/s.

Which brings us to our point, that there is a wealth of material, including the bulk of European music which can be transmitted without detriment to the composers' intentions and enjoyed even when nothing is transmitted above 8 kc/s. In the days of 78 r.p.m. shellac records the preferred cut-off was 5 to 6 kc/s. It should not be forgotten that, as Eckersley used to say, the wider you open the window the more the dirt blows in.

Frequency response is easy to specify and to measure, but it is not the only, or indeed the first criterion of good sound quality. There are many other qualities which can be treated objectively and given numbers, but we should not forget that a performance can be spoilt also by control engineers —even musicians—who sometimes have an "off" day. Frequency response or the lack of it is usually the last thing to be appreciated by the mind in selecting meaningful clues from the complex stimulus of music.

For every listener who finds the v.h.f./f.m. transmissions of the B.B.C. deficient in high-frequency response there must be thousands who are thankful that sufficient funds were made available to provide a refuge from the pandemonium of medium waves and thus to restore the possibility of once again listening to plays and good music. This was the first objective of the v.h.f./f.m. service, not the extension of frequency range. Nevertheless, the quality is transparently good (given adequate receivers, amplifiers and loudspeakers) and interposes no serious impediment to the enjoyment of the programmes. Occasionally a programme of outstanding excellence is transmitted just as there are outstanding recordings to be found in the outputs from the gramophone companies. We think it unlikely that anyone will find any correlation here with frequency response or conversely any failure that can be attributed to lack of it. Memorable experiences in sound reproduction and recording can seldom be devised, they just happen; and when they do we accept them gratefully. They are no less acceptable because the reasons ascribed for success may prove to be false. In this connection we remember the jubilation of the wideband boys at the startling improvement in sound quality which accompanied the B.B.C.'s move to Alexandra Palace and the opening of the television service in the v.h.f. bands in 1936. This was at first widely attributed to the release from the frequency constraints of medium-wave broadcasting, but was subsequently shown to be due to the simultaneous first use of a new design of microphone "A" amplifier with less than 1% harmonic distortion.

This is not to say that Mr. Hodgson is wrong in wanting a wider audio response; we would all like to run 120 m.p.h. motor cars—just in case our journeyings might one day take us to the M1.

Elements of Transistor Pulse Circuits

1.—THE PULSE CIRCUIT FAMILY

By T. D. TOWERS,* M.B.E.

IN the last two decades, many new electronic fields have opened up where the elementary circuits or " building blocks " have tended to become more and more sophisticated. In the fields of computers, control systems, data processing, instrumentation, nucleonics, radar and telemetry, etc., although the small-signal linear amplifier is still a fundamental, the engineer is now expected to have an armoury of other circuits ready to hand—particularly non-linear, large-signal pulse circuits.

This work is aimed at providing the busy engineer with a practical review of the more commonly used non-linear building blocks in their transistor versions. The treatment is mainly practical and descriptive with a minimum of detailed analysis and mathematics.

The pulse circuit family is now so numerous that it is well to begin with a review survey, to have a look, so to speak, at the family group photograph to identify the main features of the various members, before going on to a detailed consideration of each individually. This brief review of the principa basic pulse circuits is given below.

Phase Inverter: Transistor circuitry is by now so well established that most people will have no difficulty in recognizing the common-emitter transistor amplifier appearing in Fig. 1. In the small-signal circuits of communications practice, its most important feature is the signal-voltage amplification from input to output. The phase change across the stage is of secondary importance. This type of amplifier also appears widely in pulse circuits, but in this field the fact that the output is 180° out of phase with the input is much more important. So much is this so that the circuit is often known as a " phase inverter " or simply an " inverter." It is frequently used merely to invert the polarity of a pulse without amplification.

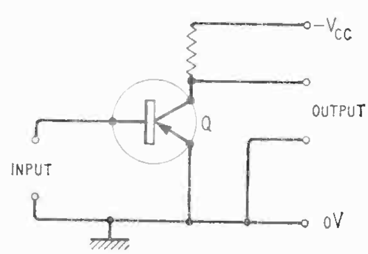


Fig. 1. Phase inverter.

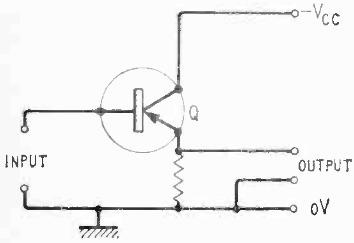


Fig. 2. Emitter follower.

Emitter Follower: The other common basic amplifier in pulse circuitry is the common-collector one shown in Fig. 2, which is usually referred to as an " emitter follower." It is, of course, the transistor equivalent of the valve cathode follower. Its principal characteristics are that the output is in phase with the input, the output voltage at the emitter always lies within a fraction of a volt of the voltage at the base (hence " emitter follower "), the input impedance is high, and the output impedance is low.

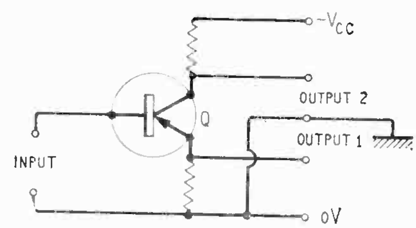


Fig. 3. Phase splitter.

Many electronic instruments take advantage of the good stability and linearity of the emitter follower. It is usually employed where there is a requirement for a high input impedance, a low output impedance or both. The input stage of a transistor oscilloscope or electronic voltmeter is usually an emitter follower. The effect of shunt capacitance in long signal leads or screened cables can be minimized by feeding from the low output impedance of such a circuit. Where one circuit feeds into another and the reaction of the second circuit on the first is to be kept low, use can be made of an emitter follower as a buffer between the two stages. The low output resistance of the emitter follower presents a barrier to feedback from the higher input resistance of the second stage. A number of other basic circuits are described below which are similar to the emitter follower in that they have a resistor in the emitter circuit.

Phase Splitter: The phase splitter (often called " balanced inverter ") shown in Fig. 3 provides two output signals of opposite polarity from a single input — hence the term " phase splitter." Output 1 (from the emitter) and the input are of one polarity, and output 2 (from the collector) is of opposite polarity. If the collector and emitter resistors are of

* Newmarket Transistors Ltd.

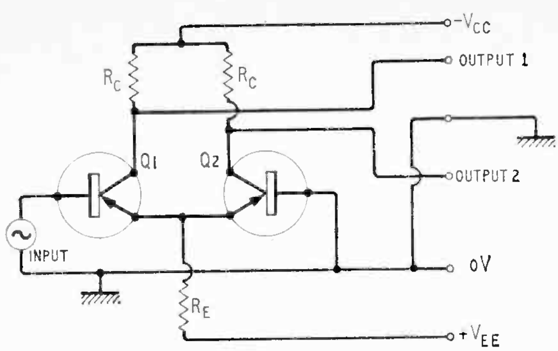


Fig. 4. Paraphase amplifier.

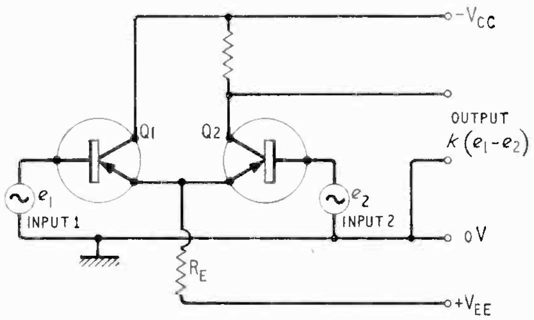


Fig. 5. Differential amplifier.

equal value, the two voltage output signals are of equal amplitude, since by transistor action the collector and emitter currents are virtually equal. The high voltage negative feedback resulting from the emitter resistor reduces the voltage gain to just below unity at both output terminals. One defect of the circuit is that while the output impedance at the collector is high (approximately equal to the collector load resistance), at the emitter it is low (approximately equal to the input source resistance divided by the transistor current gain). This impedance unbalance can be got round by including in series with the emitter output a resistance equal to the collector load resistance. The two outputs are then equal in voltage, opposite in phase and from equal source impedances. They are thus completely balanced, but the circuit has no voltage gain. A typical use of this sort of circuit is to convert a single-ended sweep voltage into a symmetrical deflection for an oscilloscope.

Paraphase Amplifier: Fig. 4 illustrates a circuit, the paraphase amplifier, which serves the same function as a phase splitter, but also provides equal signals and, without padding, equal impedances at the two outputs. This is one of the family branch known as " long-tail pairs " or " long-tailed pairs ", which all have the same feature of an emitter resistor common to two independent transistor amplifiers through which the amplifiers react on one another. The appearance of the circuit in Fig. 4 with the common emitter resistor, R_E, projecting downwards makes the term " long-tail pair " self evident. The emitters of Q1 and Q2 are close to earth potential through their forward-biased emitter-base diodes. If R_E is large, then a relatively constant direct current flows through it. If the signal voltage applied to Q1 increases, the input base current also increases. This in turn causes the emitter current of Q1 to increase. As the sum of the emitter currents of Q1 and Q2 is fixed (being equal to the total current through R_E), the current through Q2 must decrease by an amount equal to the increase in the Q1 current. These changes of current are reflected in the collector output voltages. Output 1 falls as output 2 rises. Thus for a single-ended input into the paraphase amplifier, there are available at the outputs balanced push-pull voltages from equal impedance sources (the collector resistances R_C). The circuit also provides some voltage gain from input to output.

Differential Amplifier: The paraphase amplifier described above has only one input signal. It is also possible to use this basic long-tail pair to accept two signal inputs and give an output proportional to the difference between the input signals. This is the differential or difference amplifier. The basic circuit is set out in Fig. 5. Here the two input signals are applied to the transistor bases. The voltage at the emitter of Q1 (and thus of Q2) follows the voltage at the base of Q1, so that the base-to-emitter voltage of Q2 is equal to $e_2 - e_1$. The corresponding signal voltage at the collector of Q2 is then by transistor action in Q2 proportional to this input voltage difference. When e_1 and e_2 are equal in amplitude

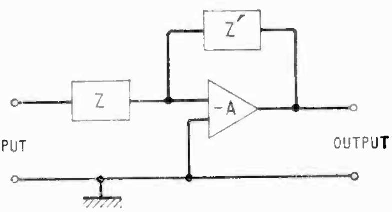


Fig. 6. Basic operational amplifier.

but opposite in polarity, i.e. when $e_2 = -e_1 = e$, then the output of the difference amplifier, being proportional to $e_2 - e_1 = 2e$, is a single sided signal proportional to the balanced input signal. This circuit can thus be used to convert the push-pull output of a phase-splitter or a paraphase amplifier to a single-sided output with respect to earth.

In the above description, signals have been shown as a.c., but they can equally well be d.c., because all have been illustrated with d.c. coupling.

Operational Amplifier: Another class of amplifiers widely used in non-linear circuits is the " operational amplifier " shown in block form in Fig. 6. The internal amplifier gain A is real and negative, i.e. it has 180° phase shift and greater than unity amplification from input to output. The external voltage feedback loop across the amplifier through the impedance Z′ combined with the series input impedance Z gives the complete operational amplifier certain useful properties. For example, where the internal amplifier gain is very large, it can be shown that the operational amplifier gain is approximately Z′/Z. The description " operational " arises because this type of amplifier may be used to accomplish a number of mathematical operations.

With transistors, the basic operational amplifier

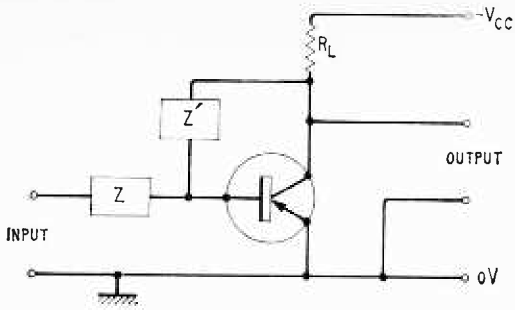


Fig. 7. Transistor operational amplifier.

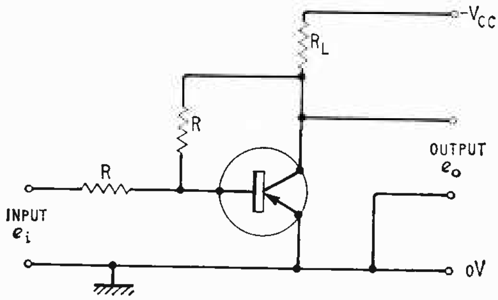


Fig. 8. Sign changer.

takes the form of Fig. 7, where a common-emitter configuration provides the necessary real negative voltage gain.

Sign Changer: To change the sign of a signal (i.e. phase change 180° without amplitude change), Z′ is made equal to Z. For d.c signals this would take the basic form shown in Fig. 8 where the feedback impedances Z and Z′ are equal resistances R.

For a.c. signals, however, the two resistors R could be complex impedances, i.e. any combination of R, L and C, although usually, for simple sign change, resistors alone are used to ensure a phase shift independent of frequency.

Scale Changer: To change the scale of a signal (i.e. amplitude change by a factor *k*), the feedback components of the operational amplifier should be selected to have $Z'/Z = k$, a real constant. Again, scale change is usually effected with Z and Z′ selected as resistors, which gives the circuit of Fig. 9. In this, the output voltage is of opposite sign to the input, and increased by a factor *k*. Often the analogy is drawn here between the scale-changer operational amplifier and a lever with its fulcrum at the transistor base. The output volts go down as the input volts go up and the output volts travel is *k* times that at the input.

Phase Shifter: To change only the phase of a sinusoidal a.c. signal, the series and feedback impedance components of the basic operational amplifier of Fig. 7 should be made equal in magnitude but should differ in phase angle. By using suitable values of capacitance or inductance, by themselves or with resistors, any phase shift from 0° to 360° may be obtained at any selected frequency.

Integrator: A specific example of phase shifting is the integrator circuit of Fig. 10 where the series input impedance is a resistor and the feedback impedance a capacitance. Here it can be shown that the output voltage e_o is related to the input voltage e_i by the formula

$$e_o = -\frac{1}{RC}\int e_i dt$$

The amplifier thus provides an output signal which is proportional to the time integral of the input voltage, i.e. it is an integrator.

Differentiator: Another phase-shift version of the operational amplifier is the differentiator circuit shown in Fig. 11. Here the series input impedance is a capacitor C and the feedback impedance a resistor R. It can be shown that the output voltage e_o is related to the input voltage e_i by the formula

$$e_o = -RC\, de_i/dt$$

The amplifier thus provides an output voltage which is proportional to the time derivative of the input voltage, i.e. it is a differentiating circuit or " differentiator ".

Adder: A final use of the operational amplifier is to obtain a single output voltage which is a linear combination of a number of input circuits. This is illustrated in Fig. 12, with two inputs, where the input series impedances R_1 and R_2 and the feedback impedance R′ are all resistive. It can be shown that the output voltage e_o in this case is related to the input voltages e_{i1} and e_{i2} as follows:—

$$e_o = -\frac{R'}{R_1} e_{i1} - \frac{R'}{R_2} e_{i2}$$

Thus the output voltage is linearly related to the two input voltages.

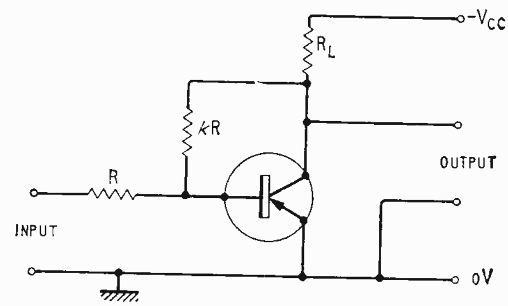
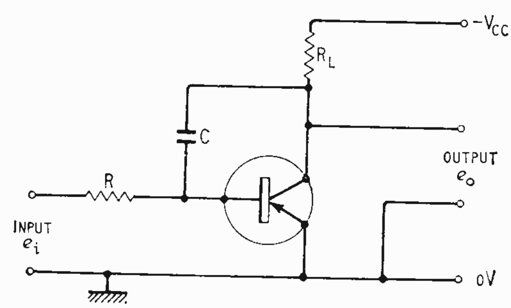


Fig. 9. Scale changer.



Fig, 10. Integrator.

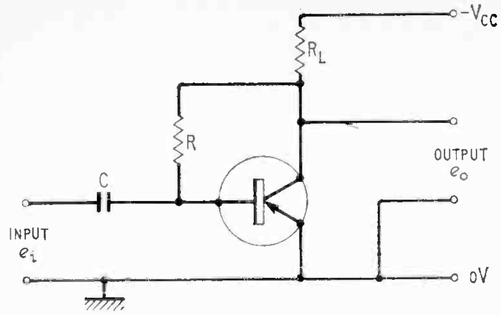


Fig. 11. Differentiator

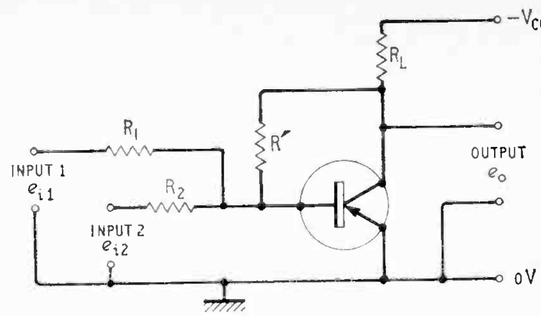


Fig. 12. Adder.

If now R_1 is made equal to R_2, the output voltage is given by

$$e_o = -\frac{R'}{R_2}(e_{i1} + e_{i2})$$

This makes the output voltage proportional to the sum of the input voltages. The circuit is then known as an "adder". The addition action has been demonstrated for two inputs only but clearly more than this could be used.

In the more general case where the input resistors have different values, by suitable selection of resistors the scale of each input can be adjusted before adding.

This is only one of the many methods of combining a number of signals but it has the advantage that it may be extended to a very large number of inputs requiring only one additional resistor for each input. With a sufficiently high gain amplifier, there is a minimum of interaction between the input sources.

Linear Sweep Generators

A common requirement in non-linear circuitry is a linear sweep generator which produces an output voltage varying linearly with time. The simplest linear sweep is obtained by suddenly applying a direct voltage, V, to a resistor R and a capacitor in series as shown in Fig. 13 and taking the voltage across the capacitor as output. The resulting voltage v_o obeys the equation $v_o = V(1 - e^{-t/CR})$.

This gives a nearly linear rise in voltage so long as t is very much less than CR. Indeed it can be shown that the deviation from a linear rise $v_o = Vt/CR$ is less than 5% if t does not exceed CR/10, or if the output voltage does not rise above V/10. The rate of change of the output voltage can be shown to be given by

$$dv_o/dt = i/C$$

where i is the charging current through the resistance. The more constant i is, the better the linearity of the sweep.

One method of improving linearity is to use the constant-current collector characteristic of the transistor whose base input current is fixed. This is illustrated in Fig. 14 where the base current of the transistor Q is fixed (neglecting the small forward drop in the base emitter diode) by the base supply voltage V_{BB} and the base input series resistor R_B. When the switch S is closed, the voltage V is applied *via* the capacitor C between the collector and emitter of the transistor, which therefore conducts, the voltage polarities being correct for a p-n-p transistor as shown. As the transistor base current is fixed, so is its collector current. Thus the capacitor charging current is fixed and the output voltage rise is virtually linear. The charging current can be controlled by varying R_B and consequently the transistor collector current.

Bootstrap Circuit: A better method for linear charging of a capacitor, however, is to use a large amount of negative feedback to keep the voltage across the series charging resistor R of Fig. 13 constant. The feedback circuit for achieving a constant charging current into the capacitor is the well-known "bootstrap" circuit. The basic arrangement is shown in Fig. 15 (a). When the input switch, S, is closed to short-circuit the capacitor C, the supply battery voltage V is effectively applied between earth and the top of resistor R, and C is discharged. If now switch S is opened, any voltage applied from V *via* R to the point X at the amplifier input, would reappear at the output of amplifier A (unity gain) and be applied *via* battery V to the top end of R. Thus the direct voltage across R (and thus the current through it) would remain constant

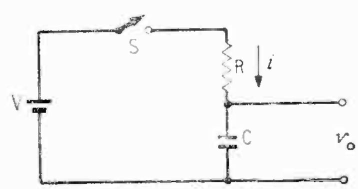


Fig. 13. Capacitor charge circuit.

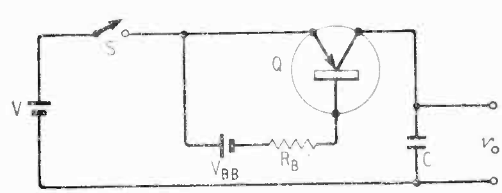


Fig. 14. Transistor linear capacitor charging.

although the voltage at X changes. Thus C charges up with a constant current and we get a linear voltage rise at the output. It should be noted that amplifier A not only should have unity gain, but must have a high input impedance so as to take negligible input current and low output impedance so as to have negligible voltage drop across the output. The bootstrap circuit is a true integrator, whose name arises from its ability to " pull itself up by its own bootstraps ".

The basic transistor version of the bootstrap integrator is given in Fig. 15(b). Here the switch S is normally closed and capacitor C is discharged. When S is opened, transistor Q acts as a unity gain amplifier to transfer the rising voltage on C to the top end of R. The capacitance C_F is very large compared with C and the voltage across it does not vary significantly as C charges up. Thus C_F substitutes for the battery V in Fig. 15(a). The current through R is virtually constant and the voltage in C rises linearly. The emitter follower Q has the requisite unity gain, high input impedance and low output impedance. The diode D is included so that as the voltage at the top end of R is bootstrapped up, and rises above the rail voltage, it reverse-biases the diode and cuts off the timing circuit from the power supply.

Miller Integrator: Another method for improved linear charging up of a voltage across a condenser is the Miller " integrator " shown schematically in Fig. 16(a). Normally switch S is closed, and capacitor C discharged. When S is opened C begins to charge up through R, and it can be shown that due to the feedback through C, the output rate of rise is the same as would have been achieved with a capacitance A×C in series with a resistance R across a voltage supply A×V, where A is the voltage amplification factor of the amplifier. This effective multiplication of the capacitance by the amplifier gain is of course the Miller effect and hence the description " Miller integrator." The apparent increase of both capacitance and rail voltage lead to a much more linear voltage rise than would have been achieved with the same values without the feedback amplifier.

A simple transistor version of the Miller integrator is given in Fig. 16(b). Here the transistor Q acts as the high gain amplifier. Normally switch S is closed and transistor Q, with base then connected to earth, is cut off. With no collector current flowing, there is no voltage drop in R, the output is at rail voltage and the capacitor C is fully charged. When S is opened, base current begins to be supplied through R′ and the transistor begins to switch on. By the feedback through C as explained earlier, the voltage at the output falls linearly from the rail voltage level towards earth.

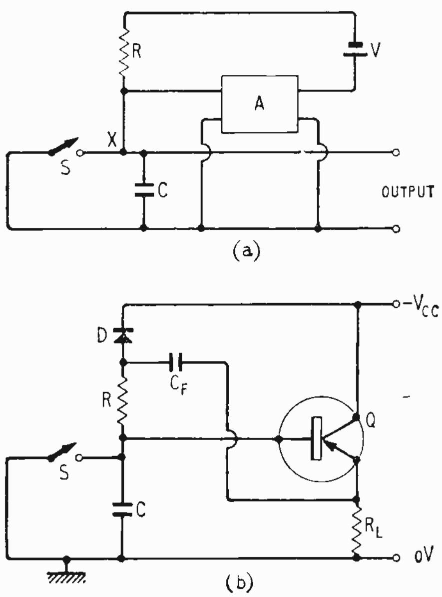


Fig. 15(a). Basic bootstrap integrator; (b). Transistor bootstrap integrator.

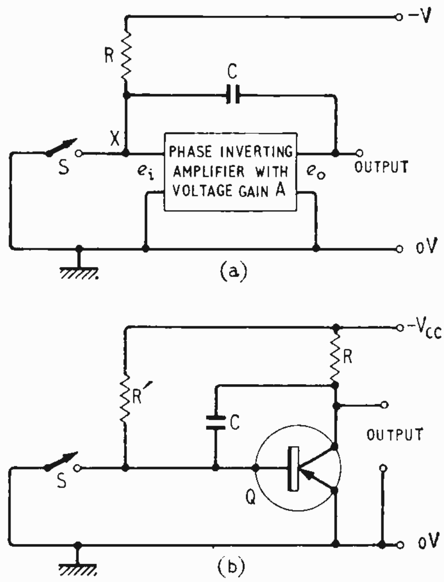


Fig. 16(a). Basic Miller integrator; (b). Transistor Miller integrator.

High Input-Impedance Amplifier

Darlington Pair: In pulse circuitry there is often a requirement for an amplifier with a high input resistance and a low output resistance. The emitter follower discussed earlier does provide these to some extent, but where they are required to a higher degree, use is often made of the compound emitter follower or " Darlington pair " illustrated in Fig. 17. To a first approximation, the current gain of this circuit is equal to the product of the current gains of the individual transistors. The input resistance is equal to the emitter load resistance multiplied by this current gain product and the output resistance to the source resistance divided by this product. From this it is clear that very high input and very low output resistances are possible.

Bootstrap Amplifier: Another circuit used to achieve high input resistance, especially where base-bias resistor networks are likely to shunt the signal input is the bootstrap input circuit in Fig. 18. Here negative feedback introduced by the unbypassed emitter resistor gives a high input impedance at the base of the transistor Q. To prevent this being shunted significantly by the base bias network R_1, R_2, the base bias current is supplied through an isolating resistor R_3 from the centre point of R_1 and R_2. A capacitor C connected between the transistor emitter and the bottom end of R_3 feeds back a signal voltage almost equal to the voltage at the top end of the emitter resistor R_E. It can be shown (if C is large enough for its reactance to be

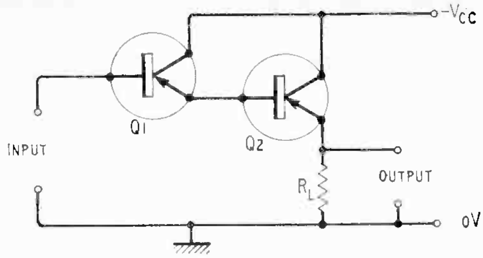


Fig. 17. Darlington pair.

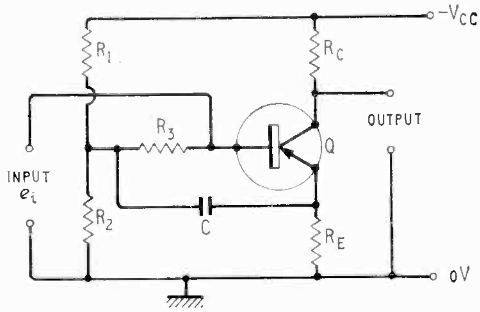


Fig. 18. Bootstrap high-impedance amplifier.

neglected at the frequency considered) that the signal voltage across R_3 is $(e_i - Ae_i)$, where A is the voltage amplification of the transistor. Thus the bias network draws from the signal source a current of only $e_1 (1-A)/R_3$. This means in effect that R_3 is effectively multiplied by $1/(1-A)$ so far as the a.c. signal current is concerned, while still representing its own value for d.c. bias purposes. With high gain transistors, A can be brought very close to unity so that $1/(1-A)$ can be very large, and the bias network does not significantly shunt the signal input. This is only one further example of "bootstrapping," i.e. multiplying the apparent value of a resistor by applying nearly equal in-phase signal voltages at each end.

Regenerative Switching Circuits

The circuits surveyed so far have all been non-regenerative. No survey of pulse circuits would be complete without mention of the group of important switching circuits which use large positive feedback to give regenerative switching between two discrete states, i.e., "two-state" circuits.

Blocking Oscillators: One of the most ubiquitous regenerative switching circuits is the blocking oscillator. This is essentially a transformer-coupled oscillator, with regenerative feedback from output to input large enough to cause the transistor to become either saturated or cut off over a substantial part of the operating cycle. Fig. 19 illustrates the basic circuit for transistors in common-emitter form. Feedback is obtained by the phase-reversing transformer T. Output can be taken directly from the collector as shown or from a tertiary winding on the transformer. It is usually arranged to produce output pulses of large magnitude and short duration. By suitable choice of the bias V_{BB}, the circuit can be made to give a periodic train of pulses (astable or free running), or single pulses when triggered by a suitable pulse input.

The blocking oscillator is often used as a clock oscillator to generate a continuous train of accurately-controlled short pulses to synchronize a series of switching operations. It is also used to obtain abrupt pulses from a slowly-varying input triggering voltage, i.e., for pulse reshaping. It can be easily arranged to generate pulses of very large peak power with a low duty cycle. It also finds uses as a frequency divider, a low-impedance switch and a gating voltage source.

Multivibrators: Another regenerative two-stage circuit frequently met with is the multivibrator. In its commonest transistor form, as in Fig. 20(a) this is a two-stage common-emitter amplifier with phase inversion over each stage, and with the output heavily coupled back to the input. This heavy positive feedback gives the circuit the property of switching rapidly between two extreme states, with one transistor switched hard on and the other cut-off. How long it stays in the extreme states is decided by the cross coupling impedances Z and Z′ selected. There are three basic possibilities all derived from the general circuit shown in Fig. 20(a).

Astable Multivibrators: When both cross-coupling impedances Z, Z′ are capacitances, we get the circuit of Fig. 20(b), which is free running (astable), and produces at each collector a train of rectangular pulses, without external triggering. Hence it is often called a square wave generator.

Bi-stable Multivibrator: When both cross-coupling impedances of Fig. 20(a) are resistances we have the bi-stable multivibrator illustrated in Fig. 20(c). This can exist indefinitely in either of two stable states with one transistor on and one transistor off, but also it can be caused to make an abrupt transition from one state to the other by a suitable external trigger pulse. It finds extensive application in pulse circuitry to generate square waves from pulses, and for certain digital operations such as counting.

Monostable Multivibrator: The last member of the multivibrator branch of the pulse circuit family is the monostable multivibrator shown in Fig. 20(d). The use of a resistor and a capacitor for cross coupling in this circuit gives the curious property of one permanently stable state (Q on and Q′ off) and one quasi-stable state (Q off and Q′ on). The circuit normally lies in its stable state but if suitably triggered it passes abruptly into the quasi-stable state for a

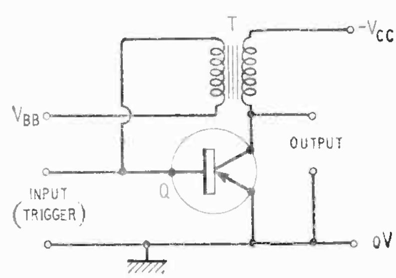


Fig. 19. Blocking Oscillator.

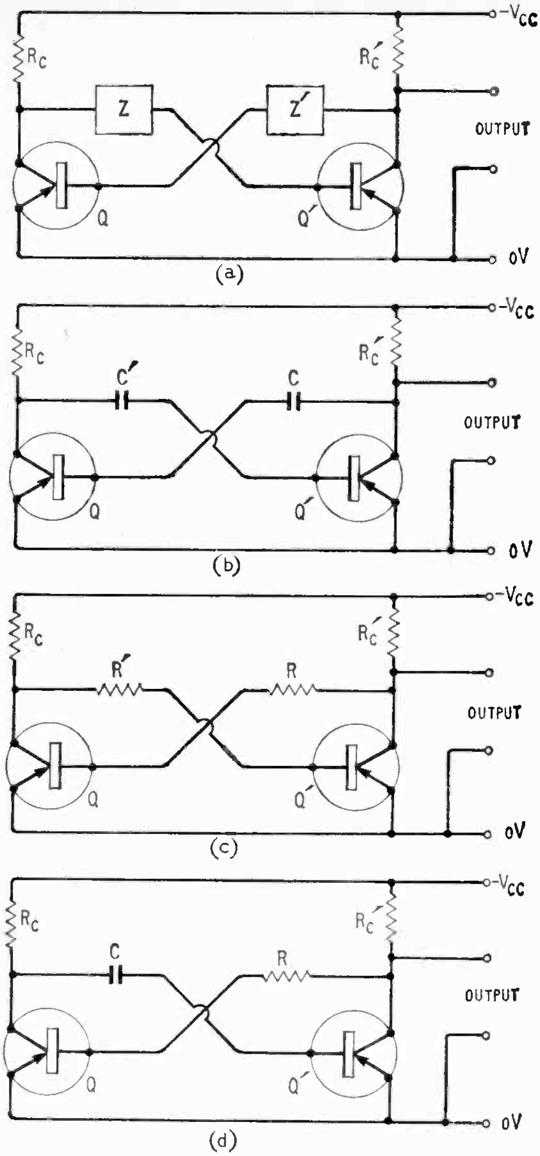


Fig. 20. (a). Basic multivibrator. (b). Astable multivibrator. (c). Bi-stable multivibrator. (d). Monostable multivibrator.

time which is long compared with the transition time between states. Eventually, however, this multivibrator will return abruptly to its stable state on its own without any external signal being required to produce the reverse transition.

The primary use for the monostable multivibrator is to establish a time interval which starts on the application of a pulse, but whose length is independent of the length of the trigger pulse. It is much used for pulse reshaping and for establishing preset delays.

Schmitt Trigger: There are many derivatives of the blocking oscillator and multivibrator circuits described above, but in this brief preliminary survey mention can be made of only one. This is the Schmitt trigger, illustrated basically in Fig. 21. It has the interesting property that when the input

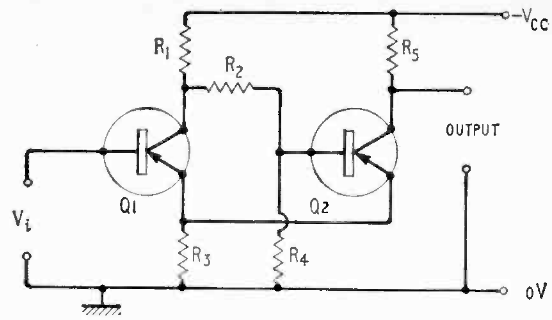


Fig. 21. Schmitt trigger.

voltage V_{in} is below a certain level, called the triggering level, the transistor Q2 is hard on and Q1 cut off. When V_{in} rises above the triggering level, there is an abrupt changeover, Q1 switching on and Q2 off. If V_{in} is reduced again below the trigger level, the circuit returns to its original state. From this it is clear that the Schmitt trigger is neither bi-stable nor monostable in the ordinary sense. It behaves like a non-regenerative switch controlled by the input d.c. level, but has the advantage that it switched abruptly at very high speed and can be designed to have an accurate adjustable trigger level. The circuit is very widely used to produce a square wave from a slowly varying input of irregular pulse shape, and as a sensitive voltage level detector.

Conclusion

This preliminary brief survey of transistor non-linear circuits is necessarily incomplete, but is designed to give the reader some idea of the variety of such circuits in common use, and how they differ from the linear small-signal circuits which are the main building blocks in the communications field. Later the properties and applications of these non-linear circuits will be dealt with in more precise detail.

New Cleaning Solvent

MANY electrical assemblies can be degreased without dismantling by a recently developed solvent. Trichlorotrifluoroethane (chemical formula —$CF_2Cl.CFCl_2$) has a boiling point of 47.6°C and a freezing point of −35°C. The surface tension at 25°C is 19 dynes/cm. The fluid is non-inflamable and no special precautions against fire hazards are necessary. It is also less toxic than many other non-inflamable solvents. However, because of its high vapour density, which is 6.5 times that of air, care is required when the solvent is used in small, ill-ventilated rooms and in pits. Contact of the vapour with open flames or red hot surfaces can lead to the production of toxic decomposition products.

Because of the low surface tension of trichlorotrifluoroethane, plastic surfaces that cannot be wetted by other solvents can often be wetted and cleaned by this fluid. Cleaning residues are also less likely. The fluid is produced under the trade name of Arcton 113 by Imperial Chemical Industries Ltd., and cold cleaning and vapour degreasing techniques can be employed. Arcton can be used on plastics, rubber and resinous materials, its properties also make it ideal for the cleaning of oxygen systems, photographic film and magnetic tape.

Arcton 113 costs from 6s 6d per lb (a gallon tin contains approximately 15lb).

BOOKS RECEIVED

Microphones, by A. E. Robertson, B.Sc. (Eng.), A.M.I.E.E. Revised second edition, considerably enlarged to cover the principles of operation of principal current types, problems of noise and the design of windshields. Pp. 357. Price 75s. Published by Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1.

Principles of High-fidelity Sound Engineering, by D. L. A. Smith, B.Sc.(Eng.), A.M.I.E.E., A.M.Brit. I.R.E. Written for those with an engineering background who also have a liking for high-quality sound reproduction and wish to come to terms with the subject on their own ground. The book opens with a brief résumé with definitions of the properties of sound, then discusses tape and disc recording, f.m. receivers, power amplifiers, loudspeakers, microphones, room acoustics and stereo reproduction. The treatment is mainly descriptive but mathematics is used when it helps to clarify basic relationships. Pp. 158. Sir Isaac Pitman & Sons Ltd., Parker Street, London, W.C.2. Price 25s.

Introduction to Microwave Spectroscopy, by Terence L. Squires, A.M.Brit.I.R.E. Explains electron spin resonance, describes simple apparatus for its excitation and measurement and concludes with a chapter on applications and a glossary of terms. Pp. 140. George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Price 30s.

Sound Facts and Figures, by John Borwick. Pocket guide to essential technical data for the layman interested in high-quality sound reproduction. Pp. 169. Focal Press Ltd., 31 Fitzroy Square, London, W.1. Price 12s 6d.

Fernsehtechnik. Edited by Fritz Schröter. Volume 5 of *Lehrbuch der drahtlosen Nachrichtentechnik*, this German text embodies authoritative contributions from leading engineers in German industry. Sections are devoted to pickup devices, transmitters, aerials, receiver design, measuring techniques, colour television and allied topics. Pp. 586. Springer-Verlag, Berlin/Göttingen/Heidelberg. Price DM.98.

Meteorological and Astronomical Influences on Radio Wave Propagation, edited by B. Landmark. Thirteen papers read in 1961 at the N.A.T.O. Advance Study Institute, Corfu. Pp. 318. Pergamon Press Ltd., Headington Hill Hall, Oxford. Price £5.

Record of Semiconductor Outlines. Second edition containing 70 drawings embodying recommendations by the Group B Engineering Committee of VASCA. Pp 88. The Electronic Valve and Semiconductor Manufacturers Association, 156/162 Oxford Street, London, W.1. Price 12s 6d.

Bibliography on Atmospheric Aspects of Radio Astronomy, by Wilhelm Nupen. National Bureau of Standards Technical Note 171 issued in May 1963 and comprising 1,013 abstracts of papers under the following headings: (1) General, (2) Theories, (3) Structure of Atmosphere, (4) Physico-chemical factors, (5) Radiation, (6) Particles, (7) Wave characteristics, (8) Radio communication parameters, (9) Methods of observation, (10) Instruments. Pp. 385. Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. Price $2.00 ($2.50 by post).

Differential Amplifiers, by R. D. Middlebrook, M.A., M.S., Ph.D. Specialized treatise on the principles of design of symmetrical circuits applied to both valve and transistor amplifiers for biological and other applications. Pp. 115, John Wiley & Sons Ltd., Glen House, Stag Place, London, S.W.1.

List of Recently-coined Terms in Electronics, by Ellen M. Codlin and C. K. Moore. Second issue, superseding that of 1960, contains about 200 terms and acronyms which are defined and for which source references are given. Pp. 21. Aslib Electronics Group. Copies available from Miss B. Newman, Information & Publication Dept., Ericsson Telephones Ltd., Beeston, Nottingham. Price 5s to Aslib members, 7s 6d or $1.50 to non-members.

Introduction to TV Servicing, by H. L. Swaluw and J. van der Woerd. Second edition of a practical manual liberally illustrated by photographs of picture faults and dealing with receivers working on the 625-line and 525-line standards. Pp. 272. Philips Technical Library, Eindhoven, Holland, or Cleaver-Hume Press Ltd., 10-15 St. Martins Street, London, W.C.2. Price 45s.

Elements of Transistor Technology, by Robert G. Middleton. Starting with the physics of semiconductors the text leads through diode action to the function of transistors, their operation in circuits, transistor equivalent circuits, amplifiers and logic circuits Pp. 288. Howard W. Sams & Co. Inc., Indianapolis 6, Indiana, U.S.A. Price $6.95.

Frequency Divider Organs for the Constructor, by Alan Douglas. Describes simple instruments based on a 12-note scale with lower notes derived by successive frequency division. Full circuit values and hints on construction are given. Pp. 71. Sir Isaac Pitman & Sons Ltd., Parker Street, London, W.C.2. Price 25s.

Radio and Electronic Hobbies, by F. C. Judd. Introduction to the wide field open to amateur experimenters in hi-fi reproduction, magnetic recording, model control and short-wave listening. Pp. 165. Museum Press Ltd., 26 Old Brompton Road, London, S.W.7. Price 21s.

Recent Developments in Network Theory, edited by S. R. Deards. Proceedings of the symposium held in Sept. 1961 at the College of Aeronautics, Cranfield, comprising fourteen papers and discussions on analysis and syntheses of passive, active, linear and non-linear networks. Pp. 250. Pergamon Press Ltd., Headington Hill Hall, Oxford. Price 84s.

Carrier Communications over Power Lines, by H.-K. Podszeck. English translation of the third edition of this standard work by the chief engineer of the power-line carrier section of Siemens & Halske A.G. in Munich. Pp. 184. Springer-Verlag, I Berlin 31 (Wilmersdorf), Heidelberger Platz 3. Price DM 36.

Basic Electricity. Part I of Standard Technical Training Notes, Radio Engineering Trade Group, Royal Air Force. A pictorial approach to the subject, for airmen and boy entrants. Pp. 197. H.M. Stationery Office, York House, Kingsway, London, W.C.2. Price 15s.

U.H.F. LOFT AERIAL

By N. W. BROWN

SIMPLE CORNER REFLECTOR DESIGN

CURRENTLY available u.h.f. aerials appear to fall into the category either of a loop variety placed on top of the television receiver for use in the very high signal areas, or of a Yagi type normally intended for external use at roof level in the weaker signal areas. The corner reflector design, being perhaps more bulky and difficult to mount, has only recently appeared on the British market, although this type of aerial has excellent bandwidth and back-to-front discrimination capabilities.

In the design of the corner reflector aerial described, a change from the normal 90° side angle to one of 60° has been made; this should provide slightly more gain but at the expense of increasing somewhat the lengths of the sides, which was considered relatively unimportant for a loft-type aerial. Figs. 1 and 2, which are based on Figs. 4 and 6 of "The Corner Reflector Antenna," by J. D. Kraus, Proc.I.R.E., Vol. 28, p. 513, Nov. 1940, show the theoretical performance of a half-wave dipole with two plane reflecting sheets positioned at various

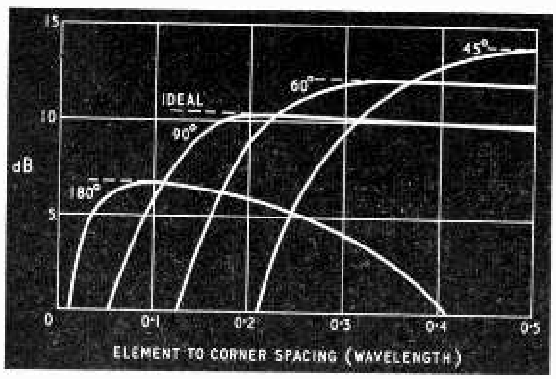


Fig. 1 Gain of corner reflector aerial relative to a $\frac{\lambda}{2}$ dipole or values of angle and element to apex spacing.

angles. A 45° design would clearly provide a high gain, but the impedance is unsuitable for a 70-ohm coaxial feed. The 60° configuration on the other hand will conveniently match into 70-ohm cable when the dipole is spaced one half wavelength from the reflector apex. To be of adequate size the reflector sheets should be about three times as long as the element to apex spacing. The width should be about one wavelength at the design frequency.

The u.h.f. channels allocated for the London area are shown in Table 1. Hence, for the purpose of aerial design a geometric mean frequency of 530 Mc/s has been used. The corresponding dipole length will be $0.95 \times \frac{\lambda}{2}$ allowing for the end effects.

$$\text{Length} = 0.95 \times \frac{300 \times 10^6}{2 \times 530 \times 10^6} \text{ metres}$$
$$= 0.95 \times 28.3 \text{ cm} = 27\text{cm}.$$

TABLE 1. U.H.F. CHANNEL ALLOCATIONS FOR LONDON AREA

Channel	Carrier frequencies, Mc/s	
	Vision	Sound
23	487.25	493.25
26	511.25	517.25
30	543.25	549.25
33	567.25	573.25

For the 60° corner reflector, the length of the reflecting elements should be not less than 3×28.3 cm and the width not less than 2×28.3 cm, or, rounded up to practical dimensions, 3ft × 2ft.

To construct the reflecting sheets the author used a 6ft × 2ft hardboard panel sawn in half, and then covered with aluminium cooking foil. The foil can be glued to the hardboard with wallpaper adhesive, the edges being turned over an inch or so on to the reverse side. The foil should be in an unbroken length across the 2ft dimension, i.e. in the plane of the aerial and all joints should be overlapped an inch or so. The completed reflectors are then mounted, foil innermost, onto two wood-strip equilateral triangles of 3ft side length and these are inset about 4in from the edge of the hardboard sheets, so that the unsupported material in between does not sag unduly.

The bow-tie element is made from two pieces of

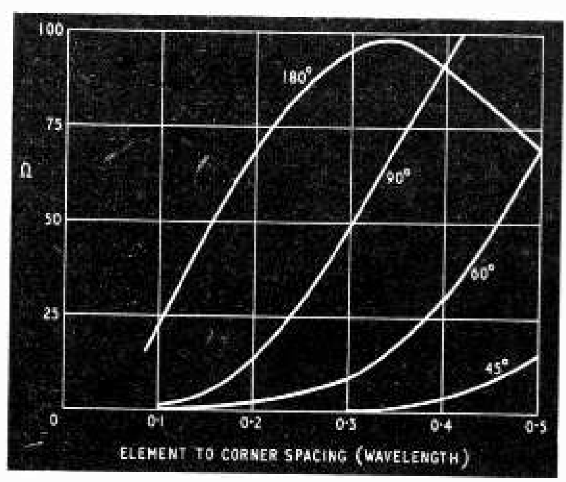


Fig 2 Radiation resistance of a $\frac{\lambda}{2}$ dipole in a corner reflector for values of angle and element to apex spacing.

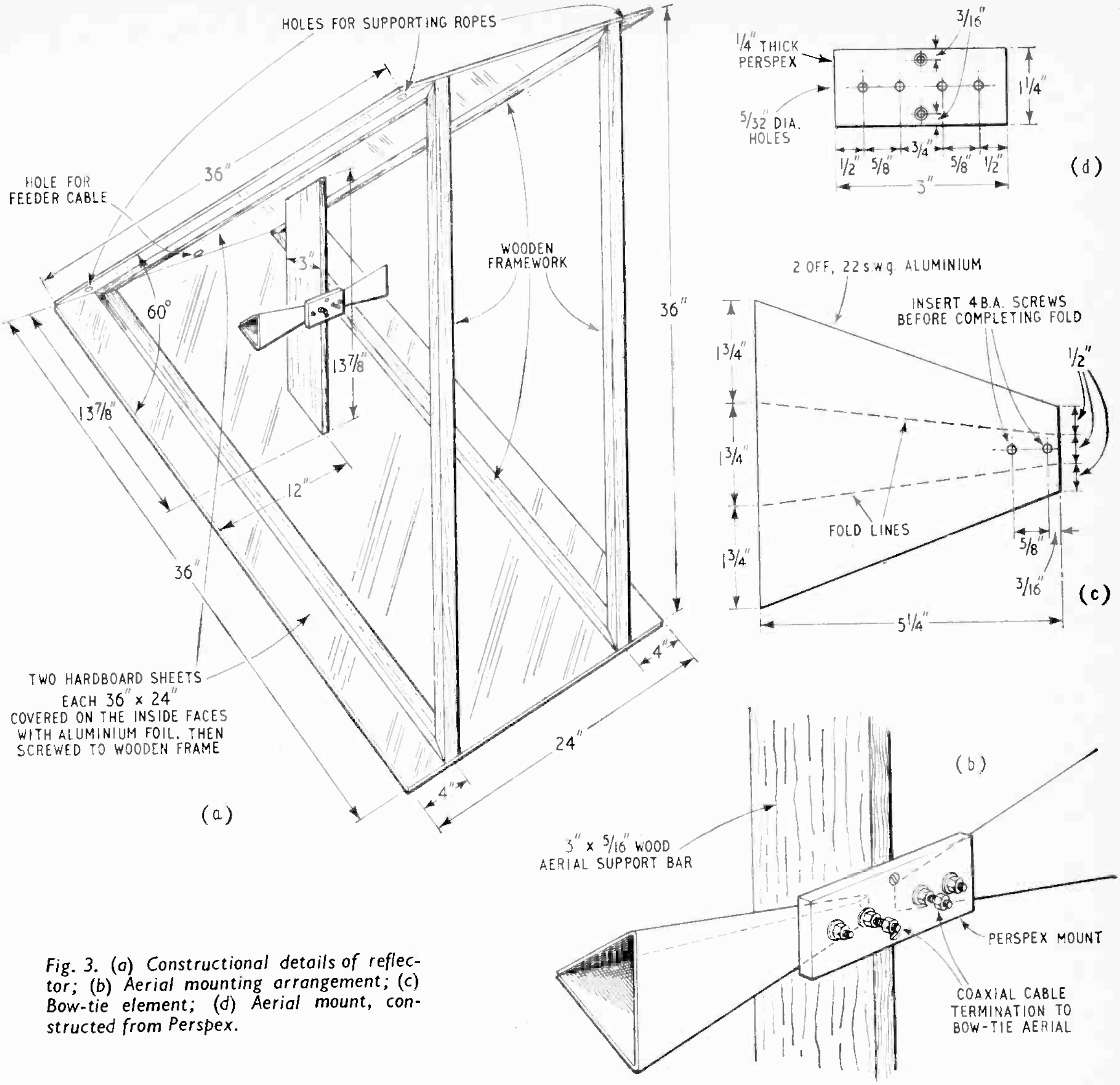


Fig. 3. (a) Constructional details of reflector; (b) Aerial mounting arrangement; (c) Bow-tie element; (d) Aerial mount, constructed from Perspex.

22 s.w.g. aluminium sheet folded into a triangular formation as shown in Fig. 3. The two halves are tapered to provide more uniform impedance transfer to the cable. A balun was not used, but could of course be incorporated at the lead-away point if required. The construction should be clear from the diagrams, but it may be necessary to unscrew temporarily the major components in order to negotiate the trap door into the loft.

To position the aerial for optimum pick-up a trial and error method could be employed, but it is definitely worth the trouble to run a long lead between the television receiver and a meter in the loft so that one can witness at first hand the effects of aerial positioning. Suitable metering points can usually be found either at the a.g.c. line, ratio detector or video drive to the tube, though in the latter case the effects of signal modulation make adjustments a little more diffcult. The picture quality should finally be checked for multiple effects, when final adjustmets should be made to the aerial position if ghosting is in evidence. In the author's case the optimum position of the aerial is about 4ft above the floor joists and the aerial has conveniently been roped to hooks screwed into the rafters. A helical membrane type of coaxial feeder was used as a down lead and a direct comparison between a commercial 13-element Yagi and the corner reflector, both optimized as regards mounting position, showed no measurable difference in signal power delivered to the receiver.

Results at the author's address, some 23 miles from Crystal Palace, are somewhat poor as a nearby hill provides a considerable diffraction loss. Hoped-for improvements in receiver noise factors, which should come from the use of u.h.f. transistors, plus the 5dB increase in transmitter power expected next year, have so far deterred the author from climbing up to the chimney stack with a commercial type Yagi, although admittedly the few extra dB may prove necessary in the long run. For readers situated more favourably the aerial described may be worth trying; the cost is trivial and it can be constructed within a few hours.

PHYSICAL SOCIETY EXHIBITION

BRITISH manufacturers were invited by the Institute of Physics and the Physical Society to submit details of up to six exhibits for this annual exhibition. From the 744 submitted 448 have been selected by the panel of referees as "conforming to the standards of originality and scientific merit" set by the organizers. These exhibits are being displayed by 124 manufacturers and in addition 30 Government research organizations, universities, colleges, etc. are taking part. The overall number of exhibitors has increased by 20 compared with last year bringing the total to 154.

A section of one of the halls is being devoted to a selection of new equipment primarily designed for the teaching of physics.

We give in these pages a preview of the exhibition compiled from information supplied by exhibitors. Some of the companies and organizations participating were not able to give us the information asked for in time for inclusion in this preview and, of course, there are others whose exhibits do not come within the purview of *Wireless World*. While, therefore, this is not a complete survey it will, we hope, serve as a useful guide to those intending visiting the exhibition and be of general interest to those of our readers unable to visit the show. Where we have thought it might be useful we have appended a number for use on the reply card by professional readers requiring further information on specific exhibits. We hope to publish a further report in the next issue after *Wireless World* staff have visited the stands.

The exhibition, the 48th in the series, opens at the Royal Horticultural Society's Halls, Vincent Square, London, S.W.1, on January 6th for four days. It will be open from 10.0 to 6.30 each day but on the 7th admission before 1.0 is limited to members of the Institute and Society and invited guests.

Admission is by ticket obtainable from exhibitors or direct from the organizers at 47, Belgrave Square, London, S.W.1. Applicants are asked to enclose a stamped addressed envelope to accommodate the tickets ($4\frac{1}{2} \times 3$in).

A Handbook (which is a useful book of reference) is again being issued by the organizers from whom it is obtainable price 10s plus 2s postage.

This year's exhibition lectures are:—

"The electrical properties of thin films" by Prof. E. H. Rhoderick (7th at 3.0).

"Patient monitoring: technical problems and its impact on hospital administration" by H. S. Wolff (8th at 5.0).

"Instruments for noise measurement" by H. J. Purkis (9th at 3.0).

LIST OF EXHIBITORS

	Stand
A.E.I.	139
AMF British Research Lab.	61
A.W.R.E.	50
Admiralty	9
Airmec	12
Aveley Electric	18
Avo	127
B.I.S.R.A.	17
Baldwin Industrial Controls	8
Beckman Instruments	75
Bell & Howell	131
Bellingham & Stanley	82
Birmingham University	89 & 90
Brandenburg	14
Brighton College of Tech.	102
Bristol University	81
British Aircraft Corp.	137
British Oxygen Co.	115
Bryans	105
C.N.S. Instruments	32
Cambridge Instrument Co.	149
Camlab	116
Central Electricity Res. Lab.	143
Chemical Electronics Co.	13
Cossor Instruments	21
Coulter Electronics	37
D.S.I.R.	54
Dawe Instruments	126
Decca Radar	55
Devices	26
Digital Measurements	33
Dynatron Electronics	101
E.M.I. Electronics	15
Edwards High Vacuum	144
Ekco Electronics	100
Electrical Remote Control	93
Electron Physical Insts.	106
Electronic Applications	27
Electronic Instruments	96
Elliott-Automation	133, 134, 136 & 153
Engelhard Industries	39
English Electric Valve Co.	58
Feedback	121 & 160
Fenlow Electronics	52
Ferranti	95
Fielden Electronics	47
Fisons Fertilizers	30
Flann Microwave Insts.	97
Flatters & Garnett	159
Fleming Instruments	23
Frigistor Laboratories	77
G.E.C.	142
Gallenkamp & Co.	74 & 163
General Radiological	16
Genevac	140
George Elliott Laboratories	46
Graphic Instruments	38
Gulton Industries	117
Guy's Hospital Med. Sch.	67
Hatfield Instruments	11
Hilger & Watts	109 & 155
Imperial College	87 & 88
Inertia Switch	4
Instron	20
International Res. & Dev	60
J. & P. Engineering	119
Johnson, Matthey & Co.	22
Kasama Electronics	40
Kent, George	146
Labgear	84 & 152
Langham Thompson	24
Lewis, H. K.	150
M-O Valve Co.	138
Mechanism	34
Megatron	41
Mercury Electronics	43
Metals Research	28
Meterflow	44
Microwave Instruments	110 & 156
Middlesex Hosp. Med. Sch.	66
Mining & Chemical Products	42
Ministry of Aviation	1
Muirhead & Co.	124
Mullard	118, 148 & 165
N.G.N.	145
National Coal Board	132
Nat. Inst. for Medical Res.	112
Newcastle University	157
Newport Instruments	92
Nuclear Enterprises	73
Optical Works	128
Oxford Instrument Co	79
Oxford Univ. (Clarendon)	80
Panax Equipment	141 & 151
Paton Hawksley Electronics	7
Perkin-Elmer	91
Planer, G. V.	98
Plessey	10
Prior & Co.	129
Pullin	108
Pye, W. G., & Co.	85
Queen Mary College	70
R.A.F. Inst. of Aviation Med.	64
Radyne	56
Research Electronics	72 & 154
Research & Eng. Controls	94
Research & Industrial Insts.	57
Res. Lab. for Archaeology	113
Rolls-Royce	59
Royal Infirmary Edinburgh	68
Royal Meteorological Society	69
Royal Military Col. of Science	65
Royston Instruments	48
S.E. Laboratories	25
S.T.C.	120
Safety in Mines Res. Estab.	125
Sangamo Weston	122
Seismograph Service	36
Shandon	78
"Shell" Research	31
Simon-Carves	86
Southern Analytical	2
Sogenique (Electronics)	51
Specto Avionics	45
Sperry	3
Sunderland Technical College	63
Techne (Cambridge)	5
Telcon Metals	104
Telequipment	162
Telford Products	103
Thermal Syndicate	19
Tinsley, H., & Co.	123
Townson & Mercer	114
Transitron Electronics	35
20th Century Electronics	135 & 158
U.K. Atomic Energy Authority	53
Ultrasonoscope Co.	71
Unicam Instruments	99
Univ. College of N. Wales	62
Vacuum Reflex	76
Vacuum Generators	147
Venner Electronics	29
Vinten, W.	130
War Office	6
Watson & Sons	83
Wayne Kerr Laboratories	49
Wood, Hugh, & Son	164
Wray (Optical Works)	107

GUIDE TO THE STANDS

A.E.I. (139)

Among the products of the company's Instrumentation Division being demonstrated is a new high-resolution electron microscope (EM6B) combining high performance with simplicity of operation. The electron optical system provides a continuous range of magnification from ×1,000 to ×250,000 and the instrument has a resolution of 5 angstroms.

The Electronic Apparatus Division will be showing a photoelectric high-speed camera tube developed to provide a means of recording events requiring time resolutions better than 10^{-1}nsec for their evaluation.

The dielectric anisotropy detector to be shown is for the detection of cracks and similar imperfections in those insulating materials which are heterogeneous and unsuitable for ultrasonic techniques. **4WW 301**

Associated Electrical Industries Ltd., 33 Grosvenor Place, London, S.W.1.

AMF BRITISH RESEARCH LAB. (61)

A fuel cell will be shown using an ion-exchange membrane to give what is effectively a gas-impermeable solid electrolyte. A bismuth telluride-copper junction has been found to give a very close approximation to a square law when used as a thermo-junction, and examples will be demonstrated. **4WW 302**

AMF British Research Laboratory, Blounts Court, Sonning Common, Reading, Berks.

A.W.R.E. (50)

Among the items to be shown by this establishment of the United Kingdom Atomic Energy Authority will be an electron tube developed for recording the modulation of light from a ruby laser. The design of the electron optics of the tube was carried out by Mullard under a design study contract.

A variety of pressure transducers (including piezoelectric, diaphragm and pressure gauges) developed for recording transient shock waves in gases and liquids will also be shown.

A section of the display will be devoted to high-speed photography including some systems employing electro-optic techniques.

Atomic Weapons Research Establishment, Aldermaston, Berkshire.

ADMIRALTY (9)

From the Baldock laboratory, a gas laser will be shown, consisting of a ring of reflectors and used for the measurement of small angular movements. Two frequencies are produced, the difference corresponding to angular velocity of the system. Light-emitting p-n junctions will be demonstrated. Other Admiralty establishments will also be represented.

Research & Development Services Department, Admiralty, Empress State Building, London, S.W.6.

AIRMEC (12)

A range of test and laboratory instruments are to be shown this year together with precision cable connectors and adaptors. Frequency standards, signal generators, wattmeters and u.h.f. slotted lines are included in the displayed range of instruments. **4WW 303**

Airmec Ltd., High Wycombe, Bucks.

AVELEY ELECTRIC (18)

Among the exhibits will be an automatic hystograph. This is an electromechanical instrument which provides a columnar display of 10 or more series of electrical impulses. The demonstration will show the operation of the hystograph in conjunction with an Aveley tolerance analyser to show the distribution of values in a batch of resistors or capacitors in the form of a hystogram. **4WW 304**

Aveley Electric Ltd., South Ockendon, Essex.

AVO (127)

A new transistor voltmeter will be presented, having an input resistance rising to 30MΩ on the higher ranges. Maximum sensitivities are 100mV and 30μA full-scale. The instrument is battery powered. A semiconductor amplifier which is to be shown is intended for the measurement of currents down to 10^{-13}A. **4WW 305**

Avo Ltd., 92-96 Vauxhall Bridge Road, London, S.W.1.

B.I.S.R.A. (17)

A method of measuring the oxygen content of gases has been developed, using a reversible, solid-electrolyte electrochemical cell. Gases of unknown and known oxygen contents are applied to the electrodes and the e.m.f. measured.

An inductive-loop digital data transmission system for cranes will be demonstrated in model form.

British Iron & Steel Research Association, 11 Old Park Lane, London, W.1.

BELL & HOWELL (131)

The Consolidated Electrodynamics division of Bell & Howell are to exhibit several types of strain gauge transducers. They are also going to show a recording oscillograph they have developed to record data, from d.c. to 10kc/s, on eighteen separate channels. **4WW 306**

Bell & Howell Ltd., Consolidated Electrodynamics Division, 14 Commercial Road, Woking, Surrey.

BIRMINGHAM UNIVERSITY (89 & 90)

The Department of Electrical Engineering propose to demonstrate a character recognition system, a linear saturable reactor and a method of measuring internal stresses in metals by ultrasonics. The first-mentioned exhibit consists of an information extraction unit, which utilizes a photodiode mosaic, and a resistance logic network forming a signal processing unit.

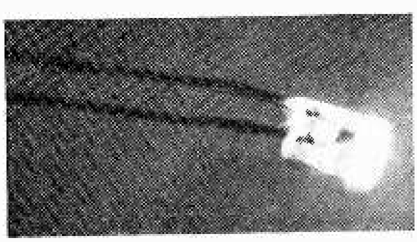
The Department of Physics will perform a number of experiments to demonstrate physical phenomena. These will include demonstrations of the Barkhausen effect (through the Curie point), Bragg's law of reflection, electron diffraction and Brownian motion.

The University of Birmingham, Edgbaston, Birmingham, 15.

BRANDENBURG (14)

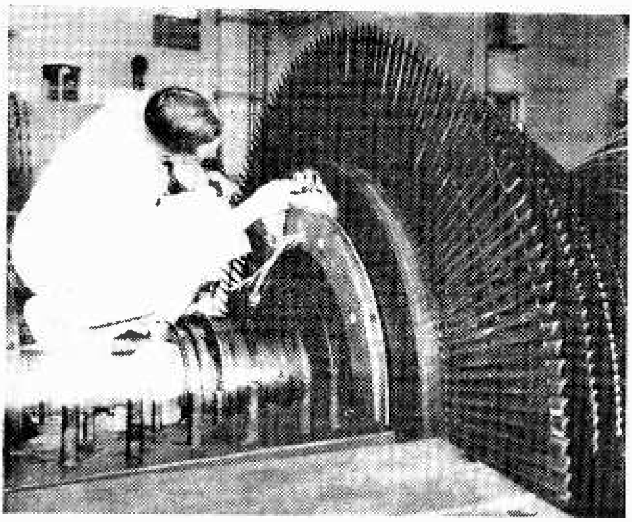
A 1 to 20kV supply unit, designed for use with electron microscopes and other similar instruments is to be displayed. It is to be shown working with a potentiometric type of pen recorder displaying its negligible drift characteristics. **4WW 307**

Brandenburg Ltd., 139 Sanderstead Road, South Croydon, Surrey.

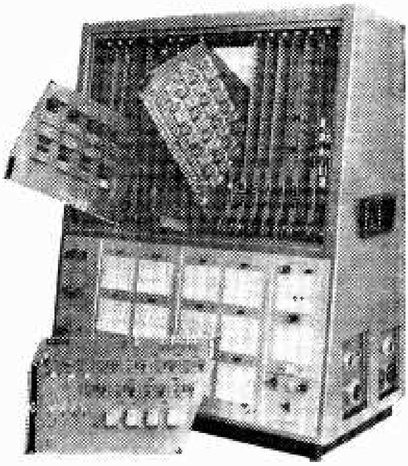


P-n junction in gallium phosphide, giving light output in forward direction. Developed by the Admiralty.

Bismuth telluride/copper thermo-junction by AMF, used in ammeters.



Radio telemetry equipment used by the Central Electricity Research Laboratories to obtain information on behaviour of turbines.



Digital data translator from Bryans

BRIGHTON COLLEGE (102)

One of the items on this stand will be an attachment for a three-terminal bridge for rapidly checking the conductance of a conducting film.

Brighton College of Technology, Moulsecoomb, Brighton 7, Sussex.

BRISTOL UNIVERSITY (81)

The H. H. Wills Physics Laboratory are to demonstrate a new photographic process based on the formation of lattice defects, charge carriers and even chemical decomposition by light in thin films of lead iodide. The method has certain advantages over conventional photography. For instance, images can be enlarged up to 1,000 times and the films, which require no processing, can be handled in daylight with complete safety.

University of Bristol, H. H. Wills Physics Laboratory, Royal Fort, Bristol 8.

BRITISH AIRCRAFT CORP. (137)

A radio-frequency extensometer for strain measurement in concrete is to be demonstrated, together with a range of miniature resistance thermometers and vibrating-diaphragm pressure transducers. In the latter, the diaphragm is maintained at resonance, variation of pressure causing a change in compliance and therefore in the resonant frequency. **4WW 308**

British Aircraft Corporation Ltd., 100, Pall Mall, London, S.W.1.

BRYANS (105)

A twin-channel digital-to-analogue converter, with buffer storage facilities, is to be demonstrated together with a portable automatic XY-TY plotting table. Information will also be available on some new prototype units which will not be at the show. These include a high-sensitivity plotting table, a twin-channel X-Y recorder and a function generator. **4WW 309**

Bryans Ltd., Willow Lane, Mitcham, Surrey.

C.N.S. INSTRUMENTS (32)

Exhibits will include the S.R.2 proportional temperature controller using a saturable reactor, the "Sirect" proportional temperature controller and a read-out extensometer which is based on a design by the National Engineering Laboratory. The bridge balance decade dials may be calibrated in terms of direct measurement or as a percentage strain of any gauge length. **4WW 310**

C.N.S. Instruments Ltd., Holmes Road, London, N.W.5.

CAMBRIDGE INSTRUMENT CO. (149)

Four prototype equipments will be displayed. A scanning electron microscope has been developed for specimens that have comparatively rough surfaces or other characteristics that make them difficult to examine, either directly or by "extraction replica" methods. A displacement transducer will be demonstrated that measures displacement over a wide range. A continuous process polarograph and a bridge unit for temperature coefficient and resistance measurements complete the stand. **4WW 311**

Cambridge Instrument Co. Ltd., Grosvenor Place, London, S.W.1.

CAMLAB (116)

An electronic vacuum microbalance designed for precise differential weighing over extended periods rather than for absolute measurement of weight is to be shown by this company. It has a capacity of 50 grammes and three read-out ranges covering from 0 to 20,000 microgrammes. **4WW 312**

Camlab (Glass) Ltd., Milton Road, Cambridge.

CENTRAL ELECTRICITY RESEARCH (143)

Telemetry equipment for the study of the moving parts of rotating machines is to be exhibited, along with an instrument intended for the determination of heat transfer coefficient at fluid/solid interfaces. Also to be shown is an automatic recorder for the study of corrosion processes.

Central Electricity Research Laboratories, Cleeve Road, Leatherhead, Surrey.

D.S.I.R. (54)

Twenty-six exhibits and demonstrations from 15 associated bodies are to be shown. A demonstration of the methods used to conduct the London Noise Survey will be mounted by the Building Research Association. The National Engineering Laboratory will have a demonstration, using a digitizer and counter, of their new five-bit binary code, which is more easily converted to decimal for servicing. They will also show a hot-wire milliameter using 170 thermojunctions to give a sensitivity of 2.5mV/mW.

Department of Scientific and Industrial Research, State House, High Holborn, London, W.C.1.

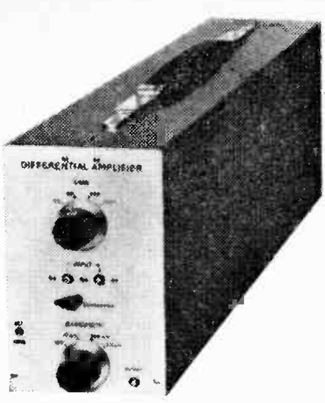
DAWE INSTRUMENTS (126)

Several newly developed instruments are to be shown. These include a precision sound level meter and analyser, an ultrasonic cleaning unit, a constant temperature anemometer, a noise-level indicator with "thermometer" display, and an acoustical-measuring system. **4WW 313**

Dawe Instruments Ltd., Western Avenue, Acton, London, W.3.

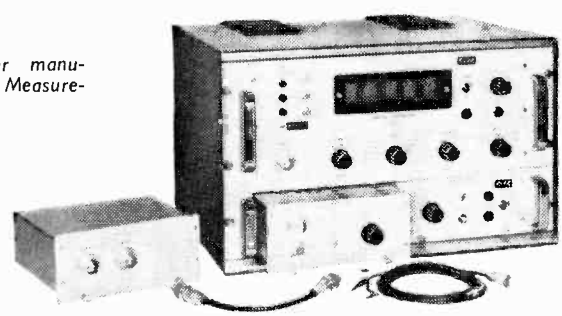
DECCA RADAR (55)

A reflectometer to be exhibited enables v.s.w.r. measurements to be made over the complete waveguide band. Only one detector is used,



A d.c. differential amplifier from Fenlow Electronics.

Ceramic thyratron (CX1157) introduced by English Electric Valve Company.



Digital multimeter manufactured by Digital Measurements Ltd.

obviating errors due to differing sensitivities, a mechanical switch being used for sampling forward and reflected energy. Electron-spin resonance equipment, a tunnel-diode 2Gc/s oscillator and a 25dB coaxial attenuator will be shown. **4WW 314**

Decca Radar Ltd., Albert Embankment, London, S.E.1.

DIGITAL MEASUREMENTS (33)

The digital logger which will be displayed demonstrates the collection and recording of meteorological data, but any variable which can be converted into electrical signals may be recorded. The equipment can type up to eight characters for each channel at a rate of one channel per second or punch paper tape at 1, 2, 4 or 10 channels per second. There are three modes of operation, namely, continuous scanning, single scans on command or a partial scan of the input channel selected. A digital multimeter for alternating and direct voltage and current and resistance measurements will also be shown. **4WW 315**

Digital Measurements Ltd., 25 Salisbury Grove, Mytchett, Hants.

E.M.I. ELECTRONICS (15)

Two new oscilloscopes, one a general-purpose instrument with a bandwidth of d.c. to 10Mc/s (—3dB) and a very sensitive d.c. coupled dual-channel instrument, are to be shown for the first time at this year's exhibition. **4WW 316**

E.M.I. Electronics Ltd., Hayes, Middlesex.

EDWARDS HIGH VACUUM (144)

Among the vacuum equipment to be seen on this stand will be the new Ion-Pirani pressure gauge operating over the range 1 to 10^{-8}torr(mm Hg) which is now being used for the deposition of micro-circuits. **4WW 317**

Edwards High Vacuum Ltd., Manor Royal, Crawley, Sussex.

EKCO ELECTRONICS (100)

A new range of transistorized counting equipment, of higher specification and complementary to the existing thermonic range is to be shown. A comprehensive autoscaler-ratemeter is to be demonstrated, to illustrate the use of some of the basic units of the new range. **4WW 318**

Ekco Electronics Ltd., Southend-on-Sea, Essex.

ELECTRICAL REMOTE CONTROL (93)

Industrial timing units are the chief products of this firm. Both electrical and pneumatic types (the latter for use in inflammable atmospheres) will be shown. **4WW 319**

Electrical Remote Control Co. Ltd., Elremco Works, Bush Fair, Harlow, Essex.

ELECTRON PHYSICAL INST. (106)

A range of electron-beam equipment will be displayed, including types for micro-etching, X-ray microscopy and X-ray diffraction. **4WW 320**

Electron Physical Instruments Ltd., Stanley Road, Hendon, London, N.W.1.

ELLIOTT-AUTOMATION (133, 134, 136 & 153)

The exhibit will include a computer based on Goto-pair tunnel-diode logic circuits, a helium laser, and a gallium arsenide laser working with an ultra-high-speed infra-red detector. A portable neutron generator with an output of 10^{-10} neutrons per second will also be seen. **4WW 321**

Elliott-Automation Ltd., 167 Great Portland Street, London, W.1.

ENGLISH ELECTRIC VALVE (58)

A new 11-in direct-viewing storage tube which has a useful viewing screen of 9.5 in diameter and is particularly suitable for the daylight viewing of radar information, is to be demonstrated. It has two electron guns, one for writing the signal on to the storage surface and the other (the flood gun) for displaying information written on the viewing screen. The flood gun is continuously operative and the information written on the screen persists for as long as 10 minutes but can be erased immediately by applying a small positive pulse to the backing electrode.

One of a range of flash discharge tubes designed for the excitation of ruby lasers will be shown working in a laser unit.

On show will also be a hydrogen-filled tetrode thyratron (CX1157), with a ceramic envelope, designed for compact medium-power radar equipment. The overall length is 3.84in, diameter 3.25in and it weighs approx. 10oz. **4WW 322**

English Electric Valve Co. Ltd., Chelmsford, Essex.

FEEDBACK (121 & 160)

Educational equipment demonstrated will include a transistor logic system consisting of small plug-in elements with a maximum operating speed of 50kc/s. An instructional servo system to be shown incorporates the elements of a complete system, with provision for variable time-constants. An 10c/s-100kc/s RC oscillator will be demonstrated which has two outputs at 90° phase difference and a variable-phase output. **4WW 323**

Feedback Ltd., Park Road, Crowborough, Sussex.

FENLOW ELECTRONICS (52)

A low-frequency spectrum analyser covering 0.3c/s to 1kc/s and a d.c. differential amplifier are the main items to be exhibited this year. The differential amplifier comprises two stabilized chopper-amplifier channels; interconnected to provide a differential input with high input im-

pedance to both common mode and differential signals. **4WW 324**
Fenlow Electronics Ltd., Springfield Lane, Weybridge, Surrey.

FIELDEN ELECTRONICS (47)

The equipment shown will include a new precision programme controller, a linear capacity/pneumatic pressure transducer and a differential pressure cell with electrical output. **4WW 325**
Fielden Electronics Ltd., Wythenshawe, Manchester 22.

FLEMING INSTRUMENTS (23)

Equipment designed for the measurement of particle size and pollution levels in the atmosphere will be exhibited. **4WW 326**
Fleming Instruments Ltd., Coxton Way, Stevenage, Herts.

G.E.C. (142)

Several demonstrations of the work undertaken by the Hirst Research Centre are to be shown. These include demonstrations on electron behaviour, the break-up of a hollow electron beam, measurement of thermal shock properties by electron bombardment, generation of pulse patterns and their properties, magnetic films for computer memories, and time parallax in binaural perception. **4WW 327**
The General Electric Co. Ltd., 1 Stanhope Gate, London, W.1.

GENEVAC (140)

Vacuum pumping and associated equipment will be presented. Two new rotary piston pumps will be shown together with an air-cooled pumping unit, a pressure gauge and a coating unit which incorporates a 2-in vacuum pump. **4WW 328**
Genevac Ltd., Pioneer Mill, Radcliffe, Lancs.

GEORGE ELLIOTT LABS. (46)

An E.M.I. vidicon camera tube, with a fibre optic faceplate, is to be displayed with other products to show the progress George Elliott Laboratories have made in the field of fibre optics. Other products to be shown include concave plano fibre optics suitable for use with image intensifiers. **4WW 329**
George Elliott Laboratories Ltd., 73 Thames Street, Sunbury-on-Thames, Middx.

GRAPHIC INSTRUMENTS (38)

Ranges of galvanometers for use in high-resolution recorders are to be exhibited, having all suspension components symmetrically disposed about the axis to increase stability. The associated recorders are small, robust, and produce a 0.002-in trace on narrow-gauge film or paper. They can also be used for colour film. **4WW 330**
Graphic Instruments (Research), Ltd., Trout Road, West Drayton, Middx.

GULTON INDUSTRIES (117)

Piezoelectric ceramics in wafers down to 0.003in thick are used in the range of electro-mechanical transducers to be seen on this stand. Pickup elements constructed of a sandwich of three plates of thin ceramic, the centre one being a high-permittivity material, are shown. The capacitance being some 20 times greater than that of more conventional elements, they are suitable for feeding directly into low-impedance transistor circuits.

Sheets of oppositely poled piezoelectric ceramic, bonded together to form a bimorph bender are used in pairs in some extremely small electrostatic relays. These benders are also usable in a piezoelectric loudspeaker. **4WW 331**
Gulton Industries (Britain), Ltd., Regent Street, Brighton 1, Sussex.

GUY'S HOSPITAL MEDICAL SCHOOL (67)

The Department of Physics will show a semiconductor d.c. amplifier developed for electrophysiological work. The amplifier is suitable for signals up to 150mV from a high-impedance source, but the bandwidth is limited to a few kc/s. The signal is applied to a bridge having two silicon junction diodes whose capacitance varies with voltage. This amplitude-modulates a carrier which in turn is amplified and rectified.
Medical School, Guy's Hospital, London Bridge, London, S.E.1.

HATFIELD INSTRUMENTS (11)

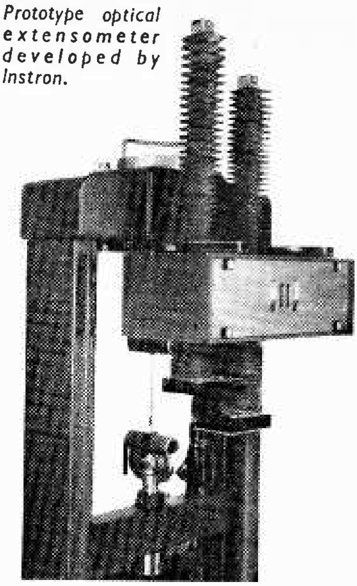
An a.c. clip-on milliammeter, designed to measure currents from 1mA to 10A over the frequency range 20c/s to 2Mc/s without disturbing the circuit under test, is to be shown. Other items to be shown include an r.f. bridge covering 50k/s to 20Mc/s and a high-performance power supply unit. **4WW 332**
Hatfield Instruments Ltd., Burrington Way, Plymouth, Devon.

IMPERIAL COLLEGE (87 & 88)

The exhibit, provided by the Department of Electrical Engineering, will show the general behaviour of a system in which a control system is used to adjust various inputs to a process to yield a maximum output and to maintain this condition for variation in the process parameters. Such systems are commonly known as "hill-climbing" systems.
Imperial College of Science and Technology, University of London, Exhibition Road, London, S.W.7.

INERTIA SWITCH (4)

Equipment to be shown includes a brake tester in the form of an integrating decelerometer, a device to indicate the occurrence of shocks exceeding a predetermined value, and vibration switches which are sensitive to vibration amplitudes of 0.005in. **4WW 333**
Inertia Switch Ltd., 123, London Road, Camberley, Surrey.



Prototype optical extensometer developed by Instron.

INSTRON (20)

A prototype optical extensometer, designed to record automatically the extension of the gauge length of a tensile test specimen, is to be shown this year. Bench marks are painted on the specimen to establish the gauge length and the subsequent movement of each mark is followed by an electro-optical servo mechanism. **4WW 334**
Instron Ltd., Halifax Road, High Wycombe, Bucks.

INTERNATIONAL R. & D. (60)

This organization is concerned primarily with research and development and are not manufacturers. They will be demonstrating ruby laser devices applied to such fields as micro-machining and micro-welding. Some of the advantages of gas lasers in such fields as photography and microscopy will also be demonstrated. **4WW 335**
International Research & Development Co. Ltd., Fossway, Newcastle-upon-Tyne 6.

J. & P. ENGINEERING (119)

A continuously adjustable e.h.t. unit, designed to provide up to 4,000 volts at 3mA with a stability of 1 part in 10^{4} is to be shown this year. The stability of the unit is demonstrated by feeding the output into a voltage drift monitor. **4WW 336**
J. & P. Engineering (Reading) Ltd., Portman House, Cardiff Road, Reading, Berks.

JOHNSON, MATTHEY & CO. (22)

The exhibit will be chiefly concerned with materials. Iron/rhodium alloys, which change from anti-ferromagnetic to ferromagnetic at 70°C will be shown. Also displayed will be an air-drying silver preparation for the application of conductive films to insulating substrates. **4WW 337**
Johnson, Matthey & Co. Ltd., 73-83 Hatton Garden, London, E.C.1.

KASAMA ELECTRONICS (40)

Two instruments will be shown. A transistor analyser Type R.K.2 and a double pulse generator Type 2/302D. This latter instrument has a square wave output of 10c/s to 1Mc/s with outputs from 0 to 100V in five ranges. Positive- or negative-going pulses can be obtained. The transistor analyser can be used for measurement of hybrid parameters in both common base and common emitter configuration. Other measurements that can be made include, leakage current range, collector turnover voltage and forward and backward characteristics of germanium or silicon diodes. **4WW 338**

Kasama Electronics Ltd., 139/149 Fonthill Road, Finsbury Park, London, N.4.

KENT (146)

Included in the exhibit will be an automatic titrimeter for continuous operation. In the field of mechanical measurements, a displacement transducer using a differential transformer will be demonstrated. Full-scale ranges are variable between 0.05in and 0.25in. **4WW 339**

George Kent Ltd., Biscot Road Works, Luton, Beds.

LABGEAR (84 & 152)

A decade counter Type D4151/A and a counting ratemeter Type D4152/A developed for educational applications, especially physics, are to be shown this year. A transistorized radio-microphone is also to be shown. **4WW 340**

Labgear Ltd., Cromwell Road, Cambridge.

LANGHAM THOMPSON (24)

Semiconductor strain gauges (including miniature silicon elements) and examples of experimental transducers employing these gauges are to be shown. Langham Thompson will also be exhibiting transducers for the measurement of pressure and vibration and a converter to produce from an analogue input an 8-digit binary output. **4WW 341**

J. Langham Thompson Ltd., Park Avenue, Bushey, Herts.

M-O VALVE CO. (138)

One of the major exhibits will be a working demonstration of a triggered cold-cathode gas discharge device with a rare-gas filling, which has been designed to protect equipment from flashover and other voltage breakdowns. Other new exhibits include a travelling wave tube for microwave applications and a ceramic power triode, shown working as a 500Mc/s oscillator. **4WW 342**

The M-O Valve Co. Ltd., Brook Green Works, London, W.6.

MEGATRON (41)

New cadmium-sulphide cells, a colour meter to measure colour in terms of C.I.E. co-ordinates, a street lighting photometer and photocells with a colour sensitivity similar to the "sensitivity of a human eye under night vision conditions" will be among the exhibits. **4WW 343**

Megatron Ltd., 115a Fonthill Road, London, N.4.

METALS RESEARCH (28)

The principal exhibit this year is a quantitative television microscope for measurement of inclusions, grain size, phase proportion and size distribution. A spark slicer accessory for cutting metallic single crystals is also on display and will be exhibited in position in their Servomet spark machine. **4WW 344**

Metals Research Ltd., 91 King Street, Cambridge, Cambs.

METER-FLOW (44)

A range of micro-miniature frequency discriminators for missile and aircraft applications is being introduced. The units, weighing 4oz, occupy 2 cubic inches and use transistors and printed circuits. Frequency ranges up to 40kc/s are available. **4WW 345**

Meter-flow Ltd., 606 North Feltham Trading Estate, Feltham, Middx.

MICROWAVE INSTRUMENTS (110 & 156)

A microwave moisture meter will be on show, together with a polarized-light mekometer—an instrument used for distance measurement. Electron-spin resonance equipment has been developed for use in schools and colleges. **4WW 346**

Microwave Instruments, 98 St. Pancras Way, Camden Road, London, N.W.1.

MIDDLESEX HOSPITAL MEDICAL SCHOOL (66)

The Department of Physics is preparing the exhibits. These will include a system for low-level counting of radioactive samples by source modulation and is designed to give accurate readings on low-activity samples. A machine dictionary for Chinese scientific terms will also be demonstrated. This is designed for a user with little knowledge of the language.

Middlesex Hospital Medical School, Cleveland Street, London, W.1.

MINING & CHEMICAL PRODUCTS (42)

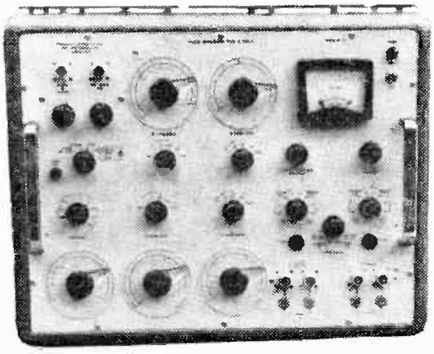
Gallium arsenide devices will be featured. One such component is a diode, infra-red emitting light source, the radiation of which can be modulated at comparatively high frequencies. Another gallium arsenide diode has a reverse leakage current of less than 10^{-11} amps. This diode is shown in a simple frequency modulation circuit as a voltage-variable capacitor. **4WW 347**

Mining and Chemical Products Ltd., Foliejon Park, Winkfield, Windsor, Berks.

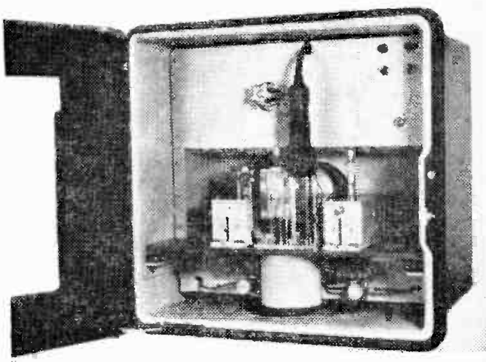
MINISTRY OF AVIATION (1)

Seven establishments of the Ministry will be participating in this joint display. Among the Royal Aircraft Establishment's demonstrations will be a gas discharge frequency multiplier. This is a microwave device in which the harmonics of the drive frequency are produced in a low-pressure gas discharge.

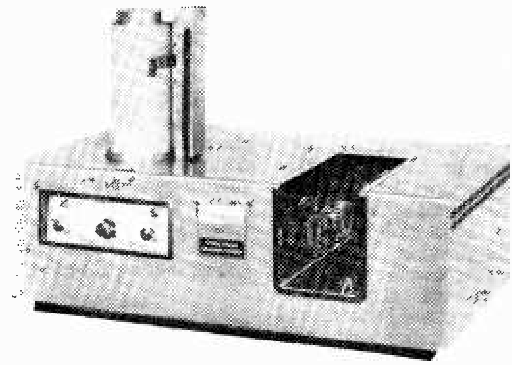
The Royal Radar Establishment will be demonstrating a thin-film, wide-band amplifier, a transistor swept-frequency oscillator for testing servomechanisms and filters, the amplification of acoustic waves in cadmium sulphide and a logarithmic



Double pulse generator Type 2/302D developed by Kasama Electronics Ltd.



Continuously sampling automatic titrimeter, intended by George Kent for quality-control applications.



Above: Low-cost, infra-red grating spectrophotometer, by Perkin Elmer.

Left: Automatic liquid scintillation spectrometer, introduced by Nuclear Enterprises.

receiver test set. This latter instrument enables the input-output characteristic of an i.f. logarithmic receiver to be displayed, or plotted, and the output measured to ±10mV.

New techniques, including reactively sputtered tantalum pentoxide capacitors and encapsulated transistors, are employed in the construction of the thin-film, wide-band (100Mc/s) 20dB amplifier.

A demonstration of frequency changing of laser radiation will be given in the section devoted to the Signals Research and Development Establishment.

Ministry of Aviation, Shell Mex House, Strand, London, W.C.2.

MUIRHEAD & CO. (124)

Apparatus for environmental testing of synchros is to be shown. Other instruments will include an automatic recording wave analyser and a digital read-out system. **4WW 348**

Muirhead & Co. Ltd., Beckenham, Kent.

MULLARD (118, 148 & 165)

Exhibits from the research laboratories will include the transluxor (a light-operated, solid-state amplifying device), an S-band tunnel-diode amplifier, and a u.h.f. wide-band amplifier. Equipment concerned with thin-film storage will also be shown. The development laboratories are to show an electroluminescent radar display and a mass-spectrometer leak detector. The Mullard educational service will be represented. **4WW 349**

Mullard Ltd., Mullard House, Torrington Place, London, W.C.1.

NATIONAL COAL BOARD (132)

The Scientific Department of the board will display their experimental, prototype ash-monitoring equipment which makes use of the back-scattering of low-energy X-radiation. The sample is ground to less than 1mm and is carried past the source on a plastic belt. The back-scattered radiation is detected by a scintillation counter.

National Coal Board, Queensborough House, Albert Embankment, London, S.E.1.

NATIONAL INSTITUTE FOR MEDICAL RESEARCH (112)

A number of research units will be showing current projects. The Cyclotron Unit will demonstrate a simple, compact radiation-measuring equipment using cadmium sulphide crystals. A positron camera being shown, makes use of the annihilation radiation of positron-emitting radioisotopes to form an image of the source. A patient automatic data recording equipment (PADRE) developed at the Division of Human Physiology is essentially an information handling system which is capable in its present form of collecting five items of information from ten separate sources. Also to be shown is an apparatus for the moisture determination of biological standards and a high-speed scanning spectrophotometer.

Medical Research Council, National Institute for Medical Research, Mill Hill, London, N.W.7.

NEWPORT INSTRUMENTS (92)

A magnet power supply having a current stability of ±1 part in 10^5 at 20kW is to be introduced. Transistors are employed for stabilization and the use of a rotary generator avoids output transients due to mains fluctuations. A proton-resonance magnetometer, working at 100Mc/s for the measurement of fields up to 25 kilogauss will be shown. **4WW 350**

Newport Instruments (Scientific & Mobile) Ltd., Newport Pagnell, Bucks.

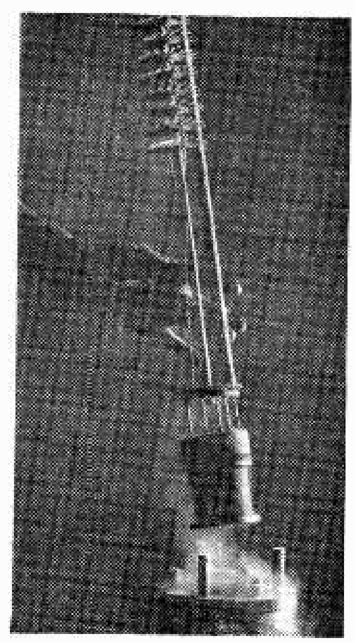
NUCLEAR ENTERPRISES (73)

The exhibit will include a dual-channel, automatic, liquid scintillation spectrometer and turntable unit for measurements on tritium, carbon-14, iron-55 and other isotopes. The detector unit of a whole-body monitor for clinical applications, using a transistorized control unit is also to be shown. **4WW 351**

Nuclear Enterprises (G.B.) Ltd., Sighthill, Edinburgh 11.

OXFORD INSTRUMENT CO. (79)

This company will show examples of their work on superconducting magnets and associated cryogenic equipment. A complete cryomagnetic system (the Type L.1000) will be demonstrated with the magnet in



A standard, 40 kilogauss, 1.5cm (inner diameter) superconducting magnet (Oxford Instrument Co. Ltd.) being raised from its cooling bath after testing.

continuous operation. A light, high-strength glass fibre case to house a 2MW conventional copper solenoid producing fields from 50 to 130 kilo-

(*continued on page* 19)

gauss will be exhibited. The case has to withstand the pressure of the cooling water, which could be up to 150lb/sq in. **4WW 352**

The Oxford Instrument Company Ltd., 27 *Northmoor Road, Oxford.*

OXFORD UNIVERSITY (80)

A superconducting solenoid—constructed by the Oxford Instrument Company—immersed in a bath of liquid helium is to be demonstrated this year to show the applications of superconductors for loss-free energy storage.

University of Oxford, Department of Physics, Clarendon Laboratory, Parks Road, Oxford.

PANAX EQUIPMENT (141 & 151)

This company's display will consist mainly of working demonstrations of their latest nucleonic measuring equipment. A demonstration kit for schools covering ten basic experiments in radioactivity will also be shown. **4WW 353**

Panax Equipment Ltd., Holmethorpe Industrial Estate, Redhill, Surrey.

PERKIN-ELMER (91)

The exhibit will be based on a low-cost infra-red grating spectrophotometer. The complete infra-red region, from 2.5 to 25 microns is covered, and a direct record is given of percentage absorption against a linear wavelength scale. Variable scan speeds are available and the drive will cover the whole range in from 6 to 56 minutes. **4WW 354**

Perkin-Elmer Ltd., Beaconsfield, Bucks.

PLANER (98)

Apparatus will be shown for the evaluation of the figure of merit of thermoelectric materials for use at temperatures of up to 600°C. A steady-state, absolute method is employed, thermal conductivity, Seebeck coefficient and electrical conductivity measurements being carried out on the same test specimen without withdrawal from the apparatus. A number of high-temperature, thermoelectric generator materials will be included on the stand. **4WW 355**

G. V. Planer Ltd., Windmill Road, Sunbury-on-Thames, Middx.

PLESSEY (10)

An electronic microbalance covering the range 5 to 500mgm is to be shown this year. Other products to be shown include a permanent magnet assembly for ion pump applications, a new sound velocity meter for use in bathythermograph applications and oceanography, and a ferrite v.h.f. inductor. Variable v.h.f. ferrite inductors operating at 500Mc/s are to be demonstrated. **4WW 356**

The Plessey Company (U.K.) Ltd., Ilford, Essex.

PULLIN (108)

The prototype recording densitometer to be shown by Pullin is an automatic instrument capable of measuring a large number of radiation monitoring films and feeding the output to a computer for "dose" assessment. They are also showing the prototype of a digital display unit which provides for the decimal display of four digital codes commonly used in metering systems. **4WW 357**

R. B. Pullin & Co. Ltd., Great West Road, Brentford, Middx.

PYE, W. G. (85)

A new microcapillary electrode assembly is to be demonstrated with other radiochromatography equipment. It is to be shown working in conjunction with an extremely accurate pH meter. **4WW 358**

W. G. Pye & Co. Ltd., York Street, Cambridge.

QUEEN MARY COLLEGE (70)

Electrical filters are easily constructed to pass low frequencies and to reject higher ones. A multi-dielectric-layer optical filter can similarly be optimized, the method being applicable to any spectral region. The principles will be illustrated by the Department of Electrical Engineering at the exhibition by models in 3-cm waveguide.

Queen Mary College, University of London, Mile-End Road, E.1.

RESEARCH ELECTRONICS (72 & 154)

The stand will be divided into two sections. The educational section will consist of simplified and inexpensive nucleonic equipment such as ratemeters and scalers, etc. The main section will be devoted to an entirely new range of transistor nucleonic instruments based on a plug-in, modular design. **4WW 359**

Research Electronics Ltd., Bradford Road, Cleckheaton, Yorks.

RESEARCH & ENGINEERING CONTROLS (94)

Temperature and pressure transducers and control equipment are to be demonstrated by this company. The equipment includes a precision comparison bridge for resistance thermometry, aircraft temperature sensors using platinum resistance thermometers and a proportional temperature controller. This latter instrument uses s.c.r.s connected across a bridge rectifier circuit in series with the load. **4WW 360**

Research & Engineering Controls Ltd., South Bersted Industrial Estate, Bognor Regis, Sussex.

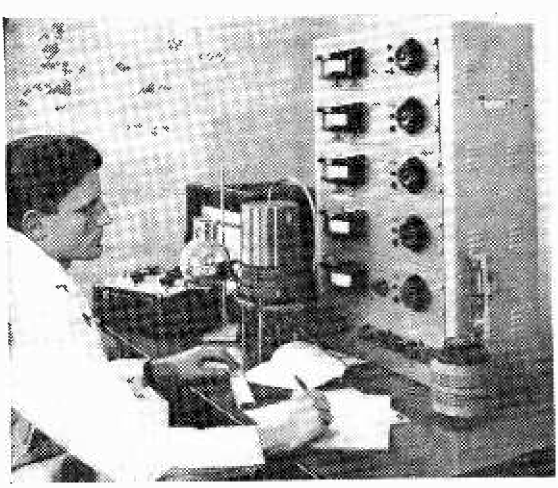
RESEARCH & INDUSTRIAL INSTS. (57)

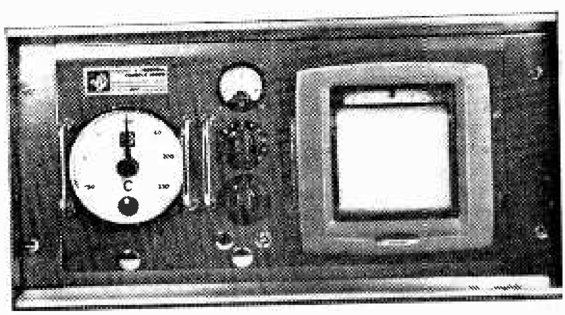
An electromicrobalance, designed to weigh up to 200mgm directly in single-pan operation and differentially up to a total of 5.5 grammes on both pans, is to be shown. Another item to be shown is an interferometer covering the far infra-red wavelength range 20 to 1,000 microns. **4WW 361**

Research and Industrial Instruments Company, 116 *Lordship Lane, London, S.E.22.*

ROLLS-ROYCE (59)

The development of a technique for coating silica fibres with aluminium alloy has made possible the production of fibre-reinforced metal, which will be exhibited. The material has





Above: Proportional temperature controller (Research and Engineering Controls).

Left: Apparatus developed by G. V. Planer Ltd. for the evaluation of the figure of merit of thermoelectric materials for use at temperatures up to 600°C.

high strength at elevated temperatures as the fibre bears the load even when the aluminium would flow under load. **4WW 362**

Rolls-Royce Ltd., Old Hall, Littleover, Derby.

ROYAL INFIRMARY, EDINBURGH (68)

The Department of Medical Physics will show a printed circuit electrode for electroencephalograph recording from the surface of the brain. The electrode is constructed by sputtering gold on to a thin plastic film through a grid. They will also show a miniature radio telemetering device for cardiac monitoring using a metal reed as the transducer.

The Royal Infirmary, Edinburgh 3.

ROYAL MILITARY COLLEGE OF SCIENCE (65)

Several of the exhibits are teaching aids including a three-dimensional model demonstrating the various possible modes of vibration of the atoms in a complex molecule. An electronic switching circuit controls the "modes."

Royal Military College of Science, Physics Branch, Shrivenham, Swindon, Wilts.

ROYSTON INSTRUMENTS (48)

Several specialist tape recorders are to be exhibited together with playback and "de-multiplexing" equipment. One of these machines, a miniature demand recorder (magnetic), has been designed to automate the process of statistical study of the consumption of electricity by various types of users. **4WW 363**

Royston Instruments Ltd., Canada Road, Byfleet, Surrey.

S.E. LABORATORIES (25)

Several pieces of electronic apparatus are to be shown this year. Among these is a transistorized synchro converter for converting synchro outputs to analogue signals for indication, computing or control. Another is an air flowmeter system, using variable-reluctance-type pressure transducers and a miniature transistorized computer. **4WW 364**

S.E. Laboratories (Engineering) Ltd., North Feltham Trading Estate, Feltham, Middx.

SAFETY IN MINES RESEARCH ESTABLISHMENT (125)

Two demonstrations will be provided. A recently developed shutter for preventing multiple exposures in high-speed, rotating-mirror cameras and an instrument for measuring respirable dust. In the first-mentioned exhibit, the shutter assembly and associated electronic equipment will be operated in conjunction with a simulated rotating mirror.

Safety in Mines Research Establishment, Red Hill, Off Broad Lane, Sheffield 3.

SANGAMO WESTON (122)

A diaphragm inductive pressure indicating system, comprising a transducer electrically connected to a moving-coil indicating instrument and designed for use in aircraft, is to be shown together with a multirange temperature measuring instrument. **4WW 365**

*Sangamo Weston Ltd., St. Georges Court, 22-26 New Oxford Street, London, W.C.*1.

SHANDON (78)

The apparatus will be mainly that associated with gas chromatography and electrophoresis techniques. A new universal ultra-violet cabinet designed to facilitate the examination of paper chromatograms will be demonstrated. It has facilities for photographic recording. **4WW 366**

*Shandon, 65 Pound Lane, London, N.W.*10.

SIMON-CARVES (86)

A radiation detector, using a crystal and photomultiplier head and a digital counter for display, is to be shown. Other items to be exhibited include a centrifugal particle size analyser and an automatic bacterial colony counter. Simon-Carves is a member company of Simon Engineering Ltd. **4WW 367**

Simon-Carves Ltd., Cheadle Heath, Stockport, Cheshire.

SOUTHERN ANALYTICAL (2)

Among the new equipments, a new polarograph, the A1670 Davis-Southern cathode ray polarograph, will be shown. Also included will be a suspended solids recorder and a new type of flame photometer which has automatic background compensation. This improves the limit of detection while retaining the simplicity of operation required for routine analysis. **4WW 368**

Southern Analytical Ltd., Camberley, Surrey.

SPECTO AVIONICS (45)

A demonstration is to be given of an electronic integrated display system, whereby an observer is presented with several channels of information in an easily assimilable form. The equipment is intended to aid operators in charge of controlling and checking processes. **4WW 369**

Specto Avionics Ltd., Hanworth Air Park, Feltham, Middx.

SPERRY (3)

Demonstrations showing the applications of fibre optic elements as mechanical filters responding to discrete audio frequencies, new developments in non-electrical chemical plating of non-metallic substrates and a new solid-state synchro to digital converter are to be included in this year's exhibits. **4WW 370**

Sperry Gyroscope Co. Ltd., Great West Road, Brentford, Middx.

SUNDERLAND TECHNICAL COLLEGE (63)

The Electrical Engineering Department of the college will display two of their current research projects. The first is a function generator for functions of two variables, which is intended for use with an analogue computer representing a process which depends on two variables. The other exhibit is a transport delay simulator which is an electronic model of the delay which occurs when fluids flow through long pipes.

Sunderland Technical College, Sunderland, Co. Durham.

TELCON METALS (104)

The dynamic hysteresis loop plotter developed by the company's research laboratory produces on paper the dynamic B-H loops of magnetic cores at frequencies between 50c/s and 5kc/s. The H and B waveforms are sampled simultaneously for periods of about 2μsec and the resulting pulses are stretched to obtain d.c. levels which are fed to the X and Y inputs of the plotter. **4WW 371**

Telcon Metals Ltd., P.O. Box 12, *Manor Royal, Crawley, Sussex.*

TELEQUIPMENT (162)

A new single-beam oscilloscope with a five-inch tube is to be shown this year. Called the S51E, it has a bandwidth of d.c. to 3Mc/s and its dimensions are 7×8×15in. **4WW 372**

Telequipment Ltd., 313 *Chase Road, Southgate, London, N.*14.

THERMAL SYNDICATE (19)

A ruby laser system and a helium-neon gas laser unit developed in collaboration with the International Research and Development Co., Ltd., are to be demonstrated. **4WW 373**

Thermal Syndicate Ltd., P.O. Box No. 6, *Wallsend, Northumberland.*

TINSLEY (123)

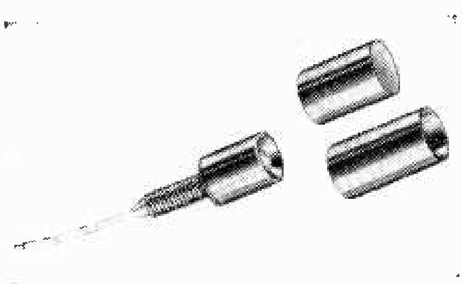
Two prototype instruments will be demonstrated. The Wheatstone bridge Type 5577 is a 6-dial bridge with switch contacts in parallel to reduce resistance to a negligible level. Conductance dials are used in place of series resistance dials. The lowest stud reading is 0.0001Ω and the accuracy at 20°C is 1 part in 100,000 of the maximum reading. An inductive ratiometer Type 5575A is intended to replace the resistance bridges normally used in resistance thermometry. The discrimination is to 1 part in 10^7. Normal operation is at 1kc/s. **4WW 374**

*H. Tinsley and Co. Ltd., Werndee Hall, South Norwood, London S.E.*25.

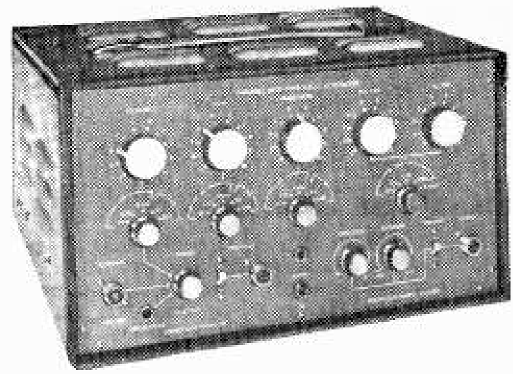
TOWNSON & MERCER (114)

The thermistor bridge control incorporated in the new range of thermostat baths to be exhibited, is an a.c. bridge the sensing arm of which is a sensitive dual thermistor mounted in the bath liquid. Amplified out-of-balance voltages from this bridge operate the thermostat heater via an s.c.r. **4WW 375**

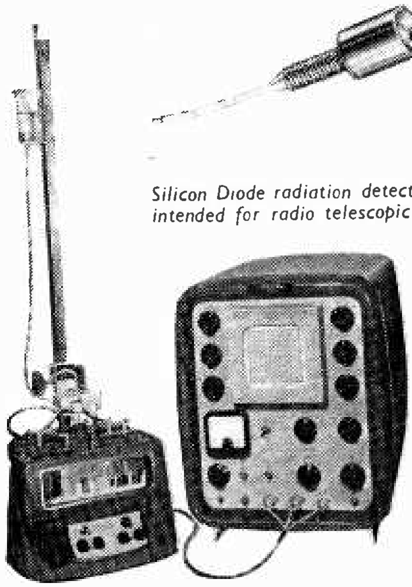
Townson & Mercer Ltd., Croydon.



Silicon Diode radiation detector, by 20th Century, intended for radio telescopic work.



Venner variable-rise-time pulse generator.



Type A1670 Davis-Southern cathode ray polarograph.

20TH CENTURY ELECTRONICS (135 & 158)

A fully-automatic leak detector for small components will be shown. Small sealed components such as transistors which are filled with helium during manufacture are automatically tested and sorted according to their leak rates, which may be as low as 10^{-6} cubic centimetres per second. The heart of the instrument is an improved type of mass spectrometer. A series of instruments for use in schools and colleges has been designed, in collaboration with the Nuffield Foundation. **4WW 376**

20th Century Electronics Ltd., King Henry's Drive, New Addington, Croydon, Surrey.

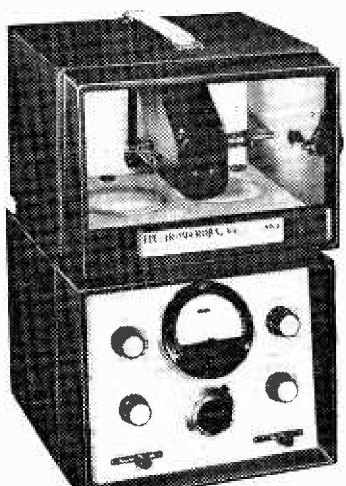
ULTRASONOSCOPE (71)

The latest developments in the range of ultrasonic flaw detectors are to be demonstrated, including fully-transistorized, wide-band equipment. The company has under development a range of glass-insulated microwire in gold, silver and lead for use in cryogenics and semiconductor devices. **4WW 377**

Ultrasonoscope Co. (London) Ltd., Sudbourne Road, London, S.W.2.

UNIVERSITY COLLEGE OF N. WALES (62)

Two d.c. motors will be shown. One, a linear type, is expected to have an efficiency which is high and comparable to that of a rotary motor. The other is a brushless rotary machine in which the commutation of the armature current is carried out by



Electromicrobalance from Research and Industrial Instruments. (See page 19)

semiconductors. Visitors will also be able to see two parametric devices. A travelling-wave parametric amplifier will be demonstrated together with a parametric delay line for signal processing.

University College of North Wales, Bangor, Caerns.

VACUUM REFLEX (76)

Sonar beacons and other ultrasonic equipment are being featured by Vacuum Reflex who are participating in the exhibition for the first time. Two types of sonar beacons for use as sea bed markers for geophysical surveys are to be shown; one a continuously transmitting "pinger" type and the other a transponder. Both use ceramic transducers which are moulded integral with the epoxy resin and glass-fibre body. An ultrasonic underwater transmission system for both telemetering and voice communication over distances of several miles, and ultrasonic transducers will also be shown. **4WW 378**

Vacuum Reflex Ltd., 6 Soho Street, London, W.1.

VENNER ELECTRONICS (29)

Among the range of instruments to be demonstrated is a new variable-rise-time pulse generator. The instrument covers the frequency range 10c/s to 1Mc/s and the manufacturers claim that every parameter of the pulse can be altered. Also to be shown is a prototype 50Mc/s frequency meter with facilities for time measurements to 0.1μsec. **4WW 379**

Venner Electronics Ltd., Kingston-By-Pass, New Malden, Surrey.

WAR OFFICE (6)

A method of movement control and position measurement for machine tools will be shown. A line-following system is used, whereby an image of the line is shared by two photocells, any unbalance being used to feed error-correcting servos, or position indicators.

The War Office, Whitehall, London, S.W.1.

WATSON & SONS (83)

To overcome the reduction of life of some television camera tubes when used for microscope applications in the vertical plane, a television eyepiece which allows a camera to be used horizontally is to be shown. This is achieved by deflecting the image-forming beam from the objective through 90°. A pointer is incorporated with controls on the eyepiece. **4WW 380**

W. Watson & Sons Ltd., Barnet, Herts.

WOOD & SON (164)

"Ealing" kits will be exhibited. These include apparatus for the determination of e/m of protons and electrons, magnetic resonance apparatus and other nuclear physics equipment. If coil winding and welding facilities are not available, parts of the kits can be obtained in "sub-assembly" form. **4WW 381**

Hugh Wood and Son Ltd., 23 Leman Street, London, E.1.

WRAY (107)

A range of copying lenses developed especially for producing micro-miniaturized printed circuits and an "inverting telescope" for improving the collimation of a laser beam are to be shown. **4WW 382**

Wray (Optical Works) Ltd., Ashgrove Road, Bromley, Kent.

WORLD OF WIRELESS

BBC-2 Test Transmissions

TRADE TEST 625-line transmissions from the B.B.C.'s London television station at Crystal Palace are to restart on 4th January. These are to assist the radio trade in the installation of receivers and aerials for reception of the second programme, BBC-2, which starts in London on 20th April. The test transmissions will be on Channel 33 (vision 567.25 Mc/s; sound 573.25 Mc/s) with horizontal polarization and will take place as follows: Mondays to Fridays 9 a.m. to 1 p.m. and 2 p.m. to 8 p.m., and Saturdays 9 a.m. to 8 p.m.

The nominal effective radiated power will be 500 kW when the installation of the new transmitting aerial is completed—about the beginning of March. Until then the e.r.p. is expected to be about 250 kW. Every effort will be made to maintain continuity of transmission, but there may be interruptions and variations in power during the installation period. The test transmissions will consist of periods of test card, with 400 c/s tone or music, alternating with periods of film chosen to give some entertainment to viewers who have u.h.f. receivers.

Interference from Medical Apparatus

REGULATIONS covering the control of radio and television interference from electro-medical apparatus have been laid before Parliament and come into force at the end of next November. The new regulations* are based on the recommendations of the Postmaster General's Advisory Committee on Wireless Interference from Industrial, Scientific and Medical Equipment.

The regulations require manufacturers, and importers, of electro-medical r.f. apparatus to ensure that under normal working conditions equipment does not exceed the prescribed limits of radiated field strength and terminal voltage. The Postmaster General has also prescribed limits for "users" but they will be invoked only in the exceptional case where undue radiation has occurred despite compliance with the manufacturers' limits.

* Wireless Telegraphy (Control of Interference from Electro-Medical Apparatus) Regulations 1963, S.I.1895, H.M.S.O.

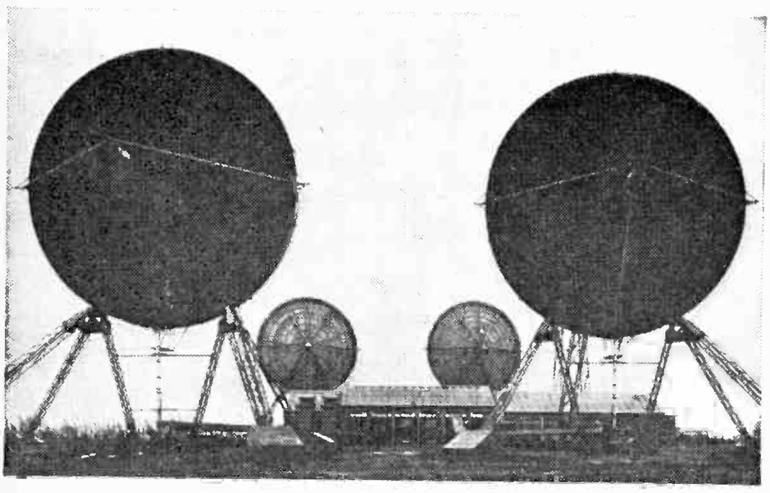
Double Anniversary

THE Mullard valve factory at Blackburn celebrated its 25th anniversary last November at a party which also did honour to the founder of the company, S. R. Mullard, M.B.E., M.I.E.E., on his 80th birthday. It

happened that a short while before this event the 500 millionth valve (a small TV receiver type) came off the production lines of the Blackburn plant and this was reserved and specially mounted inside one of the firm's original silica transmitting valve designs as a memento of the occasion. Mr. Mullard said that he pictured some future historian examining the device and trying to imagine what sort of circuit was used with it! Among other birthday gifts was a gold watch from some of his contemporaries and many friends in the radio and electronics industry.

Ace High Network

THE last link in N.A.T.O.'s Ace High communications network, which runs from northern Norway to eastern Turkey, has now been completed and accepted by Supreme Headquarters Allied Powers Europe. The network, consisting of 82 stations divided almost equally between tropospheric forward scatter and line-of-sight links, runs through Norway, Denmark, west Germany, Great Britain, Netherlands, France, Italy, Greece and Turkey. The control centre is some 40 miles north of Paris. The International Telephone and Telegraph Corporation designed and engineered the 8,300-mile network which provides 36 channels each capable of carrying up to 18 telegraph circuits. Standard Telephones and Cables Ltd., a subsidiary of I.T.T., supplied over a £1M worth of multiplex equipment. The four 65-ft dishes shown here are at the troposcatter station in southern England.



Radio Show Trade Days

THE period of the 1964 National Radio and Television Show at Earls Court has been extended to allow for two trade days, during which admission will be limited to bona-fide members of the trade. It will now run from 24th August to 5th September, the trade days being the first two. The organizers, Radio Industry Exhibitions, are also arranging for trade periods in the mornings on most of the other days. The official opening of the show will be on the first "public" day, Wednesday 26th.

Radar Trap Detectors.—The P.M.G. has announced that he will not grant licences for receivers to detect police radar traps and that their unlicensed use is illegal.

Radio Manx.—The P.M.G. has agreed in principle to the building of a commercial sound broadcasting station on the Isle of Man providing that signals are not receivable on the mainland. No licence has yet been granted but the island's Lt. Governor has appointed Pye of Cambridge as technical consultants for the station, to be known as Radio Manx, which it is planned to open this summer.

The I.E.E. and the Brit.I.R.E. are arranging a joint one-day symposium on "**Electronics in the automobile industry**" on 7th April. It will take place in the Electrical Engineering Department, University of Birmingham, and further details and registration forms may be obtained from G. K. Steel, College of Advanced Technology, Gosta Green, Birmingham 4.

R.S.G.B. membership increased by 586 during the year ended last June, bringing the total to 11,721. Of this total 7,155 are licensed transmitters. The total number of amateur (sound) licences in force in the U.K. at 30th June was 10,118.

The Geoffrey Parr Award introduced a few months ago by the Television Society to commemorate the late Geoffrey Parr, the Society's honorary secretary for many years, is to be presented for the first time in May. Application forms giving the rules governing nominations are now available from the Society at 166 Shaftesbury Avenue, W.C.2, and have to be returned by the 15th February. This international award is for presentation annually to an individual or team for an outstanding contribution to television engineering during the preceding three years.

F.M. Broadcasting in the U.S.—The Federal Communications Commission, which called a halt temporarily to the extension of f.m. broadcasting at the end of 1962, when there were nearly 1,100 transmitters in operation, has now introduced a new plan providing for 2,380 stations at 1,858 localities.

In preparation for the **African LF/MF Broadcasting Conference** to be held in Madrid in September, a meeting of experts "to establish the technical data required for this conference" is to begin in Geneva on the 20th January. The September conference will be a joint meeting of the administration in the African Region and the European Broadcasting Area.

"**Modulation and the transmission of information**" is the title of a series of eight lectures to be given at the Borough Polytechnic, Borough Road, London, S.E.1, on Thursday evenings from 30th January. (Fee 50s.)

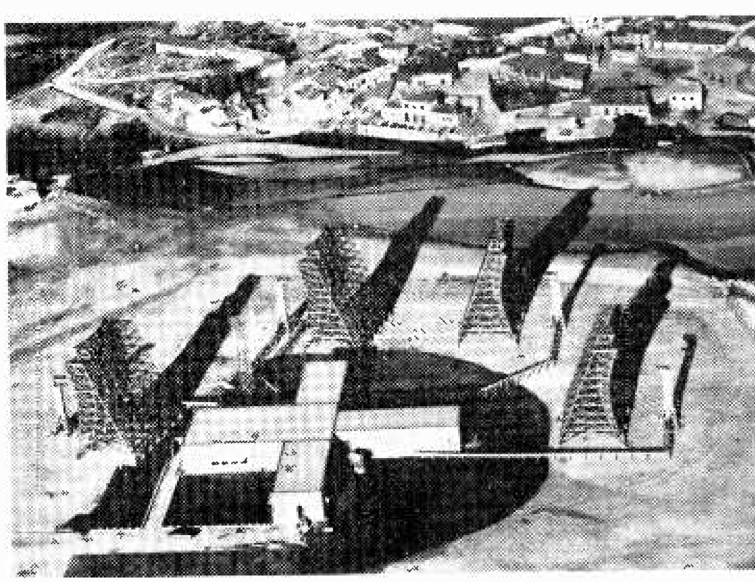
A course of eight lectures on "**625 lines and colour**" is to be given at the Hendon College of Technology, London, N.W.4, on successive Mondays from 27th January. (Fee £1.)

Colour Television Lectures.—A course of ten weekly lectures on colour television starts at the Technical College, Southall, Middx., on 15th January. (Fee £1.)

A course of twelve evening lectures on "**Transistor circuit design**" is to start on 13th January at the Twickenham College of Technology, Egerton Road, Twickenham, Middx. (Fee 30s.)

"**D.C. Inverter for Electric Shavers.**"—On page 626 of this article in the December 1963 issue the groups of waveforms of collector voltage and current in Figs. 3 and 5 should be interchanged.

We are asked, by the author of the article on the **3-W transistor audio amplifier** in our December issue, to point out that Q3 should be a Newmarket type NKT774, not NKT274.



An impressive picture of the troposcatter array near Humosa, in Northern Spain, which forms part of a chain of stations in Western Europe for the U.S. Air Force. The reflectors and the feed horns for this station and others in the chain were produced by Painter Brothers, a member of the B.I.C.C. Group.

PERSONALITIES

Air Vice-Marshal Sir Walter Pretty, K.B.E., C.B., Air Officer Commanding-in-Chief, Signals Command R.A.F. for the past two years, is to be Deputy Chief of the Defence Staff (Personnel and Logistics) from March. Sir Walter, who was knighted in 1962, was deputy director of radar at the Air Ministry in 1944 and in the following year became chief signals officer, Fighter Command R.A.F. In 1951 he was appointed director of electronics research and development (air) in the Ministry of Supply. The new A.O.C.-in-C. Signals, will be **Air Vice-Marshal T. U. C. Shirley,** C.B., C.B.E., M.I.E.E., who has been

A. V-M. T. U. C. Shirley

deputy controller of electronics at the Ministry of Aviation for the past three years. He joined the R.A.F. as an aircraft apprentice in 1925. In 1946 he was appointed deputy director of signals at the Air Ministry and in 1951 became director of radio engineering. Two years later he went to Fighter Command as chief signals officer.

G. H. W. Johnson, Assoc.Brit.I.R.E., is the new contracts manager of the Marconi International Marine Company, which he joined in 1938 as a radio officer in the *Duchess of Atholl*. Four years later he was transferred to the shore staff and in 1943 went to Oban to establish a base to serve wartime convoys. After service both abroad and in the U.K. he was appointed marine director of Marconi (South Africa) Ltd. in 1957 and in 1960 became chief executive and director of Norsk Marconikompani A/S, Norway. For the past year Mr. Johnson has been management executive at Chelmsford. He is succeeding **J. R. C. Johnson** (not related) who is retiring on 31st December after 46 years' service with the company. He served as a radio officer afloat for 32 years (including service in both wars) and had been contracts manager for the past ten years.

J. Kirkby, works director of Baird Television Ltd. since 1956, has been appointed deputy managing director. He has been with the company since 1945 having previously spent several years with A.C. Cossor Ltd.

A. B. Bamford, B.Sc., A.M.I.E.E., technical director of Baird Television for the past two years, has been appointed technical adviser to the Radio Rentals Group of which Baird is a member. Mr. Bamford, who is 41, is a graduate of Birmingham University. For 20 years prior to joining Baird in 1962 he was with Ultra latterly on the board.

A. R. A. Rendall, O.B.E., Ph.D., B.Sc., M.I.E.E., is retiring on 31st December as head of the Designs Department of the B.B.C.'s Engineering Division, a post he has held since 1950. Dr. Rendall, a graduate of King's College, London, spent thirteen years in industry before joining the B.B.C. in 1935 as an engineer in the Lines Department.

S. N. Watson

He is succeeded by **S. N. Watson,** M.I.E.E., who has been head of the television group of the same department since 1951. Mr. Watson joined the B.B.C. in 1933 and was in the Lines Department before joining the Designs Department in 1947.

H. Andrewes, O.B.E., B.Sc., M.I.E.E., technical sales executive of the Dubilier Condenser Company, retired at the end of November. After graduating in engineering at the City and Guilds College, he did

H. Andrewes

a year's post-graduate study and received the Diploma of Imperial College. He joined Dubilier as assistant to the chief engineer in 1923 but left the company in 1930 to join Dr. Robinson in the British Radiostat Corporation and was later concerned with recording developments. Mr. Andrewes joined the R.A.F.V.R. in 1939. In 1942 he was posted to India and became chief radar officer, Base Air Forces in New Delhi attaining the rank of Wing Commander. He rejoined Dubilier as laboratory manager in 1945 and six years later took charge of the Industrial Electronic Sales Department. The suppression of radio interference has been one of his special interests and he represented the R.E.C.M.F. at the Plenary Conferences of the International Special Committee on Radio Interference in 1958 and 1961.

Four of the recent grants made by the Paul Instrument Fund Committee are for the design, development or construction of electronic apparatus. **A. H. W. Beck,** lecturer in engineering at Cambridge University, has been granted £12,800 for the construction of apparatus for the amplification and generation of extremely high-frequency electromagnetic waves (below 1 mm); **Dr. T. H. Wilmshurst,** of the Department of Electronics at Southampton University, is awarded £2,300 for the construction of an electron spin resonance spectrometer for examining short-lived paramagnetic species produced by a pulsed light source; **Dr. E. T. Hall,** director of the research laboratory for archæology and the history of art at Oxford University, is to receive £1,870 for the development of a transistor differential flux-gate magnetometer and a miniature flux-gate compass; and **Dr. S. Evans,** senior assistant in polar research at Cambridge University, has been given a supplementary grant of £1,000 for the development of an instrument for measuring the depth of continental ice sheets by a radar technique. The Paul Instrument Fund is administered by a joint committee of representatives of the Royal Society, the Institute of Physics & Physical Society and the I.E.E.

Gp. Capt. Kenneth B. S. Willder, C.B.E., B.Sc., M.I.E.E., has become director of telecommunications at the Air Ministry with the acting rank of Air Commodore. Commissioned in 1940, at the age of 22, he served at the Air Ministry during the war and became chief signals officer at Air H.Q. Iraq in 1946. He has served at the headquarters of both Bomber and Fighter Commands and since March 1962 has been command electronics officer, Far East Air Force.

Bryan R. Overton, B.Sc., M.I.E.E., has been appointed to the new post of manager of the Mitcham plant of the Mullard Radio Valve Company. He was previously head of the circuit physics and applications division of the Mullard Research Laboratories, Redhill, which he joined in 1947. Mr. Overton, who is 39 and a graduate of Birmingham University, was with the Admiralty Signal Establishment, Haslemere, before joining the radio industry. He was awarded the Television Society's *Wireless World* premium in 1959 for his paper "Transistors in television receivers."

B. R. Overton

L. G. Cripps

Leonard G. Cripps, B.A., succeeds Mr. Overton as head of the circuit physics and applications division of the Mullard Research Laboratories which he joined in 1954 to do research on transistors. Mr. Cripps, who is 34, obtained his B.A. degree in mathematics and natural sciences at Trinity College, Cambridge, where he did a year's post-graduate reading in electrical engineering.

R. R. Thompson, B.Sc., A.M.I.E.E., who has been with the English Electric Valve Company for seven years leading a research team designing microwave tubes, has been appointed assistant manager in charge of the Display Tubes Department. After graduating at St. John's College, Cambridge, he taught physics at Worksop College and Cranleigh School before entering the electronics industry.

R. M. A. Jones, a director of Pye Ltd. and managing director of E. K. Cole Ltd. since 1962, has been elected to the board of Pye of Cambridge Ltd., the holding company of the Pye-Ekco Group. **J. O. Stanley,** M.A., son of the chairman of the Pye Group of companies, has also been appointed a director of the holding company on the resignation of **E. J. W. Stanley,** M.A., B.Sc. (Eng.), on reaching retirement age.

Two appointments are announced by the Cossor Communications Company. **J. W. Mordin,** who joined the company a few months ago, has become general sales manager (marine products). After service both in the Royal Navy and Merchant Navy he was with Decca Radar and A.E.I. **R. R. Roper** has joined Cossor as general sales manager (communications). He was at one time with the Post Office and has since been with S.T.C. as a development engineer, the Telephone Manufacturing Company and latterly Solartron.

OUR AUTHORS

G. P. Hobbs, B.A., Grad.I.E.E., who writes in this issue on tape recording amplifiers, read physics at Christ Church, Oxford, and obtained a second class honours degree in 1961. Since then he has been working on the design of transistor equipment in Marconi's closed-circuit television division at Chelmsford.

W. V. Richings, Assoc.I.E.E., A.M.Brit.I.R.E., chief engineer of Dawe Instruments Ltd., writes in this issue on acoustic noise measurement and analysis. He joined Dawe Instruments as a development engineer in 1945 and is particularly interested in sound and vibration measurement problems. Mr. Richings serves on the International Electrotechnical Commission's Technical Committee (29) concerned with electroacoustics and is a member of its Sound Level Meters Working Group and secretary of the Shock and Vibration Transducers Working Group.

OBITUARY

Roland John Kemp, deputy director of engineering and research of the Marconi Company, died on 22nd November at the age of 62. Mr. Kemp joined Marconi's in 1917 as a test room improver and later worked on direction finding and receiving equipment. From 1930 to the outbreak of war he was engineer-in-charge of television research. During the war he was responsible for special research at Great Baddow for the Air Ministry. In 1946 he was appointed assistant chief of research at Great Baddow and two years later became chief of research. Mr. Kemp became the deputy engineer-in-chief in 1954 and had been deputy director of engineering and research since the beginning of 1963. He was a member of the P.M.G.'s Frequency Advisory Committee and had also served on the Radio Research Board of the D.S.I.R.

S. F. Pearce, B.Sc., F.Inst.P., who had been with the Electrical Research Association for 30 years, died on the 18th November at the age of 49. Mr. Pearce received his degree from London University after joining the E.R.A. as a student apprentice in 1933. His work at the association was mainly concerned with radio interference and he served on many committees of the B.S.I., the I.E.E. and the International Special Committee on Radio Interference (C.I.S.P.R.). He was also chairman of the committee of the International Electrotechnical Commission concerned with interference in ships.

NEWS FROM INDUSTRY

Microwave Equipment for Greece

A CONTRACT, with a value approaching £750,000, has been awarded to the General Electric Company by the Hellenic telecommunications organization for s.h.f. and u.h.f. equipment. The equipment is to be used in new microwave telephone links, the largest of which will run along the Greek west coast and provide two 2-way links between Patras in the south and the island of Corfu in the north. These links are to operate at about 6 Gc/s and will provide up to 960 telephone speech channels per link.

Two subsidiary spur-links operating at about 2 Gc/s are also to be installed. Comprehensive supervisory and engineer's "order wire" facilities are to be provided on all routes and the switching arrangements of the links are such that the systems can be expanded if required at a later date.

Plessey acquire Ducon.—The offer made by The Plessey Company on 22nd July for Ducon Industries Ltd., the largest component manufacturers in Australia, has now been accepted. Ducon came into being at about the same time as Plessey and, excluding the recently acquired United Capacitor Company Pty., operates five major subsidiaries in Australia and one in New Zealand. Ducon's main plant at Villawood, New South Wales, covers a 17½ acre site and has a total production area of 350,000 sq ft. Mr. Clifford Gittoes is chairman and managing director of Ducon Industries Ltd.

Environmental Testing. — The Belling-Lee laboratories have now been approved as a Class III Test House under Air Ministry and War Office approval, and are able to undertake full type-approval testing of components to D.E.F. Specification requirements. Enquiries to Belling & Lee Ltd., of Great Cambridge Road, Enfield, Middlesex, will be welcomed for approval testing, and other type testing and specialized measurements on materials, components, and apparatus.

Marconi's £4M Army Order.—The latest of three military contracts received by the Marconi Company for h.f. mobile and static communication stations, known in the Army as the S.R. D11/R234, amounts to £1,750,000. The combined value of the three contracts now exceeds £4,250,000 and the equipment supplied under the first two contracts is now in use in many parts of the world. A feature of the equipment is that the 350-watt 2-22 Mc/s transmitter and complementary receiver can be set to any operating frequency by decade controls and does not need netting with the rest of the stations in the network.

A Decca airfield control radar, Type 424 Mark II, providing facilities for final approach surveillance, has been installed at Woolsington, the North East Regional municipal airport near Newcastle-upon-Tyne. It is remotely controlled from the display position in the control tower and can be brought into use at very short notice when necessary. The radar incorporates an advanced variable polarization system for overcoming interference caused by adverse weather conditions.

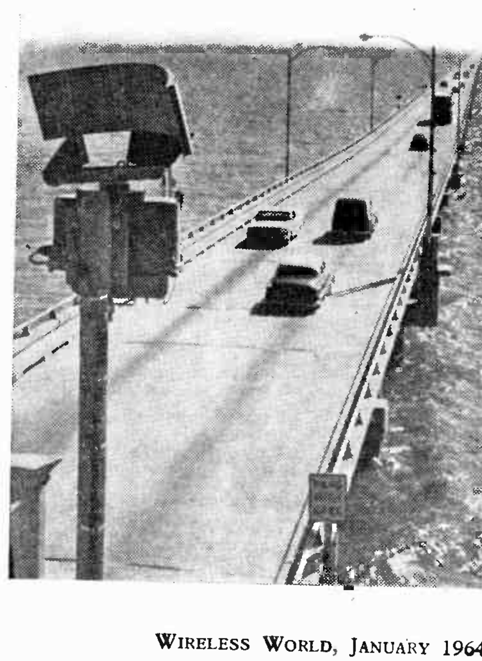
Tannoy (Ireland) Ltd. has been formed to expand and develop the range of Tannoy products and services now available in Ireland through their agents Sound Systems Ltd. It will merge with and absorb the division of Sound Systems Limited, of Upper Liffey Street, Dublin, concerned with Tannoy products, and, for the time being, operate from the same address.

The group profit after taxation of **Robinson Rentals (Holdings) Ltd.,** of which E. K. Cole is chairman, for the year ended 30th September totalled £424,920. This represents an increase of £120,585 on the previous year's results. This year's depreciation of rental assets took £1,234,306 of the £1,909,841 group profits.

Profits for the year ended 31st August of **Dictograph Telephones Ltd.,** of which Grampian Reproducers is the subsidiary, totalled £201,953; after deducting £148,991 for taxation. This year's profits represent an increase of £13,865 on the previous year's figure.

Elliott-Automation has formed a new management company, **Elliott Space and Weapon Automation Ltd.,** with headquarters at Frimley, Surrey, to co-ordinate the activities of the Group in these fields. The company has a number of projects connected with satellite development and contracts for the development of integrated weapon control systems, instrumentation and associated simulators. Elliott-Automation's work on lasers is being carried out in the new company's research laboratory. The directors of the new company are Commander H. Pasley-Tyler (chairman), W. R. Thomas, J. de M. Baynham, D. Hunter and H. Surtees.

BSR Ltd. has acquired a 180,000 sq ft factory at East Kilbride in Scotland for the manufacture of telephone and other electronic equipment.



A ship's type radar—scanner shown in the foreground—and a radiotelephone system are being used to monitor marine traffic in the vicinity of the 24-mile-long Lake Pontcharlrain Causeway and to warn craft in danger of colliding with the piers. This is the longest overwater highway bridge in the world and connects metropolitan New Orleans with the major highways serving the southern cities. Raytheon equipment is used throughout.

The recently completed Trinity House Lightship No. 20 has been fitted with radio beacon equipment designed and manufactured by **Redifon Ltd.** The installation consists of two 80-watt transmitters, together with failure alarm units, twin chronometers and code senders, and a beacon control unit. The output power of the transmitters can be altered to suit the requirements of any beacon chain in which the station is to operate and immediate indication is given of any failure of transmission. Special code discs are used in the code senders to enable the callsign and other characteristics of beacon transmission to be changed in a few minutes. Inter-ship and ship-to-shore communication is provided by Redifon GR161B 15/20-watt transistor radiotelephones. A similar installation is to be fitted to a second vessel now being built.

A technique of producing foil heating and resistance elements by a combination of foil thickness and area has been developed by **Mills and Rockleys (Electronics) Ltd.**, Swan Lane, Coventry. It is claimed that this not only solves many problems of circuit geometry but also permits variation of heating effect over the area.

High Definition Films Ltd., which was formed by Pye in 1956 to specialize in the design and manufacture of schools radio and electronic equipment, will be known in future as **Pye H.D.T. Ltd.** Its present interests also include the application of closed-circuit television to teaching, and the design and production of high-quality language laboratory equipment. B. E. Briggs is chief engineer, B. V. Soames-Charlton general manager and J. H. Jebb sales manager.

E.E.V. klystrons for BBC-2.—The B.B.C. has placed an order with the English Electric Valve Company, for a large number of 25 KW amplifier klystrons for the television transmitters now being manufactured for Bands IV and V.

Mervyn Instruments Ltd., formerly of Woking, have moved to The Hyde, Brighton 7, Sussex. Their new telephone number is Brighton 66271.

Ad Auriema Ltd., of Empire House, Chiswick High Road, have moved to Impectron House, 125 Gunnersbury Lane, Acton, London, W.3. (Tel.: ACOrn 8765.)

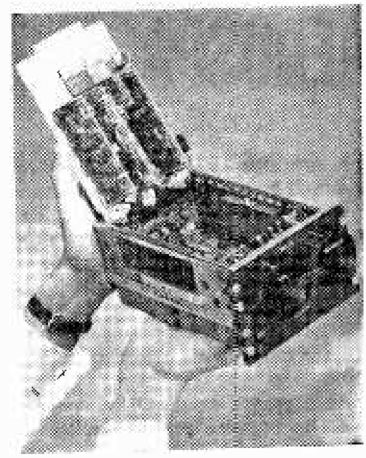
Alma Components Ltd., the manufacturers of precision resistors, have closed their London sales office and are now operating from their premises in Park Road, Diss, Norfolk. The sales office number is Diss 2287.

An **electronic reading automaton,** which reads cash register tally rolls at high speed, has been installed in the premises of Montague Burton Ltd., of Leeds, by the Solartron Electronic Group. This machine uses a video scanning technique to transfer the information from the tally rolls into punched cards and is claimed to be the first machine reading conventional printed digits optically to come into full commercial operation in Europe.

Crosfield Electronics Ltd. have placed an order with **Rank Cintel** for 25,000 9in high-resolution cathode-ray tubes. These tubes are to be used in Crosfield "Scanatron" equipment designed for automatically correcting colour and tonal distortions in photographic separations for process colour printing.

British Telemeter Home Viewing Ltd. is not a subsidiary of International Telemeter as stated on page 607 of our last issue but is an independent British company set up to "manufacture and exploit Telemeter systems in this country and elsewhere."

Grundig (Great Britain) Ltd. have opened new showrooms at 15 Orchard Street, London, W.1. (Tel.: WELbeck 4898.)



One of the v.h.f. airborne communication equipments Standard Telephones and Cables are to supply to the Army and R.A.F. under a recent contract valued at approximately £100,000. This equipment uses transistors throughout, with the exception of two valves in the p.a. stages, and with 50kc/s channel spacing, covers the frequency range 116.0 to 135.95 Mc/s.

Hewlett-Packard Ltd., of Dallas Road, Bedford, are taking over an adjoining factory to increase their production floor area.

NEW AGENTS

The **English Electric Valve Company** has appointed Leon Kouyoumdjian of Sa'addon Street, Aliwiya, Baghdad, as the exclusive agent for Iraq.

Impectron Ltd., the U.K. agents for **Sennheiser Electronics,** of west Germany, have moved to Impectron House, 125 Gunnersbury Lane, Acton, London, W.3.

Southern Instruments, of Camberley, Surrey, have been appointed U.K. agents for **Kistler Instruments Ltd.** of Winterthur, Switzerland. The products they are to handle will include pressure, acceleration and load transducers, and associated amplifiers.

Wayne Kerr Laboratories Ltd., of New Malden, Surrey, have signed a new licensing agreement with the **United Systems Corporation,** of Ohio, U.S.A. It provides for the marketing—and the eventual manufacture—of the U.S.C. Digitec range of digital voltmeters by Wayne Kerr in the United Kingdom.

Silicon Transistor Corporation, of America, have appointed Walmore Electronics Ltd., of 11 Betterton Street, Drury Lane, London, W.C.2, sole U.K. agents.

Sound Systems Ltd., of 11 Upper Liffey Street, Dublin, have been appointed Eire and Northern Ireland distributors for the full range of industrial electronic metal detectors and laboratory instruments manufactured by Rank Cintel, a division of The Rank Organisation.

North Atlantic Industries Inc., of Plainview, L.I., New York, manufacturers of instruments and servo devices, have appointed Aveley Electric Ltd., of South Ockendon, Essex, as their exclusive U.K. representatives.

G.E. Industrial Supplies Ltd., of 3 Percy Street, London, W.1, have been appointed U.K. agents for **Industrial Electronic,** aerial manufacturers of Copenhagen, and the American manufacturers **Pendar Incorporated** whose products include illuminated push-button switches and indicator lamps.

AEROSPACE TELEMETRY—Some Recent Developments

IN providing an instrumentation service for "vehicles" which have usually been under intensive development and investigation, aerospace telemetry has also tended to take on something of an experimental character. However, a considerable degree of finality has now been reached with many projects, so that their telemetry requirements have become much less fluid. In turn this has meant that it has been possible to "freeze" at least some of the elements of these telemetry systems during the past few years.

As a result, standardized modular units have made their appearance on both sides of the Atlantic and, especially in the U.S., complete telemetry system packages have been produced, often associated with a particular missile or satellite programme. Furthermore manufacturers in the U.S. have been encouraged in this policy by the establishment of standards for telemetry system characteristics from as early as 1948. These standards have been revised and the present Inter-Range Instrumentation Group (I.R.I.G.) standards cover a wide variety of system arrangements.

Similar standardization has, of course, been carried out in the United Kingdom and linked with the range programmes, as for example in Australia. In general, for a number of reasons—particularly relative sizes of missiles and scales of operation—the U.K. systems are apt to be much less complex than their American counterparts.

Two illustrations of this approach can be quoted from the Sept., 1963, International Telemetering Conference in London. The first was a neat and simple solution to the problem of obtaining accurate event marking with the relatively slow speed "465" time division analogue telemetry system.

In this system multiplexing of the data signals is carried out by a 24-channel mechanical sampling switch with a nominal frame rate of 80 c/s (i.e., one 24 channel frame occupies a period of just over 10 msec). The composite multiplexed signal is applied to a sub-carrier f.m. oscillator with a range of 130-160 kc/s, which is fed in turn to the a.m. radio-frequency output stage. The preferred method which gave event marking without demanding modification of existing equipment, was based on the injection into the sub-carrier f.m. stage of a marking oscillator signal with a frequency outside the working band. This principle has been applied for single event marking by embodying it in an override technique. In this case the "event pulse" depresses the sub-carrier frequency beyond its normal band for the relatively short period of 2 msec, so that the loss of data is small. On the ground the pulse is extracted by wideband short delay networks in the receiver.

The other illustration, due to E.M.I. Electronics Ltd., was a sensitive frequency modulator for use with systems of the "465" type. Shown at the International Telemetering Exhibition in "breadboard" form, this modulator makes it possible to dispense with d.c. amplification of low level (millivolt) signals from thermocouples, strain gauges, etc., and hence to eliminate one source of drift in analogue systems. The necessary amplification still has to be provided but this is achieved at carrier frequency. The action of the modulator depends on the reactive current in a tuned circuit being zero; and this principle is applied to a reactance modulator where the variable reactance is an amplitude modulator followed by a current amplifier. The input of the amplitude modulator is fed with a sample of the oscillator current phase-shifted by 90 degrees in addition to the data signals. As a result, the oscillator frequency varies with the input signal to give the desired frequency modulation while the reactive current in the tuned circuit is kept at zero.

Another aspect of the art, discussed at the International Telemetering Conference, was that of the desirability or otherwise of having available a visual record of telemetry data. With ever-increasing numbers of measurement channels required for complex trials and investigation programmes, it becomes almost inevitable that analysis of data ceases to be carried out by visual inspection, and complete reliance is placed upon computers. However it was agreed that a graphical pilot record—the so-called "quick-look" record—provided a means of detecting physical trends and their interrelation.

Therefore there is still a demand for accurate graphical presentation of telemetry data in "real time," and in addition for instantaneous monitoring facilities for use by operational staff. Thus at the extremely large "Data Central" installed in the Goddard Space Flight Center, Greenbelt, Maryland, four cathode ray tube displays are provided for this purpose, each capable of showing up to 150 channels. These displays enable satellite system deterioration and catastrophic faults to be detected, in addition to giving checks of system operation during pre-flight testing.

The high-speed tape recorder is becoming the universal medium for data recording. One of the main problems is the maintenance of a constant tape speed to the order of accuracy required for telemetry purposes, particularly where high frequency response is involved. This is especially relevant with regard to what has become known in the U.S. as "Intrachannel Time Displacement Error." I.T.D.E. is a function of the difference between the tape speed when recording and when reproducing, and has an instantaneous and a long-term aspect. The long-term value can be reduced by several orders by servo control relative to a recorded time reference signal. This method, however, tends to increase the instantaneous error because of the inherent lag in the servo system. Clearly if the mass of the mechanical elements of the servo system can be reduced, following is improved and instantaneous I.T.D.E. is brought down.

The Sangamo Electric Company claim to have developed a system with sufficiently low following error to give practically negligible instantaneous displacement error. Values given for the higher tape speeds, where the problem is easier, are 10 μsec for 30 in/sec, 5 μsec for 60 in/sec, and 3 μsec for 120 in/sec. The system is based on eddy current braking of a thin copper disc, the braking current being the speed correcting error signal. The latter is derived from two error detecting sub-systems. One of these is a frequency discriminator with a centre frequency equal to that of the recorder stable crystal reference, and the other is a phase comparison bridge fed from the reproduced tape reference signal and the crystal reference. The two outputs are combined and after power amplification are fed to the winding of the braking electromagnet. R. E. Y.

MANUFACTURERS' PRODUCTS

NEW ELECTRONIC EQUIPMENT AND ACCESSORIES

Miniature Capacitors

SILVERED mica capacitors in values from 10 to 2,000 pF are available from Alston Capacitors Ltd., of Diss, Norfolk. The components are epoxy-resin encapsulated and meet the DEF5132 specification to H1 humidity category from −55 to +125°C.

4WW 383 for further details

Colour Television Monitor

IN anticipation of the development of colour television broadcasting in Europe, Standard Elektrik Lorenz A.G. have developed in their Schaub-Lorenz division at Pforzheim a transistor monitoring receiver using a rectangular shadow mask tube giving a picture of 28 × 21 cm. Silicon planar transistors (BFY37 and BFY39) are used in the line timebase and the circuit is subdivided into plug-in (DIN41 490) printed circuit units performing separate functions. Front controls include the usual contrast, brightness, saturation, line and vertical hold.

4WW 384 for further details

Low-frequency Signal Generator

SINE or square wave outputs may be obtained over a frequency range of 5 c/s to 125 kc/s from the SG66 low frequency signal generator manufactured by Advance Components Ltd., Hainault, Essex. The output voltage may be read from a calibrated voltmeter. The sine wave output has an impedance of 5 or 600Ω. At the full output of 1 W, the distortion is less than 0.5%; hum and noise level is less than 0.25% of full output. The rise-time of the square wave is not greater than 0.75μsec at all frequencies.

The frequency coverage of the instrument is achieved in five ranges and the accuracy of calibration is within ±1%. The cost is £65 and a mains power supply of 100/130 or 200/260 V 40 to 60 c/s is required. The dimensions are $16\frac{1}{2} \times 10\frac{1}{2} \times 8\frac{3}{4}$in.

4WW 385 for further details

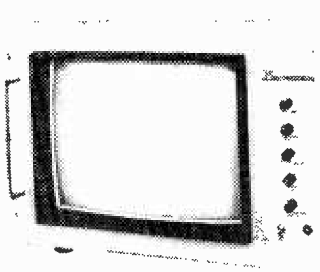
Audio Amplifier

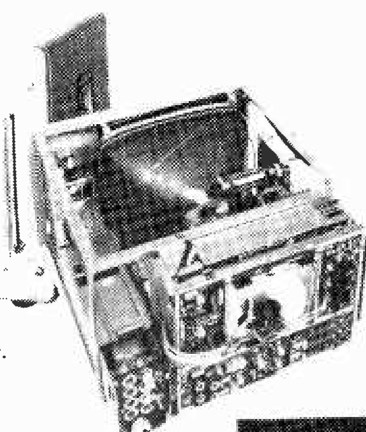
A MINIATURE audio amplifier suitable for the audio stages of a car radio receiver, high-power domestic radio and record player is available from Newmarket Transistors Ltd., Newmarket, Suffolk. The power requirement of the amplifier, which is transformerless, is 12 V (direct). The input impedance is 1 kΩ and two versions, differing in sensitivity, are available. The PC5 requires an input signal of 50 mV r.m.s. for 3 W output, the PC5+, 5 mV for 3 W output. At this output, and with a 1kc/s signal, the total distortion is 3%. The frequency response extends from 50 c/s to 15 kc/s. The amplifier operates satisfactorily over a temperature range of 0 to 45° C. Weighing only 2 oz, the dimensions are $5\frac{1}{2} \times 1\frac{3}{4} \times \frac{3}{4}$ in.

4WW 386 for further details

Synthetic Sapphire Components

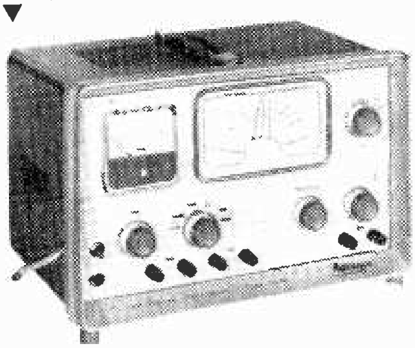
WINDOWS for optical and microwave applications are fabricated in synthetic sapphire by Agate Products Ltd. of Sutton, Surrey Discs from

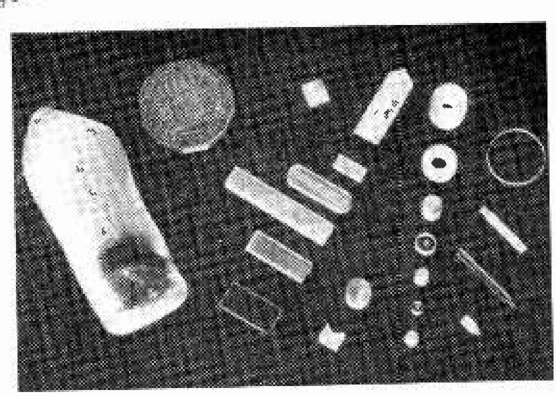




▲ *S.E.L. colour television monitor.*

Type SG66 low frequency signal generator manufactured by Advance Components. ▼





▲ *Synthetic-sapphire components manufactured by Agate Products.*

¼ in to 2 in in diameter are available in various thicknesses—down to a possible 0.002 in with a 2-micron surface polish.

Optical transmission to 1700 angstroms in the ultra violet and 5.5 microns in the infra red makes the material particularly useful for the protection of space vehicle solar cells while the low losses, high dielectric constant and mechanical stability suggest useful applications in the microwave field.

4WW 387 for further details

Television Mains Rectifier

A SILICON rectifier, intended for use in television receivers, is available from Ferranti Ltd., Hollinwood, Lancs. Designated the Type ZS800, the diode has a maximum peak recurrent reverse voltage of 800 V and a peak transient reverse voltage of 1,350 V. The maximum recurrent peak current is 5 A, the peak surge current being 50 A maximum. The case of the rectifier is isolated from the mains. The overall length of the body is 0.48 in. The maximum diameter is 0.255 in and connection is by means of flexible leads.

4WW 388 for further details

Transistor Oscillator

THE range of S.T. and C. transmission testing apparatus has been increased by the production of a transistor oscillator covering from 10 kc/s to 20 Mc/s in 8 ranges. The instrument is powered by dry batteries housed within the case, but an external d.c. supply may easily be connected. When the lid of the oscillator is closed, a safety switch disconnects the power supply.

The output is thermistor stabilized and can be adjusted from 0 to −50 dBm into 75 Ω unbalanced circuits. By means of a transformer and "U" link the output can be fed into 140 and 600 Ω balanced circuits at frequencies up to 600 kc/s. The output monitoring meter can also be used for checking the power supplies.

Designated the Type 74306-A, the instrument weighs 15 lb and measures 16¼ × 12½ × 7 in. It can be obtained from the Transmission Systems Group, Standard Telephones and Cables Ltd., North Woolwich, London, E.16.

4WW 389 for further details

Transistor Curve Tracer

THE Transiscope TS/01 transistor curve tracer, available from A.E.S. Electronics Ltd., Theobalds Road, London, W.C.1, has a 3-in diameter display tube upon which a family of ouput characteristic curves of collector current against collector volts may be displayed. The characteristics of two transistors can be displayed simultaneously. The instrument can also be used for the measurement of β, I_{co} and collector to emitter leakage current. These values are directly indicated on a meter. The collector volts can be varied from 2 to 48 V, the maximum collector current being 1 A. β can be measured on 0-100 and 0-300 ranges of the meter. The range of base current extends from 5 μA to 5 mA. A 200/250 V alternating mains supply is required.

4WW 390 for further details

Coaxial Cable

TWO low-loss, television down-lead cables have been introduced by the Cable Division of Associated Electrical Industries Ltd., Hatton Garden, London, E.C.1. Both types have a stranded, copper wire inner conductor insulated with cellular polythene. The copper wire braid is sheathed with brown p.v.c.

Cable, Type 75/R/12 is a general purpose cable, whereas the Type 75/R/9 is intended for use in "fringe" areas. This latter variety is a larger cable with a lower loss. The nominal impedance of both cables is 75 Ω. At 200 Mc/s the attenuation in dB/100ft is 2.8 for the g.p. cable and 2.3 for the low loss type. At 800 the figures are 5.8 and 5.3 dB/100ft. The velocity ratio of both types is 0.81.

4WW 391 for further details

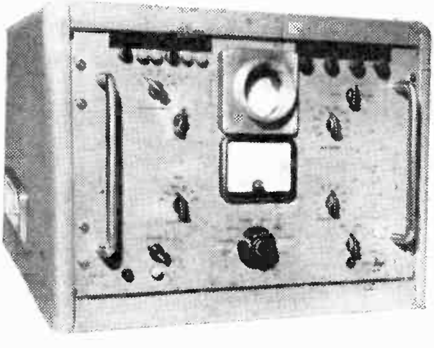
Miniature Collet Knobs

A FEATURE of the new range of miniature collet knobs developed by the Plessey Company Ltd., Titchfield, Hampshire, is that the same basic phenolic moulding can be fitted to shafts of both ⅛in and $\frac{3}{16}$in diameter, using alternative collets.

▲ S.T.C. transistor 10kc/s to 20Mc/s oscillator.

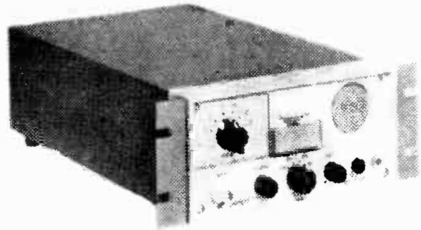
▲ Plessey miniature collet knob.

Transiscope TS/01 (transistor curve tracer) available from A.E.S. Electronics.
▼

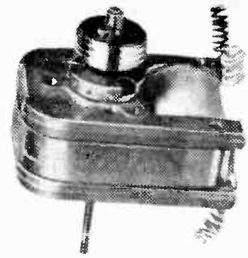


The knob assemblies require a radial groove in the shaft and a slot across its end. Tightening the locking screw contracts the collet so that it locates in the radial groove; this prevents the knob from being pulled off the spindle. The drive is transmitted by a key which engages in the slotted end of the spindle.

4WW 392 for further details



▲ *Gertsch standard- frequency receiver Model RHF-1 is available from Wayne Kerr.*



▲ *Sigma Cyclonome Model 9AB2 stepping motor. A maximum stepping rate of 400 steps per second may be attained.*

Standard-frequency Receiver

A TRANSISTOR, superheterodyne receiver of high sensitivity designed for the reception of all international standard-frequency transmissions is announced by Wayne Kerr. Applications of the Wayne Kerr-Gertsch, Model RHF-1 include precision time measurement, reception of standard audio frequencies and pulse code modulation. Output terminals are provided for oscilloscope connection. The receiver can be powered by 115/230V a.c. mains or by a 12V battery. Operating frequencies are 2.5, 5, 10, 15, 20 and 25Mc/s, but up to three frequencies between 2.5 and 25Mc/s may be added. The working sensitivity is 1μV. Normally a bench mounting receiver, it can easily be adapted for rack mounting.

4WW 393 for further details

Stepping Motors

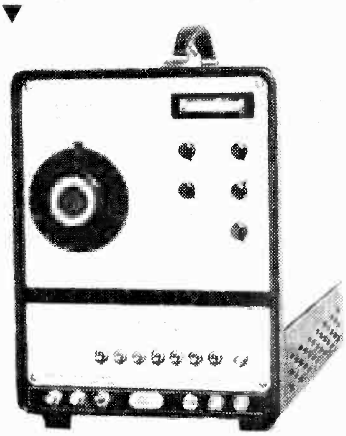
SINGLE-PHASE, high-torque, synchronous stepping motors designated "Cyclonome" motors are obtainable from Ad. Auriema Inc., 414 Chiswick High Road, London, W.4. Torque can be developed in 18° steps over a wide range of stepping speeds with "instant" stop and start action. Motors from the series can be driven from mains, oscillators, flip-flop circuits, relays or manual switches. A typical model of the range, the Type 9AB2, has a maximum stepping rate of 400 steps per second with damping or 50 steps per second without damping.

4WW 394 for further details

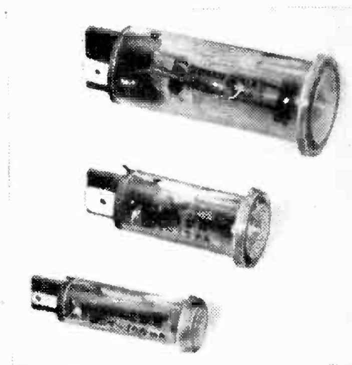
V.H.F. Sweep Generator

A FREQUENCY range of 20 to 220 Mc/s is covered by the Telonic Model SV-13 sweep generator. The instrument, which is marketed in the U.K. by Livingston Laboratories Ltd., Camden Road, London, N.W.1, was designed primarily for the alignment of television and v.h.f. equipment. Thirteen plug-in units are used to cover the frequency range; channels for American, Australian, Italian and other European television standards are available. The sweep width for r.f. stages is variable from

The Telonic sweep generator Model SV-13 available from Livingston Laboratories. ▼



Cerberus neon indicator units. ▼



5 to 20 Mc/s and for the i.f. stages, variable from 10 to 40% of the centre frequency. The metered output is variable from 3.5μV to 1 V r.m.s. into 75Ω. Pulse-type markers are provided at the appropriate sound and video frequency spacing. The price of the basic instrument is £280. R.f strips vary from £7 to £8 5s dependent on the frequency required.

4WW 395 for further details

Neon Indicating Units

NEON indicators from the Cerberus G.F.-range of components are available in three sizes. The units are easily mounted by a "push-fit" into a circular hole. A range of colours are available and the indicators can be supplied with either square or round fronts. Dependent on the size required, 100/130 or 200/250V versions may be obtained. The U.K. agents for these indicators are Walmore Electronics Ltd., Betterton Street, Drury Lane, London, W.C.2.

4WW 396 for further details

Instrument Trolley

WHEN it is found necessary to convey test instruments for routine testing or maintenance, the Avoncel TM2SE test instrument trolley provides many facilities. The basic trolley is constructed of heavy gauge steel and rectangular-section steel

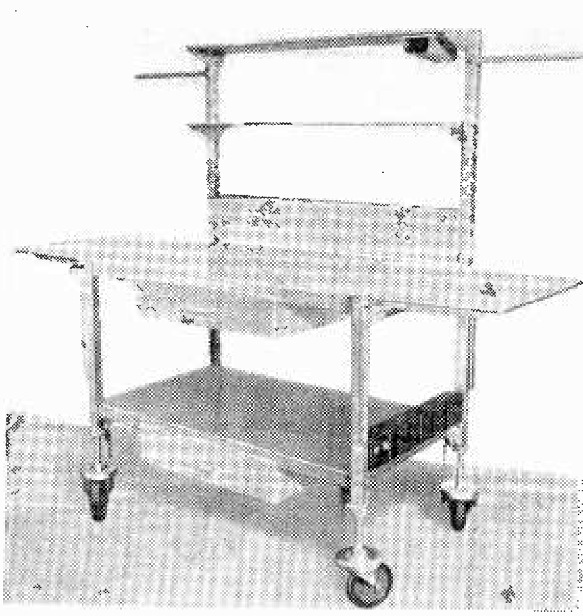
INFORMATION SERVICE FOR PROFESSIONAL READERS

To expedite requests for further information on products appearing in the editorial and advertisement pages of *Wireless World* each month, a sheet of reader service cards is included in this issue. The cards will be found between advertisement pages 32 and 35.

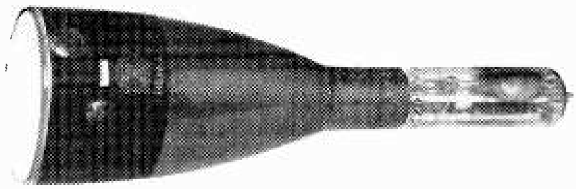
We invite readers to make use of these cards for all inquiries dealing with specific products. Many editorial items and all advertisements are coded with a number, prefixed by 4WW, and it is then necessary only to enter the number(s) on the card.

Readers will appreciate the advantage of being able to fold out the sheet of cards, enabling them to make entries while studying the editorial and advertisement pages.

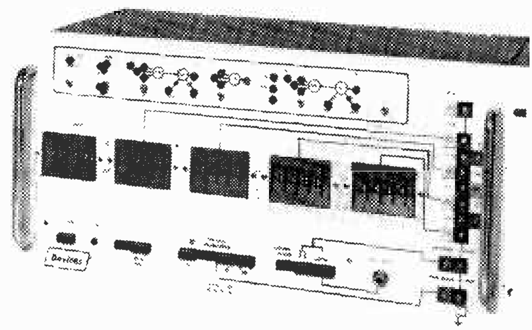
Postage is free in the U.K., but cards must be stamped if posted overseas. This service will enable professional readers to obtain the additional information they require quickly and easily.



▲ *A comprehensive instrument trolley developed by Avon Communications and Electronics Ltd.*



▲ *Cathode ray tube Type T948H manufactured by the English Electric Valve Company. Two phosphors are available.*



▲ *Devices " Digitimer " (digital time marker).*

tubing welded to provide two side sections to which the top and bottom shelves are bolted. The height of the trolley may be adjusted between 30 and 36in. The main shelves constructed from $\frac{1}{8}$in steel plate, are 18in apart and the dimensions are 42×24in. The trolley runs on heavy-duty Flexello castors using ball bearing swivels. Accessories include side extension shelves, handbook rack, two supplementary shelves, drawer assembly and an asbestos-insulated electric soldering iron holder. Two of the castors are fitted with braking facilities and the trolley can carry an 800lb load. Power distribution is effected by five 3-pin sockets and 30ft of 3-core mains cable; a mains switch and neon indicator are provided. The manufacturers, Avon Communications and Electronics Ltd., Christchurch, Hampshire, can provide linoleum, rubber or Formica surfaced shelves if required. A fully equipped trolley costs £98 15s. The basic unit is approximately £60.

4WW 397 for further details

Core Stores

A RANGE of standard magnetic core stores are available from Mullard. They have been designed to meet most applications in computer, data processing and other similar fields. A series of stores with a cycle time of 2 μsec and capacities of up to 16,384 words are included in the range. Previous stores were custom manufactured, thus the new range, being manufactured on a production basis, will cost less and can be obtained quicker.

The 16D2 Series of random-access, coincident current stores is characterized by the availability of standard capacities of 16,384, 4,096 and 1,024 words of up to 50 bits each. The minimum cycle time for a read-rewrite cycle is 2 μsec and the access time is not greater than 1 μsec. The 4B6 series of random-access stores has a maximum word capacity of 4,096 words of 40 bits. The minimum cycle time is 6 μsec and the access time is not greater than 2 μsec. The stores of the 4C20 series are compatible with the range of 100 kc/s encapsulated circuit blocks marketed by Mullard Equipment Ltd. and the standard capacities available are 256, 1,024 and 4,096 words.

4WW 398 for further details

Time Interval Marker

ELECTROPHYSIOLOGICAL investigations frequently require the use of a cathode ray oscilloscope to plot the time course of the electrical activity evoked by a stimulus. To effect this, there should be provision for adjusting the repetition rate of the stimuli, a means of calibrating the time axis of the oscillograph and the possibility of triggering the oscilloscope timebase and stimulus generator at pre-determined times within the period of the experiment. The transistor "Digitimer," manufactured by Devices Ltd., Welwyn Garden City, Herts., provides all these facilities. A time scale derived from a crystal-clock pulse generator drives several ring-of-ten dividers to give time markers within the range 0.1msec to 100msec. Square waves are provided by the instrument and sufficient power is available to operate relays.

4WW 399 for further details

Delay Lines

LOW-COST delay lines for use in colour television receivers (SECAM) are being produced by C.S.F., boulevard Haussmann, Paris. Constructed from mild steel, the tolerance for the nominal delay time of the line is ±0.17μ sec over a temperature range of 20 to 55° C. The bandwidth of the line is 2 Mc/s, the centre frequency being 4.43 Mc/s. Between 3.4 and 5.4 Mc/s the attenuation reaches a maximum of 24 dB. The transducers at either end of the line are lead-titanate piezoelectric ceramics, the thickness being such that the frequency of the shear wave used for transferring the signal corresponds to a frequency of 4.43 Mc/s. The overall dimensions are 22×1.7×1.7 cm. The weight is 235 gm.

4WW 400 for further details

Cathode Ray Tube

A 5-in cathode ray tube has been developed by the English Electric Valve Company for use in wide-band, high-speed oscilloscopes. The deflection sensitivities in x and y directions are 3 and 9 V/cm respectively. The p.d.a. mesh is positioned a few millimeters from the phosphor screen. This reduces raster distortion and improves the stability of the x and y deflection sensitivities to changes in temperature. Two phosphors are available; the type T948H tube has a blue green afterglow (equivalent to P31), the Type T948N version is characterized by a yellowish green afterglow (equivalent to P2). Both versions have medium short persistance. The tubes are manufactured by the English Electric Valve Company Ltd., Chelmsford, Essex.

4WW 401 for further details

Porcelain Capacitors

SUITABLE for high-voltage, large-current radio frequency applications, Vitramon Laboratories of Harmondsworth, Middlesex, present their first "all-British" component. These are comparatively small porcelain capacitors designed to pass currents of up to 60A at 2000V r.m.s. in the frequency range 2 to 30 Mc/s. The preferred working temperature range is −40 to +100°C; the maximum temperature, however, is +150°C. Standard values ranging from 250 to 2,000pF, are available but others can be produced to special order. The power factor is quoted as being less than 0.002 at 1 Mc/s (125°C). The dielectric strength is 4,000 V d.c. (at 25°C for 10 sec.).

4WW 402 for further details

Phase-comparison Receiver

PRECISION oscillators may be standardized against v.h.f. standard-frequency transmissions with the Wayne Kerr—Gertsch, transistor v.h.f. phase comparison receiver Model PCR-1. The instrument is intended for use with local frequency standards accurate to 1 part in 10^7 or better. It has a built-in, strip-chart recorder and a two-speed, phase-locking servo system providing a very narrow effective bandwidth. Four transmissions can be switch selected within the frequency range 10 to 100 kc/s. The PCR-1 operates to a sensitivity of 0.1 μV into 50 Ω for stable, phase-locked tracking. Measuring 19in × 7in × 14in, the receiver can be obtained from The Wayne Kerr Laboratories Ltd., New Malden, Surrey.

4WW 403 for further details

Television Monitor

A NEW range of television receivers have been introduced recently by Rank-Bush Murphy Electronics, Welwyn Garden City, Herts. The precision, television monitor MR752 from this range is a 14-in, 405, 525 and 625 line monitor designed for 19-in rack mounting, but can also be obtained as a free-standing version. The receiver can adapt itself to the scanning standard of the incoming signal without manual adjustments. Variations include receivers for u.h.f. or v.h.f./u.h.f. sound and vision reception and receivers suitable for reception of N.T.S.C. colour signals.

4WW 404 for further details

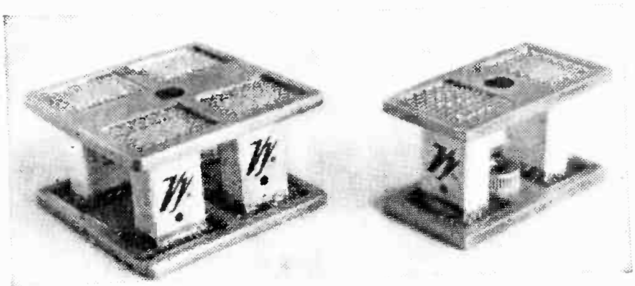
Tunable Filter

THE Allison Laboratories Model 2A tunable filter is a passive network device with independent high cut-off and low cut-off sections. The maximum passband is 15 c/s to 10 kc/s or, if the high cut-off section only is used, from z.f. to 10 kc/s. The maximum input is 1 V r.m.s. and both input and output impedances are 600 Ω. The insertion loss does not exceed 2 dB and the attenuation rate is 30 dB/octave. Cabinet and rack mounting versions are available in the U.K. from Livingston Laboratories Ltd., Camden Road, London, N.W.1. The cost of the Model 2A is £206 exclusive of duty.

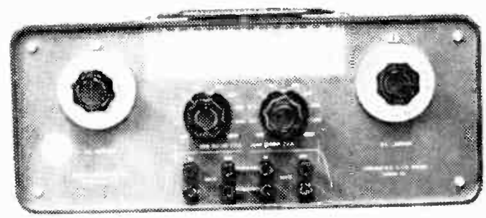
4WW 405 for further details

Audio-band Pre-amplifier

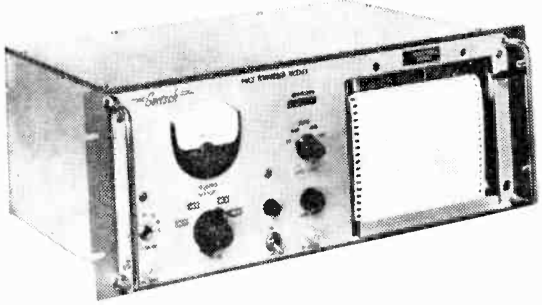
THE frequency response of the Furzehill Type P.A. 80 low noise, audio-band pre-amplifier extends



▲ *Porcelain capacitors manufactured by Vitramon Laboratories Ltd.*

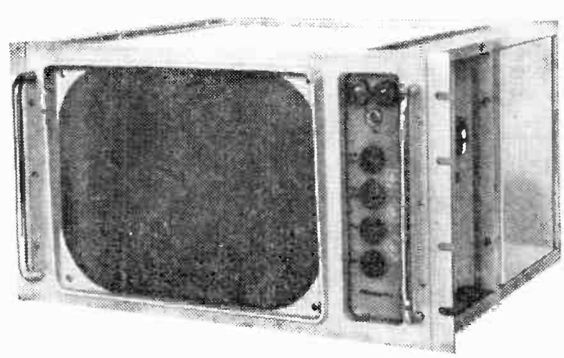


▲ *Allison Laboratories Inc. audio tunable filter Model 2A*



▲ *Wayne Kerr—Gertsch transistor v.h.f. phase comparison receiver.*

The 14-in television monitor Type MR752 manufactured by Rank-Bush Murphy Electronics is suitable for 405, 525 and 625 line systems. ▼



from 20c/s to 20kc/s ±1dB. The equipment is battery operated, 3 internal 4V Mallory cells providing 350 hours operating life before replacement. The voltage gain is 34dB and the signal to noise ratio is better than −6 dB at 1mV input. The harmonic distortion is less than 0.3% at 150mV input. The pre-amplifier can be operated in an ambient temperature of up to 45°C. The input impedance is greater than 30kΩ, the output being less than 100Ω. The dimensions of the instrument are $3\frac{1}{2}\times1\frac{1}{8}\times2\frac{1}{4}$in. The manufacturers are Furzehill Laboratories Ltd., Borehamwood, Hertfordshire.

4WW 406 for further details

Plug-in Decade

TWO inexpensive decade assemblies, suitable for incorporating into counting equipments, are announced by Panax Equipment Ltd., Redhill, Surrey. The unit, Type TD1, has scaling rates of up to 5,000 counts per second and has a resolution time of 200 μsec. The TD 2 has a maximum scaling rate of 50,000 counts per second and a 20 μsec resolution time. The decade tube in the former assembly is a Type Z504S, that in the latter is a Z505S. Both units require a 12 V power supply and driving pulses of 12 V (positive) are required.

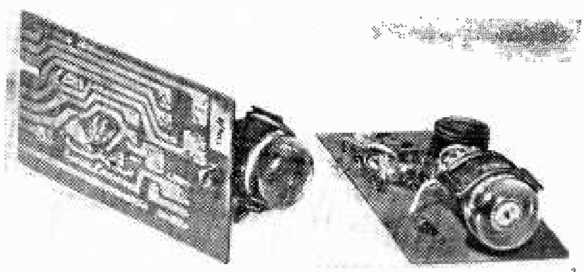
4WW 407 for further details

Transistor and Diode Tester

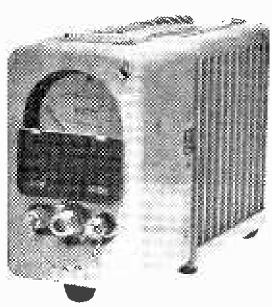
THE SERIES 250 Fairchild transistor, multi-parameter tester presents many interesting features. Up to 16 separate tests can be performed on a component in two seconds. Individual red lights on the front panel of the equipment indicate which of the tests the transistors fail. The tester can be programmed for routine testing and sorting and, once programmed, can be operated by unskilled personnel. The regulation of the power supply is better than 0.05%. The transistor under test is inserted into the test head and the shield closed. The operator observes the "go/no go" conditions on the light indicators and the component can then be removed.

A "classification" chassis can be obtained which counts the number of times rejection of a test occurs. Counters are provided for each test, the total number of rejects and the total number of transistors tested. An additional facility enables the sixteen tests to be grouped into a classification. This consists of pass and reject combinations. Counters are provided to count the number of transistors that fall into 9 classifications (or fewer). The equipment is marketed in the U.K. by Aveley Electric Ltd., South Ockendon, Essex.

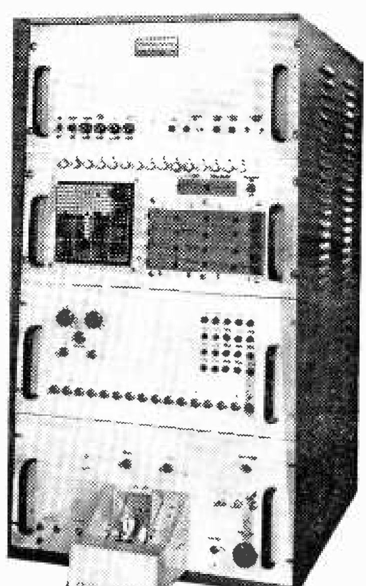
4WW 408 for further details



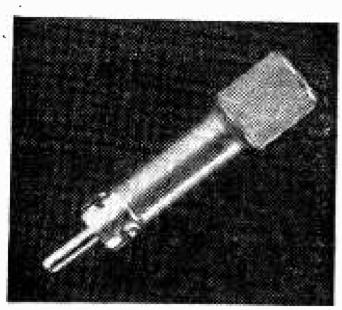
▲ Plug-in decade assembly manufactured by Panax Equipment Ltd.



▲ Direct-reading r.f. wattmeter manufactured by Bird Electronic Corporation.



▲ Fairchild Series 250B semiconductor tester (distributed in the U.K. by Aveley Electric Ltd.)



◀ Coaxial attenuator plug introduced by A.E.I.

R.F. Wattmeter

A WATTMETER consisting of a coaxial resistor within a finned radiator and a dual-range crystal voltmeter designated the Model 612 Termaline r.f. load wattmeter can be used over the frequency range 30 to 500 Mc/s. The power ranges are 20 and 80 W full scale with reading accuracy of ± 5% of full scale. A direct-reading instrument, it can be used for absorbing and measuring r.f. power in 50 Ω coaxial systems. The wattmeter is manufactured by the Bird Electronic Corporation and is available in the U.K. from Livingston Laboratories Ltd.

4WW 409 for further details

Coaxial Plug

A NEW coaxial plug produced by the Telecommunications Division of A.E.I. Ltd., Woolwich, enables an attenuating resistor to be wired within the body of the plug. It is envisaged that the plug will be of particular value to the hi-fi community who wish to adjust signal levels from microphones, tape recorders and pickups to a level acceptable to a common pre-amplifier.

The plug, produced in tinned brass, with an inner conductor of nickel-plated brass will, accept coaxial cables up to $\frac{3}{16}$in diameter. Suitable for use with the existing range of A.E.I. single and multi-way coaxial sockets, the new plug has an overall diameter of 0.430 in.

4WW 410 for further details

THEVENIN AND NORTON

By "CATHODE RAY"

BOOKS on the principles of circuits usually contain a section on circuit theorems. Prominent among these are Thévenin's and Norton's. They are, as it were, the two sides of one coin, either of them being derivable from the other by turning it upside down; more specifically, by applying the principle of duality.

Before we get on to that I would remark that it is rather odd that both Thévenin and Norton seem to have questionable titles to these theorems. The late Prof. G. W. O. Howe pointed out* that Helmholtz anticipated Thévenin by 30 years, though he agreed later in correspondence with me that Thévenin deserves some credit for stating the theorem more clearly and giving it publicity. In the same article he also credited H. Wigge with what is generally called Norton's theorem, after E. L. Norton of the Bell Telephone Laboratories. So far I have been unable to track down any reference to a publication of this theorem by him, to compare with Wigge's.

But that is by the way. For convenience I shall here use the generally accepted names, without prejudice to any claims the ghosts of the interested parties may care to lodge. And although Thévenin's theorem was originally stated for d.c., its later extension to a.c. is assumed.

Norton's, as I said, is the dual of Thévenin's, and *vice versa;* which means that one can be derived from the other by interchanging resistance and conductance, current and voltage, and series and parallel. Thévenin's is sometimes called the equivalent series (or voltage) generator theorem, because in effect it replaces any actual source of power (a) in Fig. 1, however complicated its circuit, by an ideal constant-voltage generator in series with a single impedance Z, as in (b). The voltage E of this generator is equal to the open-circuit terminal voltage of the real generator, and the impedance is as measured at the output terminals of the real generator, with its voltage(s) reduced to zero. In Norton's theorem the replacement is an ideal current generator in parallel with the same impedance (c), the current I being that which the real generator would supply to a short-circuit.

A reader has written to say he finds some aspects of this rather puzzling. "When converting a voltage source of internal impedance Z to its current dual," he says, "how does one account for the power dissipated on open circuit when the energy is supplied by a constant-current source?"

His difficulty seems to be that removing the load Z in Fig. 1(b) interrupts the flow of current and therefore the dissipation of power in Z, whereas doing the same thing in (c) results in the full current I flowing through Z and therefore power therein is a maximum.

The answer to this particular query is simple; namely, to remember that (c) is the dual of (b), and that the dual of an open-circuit is a short-circuit. So the correct way to remove the load in (c) is to short-circuit it; this removes all current from Z, just as the open-circuit does in (b). (To carry out the dual transformation thoroughly, Z and Z_L should be replaced in (c) by Y and Y_L, the corresponding susceptances, equal to $1/Z$ and $1/Z_L$.)

Similarly, corresponding to open-circuiting Z_L in (c), which leads to maximum power loss in Z, is short-circuiting Z_L in (b), which does the same. Put another way, zero Z_L in (b) is the dual of zero Y_L in (c).

If anyone is getting worried about the possible consequences of short-circuiting Z in (c), thereby removing all visible impedance in the circuit, I would remind him that, according to the terms of the theorem, I is constant, so cannot increase without limit as he may have feared.

Are the maximum internal power losses in (b) and (c) equal? For values of Z_L in general, the values of E, I and Z must be such that (b) and (c) are exactly equivalent, at least as regards the load (which is all the equivalence claimed by Thévenin and Norton). Take the voltage across Z_L, for example:

$$V_L = \frac{EZ_L}{Z + Z_L} = \frac{IZZ_L}{Z + Z_L}$$

$$\therefore E = IZ$$

(Although I haven't troubled the printer to use heavy type for Z and Z_L, they are of course vector quantities and must be treated accordingly.)

Now on no-load the power loss in Z in (c) is I^2R (where R is the equivalent series resistance of Z), and in (b) is $I_1{}^2R$ (where I_1 is the current). I_1 is E/Z, which we have just found to be equal to I, so the maximum amount of power dissipated in the generator's internal resistance is the same in both (b) and (c).

But is it the same in the real generator? Thévenin and Norton did not say that it was. But the Editor of *Industrial Electronics*† fears that present-day students might wonder. If so they would find it instructive to consider a numerical example; for

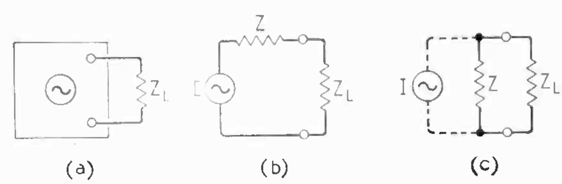


Fig. 1. A generator or signal source of any kind, feeding a load impedance Z_L, is represented by the box in (a). The alternative series and parallel "equivalent" generators are shown at (b) and (c) respectively.

*Wireless Engineer, July 1943, pp. 319-322.

† September 1963 p. 606.

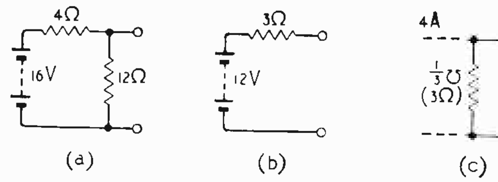


Fig. 2. Simple d.c. example of Fig. 1.

simplicity, d.c. Fig. 2(a) is the real circuit, and (b) and (c) the equivalents (so far as concerns whatever is connected to the terminals) according to Thévenin and Norton respectively. In both of them the equivalent internal resistance, which is equal to 4Ω and 12Ω in parallel, is 3Ω, though in (c) it is more correctly described as a conductance of ⅓ mho (denoted by ℧). The matching load is therefore 3Ω.

I have calculated the load power and the internal loss power in watts for all three circuits for the values of load resistance shown in the first column.

	Load				Circuit: (a)	(b)	(c)	All
	R_L ohms	$\frac{R_L}{R_O}$	G_L mhos	$\frac{G_L}{G_O}$	Internal dissipation, watts			Load watts
S/C →	0	0	∞	∞	64	48	0	0
	¾	¼	1⅓	4	46.75	30.75	1.92	7.68
	1½	½	⅔	2	37.3	21.3	5.33	10.66
Matched →	3	1	⅓	1	28	12	12	12
	6	2	⅙	½	21.33	5.33	21.3	10.66
	12	4	$\frac{1}{12}$	¼	17.92	1.92	30.75	7.68
O/C →	∞	∞	0	0	16	0	48	0

These wattages are all plotted against load resistance in Fig. 3.

The truth of our two theorems allows one output power column to serve for all three circuits. Fig. 3 illustrates the truth of another theorem—the one that says maximum output is obtained when the load resistance is equal to the internal resistance (i.e., when the load is matched to the generator.) With a.c., the load and generator impedances must be conjugates. We also see that the further statement that under matched conditions the efficiency is 50% is true, in this example, of the two equivalent circuits (internal and external power being each 12W) but is untrue for the real circuit, whose efficiency is only 12/(12 + 28) = 30%.

This, of course, answers our question: The equivalent generators are *not* equivalent internally. Nobody said they were, but it is nice to know.

In passing we might note that the matched condition isn't always necessarily the best. Using double the matched load resistance drops the output power by only 11% but the loss in the series equivalent is more than 55% less and the efficiency is raised to 66⅔%. With fourfold load resistance it is 80%. On the other hand, reducing the load resistance is bad both ways. The graph shows plainly that with the real generator the maximum improvement in efficiency is much less; hardly worth the reduction in output obtained by mismatching.

Closer examination reveals the interesting fact that the amount by which the power loss in the real generator exceeds that in the equivalents is constant with load resistance and is therefore equal to its no-load loss. So the loss figures for the equivalent generators indicate the *increase* in loss in the real generator due to the load. Is this a coincidence, true only of Fig. 2(a), or does it hold in general? Prof. Howe made a somewhat similar calculation* for quite a different form of circuit, with different values, and obtained the same result. With a little straightforward (if slightly voluminous) algebra one can easily prove it to be true for all generator circuits of the form shown in Fig. 2(a) regardless of resistance values. Perhaps one of our bright readers will prove it for generators in general and thereby earn the right to introduce it as a theorem under his own name.

Prof. Howe's object was to investigate an assertion by a Dr. Bernard Salzberg in the same issue, that (in relation to valve equivalent circuits at least) the series equivalent was more fundamental than the parallel. After some initial scepticism, Prof. Howe came out with some qualified support for Dr. Salzburg. He noted, as we have just done, that the series circuit gives the power supplied to the load and also the increase of internal loss due to it, and went on: " The parallel circuit gives the power supplied to the load, but not the internal loss directly; it can be obtained by modifying the load in a manner that is of little more than academic interest " (which manner he did not specify).

Perhaps the greater familiarity we have now with such sophistications as duality and normalization have made what was academic in 1947 quite practical in 1964, and Prof. Howe would have written differently now. Anyway, I am going to, by means

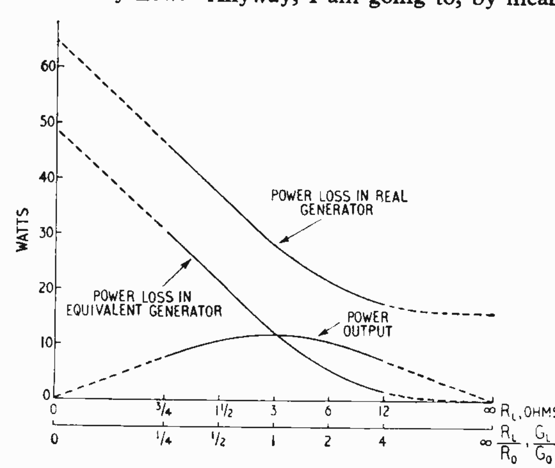


Fig. 3. Graph showing the power output of all three arrangements in Fig. 2, and the internal power loss in the real generator (a) for comparison with that in the "equivalents", (b) and (c).

of the three other columns under " Load." Nowadays we tend to give our graphs a more general application by the process called normalization. In Fig. 3, for example, the load resistance in ohms is significant only with the particular values shown in Fig. 2. The more generally significant quantity is the ratio of load resistance (R_L) to matched load resistance, which we will denote by R_O. If we rescale the load axis in R_L/R_O values, and the power axis in ratios of actual power output to output with matched load, the graph is immediately made to apply to all series equivalent generator circuits. And if the same scale is taken to signify also G_L/G_O,

* *Wireless Engineer*, April 1947, pp. 97-99.

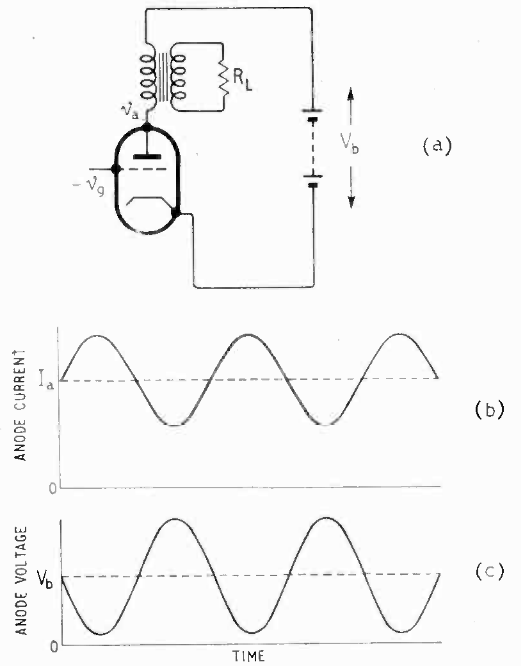


Fig. 4. The anode current and voltage of an amplifying valve (a) during a few cycles of a sinusoidal signal are shown at (b) and (c).

the ratio of conductances in the parallel circuit, the graph applies equally to it too.

To declare the series circuit more fundamental than the parallel—or *vice versa*—is, to my way of thinking, to act in contempt of the principle of duality. It is the sort of idea that Einstein effectively demolished with his relativity, by denying that any frame of reference is superior to any other. But while on the theoretical level there is no reason why one observation point should be preferred to any other, there are admittedly some sound practical reasons why we should prefer the Earth to (for example) Venus. In the matter of equivalent circuits, however, a simple modification of the load scale in Fig. 3, in full accord with contemporary practice, removes any superiority the series kind may have been able to claim in 1947.

By far the commonest use of the series and parallel equivalent generators, I would guess, is to represent valves. The fact that transistors now occupy more attention than valves is hardly likely to upset this guess, because such a representation of transistors is really too simple except perhaps at a very elementary stage. Anyway, let us consider valves. It must surely be obvious to the rawest beginner in such matters that whereas the real valve works by variations of d.c., regarded for convenience as steady d.c. with a.c. superimposed, the equivalent generators take account of the a.c. only. He could therefore hardly, at his most inattentive, imagine that the internal power loss indicated by equivalent-generator calculations could be even approximately the same as the power loss in the real valve, since most of the real loss is the d.c. part, which is there even when (above all when, actually, with Class A) the valve is supplying no a.c. output at all.

But some of the power relationships in valves and their loads are less obvious, even if again we exclude complications by taking the simplest possible case: an ideal valve (which means one whose characteristic curves are straight parallel lines; in one word, linear) driving a pure resistance load through an ideal 1 : 1 transformer in Class A (which means that the positive and negative half-cycles of anode current are equal). Fig 4(a) is the theoretical circuit diagram, and (b) shows the anode current alternating above and below its average value, I_a, during a few cycles of the signal. This anode current can therefore conveniently be considered as a steady d.c., I_a, with an a.c., i_a, superimposed. The purpose and effect of the ideal transformer is to insert the load resistance, R_L, in series with the valve for the a.c. without any loss of the steady component of anode voltage. A d.c. voltmeter (taking negligible current) would therefore show the full battery voltage, V_b, across the valve at all times. Likewise a d.c. milliammeter (having negligible impedance) would read I_a.

Now when this valve is working as indicated, the load is receiving some power. Otherwise the whole scheme would be pointless. Yet the power supplied by the battery is equal to V_bI_a whether the signal is on or off. Switching the signal on causes the load to receive power, where there was none before, yet the power supplied by the battery (which is the only source) is unchanged. Therefore, unless the laws of physics have gone haywire, the valve is receiving that much less than before. One may wonder why the presence of a.c. in the load resistance develops power there, whereas the same a.c. through the valve reduces the power there. Even when the alternations of anode voltage are plotted, as in Fig. 4(c), and are seen to be opposite in phase to i_a, the explanation may not be obvious. It looks as if decreases in anode current at any moment would be offset by simultaneous increases in anode voltage, and *vice versa*.

The simplest and quickest way of getting a clue to the problem is to suppose that the signal amplitude is sufficient to bring either anode voltage or current down to zero at its negative peak. Then clearly the power reaching the valve at such instants must be zero, notwithstanding that the other factor has been doubled. Or suppose that the peak values of i_a and v_a are equal to $I_a/2$ and $V_b/2$ respectively. At such moments the 50% drop in one factor more than counterbalances the 50% rise in the other; $1\frac{1}{2} \times \frac{1}{2} = \frac{3}{4}$, not 1.

This way of looking at it is quicker and more convincing than working it out in the orthodox manner by algebra, useful though that is for obtaining precise values, power efficiency, and so forth. It should be quite clear, too, that since V_b is constant, the alternating voltages across load and valve are opposite in phase, so that the voltage across the load

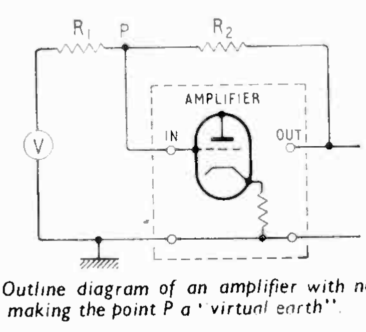


Fig. 5. Outline diagram of an amplifier with negative feedback for making the point P a "virtual earth".

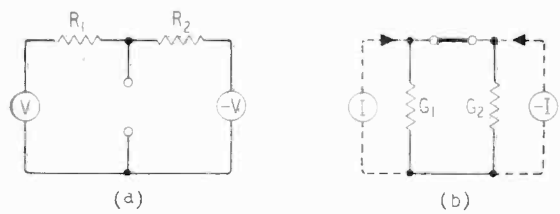


Fig. 6. The basic network of Fig. 5 is shown at (a), and when transformed into its dual is as (b).

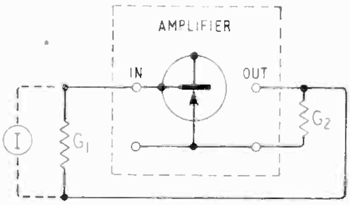


Fig. 7. Fig. 6(b) is here elaborated to show the current amplifier, for comparison with Fig. 5.

is in phase with the current there, and so means power received by the load.

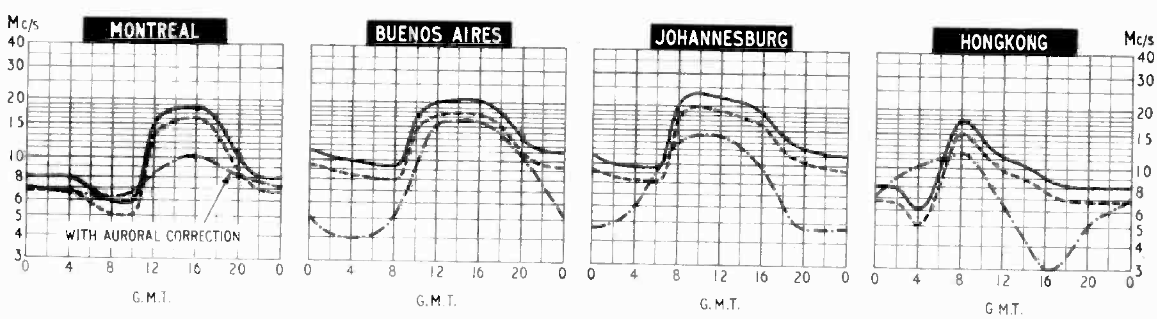
I shall finish with another question asked by my correspondent, which was new to me. He wanted to know what was the dual of a "virtual earth". Possibly he had in mind my treatise on the virtual earth in the November 1961 issue. For the information of any who may be unfamiliar with this term, it refers to the fact that the "live" input terminal of a high-gain amplifier having a large amount of negative feedback behaves almost as an earthed point, even although it may have a very high impedance to real earth. This is shown in Fig. 5, where V is a signal source. The amplifier is designed so that its output is in opposite phase to the input. Suppose its output was $-V$ volts and $R_2 = R_1$; then obviously the point P would be at zero potential and therefore indistinguishable from earth, despite the best efforts of the signal V to make it vary. This situation is of course impossible, because the amplifier would have no input to amplify for producing $-V$. But the potential at P can be made as small as one likes by making the gain large enough. A typical application of this device is an analogue computer. Subject to the small imperfection just mentioned, the current in R_1 is proportional to V. So a number of signal sources can be connected to P, each through its own resistance, and the output of the amplifier is a measure of the sum of them.

Basically, then, a voltage amplifier is used in such a way that ideally the net voltage across an open-circuit is zero. So in the dual a current amplifier must be used in such a way that ideally the net current through a short-circuit would be zero. The necessary transformation is most easily seen by drawing the essential circuit network, as in Fig. 6(a). Here we have the high-impedance amplifier input (represented by the open-circuited terminals) in parallel with a pair of voltage sources, each in series with its resistance. So the dual must consist of a low-impedance amplifier input (represented by the short-circuited terminals) in series with a pair of current sources, each in parallel with its conductance, as in Fig. 6(b).

If $G_1 = G_2$, then no current would flow between the terminals, and the current amplifier whose input terminals these are would fail to produce the current output, $-I$. So the output falls sufficiently short of $-I$ to yield a net current flow between the terminals sufficient to produce that output of nearly $-I$.

We can now translate this back into a more or less practical version by putting in the amplifier, as in Fig. 7. G_1 and G_2, like R_1 and R_2, include in themselves the conductances of the signal source and amplifier output system, but—again as with R_1 and R_2—in practice they would consist mainly of actual components of relatively high and stable value. A high conductance is, of course, a low resistance. The conductance of the amplifier between its input terminals is ideally infinite (i.e., a perfect short-circuit), just as in Fig. 5 the corresponding resistance is ideally infinite. Yet, just as in Fig. 5 the voltage across these terminals is maintained at nearly zero, so the current through the short-circuit in the dual arrangement is maintained at nearly zero.

H. F. PREDICTIONS — JANUARY



MEDIAN STANDARD MUF
OPTIMUM TRAFFIC FREQUENCY
LOWEST USABLE HF

The high daytime MUFs characteristic of winter months will be maintained. The shapes of the MUF curves are similar to those of a year ago but about 5% lower. This reflects the very slow decline of the sunspot cycle.

The prediction curves show the median standard MUF, optimum traffic frequency and the lowest usable high frequency (LUF) for reception in this country. Unlike the MUF, the LUF is closely dependent upon such factors as transmitter power, aerials, local noise level and the type of modulation; it should generally be regarded with more diffidence than the MUF. The LUF curves shown are those drawn by Cable and Wireless, Ltd., for commercial telegraphy and they serve to give some idea of the period of the day for which communication can be expected.

LETTERS TO THE EDITOR

The Editor does not necessarily endorse opinions expressed by his correspondents

B.B.C. Transmission Fidelity

FOR many years now interest in High Fidelity sound reproduction by people in all walks of life has been increasing enormously and considerable capital has been invested by enthusiasts in high-grade equipment, receivers, gramophone motors and pickups, amplifiers and loudspeakers, etc.—a tendency which to date shows no sign of abating.

During the last decade the British Broadcasting Corporation have done wonders in their planning and installation of a network of V.H.F./F.M. transmitters, which now virtually covers the whole country and is potentially capable of giving really Hi-Fi performance! At the same time they have made great strides in the output quality of their studios, with new microphones and improved magnetic tape recorders, etc., and for all these achievements they deserve our sincere congratulations.

All this is fine and listeners all over the country could —and should—by now be able to enjoy and appreciate something which we have not had so far over the length and breadth of this land, a broadcast service of really High Fidelity Sound! Whilst it is true that listeners to the B.B.C.'s London Area transmitters (F.M. and TV) *do* have such "quality" transmissions, regrettably this does *not* apply to all the many more millions, the majority, who receive their "Service" via one or the other of the B.B.C.'s provincial transmitters, because of the totally inadequate—so called—"Music Circuits" which are at present provided by the G.P.O. to interconnect such centres to London. Even the best of such land lines to the more distant transmitters have, according to what meagre information on the subject the B.B.C. have published, the very mediocre pass-band of some 8 kc/s, whilst others of pre-war vintage are still in service. One at the time of writing serves, usually alternating each six months, either the Light or Home programmes to our local Pontop Pike F.M. transmitters and handles frequencies to only some 6.5 kc/s, a standard which is inadequate to give really faithful and natural reproduction of speech, let alone music!

Nevertheless, the G.P.O. equally deserve complimenting on their achievements since they have in recent years engineered the coaxial cable and radio links which today transmit the TV picture signals embracing a bandwidth of three million cycles per second over the British Isles, soon to be increased to some five million for the new 625 line pictures. No technical or cost problem exists to using these links to additionally provide really high quality sound circuits to the transmitters, not only for the forthcoming B.B.C.2 service but all "Sound" and TV (Sound) programmes. In fact, an advertisement on page 26 of the latest issue to reach me of the "Post Office Electrical Engineers Journal" (Vol. No. 56 Part 2) offers equipment to provide "Music on TV Microwave Links—two new systems for the transmission of high-quality 15 kc/s sound channels for broadcast services." Additionally, since the B.B.C. F.M. sound broadcasting network of transmitters were engineered some eight years ago, transistorized repeater amplifiers have not only become available but have been proved in service and now offer the opportunity to up-grade many of the older cable circuits easily and cheaply.

How far out of date the B.B.C.'s present set-up of "Music Circuits" is can be realized only by bearing in mind that as far back as 1927 the G.P.O. were providing the B.B.C. with the then, so called, "simultaneous broadcasting" links to the provincial transmitters, which had a bandwidth of 10 kc/s, so we have gone backwards in this respect in the intervening years. In contrast, Germany and some other Continental countries today have networks, I understand, which transmit to a top limit of some 12 kc/s, which proves that no technical or cost problems apply—*if the will to achieve such a standard exists!*

I am sure that thousands of your readers will agree with me that it is high time the B.B.C. and G.P.O. gave this "bottle-neck" in the fidelity of present-day British broadcasting the attention it merits, so why not let us have a start made in 1964, the year in which the B.B.C.2 service is due to commence? Accordingly, I make a clarion call to all music lovers, Hi-Fi enthusiasts and ordinary listeners over the length and breadth of this country to join me in sending a postcard to the B.B.C.'s Engineering Division at Broadcasting House, London, to arrive early in the New Year, calling for "Quality" (12/15 kc/s) transmission links to all the Corporation's u.h.f. and v.h.f. transmitters to be engineered without further delay.

After all, a chain is only as strong as its weakest link, and whilst it is fine that our present day broadcast transmission chain has first-class terminal ends, we must additionally see to it that the "in between links" are equally sound and worthy of the times.

Newcastle upon Tyne.
CHRISTOPHER C. V. HODGSON

The B.B.C. replies:

Your correspondent, Mr. C. C. V. Hodgson, draws attention to the desirability of making a greater bandwidth available on the line distribution network used for the B.B.C.'s V.H.F./F.M. transmissions, so that listeners who appreciate high-fidelity sound broadcasting can obtain the best possible quality.

The internationally accepted bandwidth for long-distance music lines is 10 kc/s. Most of the G.P.O. circuits linking B.B.C. studio centres and transmitters reach this standard, or very nearly, having a bandwidth of 9 or 10 kc/s. In a few cases lines are still in use with a bandwidth of 7.5 or 8 kc/s, but these are being improved as more 10-kc/s circuits become available. The lines for distributing the sound component of B.B.C.-2 will also, in general, go up to 10 kc/s.

It is true, as Mr. Hodgson says, that there is no *technical* reason why the bandwidth of all these circuits could not be increased to 15 kc/s. No doubt the G.P.O. could, in the course of time, upgrade all the circuits to this standard, but at a substantial additional cost to the B.B.C. in line rentals. This cost could be met only by reducing expenditure elsewhere. We believe we can do the greatest good to the greatest number by extending the coverage to people who are still without any television or V.H.F. sound services at all rather than by making an improvement in sound quality that could be appreciated only by a minority, though an important minority, of listeners and viewers.

Mr. Hodgson raises a particular point about the bandwidth of the lines to the Pontop Pike V.H.F./F.M. transmitters. In fact, the line used for the Light Programme reaches just over 7.5 kc/s and this is scheduled for improvement very soon. The line used for the

Home Service has a bandwidth of 10 kc/s. There have occasionally been short periods during fault conditions when the normal bandwidth may not have been maintained, but the lines are not regularly interchanged as Mr. Hodgson suggests.

London, W.1. L. W. TURNER
Head of Engineering Information Department,
British Broadcasting Corporation.

Colour Television Systems

FROM Mr. Cox's excellent article on PAL (December 1963 issue) it may be inferred that colour phase alternation at field rate produces such a flicker problem that line rate switching is at all times preferable. It is probably worth recording that the embryonic N.T.S.C. system used field rate switching for two reasons. First, field rate switching allows complementary quadrature information to lie on adjacent lines. Secondly, the experimental evidence was that when the onset of phase distortion produced just noticeable crawling bars with line rate switching, for field rate switching the flicker was negligible. Whether this would be true for a 50-c/s field repetition is a mater for experimental investigation.

Later in the article the phase stability of the N.T.S.C. type reference burst is questioned. Mr. Cox has told me he is particularly interested in the cumulative phase errors in this burst which may be produced by black level clamp devices. Study of the B.B.C. publication "Specification of Monochrome and Colour Television Standards for 625-line Experimental Transmission", dated October 1962, does show that under conditions of limit adverse tolerances on line blanking and burst phase positions it is possible to find a true black level from between 8.5 to 9.9μsec (including a 100 nsec protection) after the time datum on the leading line synch. pulse edge.

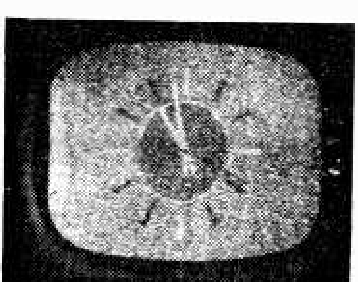
It does not appear unreasonable to perform black level setting within these time limits without the need for "soft" clamps. It would be of interest to have specific comment from those American readers of *Wireless World* who have operational experience of clamps for colour transmitters.

It is implicit in Mr. Cox's concluding argument that the disappointing growth of colour television in the U.S.A. can be attributed to the shortcomings of the N.T.S.C. system. Perhaps one should not forget that the early instrumentation for colour in the studio together with the poor brightness of the early shadow mask tubes and high cost of receivers themselves acted to limit the growth of colour broadcasting. It is possible that such equipment coupled by the SECAM signal transporting process would have made the commercial prospects for colour no better.

Hoddesdon. I. MACWHIRTER

Long-distance Reception on Band IV

I READ with interest the account of Mr. Pittam's TV-DX successes on Band IV in your Dec. 1963 issue (p. 617). Living only 12 miles from Wolverton I am most interested in Mr. Pittam's results.



Interval signal received at Twyford from Lopik (Holland) on Channel 27 on 28th October, 1963.

I have carried out similar experiments on Band IV and have been successful in receiving 10 west German u.h.f., 1 Dutch, 1 French and Crystal Palace Ch.33 test transmissions, also previously on Ch.34.

LIST OF U.H.F. STATIONS RECEIVED

Channel	*Station*	*Country*
21	Gottingen	W. Germany
23	?	,, ,,
24	Aachen	,, ,,
31	Koblenz	,, ,,
31	Baden-Baden	,, ,,
32	Saarbrucken	,, ,,
34	Feldberg	,, ,,
35	Kassel	,, ,,
37	Aachen	,, ,,
29	Dusseldorf	,, ,,
22	Paris, Eiffel Tower	France
27	Lopik	Holland
33	Crystal Palace	London
34	,,	,,

The aerial in use is a home-made 19-element array tuned to Ch.33, mounted 30ft above ground level and beamed on London.

The receiver is a G.E.C. BT311 14in fringe model modified to receive 625-line transmissions from the Continent.

I have been experimenting with DX-TV since May 1959 and to date have received 80 TV stations on Bands I, III and IV.

As Mr. Pittam says Oct. 11th was an excellent day.

Twyford. IAN C. BECKETT

Direct Voltage Trigger Circuit

I READ with interest the description of a direct voltage trigger circuit by T. K. Hemingway and J. Willis (*W.W.*, Oct. 1962, p. 460) and I had occasion recently to adapt this for use with a photo-transistor. This led to an interesting development of the original circuit which

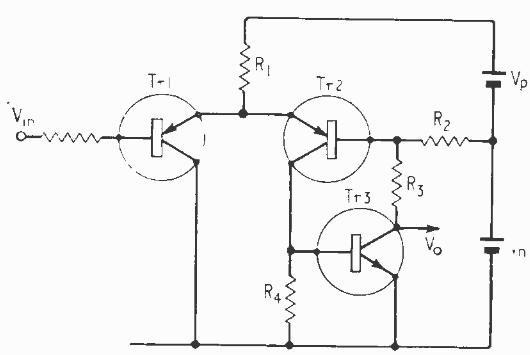


Fig. 1.

I would like to describe. First I would like to make one or two comments on the original circuit which may be of use in design of specific circuits.

1. The appendix does not make clear to which diagram it refers for its terminology. Referring to the accompanying Fig. 1, the trigger levels are approx. zero and $\frac{V_n R_2}{R_2+R_3}$ neglecting V_{be} for both transistors. This must be taken into account if silicon transistors are used.

2. No mention is made of the loop gain of the comple-

(*Continued on page 41*)

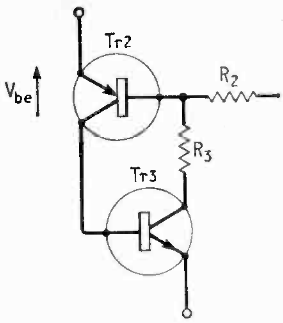


Fig. 2.

mentary pair. It is essential that this be greater than unity in order that regenerative switching will occur. Referring to Fig. 1, the loop gain is given by:—

$$G=\frac{\alpha_1\beta_1\beta_2R_2}{R_2+\beta_1R_1}$$

$$\text{or if } \beta_1\gg1,\ G\simeq\frac{\alpha_1\beta_2R_2}{R_1}$$

ignoring the current in R_4.

The hysteresis of the circuit is given by:—

$$H=\frac{R_2V_n}{R_2+R_3}$$

since one trigger level is zero.

Hence we may write H in terms of G or vice versa, viz.,

$$H=\frac{GV_n}{\alpha_1\beta_2(R_2+R_3)} \quad \text{or } G=\frac{\alpha_1\beta_2H(R_2+R_3)}{V_nR_1}$$

The circuit is fundamently a complementary bi-stable (Fig. 2) in which the break-over potential is determined by the potential at the base of Tr2. In the above circuit this is controlled by Tr1, which to switch off the bi-stable draws current through the common emitter resistor R_1. In the modified circuit, Fig. 3, Tr1 is replaced by a photo-transistor, the collector current of which is determined by the light incident on its exposed base-emitter junction region. The base of this transistor is held at earth potential by resistor R_5, it may be preferable in some cases to return R_5 to the emitter.

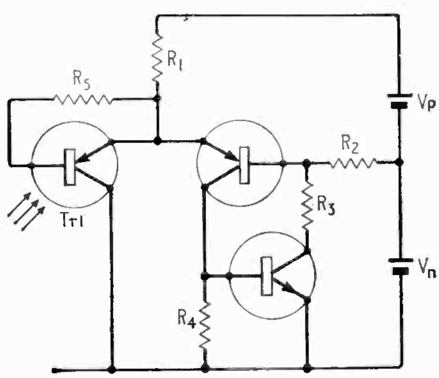


Fig. 3.

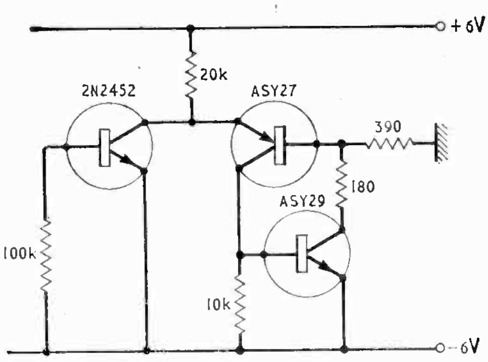


Fig. 4.

With no light on Tr1, only the dark current will flow and it is necessary that this current produces negligible volt-drop in R_1. With Tr1 illuminated current is diverted from the emitter of Tr2 and the bi-stable switches off. This current is

$$\frac{V_nR_2}{R_1(R_2+R_3)} \text{ approx.}$$

The circuit may be designed to operate from low light levels provided the collector current is substantially greater than the collector dark current. This may be considerably improved by using silicon transistors and photo-transistors. Alternatively a photo-diode could be used but I have not tried this version.

A typical circuit, designed on the above principles, is shown in Fig. 4.

London. H. R. HENLY,
G.P.O. Engineering Dept.

Demonstrating A.C. Theory

I REGRET to notice that the reference quoted in my letter on pp. 617-18 of the Dec. 1963 issue should have been to *Electronic Engineering* and not to *Electrical Engineering*.

I am very sorry about this, and should be grateful if you could publish a correction.

London, E.C.1. M. D. ARMITAGE

Laser Action

MAY I make a few comments on the article of Mr. Harris on lasers published in your August and September issues. This is a good review of the present state of development of optical masers but it seems that some minor corrections are necessary.

1. In Fig. 12 the energy states E_4 and E_5 of neon are regarded as metastables. But it is known that radiative transitions are forbidden for the metastables and atoms excited to the metastable state return to the normal state by dissipating energy in collisions of the second kind. Atoms can be excited to the metastables usually by falling from higher states and these metastables have a much longer life. The basic principle in He-Ne lasers is to utilize the metastable state of He atoms in causing population inversions between several Ne levels by means of excitation transfer. The He metastables are used as carriers of energy to excite the levels of Ne nearest to it. In Fig. 12 levels E_2 and E_3 should be metastables.

2. In Fig. 13 the Brewster's angle should be $(90°-\theta)$. Here Brewster's angle is the angle which the axis of the discharge tube makes with the normal to the end plate.

3. In the last few lines of page 427 it is said that total internal reflection prisms have three mutually perpendicular surfaces. But they have two mutually perpendicular surfaces. One angle is a right-angle and the other two acute angles being exactly equal.

4. In Fig. 13 the external reflectors are drawn as plane mirrors. But when using external reflectors it becomes much more convenient to use confocal plano-concave mirrors with radius of curvature equal to the separation between them. External plane mirror reflectors are very difficult to align for parallelism.

5. It has been mentioned that the active substance in a semiconductor laser must possess a large number of mobile carriers and electrons must be able to move freely between energy levels. These are not the only requirements for maser action. In germanium and silicon, carrier concentration is very large with high values of electron and hole mobilities but still these only

emit very feeble light and so far have not produced maser action. This is due to their indirect bandgap. For optical maser action the bandgap must be direct for the crystals used. Considerations of bandgap, bandshape, electron and hole mobilities, electron-hole recombination rate, traps and impurity centres, absorption coefficient, quantum fluorescent efficiency, exciton formation and radiative annihilation of excitons—all these to be taken into account when choosing a suitable semiconductor material for masers. Zinc phosphor as mentioned has not yet produced maser action.

6. The power output of Ga-As laser is 10-25 mW and there is no reason to consider it as inferior to gas discharge types whose output is about 15 mW. Ga-As type is particularly superior as regards compactness and conversion efficiency which is about 10-80%, whereas in the solid-state ruby and gas discharge types it is about 1% only.

7. The device as illustrated in Fig. 17 actually uses four He-Ne gas-discharge laser tubes, one mounted on each side of a square. Mirrors are placed at the four corners of the square. These four tubes are linked to act as a single laser.

AMARNATH CHAKRAVARTY
Institute of Radiophysics & Electronics,
University of Calcutta.

SUBSCRIPTION TELEVISION

CONTRARY to the Pilkington Committee's recommendation, the Government's second White Paper on Broadcasting recommended that an experiment in subscription television should be undertaken. Some months ago the P.M.G. therefore invited potential purveyors of a television subscription service to apply to participate in a series of tests. A large number of applications were made. Some were prepared to provide the programmes, some a subscription system, others a means of transmission (wire or radio), while others were "consortia" prepared to provide a *service*.

The P.M.G. has now announced the names of five organizations which will be taking part in a three-year experiment to be conducted initially in eight areas, including several London boroughs, Edinburgh, Leicester, Sheffield, the Bedford-Luton area and a centre in the North of England. The areas have been chosen to cover as wide a cross-section of the community as possible, and it is hoped the companies will start a service by the end of this year.

To reach the widest possible potential audience subscription television would have to be radiated over the air and, to give a truly balanced "fare," should be broadcast on several channels. With the limited number of channels available this is considered impracticable and, moreover, the use of radio necessitates some form of scrambling to ensure that only those who have paid can receive the programmes. However, in the "pilot scheme" cable distribution will be used.

The companies to be offered licences and the areas in which they will operate are:—

Caledonian Television.—Penicuik, near Edinburgh, with possible extension elsewhere in Scotland.

Choiceview.—Leicester, with an option later of an extension to London.

Pay-TV.—Sheffield and London (initially Westminster and Southwark).

Telemeter Programmes.—An area in the north of England and London (Merton, Morden, Mitcham and Wimbledon).

Tolvision.—Luton and Bedford (and probably some towns in Hertfordshire) and a London area.

Choiceview is a joint venture of the Rank Organisation and Rediffusion. This h.f. twin-cable system employs a "deferred payment" coin box. At the end of a programme a series of pulses (each representing 2d) is sent along the line, the cost of the programme is indicated on the coin box, and the requisite amount has to be inserted before another programme can be viewed.

The Telemeter system also employs a coin box, but this includes a small magnetic recorder which, when a programme is bought by placing the requisite amount in the coin box, records the price and details of the programme for accounting purposes. The U.K. franchise for the Telemeter system, which originated in North America, is held by British Telemeter Home Viewing Ltd., with whom Telefusion is associated.

Tolvision is also of American origin, and the U.K. franchise is held by Tolvision Ltd. Operated over a coaxial network, it employs a central billing system. Each selector box is "interrogated" by a signal from a central office and the "replies" are recorded on magnetic tape.

Pay-TV (the new title for Toll TV) is a British Relay system. A distinguishing feature is that payment is for viewing time rather than for whole programmes.

Details of the system to be used by Caledonian have not been disclosed at the time of going to press.

It should be stressed that the field trials are not being undertaken to decide which system would be chosen for a national network, but to ascertain if there is a demand for a subscription television service

OUR COVER

A slice of silicon on which a batch of planar transistors has been produced by a photo-lithographic process is magnified 150 times and displayed on a 21in television monitor at the Marconi Research Laboratories, Chelmsford, to facilitate inspection for mechanical faults. The television camera is fitted to the microscope from which the normal eyepiece has been removed.

New British Standards

THE latest in the B.S.I. series of standards for components in telecommunications and allied equipment covers fixed mica dielectric capacitors. Part 1 of the new standard, BS2132, lays down the general requirements and tests, and is available at 12s. Part 2 is being prepared and will give a list of standard sizes and ratings.

Magnetic tapes for automatic data processing are covered in BS3658. This new publication, priced at 6s, is the first in a series and a companion specification dealing with precision spools has been completed and is to be published shortly.

The standard for silk- or rayon-covered copper wire, BS2480, is being replaced by two new specifications as the type of rayon specified is no longer available. A standard relating to silk only—with no changes to the technical requirements—is available as BS3684 and a standard for rayon-covered wire is being prepared. The silk only specification is available in two parts—published separately at 7s 6d each—the first giving gauge dimensions in British units and Part 3 in metric units.

An addition has been made to BS488, which deals with electronic-valve bases, caps and holders. The addition, published separately at 3s, covers the B9A/D base.

Copies of the above standards are available from the B.S.I. Sales Branch, 2 Park Street, London, W.1. An additional charge is made for postage to non-subscribers.

PARAMETRIC FREQUENCY DIVIDERS

SINUSOIDAL OUTPUT WITH FAIL-SAFE OPERATION

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

TO understand this development it is necessary to have some idea of the principle of operation of a parametric amplifier. Broadly speaking, such an amplifier takes in energy at one frequency and by reactance changes uses it to obtain power gain at another frequency. The two frequencies need not be harmonically or sub-harmonically related to each other, though in its simplest possible form a parametric amplifier provides gain at a given frequency by taking power from an oscillator working at twice this frequency. If the power supplied from the pump oscillator is small in relation to the losses of the tuned circuit to which it is coupled, the effect is merely to reduce these losses or to reduce the decrement of the circuit. Higher power will result in stable power gain while excessive drive power will produce sustained oscillations at half the drive-oscillator frequency. This action amounts to frequency division by a factor of two and is used in the circuits to be described.

A characteristic feature of parametric amplifiers is the use of variable reactance in the primary tuned circuit. An iron-cored coil is an example of a non-linear inductance. A reverse-biased semiconductor diode acts like a variable capacitance, the value of which depends on the bias voltage. The collector-base diode of a transistor falls into this category and there are other examples which will be discussed later in this paper.

Principle of Parametric Amplification

Fig. 1(a) shows a lossy tuned circuit LCR in which damped oscillations can be produced by switching a charged capacitor across an inductance L of resistance R. The rate of decay of the oscillations depends on the Q-factor of the coil. In Fig. 1(b) we have a similar arrangement but with provision for varying C at strategic points in the cycle of operations. For simplicity it may be supposed that C is varied mechanically by altering the separation of its plates. If a change Q is placed on a capacitor C the voltage across its plates is given by $V=Q/C$. The stored energy is $\frac{1}{2}CV^2$. If C is made smaller, e.g. by separating the plates, then V must become larger since Q remains unchanged. If C_1 is the new capacitance and V_1 the new potential, $V_1 = Q/C_1$ and the new energy is $\frac{1}{2}C_1V_1^2$. If $C_1 = C/2$ then $V_1 = 2V$ so that the new energy is $\frac{1}{2}\frac{C}{2}(2V)^2 = CV^2$. This is exactly twice the original energy. The excess energy comes from the mechanical work done in separating the plates against the force of attraction between them.

Imagine now that C in Fig. 1(b) is charged and connected to the coil. This starts a train of damped oscillations. After one-quarter of a cycle, suppose that the plates of C are pulled suddenly apart, causing a reduction of capacitance. There is a corresponding sudden increase of potential, shown as a step at the crest of the voltage waveform, and a supply of extra energy resulting from the mechanical work which has been done. After another quarter of a cycle, the capacitor voltage sinks to zero. At this instant we restore the capacitance to its original value C but, because of the momentary absence of charge on C (or potential across its plates), we recover none of the energy previously used in separating the plates. One more quarter-cycle is allowed to elapse, after which the capacitor is charged to its peak negative voltage and once more we separate the plates. Another step is produced in the waveform and more mechanical energy is converted into electrical form. Finally, the oscillation is allowed to complete its cycle and the capacitance once more reverts to the value of C with no return of energy to the driving source.

By supplying energy in pulses at twice the natural frequency of oscillation the circuit losses may be reduced, cancelled or over-compensated. In the last case sustained oscillations will occur at the first sub-harmonic of the driving pulse frequency.

There is no need to vary C mechanically. A voltage-variable capacitor driven at frequency $2f$ can generate oscillations of frequency f. Needless, to say, a variation of L, if it could be accomplished, would serve just as well as varying C.

The simplest possible practical embodiment of

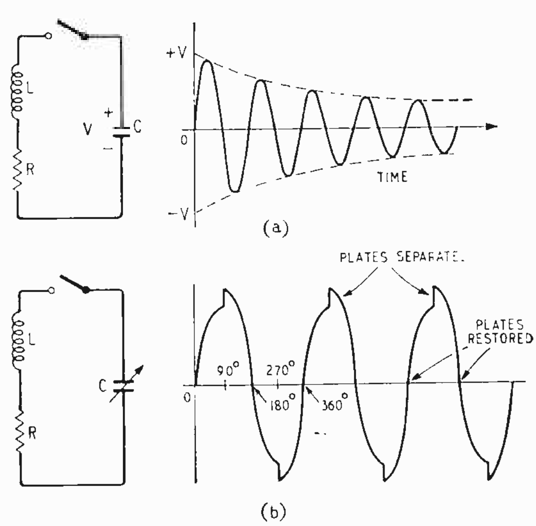


Fig. 1. Principle of parametric amplification.

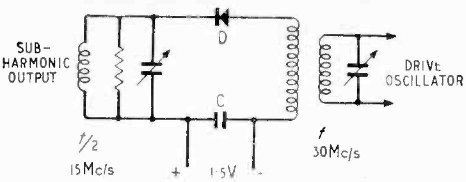


Fig. 2. Regenerative divider due to O. Nourse.

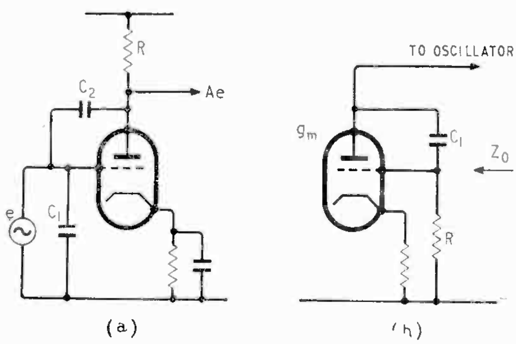


Fig. 3. Circuits giving capacitance multiplication.

Fig. 1 has been described by O. Nourse in a D.S.I.R. Report.[1] It is shown in Fig. 2. In this, D is a reverse-biased junction diode or Varicap device. The drive oscillator swings its capacitance above and below the mean value at 30 Mc/s and generates an exact sub-harmonic at 15 Mc/s in the other tuned circuit. Varicaps are normally of quite small capacitance and are thus well suited for working at very high frequencies where division by other means is fairly difficult to achieve. They are less suitable for low-frequency use.

Nourse shows that to sustain oscillations at the sub-harmonic frequency requires a fractional swing of capacitance of $8/Q$ where Q is the quality-factor of the tuned circuit.

Alternatives to Varicap Diodes

One of the simplest ways of obtaining the equivalent of a large variable capacitance is to connect a small one between the input and output terminals of a phase-reversing amplifier of high gain. The well-known Miller effect in triode amplifiers is one example. Another, related quite closely to the Miller circuit, is the reactance modulator which is used to provide a variable reactance across an oscillator circuit in order to swing its frequency. Both circuits are shown in Fig. 3.

It is shown in standard textbooks that the input capacitance of the Miller stage is $C=C_1+(1+A)C_2$ where C_1 is the grid-cathode capacitance, C_2 the anode-grid capacitance and A is the voltage-amplification or stage gain. If the load resistance is small compared with the valve anode slope-resistance and if C_1 is negligible, the input capacitance is simply $C=(1+g_mR)C_2$. If $g_mR\gg 1$, $C=g_mR\,C_2$.

The reactance modulator shown in Fig. 3(b) is only one of many possible circuits[2]. When it is coupled across the tuned circuit of an oscillator, the reactance connected across this tuned circuit is capacitive and is given approximately by $C=g_mR\,C_1$. The resemblance to the Miller stage is apparent.

In both cases the capacitance is a function of g_m. The dynamic mutual conductance of a triode valve is in turn a function of the grid bias so that by varying the bias, the effective capacitance C can be swung over a wide range. Even more marked effects are noticeable in transistors where the input impedance, electrode capacitances and mutual conductance all depend strongly on the base bias and on the collector voltage and current. If g_m is subjected to step-changes, or is modulated sinusoidally, there are corresponding changes of capacitance at the same frequency.

It is a simple matter to set up a frequency divider circuit to exploit this effect. Although the principle of the parametric divider has been explained by reference to step-changes in capacitance, the actual circuit works equally well with sinusoidal variations, provided of course that these have twice the frequency of the desired output from the divider.

Practical Divider Circuits

Fig. 4 shows the extreme simplicity of the parametric divider. The inductance L is tuned to the desired output frequency by a fixed capacitance C and a variable capacitance which is a function of C_1. That part of the total capacitance which is due to C_1 is modulated at the input frequency and is responsible for the parametric operation. It is convenient to set the physical size of C_1 at around 10-20 per cent. of C. Sufficient capacitance-swing can then be ensured to give reliable operation. The L/C ratio should be moderately high and it is of advantage to use a low-loss inductance. The base-bias resistance R should be set to give a reasonable standing current with no input drive; 1mA at 6V is suitable. Values of R usually lie in the range 220-680 kΩ, depending on the transistor characteristics.

The input drive current is controlled by a 10-25 kΩ variable resistance in series with a blocking capacitor.

With a low input drive current the output waveform is as shown at (a). It is a sinusoid of frequency f, the input frequency. Increasing the drive amplitude gives the waveform at (b). A further increase gives the desired output as at (c) which has a strong

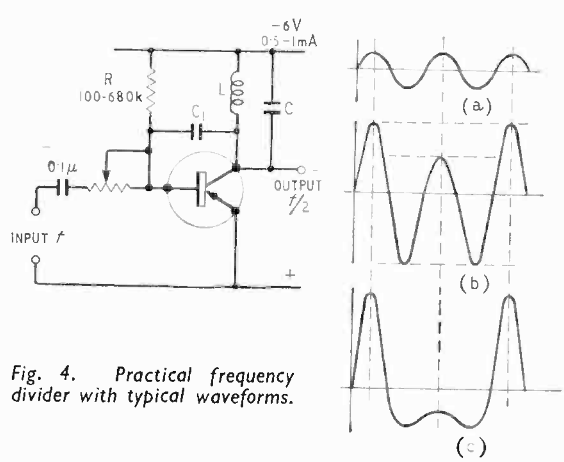


Fig. 4. Practical frequency divider with typical waveforms.

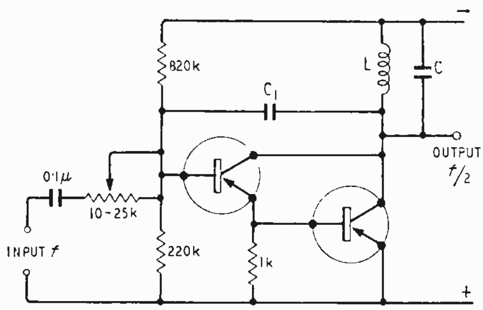


Fig. 5. Compound-connected transistors in parametric divider.

component at the frequency $f/2$. There is no output if the drive is removed.

With proper adjustment of the values of R, L, C and C_1, and with sufficient drive the operation is extremely stable and a high output is delivered at high impedance. Experiments show that division holds good over 3-to-1 changes in supply voltage and for input frequency variations of ± 20 per cent. about the tune position, but it is essential to provide adequate drive power.

Suggested component values for typical operating frequencies are given below:—

f	$f/2$	L	C	C_1
100 kc/s	50 kc/s	10 mH	820 pF	82 pF
50 kc/s	25 kc/s	20 mH	1,000 pF	56 pF
10 kc/s	5 kc/s	125 mH	0.01 μF	820 pF
1,000 c/s	500 c/s	4 H	0.02 μF	0.005 μF
300 c/s	150 c/s	4 H	0.1 μF	0.02 μF

The two smallest coils may be wound on ferrite pot cores; the 125-mH inductance can be assembled from miniature E-I laminations of nickel iron. The 4-H coil requires some 1600 turns of wire on a small Mu-metal toroid. Waveform distortion due to incipient saturation is noticeable at 150 c/s. It disappears when operating from a 2-V supply instead of the normal 6V.

The component values listed above have not been optimised for each case. A little development work might easily result in an improved output waveform and a reduction of the drive power requirements. A buffer amplifier is necessary if the divider is required to feed into a low-impedance load since any reduction in the tuned circuit Q-factor calls for a greater fractional capacitance swing.

Variants of the Basic Circuit

In Fig. 5, compound-connected transistors are used to give a higher current gain which allows the use of a smaller value for C_1. For use at frequencies around 100 kc/s the intrinsic collector—base capacitance of the transistor is sufficient to allow reliable frequency division without the necessity for any external capacitance[3]. An odd feature is that the circuit makes use of those properties of a transistor which are objectionable in high frequency or wide-band amplifiers.

It has already been remarked that high-Q coils are required in the simple circuit of Fig. 4. To get round this difficulty one may couple a form of Q-multiplier to the LC circuit and thus reduce the drive power requirements. Normally this extra complication is not justified since it tends to destroy the basic simplicity of the divider.

Finally, Fig. 6 gives the circuit of a quartz oscillator which can be made to give an output at half crystal frequency. It is somewhat tricky to set up, works only at relatively low frequencies and calls for the use of a high-grade crystal. It is an engineering curiosity rather than a useful practical circuit. The base bias resistance is necessarily very low so that the transistor draws a large current. To reduce dissipation, it is operated from a single dry cell. Feedback through the series-resonant crystal is taken to the transistor emitter from the centre-tap of L as in a normal oscillator. It is by no means certain that this circuit operates as a true parametric divider. It was tried out with this in mind and the difficulty is to think up any plausible alternative explanation which would account for its behaviour.

Comparisons with other Divider Circuits

Blocking oscillators, multivibrators, flip-flop (toggle) circuits and regenerative modulators are all possible alternatives to the parametric divider. The first gives a pulse output and may free-run on an unstabilised frequency if the drive fails. Multivibrators need more components, give a rectangular output waveform and also run uncontrolled if drive fails.

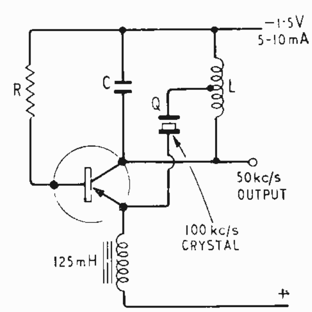


Fig. 6. Quartz oscillator giving output at half the crystal frequency.

Toggle circuits are excellent binary dividers with a fail-safe characteristic but a single stage needs two regulated power supplies, uses two transistors, four diodes, four capacitors and eight resistors. It must also be triggered by a high amplitude step-voltage, the production of which, from a sinusoidal source, calls for extra components. It is of course ideal for use in digital circuits.

We are left with the regenerative modulator. In the divide-by-two form it is simple and reliable. Fig. 7 shows a transistor version for comparison with the parametric divider of Fig. 4. The 25 mH coil tunes, with various shunt and reflected capacitances, to 50 kc/s and, assuming operation on this frequency, the diodes in the bridge rectifier are all driven into brief conduction at a 50 kc/s rate and are non-conducting when reverse biased. Gated pulses at half the input rate of the 100 kc/s source are thus applied to the transistor and serve to maintain the 50 kc/s output. The series-connected 200 pF and 1,000 pF capacitors provide at their junction a source of positive feedback or regeneration for application to the transistor emitter. Self-oscillation in the absence of 100 kc/s drive is prevented by reverse emitter bias taken from the junction of the 2.7 kΩ and 1.8 kΩ resistors.

Simple as this circuit may appear, it is less toler-

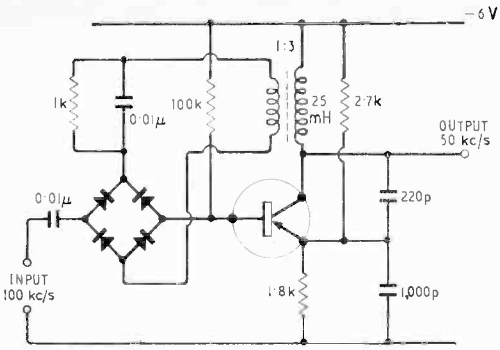


Fig. 7. Regenerative modulator divider.

ant of supply voltage, drive frequency and drive amplitude changes than the parametric divider of Fig. 4. Moreover, the waveform is no better.

For use in low power circuits the parametric divider is a useful alternative to the other possible arrangements. It is simple to align and adjust, has an inherent fail-safe property and gives a near-sinusoidal output which is easily filtered to remove unwanted harmonics. It can be designed to operate over an enormous range of frequencies and is potentially useful in frequency-synthesizers which rely on binary division and mixing to generate a wide range of stable frequencies. The output is free from random noise and, with care, the output of one stage may be used to drive the next although there are advantages in separating two such stages by a tuned amplifier which may then be used to supply useful power to an external load.

REFERENCES

1. O. Nourse, " A New Type of Regenerative Oscillator Frequency Divider and Super-Regenerative Amplifier." D.S.I.R. Report, 22nd July, 1957.
2. F. Butler, " Reactance Modulator Theory." *Wireless Engineer*, Vol. XXV, No. 294, March, 1948, p. 69.
3. A. R. Saha, " Transistor Parametric Subharmonic Generator," *Journal of Electronics and Control*, 1st Series, Vol. XV, No. 1, July, 1961, p. 21.

Commercial Literature

The "**Taylor Transistor Handbook**" recently introduced as a companion to their transistor tester is now available separately, priced at 25s, from Taylor Electrical Instruments Ltd., Montrose Avenue, Slough, Bucks. This 116-page publication contains information on British, Continental, American and Russian transistors and also includes a list of manufacturers' names and addresses. All the basic parameters are given together with maximum ratings and connection data.

4WW 411 for further details.

The engineering staff of E. H. Research Laboratories, Inc., of California, have prepared a booklet to assist engineers in **selecting and using pulse generators.** Although occasional reference is made to E. H. equipment, the publication is of general nature and is subdivided into four sections covering basic pulse generator definitions, pulse generator circuits, pulse characteristic measurements and applications. Copies of this 36-page booklet are obtainable from the U.K. agents, Livingston Laboratories Ltd., 31 Camden Road, London, N.W.1.

4WW 412 for further details.

Thorn-A.E.I. Radio Valves & Tubes Ltd. have produced a booklet describing the mass production of **television cathode ray tubes** at their Sunderland tube factory. The booklet, entitled "Quality in Quantity," was written originally for presentation to visitors touring the factory, but it may be of general interest. It describes the assembly processes, the function of each component and its contribution to the tube performance and reliability. Copies are available from the Thorn-A.E.I. Publicity Department, 155 Charing Cross Road, London, W.C.2.

4WW 413 for further details.

A number of technical bulletins have been sent to us by the Telegraph Condenser Company, of North Acton, London, W.3, on their **capacitors.** Bulletin No. 89R deals with their " Supamold " paper dielectric capacitors, 90R with "Duomold" mixed dielectric capacitors, 93 with miniature metallized polyester capacitors, 95 with ceramic disc power capacitors and 98 with " Metamold " tubular metallized polyester capacitors.

4WW 414 for further details.

The 1963-64 **Marconi Instruments catalogue** is now available from their head office at St. Albans, Herts. This 208-page catalogue contains general and technical information on all the instruments and accessories they manufacture. These include oscilloscopes, oscillators, generators, voltmeters, frequency meters and counters, power meters, impedance bridges and "Q" meters. Associated companies and distributors are also listed in this catalogue. There are also French, German and Italian editions of this catalogue.

4WW 415 for further details.

Single-phase and three-phase **Trinistor a.c. power regulators** are described in the Westinghouse engineering publication 22-4/2. It contains full technical details and explanatory diagrams on the method of regulation. Copies of this publication are obtainable from the rectifier division of the Westinghouse Brake and Signal Company, 82 York Way, King's Cross, London, N.1.

4WW 416 for further details.

"**The use of voltage reference diodes in stabilized supplies**" is the title of a new 20-page application report on semiconductor devices, published by A.E.I. Temperature compensation, output voltage stability and the design of a high stability reference are among the subjects dealt with in this booklet. Copies of the publication (4450-203) are available from the valve and semiconductor sales department of the Electronic Apparatus Division of Associated Electrical Industries Ltd., Carholme Road, Lincoln.

4WW 417 for further details.

Muirhead and Co. Ltd., of Beckenham, Kent, have produced a booklet titled: "**A comparison of the unsaturated standard cell and the Zener diode as a voltage reference.**" It is based upon a paper by John M. Fluke and Robert W. Hammond, of the John Fluke Manufacturing Company, of Washington. Copies of this booklet which are intended "to place the relative merits of these two voltage references in perspective and assist those concerned with them to choose the right device for every application" and leaflets on Muirhead standard and reference cells are obtainable from the Publicity Dept. of Muirhead's.

4WW 418 for further details.

Tape Recording Amplifier

CIRCUIT WITH CATHODE FOLLOWER OUTPUT STAGE

By G. P. HOBBS, B.A., Grad. I.E.E

THERE are, no doubt, numerous permutations of circuit arrangements to be found in use in amateur built tape recording equipment. Indeed, in the integration of his equipment the constructor may prove to be very much of an individualist, perhaps taking special pride over the particular switching facilities he has evolved. It is thought that readers might be interested in the line of thought followed in this article over the design of one section of the electronics: the record amplifier.

A few words about the other elements of the writer's equipment may also be of interest. At one time the replay amplifier had used three EF86 valves in a circuit arrangement equivalent to the transistor amplifier described in *Wireless World* by P. F. Ridler.[1] It was found, however, that the three-transistor circuit achieved a better noise performance. Subsequent replacement of the first EF86 stage by an OC44 gave a performance as good as that of the Ridler circuit. For a really good signal to noise ratio on the tape a first-rate bias oscillator is necessary, and here a twin triode as a push-pull oscillator is made to drive a power amplifier, also in push pull. Using high-Q circuits in the oscillator and at the anodes of the power amplifier a good waveform is readily attained.

Recording Considerations

In the recording stage a transistor amplifier might be considered. However, if the head is of high impedance and is driven through a series resistor in the conventional manner there is likely to be lack of sufficient voltage drive. A high source impedance from a transistor circuit can be achieved by other means,[2] but here the design is centred around the familiar 12AT7. Too often the recording amplifier and equalizing circuits receive less attention than they deserve. The weakest link ought to lie in the tape itself: the distortion and dynamic range should only be determined by the actual physical recording process and not by the driving amplifier.

The amplifier should have, as well as better linearity than the tape, a really adequate signal-handling capacity. The tape will then saturate well before the amplifier limits. Full modulation of the tape is generally taken to correspond to the signal level that produces 3% harmonic distortion in the recording, and the programme level will be set to allow just the loudest passages to reach this. It takes, however, a signal 12dB greater than this to saturate the average commercial tape. Exceeding the maximum recording level does, of course, introduce bad non-linearity but this extra 12dB can serve a useful purpose. Accidental over-recording immediately springs to mind, but more important than this is the handling of short-duration peaks. Both music and speech do contain occasional peaks well above the general level of sound intensity which last perhaps only for a few milliseconds. By good fortune the ear is unable to detect whether these have become distorted—provided their duration is short. If the level indicator is unresponsive to these peaks, showing the peak level of longer signals only, the level will unconsciously be set to allow these peaks to overmodulate.[3] Thus we have an advantage to be gained if the recording amplifier will handle the peaks without clipping.

To visualize the demands we have made on the recording amplifier, consider a typical head with inductance 250mH. For maximum recording level the head will require about 100μA r.m.s. signal current. A substantially constant current drive versus frequency will be obtained with a feed resistor of 100 kΩ. The voltage drive for full modulation is therefore 10V r.m.s. Well in excess of 40V r.m.s. must be available before limiting occurs. Much the same drive will be needed for heads of other inductance as the following analysis shows.

The voltage drive is

$$V = RI \quad \ldots \quad (1)$$

where R is the feed resistor and I the recording current Now all heads will require about the same ampere turns for a given recording flux. Therefore

$I \propto \frac{1}{n}$ where n is the number of turns on the head bobbin and this in turn is proportional to the square root of the inductance

$$\therefore I \propto \frac{1}{\sqrt{L}}$$

Now we must also choose $R \propto L$ for a substantially constant current drive From expression (1) we have $V \propto \frac{L}{\sqrt{L}} \propto \sqrt{L}$, that is the voltage drive required is proportional to only the square root of the inductance. This shows that it is an advantage to go for a head of low inductance, quite apart from the advantage this brings of low self capacitance.

Circuit

The drive requirements for a 250mH head are amply met by the circuit of Fig. 1. This employs a cathode follower output stage and a degree of overall feedback.

The foremost advantage the cathode follower brings is in isolating the a.c. loading of R_{11} from the anode of V2. As the anode resistor of a triode stage is increased, the distortion, for a given output swing, tends to decrease. The loading factor for a capacitively coupled 100kΩ resistor would, however, deteriorate. The cathode follower output stage avoids any compromise solution here and makes certain of ample available swing.

The arrangement has attendant favourable properties for rejection of the bias voltage. The bias signal across the recording head generally lies between 20 and 100V r.m.s.—quite a considerable voltage owing to the high head impedance at bias frequency (the bias current being several times greater than the peak-recording current). Should much of this voltage be allowed to reach the output of the recording amplifier, the working point would be forced to move at bias frequency. To prevent any distortion the amplitude of bias voltage at the amplifier output must be kept low, especially if the recording-level indicator is also connected to this point. By now the reader may have realized that the cathode follower inherently gives excellent bias rejection—by virtue of its low output impedance. The bias voltage is attenuated, by the potentiometer formed by R_{14} and the impedance at the cathode of V3 to a very small amplitude. Moreover, this arrangement is effective at all frequencies and no setting up is necessary as is the case with a tunable rejector filter. V3 then, is the cathode follower output stage. V2 is a straight amplifier providing 10V r.m.s. signal at the anode for maximum recording level.

With the component values shown and an anode current of 2mA for V2, there will be about 4% harmonic distortion at this level. V1, also a voltage amplifier, has feedback from V3 applied to the cathode. Noting that the harmonic distortion would be small in the first place (4%), we may safely say that the distortion will be reduced by an amount equal to the feedback factor. At most frequencies the harmonic distortion should not exceed 0.2% for 10V r.m.s. output. At the frequency for which maximum treble boost occurs there is less feedback but the distortion should still be under 1%. We have an amplifier therefore that introduces negligible additional distortion to that incurred in the actual recording process. The characteristics of the magnetic tape will be fully exploited.

One elementary point that needs attention is the application of feedback around a loop containing two coupling capacitors, C_3 and C_6. Should the time constants associated with these two be similar, a phase shift exceeding 90° could occur. Instability at very low frequencies has been avoided by making the time constant at C_6 very long. Due to cathode follower action, the impedance at the grid of V3 is of the order of 15MΩ and only a small coupling capacitor would have been needed if it had not been for this problem. In fact, using $C_6 = 0.01\mu F$ caused some ringing at a sub-audio frequency, $0.1\mu F$ was found to be quite free from this effect, and a $0.25\mu F$ was adopted to give a wide margin of stability.

A single pole switch, SW_1, is used to break the H.T. supply to the oscillator and to the anode of V1. In the absence of anode current the grid of this valve is still held negative with respect to the cathode because the anode current of V3 also flows through R_4. The audio signal is effectively cut off, and, provided the record head is not used for the playback function, there is no need for any switching at the head itself.

The gain from the input to output of the amplifier

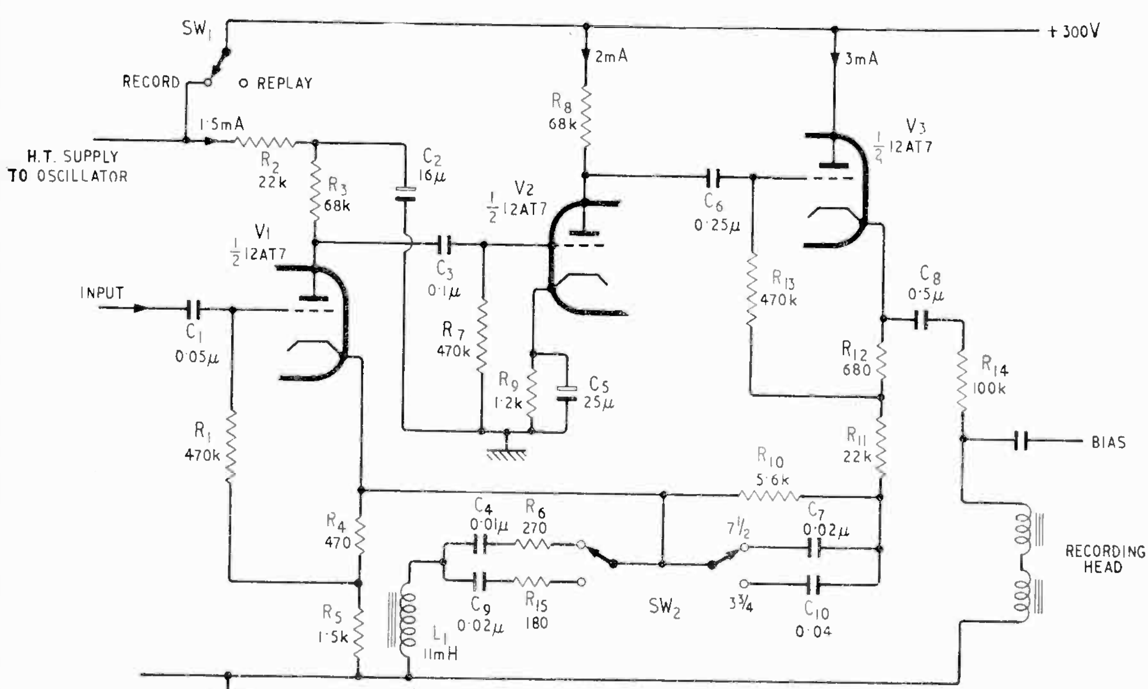


Fig. 1. Circuit of recording amplifier. The resistors are all ½W 10%. Inductance L_1 is 11mH (approximately 175 turns 34 s.w.g. on Mullard LA1 pot core).

at low frequencies is given very nearly by

$$\frac{R_4 + R_5 + R_{10} + R_{11} + R_{12}}{R_4 + R_5} \quad .. \quad (2)$$

which with the values used is $\frac{30k\Omega}{2k\Omega} = 15$.

Therefore at maximum recording level 700mV r.m.s. signal input is required. The odd half of a 12AT7 left over could well serve as a pre-amplifier to provide this. In the writer's case it is used as a cathode follower in front of V1. In this way it serves as a buffer stage which enables a monitoring amplifier to be connected to the grid of V1 without disturbance of the level.

The expression given for the gain in expression (2) is modified at high frequencies by the parallel impedance presented by R_6, C_4, L_1 across $R_4 + R_5$. The gain rises with frequency as the impedance of the network R_6, C_1, L_1 drops. At first C_4 mainly determines the shape of the rising characteristic, but L_1 becomes increasingly effective until the gain rises sharply towards the resonant frequency of the series tuned circuit. The degree of boost at the resonant frequency is controlled solely by R_6. The higher the chosen resonance, the more lift will be required and the larger the Q of the tuned circuit. This is typically about 4 so that we are justified in neglecting the losses in the pot core. The bandwidth in playback is about equal to the resonant frequency of C_1 and L_1. So much for the effects of R_6, C_1 and L_1 but what determines the choice of their component values?

This is best answered by examining the recorded magnetic flux on the tape that results from a constant current versus frequency recording. This is illustrated by the broken curve of Fig. 2. The full curve shows the recorded flux according to the C.C.I.R. standard for a tape speed of 7½in/sec. Because it is a comparatively simple matter to arrange a CR network in the playback amplifier to replay a tape recorded to the full curve characteristic correctly, the problems of equalization are relegated to the recording amplifier. Basically we need to provide pre-emphasis to make up the difference between the two curves of Fig. 2; how far this is carried out is a compromise between frequency response and dynamic range at the higher frequencies.

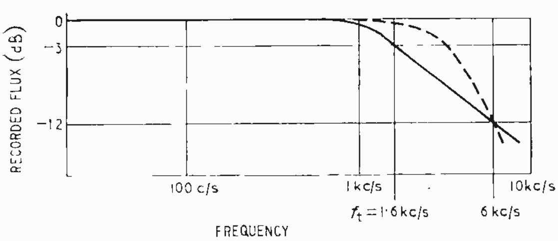


Fig. 2. A plot of recorded magnetic flux against frequency. The continuous line is the C.C.I.R. characteristic for 7½ in/sec. The broken line represents a constant current recording.

The C.C.I.R. standard specifies that the recorded magnetic flux should be constant at low frequencies and fall at 6dB/octave above the turn over frequency f_t. More familiar with most people will be the plot of signal voltage developed across an ideal replay head shown in Fig. 3.

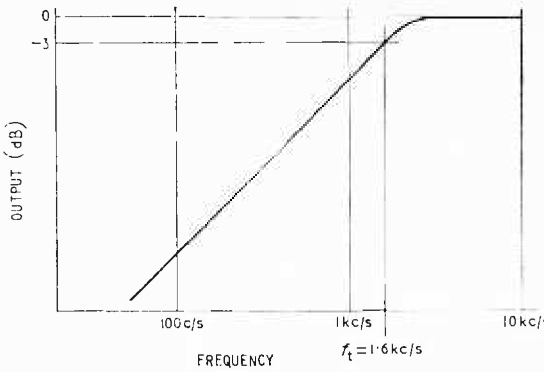


Fig. 3. Output from an ideal replay head from a tape recorded to the C.C.I.R. characteristic for 7½in/sec.

This includes the 6dB/octave rise in output derived from the inductive nature of the head. The output voltage is, of course, proportional to the rate of change of magnetic flux induced in the head and doubles as the frequency doubles. Both characteristic curves of Figs. 2 and 3 have a flat region and a sloping region with a turn over or 3dB point, f_t. In terms of a CR time constant, we have $f_t = \frac{160}{CR}$kc/s, where CR is in microseconds. At 7½in/sec. the C.C.I.R. standard is 100μsec. so that f_t = 1.6kc/s. The playback amplifier requires equalization which is the mirror of Fig. 3 and so CR is also the time constant needed there. Some slight high-frequency lift may also be necessary in this amplifier to compensate for losses resulting from the finite gap width of the replay head.

Returning to the broken curve of Fig. 2, the recorded flux is seen to remain constant over the low and middle frequency range, but, because of severe losses incurred in the recording process, falls rapidly at high frequencies. The standard characteristic also falls at high frequencies—but only at a rate of 6dB/octave—and is a concession to the great losses that do occur. The broken curve first lies slightly above the full curve but then rapidly falls below it. The network C_7 R_{10} introduces a small loss to offset this former condition. The overall response would otherwise have a small hump of about 2dB at 4kc/s. Experiment then showed that a pass band up to 15kc/s could be obtained with $R_6 = 270\Omega$, $C_4 = 0.01\mu F$ and L_1 = 11mH, the maximum lift being 14dB relative to 1kc/s. Some of this lift could, however, be making good gap losses on playback, which, in the absence of a test tape going above 10kc/s were not known. It would be prudent to mention the conditions under which this result is achieved, as slightly different equalization may be needed by other people's equipment.

Recording head	Brenell R-P, 0.00025in gap.
Bias frequency	90kc/s.
Bias amplitude	Optimum — maximum output at 1kc/s.
Tape	Scotch 150.
Replay head	Bogen UK 100, 0.00012in gap.
Replay amplifier	100μsec., 7½in/sec. characteristic.

All these items will be individual to a particular set-up, but the factor which has by far the greatest influence on the results is the bias amplitude. The optimum bias current is defined as that which gives the greatest output on playback from a 1kc/s tone. The distortion for this value of bias is around a minimum. The maximum output at other frequencies occurs at only slightly different bias settings but a given increase in bias current causes a loss in output which is much greater at high frequencies. For instance, an increase above optimum for a drop of 1dB at 1kc/s (7½in/sec.) causes a drop of 2.5dB at 10kc/s and 6dB at 15kc/s.

The circuit of Fig. 1 also shows equalizing components for 3¾in/sec. tape speed. This is intended for a replay time constant of 200μsec. and gives a pass band up to 11kc/s. Although 200μsec. has been a popular choice for 3¾in/sec. in this country, the appearance of American "pre-recorded" tapes has caused some manufacturers to change over to 120μsec. The 120μsec. characteristic does fit the equivalent constant current curve of Fig. 2 better than 200μsec. in that no hump occurs; C_7 becomes unnecessary. However more pre-emphasis is required for a given pass band. Excessive lift might mean that the recording level would have to be held back to prevent unpleasant treble distortion. The dynamic range would be less and this is equivalent to saying that the signal to noise ratio would be worse. Some treble lift is usually permissible with most types of programme material without reduction of the recording level because less energy is concentrated in the upper audio frequencies. However the problem at 3¾in/sec. is aggravated by the lower frequency of maximum boost and the desire to use as much boost as possible to obtain the widest bandwidth.

In conclusion the writer would like to emphasize that the necessary equalization on record will vary from one tape machine to another. The component values given for R_6, C_1 and L_1 are intended as a guide only.

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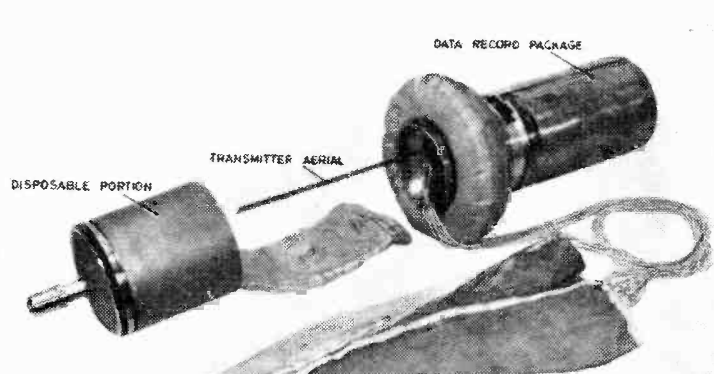
AIRCRAFT ACCIDENT RECORDER

THE rapid conclusion of the enquiry into the B.A.C. One-Eleven crash has demonstrated in no uncertain manner the value of ejectable data recorders. When one remembers the months of work that were needed to locate and analyse the debris of the Comet II that disintegrated in the Mediterranean, the fact that only recently have recorders been used seems all the more remarkable. It appears almost certain that the more expensive prototypes and larger civil aircraft will now carry recorders, and Redifon have recently announced that the later TSR-2 prototypes will be fitted with their new accident data recorder, which is based on a design by R.A.E., Farnborough. This is designed to provide a record which will survive under extreme conditions of heat, humidity and vibration, of the last 15 minutes of flight.

Using the principle of time-division multiplexing, 280 channels per minute are sampled, and a channel is provided for recording the pilot's speech. The 1-in wide tape takes 7½ minutes to traverse in one direction, after which it reverses and changes to the other track. When both tracks have been recorded, that is, after 15 minutes, the data first obtained is continuously erased and new data recorded. Normally, the recorder and its associated encoders are powered by the aircraft's supply, but if this fails, internal batteries are quickly brought into service automatically.

The recording head and tape cassettes are enclosed in a cylindrical capsule and are ejected by a mechanism, developed in collaboration with M.L. Aviation, when in contact with water, fire or excess G forces, the "trip" limits for the latter being adjustable. Ejection can take place at altitudes up to 70,000 feet and speeds up to 1,000 m.p.h., and from 30ft below the surface of the sea. A parachute and flotation bags are deployed on ejection, and the capsule has a transmitter with batteries giving 48 hours of transmitting time.



Left: Recording head and tape canisters, which are ejected. Right: Components of ejected capsule.

Acoustic Noise Measurement and Analysis

By W. V. RICHINGS,* Assoc.I.E.E., A.M.Brit. I.R.E.

THE recent publication of the Wilson Committee Report [1] has focused attention on the growing problem of noise, defined here as unwanted sound. In the extreme, prolonged exposure to very high level sounds creates a serious risk of permanent hearing loss and even damage to structures when the exceedingly high noise levels from rocket motors are considered. At the levels commonly encountered noise can be distracting, annoying and interfere with speech or other wanted sounds.

The purpose of this paper is to describe some of the applications of modern electro-acoustical instrumentation to the problems of noise measurement. By way of introduction, the various terms used in noise measurement are explained.

Sound Pressure and Decibels

Sound waves cause variations in the normal atmospheric pressure. The atmospheric pressure is expressed in dynes per square centimetre (dyne/cm²) for scientific work, one dyne/cm² being about one millionth of the normal atmospheric pressure. The range of sound pressure to which the ear responds is approximately 0.0002 to 200 dyne/cm², the relative levels of typical noises being shown in Table 1. For convenience a logarithmic unit, the decibel, has been borrowed from telecommunications engineering to cover this wide range with easily manageable numbers. Strictly the decibel (dB) is ten times the logarithmic ratio of two powers and since sound power is proportional to (sound pressure)² the number of decibels, N, between two pressures p and p_0 is given by:

$$N \times 10 \log_{10} \left(\frac{p}{p_0}\right)^2 \times 20 \log_{10} \frac{p}{p_0}$$

Since the decibel value implies a ratio, the reference level p_0 must always be stated or at least clearly understood. For sound pressures, the internationally agreed reference level is 0.0002 dyne/cm² which is in

* Dawe Instruments Ltd.

TABLE I

Noise	Decibels	Relative Energy	Sound Pressure Dyne/cm²	Typical Examples
PAINFUL				
	120	1,000,000,000,000	200	
DEAFENING	110	100,000,000,000		Jet aircraft at 500ft. Inside boiler making factory Near pneumatic drill Motor horn at 20ft.
	100	10,000,000,000	20	
VERY LOUD	90	1,000,000,000		Inside tube train Busy street Workshop Small car at 24ft.
	80	100,000,000	2	
LOUD	70	10,000,000		Noisy office Inside small car Large shop Radio set—Full volume
	60	1,000,000	0·2	
MODERATE	50	100,000		Normal conversation at 3ft. Urban house Quiet office Rural house
	40	10,000	0·02	
FAINT	30	1,000		Public library Quite conversation Rustle of paper Whisper
	20	100	0·002	
VERY FAINT	10	10		Quiet church Still night in the country Sound-proof room Threshold of hearing
	0	1	0·0002	

the region of the threshold of audibility for a 1000 c/s pure tone. Sound pressures referred to this level are defined as "sound pressure levels". Thus:—

$$\text{Sound pressure level} = 20 \log_{10} \frac{p}{0.0002} \text{ dB}$$

Table 1 also shows the corresponding sound pressure levels for typical noises.

Sound pressure levels expressed in decibels, cannot be added arithmetically, for example 80dB + 80dB does not equal 160dB. In fact two equal sound pressure levels give an increase of 3dB. Thus 80dB + 80dB gives a total sound pressure level of 83dB. In the general case it can be shown that:—

$$N = 10 \log_{10} (10^{\frac{N_1}{10}} + 10^{\frac{N_2}{10}} + 10^{\frac{N_3}{10}} + \ldots)$$

where N = total sound pressure and N_1, N_2, N_3 .. are the separate levels being added.

This expresses in terms of decibels, the well-known relation that the effective (r.m.s.) value of a number of random electrical or acoustic signals is the square root of the sum of the squares of the individual voltages or sound pressures. It may be noted in passing that for the very special case of adding two voltages or sound pressures which have the identical frequency and phase, the increase in overall level is 6dB.

The scale, Fig. 1, simplifies the problem of combining sound pressure levels. First subtract the largest sound pressure level from the second largest value. Below this difference on the upper scale, the number of decibels to be added and to give the total sound pressure level is determined from the lower scale. Taking the previous example, for $N_1 = N_2 =$ 80dB, $N_1 - N_2 = 0$ on the upper scale, which corresponds with 3dB on the lower scale, giving a total value of 80 + 3 = 83dB. To find the sum of more than two levels, the two largest are first added as described above and the other levels then added one at a time. When the difference in levels is more than 10 to 15dB, the amount to be added becomes negligible since the accuracies with which sound pressure levels can be measured rarely justifies quoting values to closer than the nearest whole decibel.

Loudness and Loudness Level

A major subjective characteristic of a sound is the loudness, that is an observer's auditory impression of the strength of the sound. The loudness is primarily related to the sound pressure although, due to the complexity of the response of the human ear, other factors are also involved. The unit of *loudness level* is the *phon* which is defined[2] on the basis of a subjective comparision between the sound being considered and a sensibly plane sinusoidal progressive sound wave of 1000 c/s coming from directly in front of the observer. When the two are judged to be equally loud, the loudness level in phons is numerically equal to the sound pressure level of the 1000 c/s reference tone.

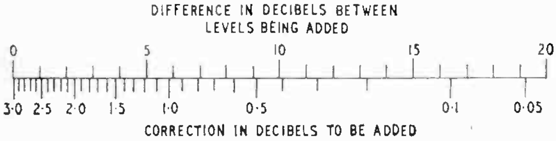


Fig 1. Scale for combining sound pressure levels.

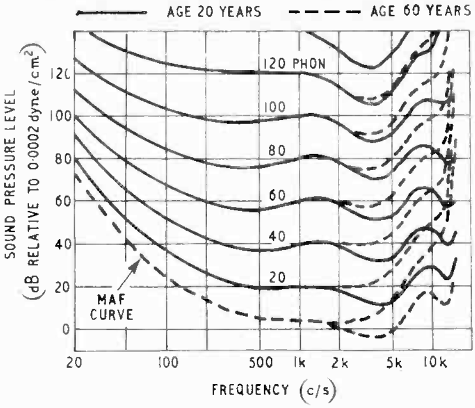


Fig. 2. Equal-loudness contours for pure tones. (Robinson and Dadson).

The ear is not equally sensitive to all frequencies and Fig. 2 shows the sound pressure level in decibels of pure tones at various frequencies required to produce equal sensations of loudness in phons, taking the average of a number of observers. For a group of observers the majority will normally agree within 6 phons, although individual estimates may differ by 10 phons or more. The equal loudness contours of Fig. 2 are taken from the results of work carried out at the National Physical Laboratory by Robinson and Dadson[3] and form the basis of British Standard 3383 : 1961[4]. These curves differ to some extent from those obtained earlier by Fletcher and Munson (1933) and by Churcher and King (1937).

No zero phon curve is given, because the threshold of hearing at 1000c/s has been found to be about 4dB above the standard reference level (0dB = 0.0002 dyne/cm^2), so that the lowest curve is that for the minimum audible field (M.A.F.).

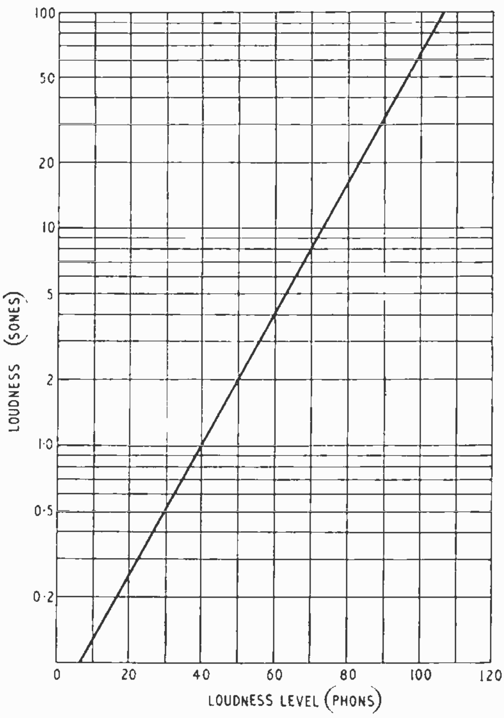
The phon scale relates the sensitivity of the ear at various frequencies to that at 1000c/s but does not give a direct indication of the change in level necessary, to, say, double the loudness of a sound. For this purpose the *sone* scale of *loudness* has been devised. The reference point of this scale is taken arbitrarily as a loudness of 1 sone for a loudness level of 40 phons. Then a sound which is *n* times as loud as the reference has a loudness of *n* sones. It has been found experimentally that for practical purposes, doubling the loudness corresponds to an increase of loudness level of 10 phons. Similarly a reduction in loudness level of 10 phons halves the loudness. The relationship between the loudness level (P) in phons and the loudness (S) in sones is given by the formula:—

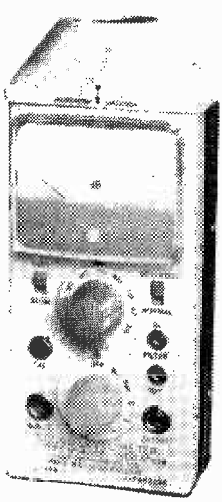
$$P = 40 + 10 \log_2 S$$

This phon—sone function has been standardized in Great Britain, British Standard 3045 : 1958[5], and internationally[6] and is shown graphically in Fig. 3.

It should be noted that equally loud sounds are not always equivalent in other respects, for example two sounds of equal loudness may differ in annoyance or in the degree to which they interfere with speech.

The fundamental method for determining loudness level in phons requires a number of observers and carefully controlled laboratory experiments. This is impractical for routine noise measurements and an objective method of measurement using a sound level meter has been standardized. The *sound level*





Above—Fig. 3. Relation between loudness and loudness level.

Left—Typical sound level meter to British Standard and I.E.C. requirements (Dawe Instruments)

Right—Fig. 4. Overall frequency response with three different weighting networks.

in decibels is defined as the sound pressure level measured with a sound level meter having certain frequency characteristics and other performance requirements specified in British Standard 3489: 1962[7] and International Electrotechnical Commission (I.E.C.) Publication 123[8].

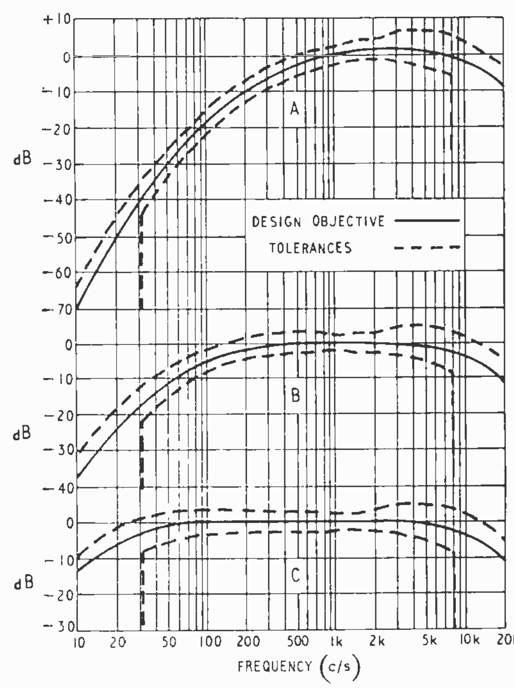
The sound level meter consists of a microphone, amplifier, weighting networks and an indicating meter. The weighting networks provide the frequency response characteristics A, B and C shown in Fig. 4. Historically these were intended to simulate the frequency characteristics of the ear at low, medium and high levels respectively. However, extensive tests have shown that in many cases sound level A is found to correlate best with subjective noise ratings. Current recommendations for rating noise with respect to hearing conservation, speech communication and annoyance propose that sound level A should be used for screening purpose to indicate whether more detailed measurements are necessary. When the sound level meter is used with a filter for frequency analysis, sound level C is required to provide a substantially flat response over the frequency range 31.5c/s to 8000c/s.

The sound level meter reading does not in general correspond with the loudness level in phons. However, in spite of this limitation, the sound level meter is widely used for practical noise measurements. It provides a simple, consistent means for the comparison of results and to place noises of similar character in rank order.

In reporting the results it is important to state the weighting network which was used, for example to note that the sound level was, say, 85dB(A).

Loudness Calculation

Various procedures have been evolved to calculate a value of loudness level from a frequency analysis of the sound pressure level, taking into account some of the more complex characteristics of the ear.



A method of calculation proposed by Stevens[9] forms the basis of a draft I.S.O. procedure using a broad-band frequency analysis. The level in each band is converted into a " loudness index " by means of curves (Fig. 5) or tables. These curves originate from equal loudness contours for bands of noise in a diffuse sound field. The total loudness index is then found by means of the formula:—

$$S_t = S_m + F(\Sigma S - S_m)$$

where S_m is the greatest of the loudness indexes.
ΣS is the arithmetic sum of the loudness indexes of all the bands.
F depends on the bandwidth (0.15 for one-third octave or 0.3 for octave bands).

The calculated loudness level is then determined

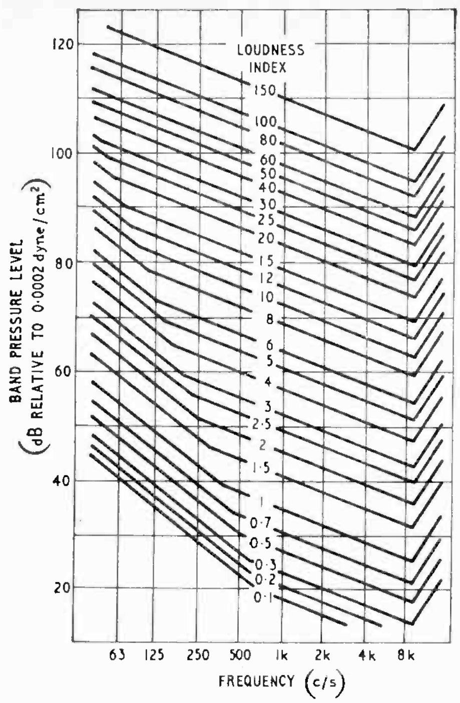


Fig. 5. Relation between band pressure level and loudness index.

by means of the formula corresponding to the phon-sone relationship described previously (Fig. 3).

The draft recommendation gives preference to octave bands for this method, but one-third octave bands can also be used. For the I.S.O. procedure using octave bands, the loudness index is in units of sones (OD) and the loudness level in phons (OD), the "OD" signifying " octave, diffuse " as the basis of computation.

The preferred procedure using one-third octave band levels is based on a method proposed by Zwicker[10]. The total loudness is determined from the band levels as the area under specially prepared graphs which take into account subjective characteristics such as masking. The loudness level is then obtained from the phon-sone relationship. (Fig. 3.) For a diffuse sound field, the units of loudness and loudness level calculated by this method are sones(GD) and phons(GD) respectively. For a free sound field the corresponding units are sones (GF) and phons(GF).

It should be noted that the calculated results obtained by the various methods do not always agree exactly with one another or with the subjectively determined loudness level in phons.

Noise of Motor Vehicles

The results of a survey reported by the Wilson Committee[1] show that road traffic is the major source of noise which disturbs people at home or outdoors. This is perhaps not surprising with the rapidly increasing number of vehicles on the roads together with their improved performance and power. Extensive tests have been carried out in this country by the Ministry of Transport, the Motor Industry Research Association and the National Physical Laboratory on methods of measurement of vehicle noise. As a result of this work a British Standard 3425 : 1961[11] has been published describing the procedure necessary to achieve consistent and reproducible measurements. The procedure requires an open test site to avoid reflections from surrounding buildings and other obstacles The vehicle accelerates at full throttle from a stated driving condition past the microphone of a sound level meter. The microphone is mounted at a height of 1.2 metres (3ft 11in) and at a distance of 7.5 metres (24ft 7in) from the centre line of the vehicle. The work mentioned above and similar experiments abroad have shown that the sound level A gives an acceptable correlation with subjective listening tests and has thus been specified for vehicle noise measurement.

British Standard 3539 : 1962[12] specifies the performance of the high-quality sound level meters needed to carry out these tests. Two special sound level meters are described elsewhere[13]. The first, known as a " Vehicle Noise Meter," is for testing stations and vehicle manufacturers where the full requirements of British Standard 3425 : 1961 relating to the method of driving the vehicle apply. The second instrument, known as a "Traffic Noise Meter," is intended for roadside checks by police and other authorities where it is required to determine whether the noise exceeds a specified value. The operation is simplified to avoid the possibility of incorrect setting of the controls by the non-specialist user.

The Ministry of Transport has recently issued draft regulations proposing that the noise level of new motor vehicles when tested in accordance with British Standard 3425 : 1961 should not exceed 90dB(A) for motor cycles and 85dB(A) for other vehicles. The higher value suggested for motor cycles has been chosen to allow for the consistently higher reading on a sound level meter given by motor cycles as compared with other vehicles which were judged equally noisy. The draft regulations also propose that the noise levels of vehicles on the road should be measured under suitable conditions and that it should be an offence for the noise measured to exceed by more than 3dB the levels given above for new vehicles. These limits are a compromise between what is acceptable to the public and what is technically possible at reasonable cost. However the recommendations, if adopted, should considerably reduce the number of noisy vehicles and discourage drivers from creating unnecessary noise.

Aircraft Noise

The total acoustic power radiated by a modern jet aircraft amounts to tens of kilowatts. This indicates the magnitude of the noise problem in the vicinity of airports and it is not surprising that the number of complaints has increased rapidly in recent years. Strenuous efforts to reduce the noise are being made by the engine manufacturers, but since the acoustic output is already no more than a few per cent of the total power output, only gradual improvements can be expected. The noise can be alleviated to some extent by adopting special take-off and landing procedures and where possible using runways directed over the sea or sparsely-populated areas.

The noise of aircraft using major airports is monitored and recorded as *perceived noise level* in units of PNdB (perceived noise decibels). Maximum levels of 110-112 PNdB have been adopted for daytime operations and about 102 PNdB during the night. This method of noise rating[14] is patterned after that proposed by Stevens for calculating loudness and loudness level[9] using a broad-band frequency analysis. In this case equal *noisiness* contours or tables are used to convert the band pressure level into noisiness in *noys*. The total noisiness is calculated from:—

$$N_t = N_m + F(\Sigma N - N_m) \text{ noys}$$

where N_m is the noisiness in the noisiest band.

ΣN is the sum of the noisinesses of all the bands.

F depends on the bandwidth (0.15 for one-third octave or 0.3 for octave bands).

The perceived noise level in PNdB can then be determined from the phon-sone relation (Fig. 3).

It may be noted that noys are analogous to sones and PNdB to phons in the Stevens method.

For aircraft noise, it is possible to obtain an close approximation to the calculated perceived noise level by using a sound level meter with the N weighting curve (Fig. 6).

Some modification of the equal-noisiness contours and tables for frequencies above 1000 c/s has recently been proposed as a result of further work[15]. Both the original 1959 and the revised 1963 curves are shown in Fig. 6.

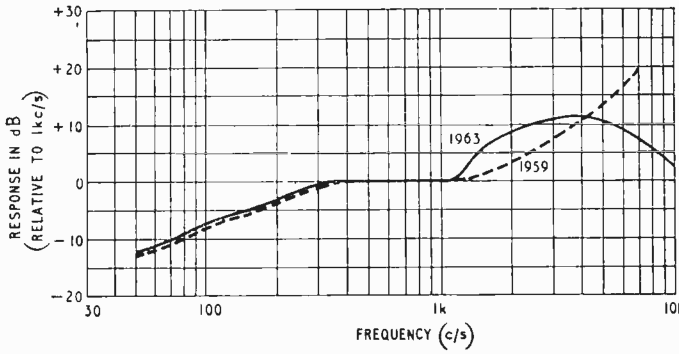


Fig. 6. N weighting curve for perceived noise.

Noise Rating

Various methods for rating with respect to hearing conservation, speech communication and annoyance have been proposed and are under discussion as the basis for an I.S.O. recommendation. From a frequency analysis of the noise using a sound level meter and octave band filter, the "noise rating" of each octave band sound pressure level is determined from noise rating curves (Fig. 7. The *noise rating number N* of the noise is the highest of the octave band values.

In rating a noise with respect to the risk of permanent impairment of hearing the octaves with mid-band frequencies of 500c/s, 1000c/s and 2000c/s are of major importance. A vital concept in this connection is that of "noise exposure." Thus if the noise only occurs intermittently each day, a higher level can be permitted. The total time of exposure during a working life must also be considered.

To estimate the interference with speech communication, the noise rating number of the noise is determined for the octaves with mid-band frequencies of 500c/s, 1000c/s and 2000c/s. The expected intelligibility is indicated in the following table:—

Noise Rating Number	Distance at which speech is intelligible	
	With normal voice	With raised voice
40	23ft	46ft
45	13ft	26ft
50	7ft	14ft
55	4ft	8ft
60	2ft 3in	4ft 6in

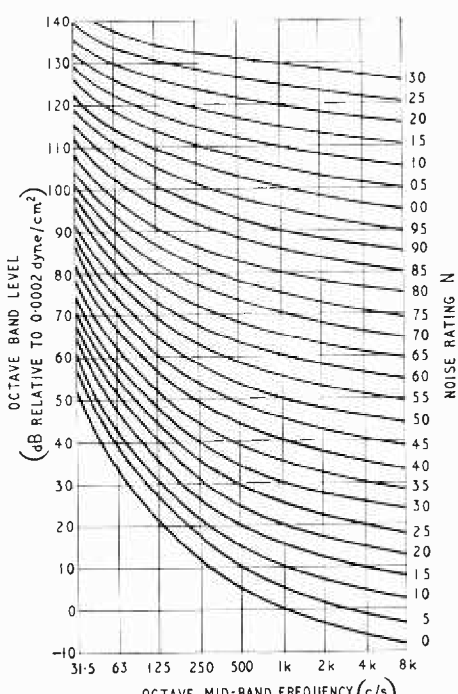


Fig. 7. Noise rating curves.

For rating with regard to annoyance, the noise rating number is first determined for the octave bands from 31.5c/s to 8000c/s. The noise can be considered annoying if the noise rating number exceeds an accepted criterion for the particular circumstances. Suggested maximum noise rating numbers inside schools, offices, workshops and other non-residential buildings are as follows:—

Noise Rating Number	Examples of type of room
20–30	Classroom, hospital, church, theatre, concert hall, small office, conference room.
30–40	Large office, laboratory, department store, quiet restaurant.
40–50	Larger restaurant, secretarial office, gymmasium.
50–60	Large typing pool.
60–70	Workshop.

In residential areas, basic noise rating criteria of 20-30 indoors and 30-40 outdoors have been proposed. Corrections are then made to allow for the type and duration of the noise, neighbourhood and similar factors which determine the annoyance of noise in the home. Typical corrections are as follows:—

1. Pure tone easily perceptible	.. ..	−5
2. Impulsive and/or intermittent noise	..	−5
3. Only occurs during day time	.. ..	+5
4. Noise during 25% of time	..	+5
6%	.. .. ..	+10
1.5%	.. .. ..	+15
0.5%	.. .. ..	+20
0.1%	.. .. ..	+25
5. Neighbourhood—quiet suburban	..	−5
—suburban	.. ..	0
—residential, urban	..	+5
—urban near some industry		+10
—urban near heavy industry	.. ..	+15

The sum of the corrections in each section above is added to the basic noise rating to obtain a corrected criterion against which the noise rating number is compared.

A simpler method[16] of rating residential noise is based on sound level A instead of an octave analysis.

These noise rating procedures are largely empirical and the corrections and criteria will undoubtedly be revised as more experience is accumulated. However, they form a practical guide to the likely annoyance of a given noise situation.

Conclusions

The measurement and analysis of airborne noise is an extremely broad subject so that it has only been possible to outline some of the many problems. Noise is undoubtedly of growing importance and much work is still needed both on the fundamental mechanism of hearing, so that improved measuring techniques can be developed, and on methods for noise reduction.

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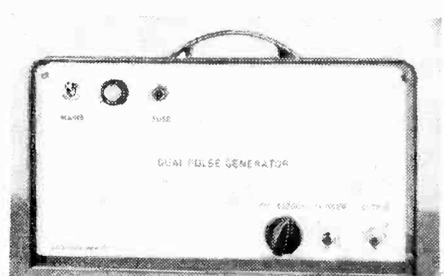
Dual Pulse Generator

THE ORBA Type 01 492 dual pulse generator provides accurate pulse trains for applications such as fault location, impedance end level and uniformity tests on coaxial cables. The instrument was designed to meet the requirement of the Post Office Engineering Department LW543 Specification.

Mains powered, the generator produces trains of +40V pulses at a p.r.f. of 15kc/s into 75Ω. The pulse widths taken at the pulse half-height are 100nsec and 200nsec respectively for alternative trains. Synchronous trigger pulses of 10V into 2kΩ are also available. The instrument, manufactured by Alexander Orba Ltd., Woolston, Southampton, costs £85.

4WW 419 FOR FURTHER DETAILS



Orba dual pulse generator.

INDUSTRIAL AND TECHNICAL FILMS

DURING the past few months we have received information on many new 16mm films and 35mm film strips from companies and film libraries. Here are details of a few which we feel may be of interest to colleges, schools, clubs, etc.

Further information on those films marked with an asterisk can be obtained from the Central Film Library of the Central Office of Information, Government Building, Bromyard Avenue, London, W.3, and on those marked with a dagger from the Rank Film Library, 1 Aintree Road, Perivale, Middlesex. The film titled "Analysis by Mass" is available from the A.E.I. Film Library, 33 Grosvenor Place, London, S.W.1. Incidentally, this film received first prize in the category on "the industrial applications of scientific principles and research" at the fourth International Film Festival, which was held in Madrid.

Except where otherwise stated, a hire charge is made.

Principles of the Optical Maser (V 640)*. In this 30-minute colour film Dr. C. G. B. Garrett, of Bell Telephone Laboratories, compares masers with standard radio oscillators and explains, with diagrams and lab. experiments, how the "photon chain reaction" is induced.

The Ultimate Speed—an exploraton with high energy electrons (V 646)*. An experiment in the Massachusetts Institute of Technology to determine the relationship between the kinetic energy of electrons and their speed forms the basis of this 38-minute film.

Analysis by Mass (on free loan from A.E.I.) describes the structure of atoms of elements, the combination of atoms to form molecules, and the use of a mass spectrometer to determine accurately the mass of an unknown molecule.

Similarities in Wave Behaviour (V 618)*. A lecturer explains the behaviour of waves using a mechanical wave simulator in this 27-minute Bell Telephone film.

The World of Semiconductors (UK 2230)*. Based on the I.E.E. 1961 Faraday lecture by L. J. Davies, of A.E.I., this 38-minute film (on free loan) deals with the properties, construction and uses of semiconductors.

The Printed Circuit Story (V 633)*. Several methods of producing printed circuit boards and techniques for servicing and repair are illustrated in this 25-minute colour film from the U.S.A.

Microminiaturisation of Electronic Equipment (UK 1707)*. This 28-minute colour film shows the techniques of making micro-components and assemblies. Originators: Royal Radar Establishment.

The 1500 Electronic Data Processing System.† This (free loan) 11-minute colour film gives an overall picture of the potential of the I.C.T. 1500 and deals specifically with three typical installations in small-, medium- and large-sized undertakings.

Memory Devices (V 619)*. The binary system, how binary information is stored, types of memory devices and their function in electronic computers are explained in this 27-minute Bell Telephone colour film.

Story of a Network.† This 20-minute film (on free loan) is centred on the building of a new television transmitter in the Presely mountains in South Wales and shows how the station fits into the national I.T.A. network.

I am going to be a Television Technician (UK 1733)*. The technical work entailed in mounting a television programme is shown in this 26-minute film. A lighting supervisor, a senior cameraman and a sound supervisor speak of their jobs, and a deputy technical controller describes the work of television engineers.

At Your Request (UK 1710)*. This 16-minute colour film shows the National Lending Library for Science and Technology in action. This library, which comes under the aegis of D.S.I.R. was opened last year and now has the largest scientific loan collection in Europe.

Ariel—the first International Satellite (V 637)* deals with the construction of Ariel and its equipment. The space experiments undertaken by the satellite are also mentioned in this 13-minute colour film.

FILM STRIPS

All the film strips listed below are in colour and have been prepared by the Mullard Educational Service and are available, priced at 25/- each with comprehensive teaching notes, from Unicorn Head Visual Aids Ltd., 42, Westminster Palace Gardens, London, S.W.1.

Electrical Meters and Measurement. This 28-frame film strip is in two parts. The first deals with the principles and construction of various types of meter movement and the second shows the correct approach to the use of measuring equipment.

Principles of Electrostatics. Most of the 28 frames are used in describing electrification, the structure of the atom, electrostatic induction, charge density, lines of force, and potential and capacitance. The film concludes with a description of various electrostatic machines and measuring devices.

Power Supplies for Communications. 32 frames are used to cover this subject. Among the items covered are rectifiers, filters, voltage stabilizers, multipliers, d.c. converters and e.h.t. units.

History of Magnetism. This 28-frame strip is the third in the series "History and basic principles" and outlines many of the early devices used to establish today's well-known principles of magnetism.

Detection and Detectors. After explaining the principles of detection and detectors, this 30-frame strip concludes with a number of amplitude-modulation detector circuits. This is one of a series which includes thermionic oscillators; amplification and amplifiers; and modulation and modulators.

INFORMATION SERVICE FOR PROFESSIONAL READERS

To expedite requests for further information on products appearing in the editorial and advertisement pages of *Wireless World* each month, a sheet of reader service cards is included in this issue. The cards will be found between advertisement pages 32 and 35.

We invite readers to make use of these cards for all inquiries dealing with specific products. Many editorial items and all advertisements are coded with a number, prefixed by 4WW, and it is then necessary only to enter the number(s) on the card.

Readers will appreciate the advantage of being able to fold out the sheet of cards, enabling them to make entries while studying the editorial and advertisement pages.

Postage is free in the U.K., but cards must be stamped if posted overseas. This service will enable professional readers to obtain the additional information they require quickly and easily.

JANUARY MEETINGS

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

LONDON

6th. I.E.E.—"Operational experience with wide-band radio links" by D. G. Jones at 5.30 at Savoy Place, W.C.2.

9th. Radar & Electronics Assoc.—"Medical automation" by Dr. L. C. Payne at 7.0 at the Royal Society of Arts, John Adam Street, W.C.2.

10th. Television Society.—"Managing a regional television station" by Nathan Hughes at 7.0 at I.T.A., 70 Brompton Road, S.W.3.

13th. I.E.E.—Discussion on "Getter ion pumps" opened by W. F. Gibbons at 5.30 at Savoy Place, W.C.2.

14th. I.E.E.—"Non-linear circuit theory" by Prof. J. C. West at 5.30 at Savoy Place, W.C.2.

15th. I.E.E.—"The quest for controlled thermonuclear reactions" by Dr. A. A. Ware at 5.30 at Savoy Place, W.C.2.

15th. Brit.I.R.E. — Three short papers on "Acoustical filters" at 6.0 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

16th. I.E.E.—Five papers on "Waveguides" at 5.30 at Savoy Place, W.C.2.

17th. B.S.R.A.—"Magnetic tape specifications and performance" by G. Balmain at 7.15 at the Royal Society of Arts, John Adam Street, W.C.2

22nd. Brit.I.R.E. & I.E.E.—"Non-canulated methods of measuring blood flow" by Dr. A. Guz and Dr. C. A. F. Joslin at 6.0 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

23rd. Institution of Electronics.—"Microminiaturization of electronic components" by D. Boswell at 7.0 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

23rd. Television Society.—"An historical survey of band shared colour television systems" by I. Macwhirter at 7.0 at I.T.A., 70 Brompton Road, S.W.3.

27th. I.E.E. & Brit.I.R.E.—Colloquium on "The interconnection of peripheral equipment" at 2.30 at Savoy Place, W.C.2.

29th. Brit.I.R.E.—Papers on "Television receiver production techniques" at 6.0 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

BIRMINGHAM

6th. I.E.E.—Discussion on "Training for the profession" opened by P. L. Taylor at 6.30 at the James Watt Memorial Institute, Great Charles Street.

15th. Television Society.—"The television studio—1: the camera" by H. Anstey at 7.0 at the College of Advanced Technology, Gosta Green.

23rd. Brit.I.R.E. — "Teaching machines" by Max Sime at 7.0 at Electrical Engineering Dept., University of Birmingham, Edgbaston.

27th. I.E.E.—"Electronics in railway signalling" by B. H. Gross at 6.0 at the James Watt Memorial Institute, Great Charles Street.

BRIGHTON

22nd. I.E.E.—"Synthetic speech and communication" by K. Holywell at 6.30 at the College of Technology.

BRISTOL

22nd. Brit.I.R.E.—"Ballistic missile early warning systems (BMEWS)" by G. G. Boyts at 6.30 at the University, Engineering Lecture Rooms.

27th. I.E.E.—"Semiconductor devices" by D. D. Jones at 6.0 in the Demonstration Theatre, Electricity House, Colston Avenue.

CARDIFF

8th. Brit.I.R.E. — "Stereophonic sound" by F. H. Brittain at 6.30 at the Welsh College of Advanced Technology.

CHELTENHAM

9th. Society of Instrument Technology.—"Vibration in the field of environmental testing" by S. C. Marks at 7.30 at the Belle Vue Hotel.

CHESTER

30th. Society of Instrument Technology.—"Solid state instruments for process control" by I. C. Hutcheon at 7.30 at the Stanley Palace, Watergate Street.

EDINBURGH

8th. Brit.I.R.E.—"Transistors in television receivers" by P. L. Mothersole at 7.0 at Department of Natural Philosophy, the University, Drummond Street.

14th. I.E.E.—"The present state of colour television" by S. N. Watson at 7.0 at the Carlton Hotel, North Bridge.

FARNBOROUGH

28th. I.E.E.—"Applications of superconducting" by A. C. Rose-Innes at 6.30 at the Technical College.

GLASGOW

9th. Brit.I.R.E.—"Transistors in television receivers" by P. L. Mothersole at 7.0 at the Institution of Engineers and Shipbuilders, 39 Elmbank Crescent.

13th. I.E.E.—"The present state of colour television" by S. N. Watson at 6.0 at the Royal College of Science and Technology.

31st. Society of Instrument Technology.—"Electronics versus pneumatics" by C. H. Gregory at 7.15 at the Scottish Building Centre, 425 Sauchiehall Street.

LEEDS

8th. Brit.I.R.E.—"A multi-function static switching system" by C. G. Cargill at 6.30 at the Department of Electrical Engineering, the University, Woodhouse Lane.

28th. I.E.E.—Discussion on "The New Ordinary National Certificate in engineering and its effect on training schemes" at 6.30 at the College of Technology.

LIVERPOOL

15th. Brit.I.R.E.—"Masers and lasers" by Dr. W. A. Gambling at 7.30 at the Walker Art Gallery.

20th. I.E.E.—" Pulse techniques in line communication " by R. O. Carter at 6.30 at the Royal Institution, Colquitt Street.

LOUGHBOROUGH
21st. I.E.E.—" Recent developments in the theory of automatic control " by Dr. A. R. M. Noton at 6.30 in No. 1 Lecture Theatre, Union Building, College of Technology.

MALVERN
13th. I.E.E.—" Satellite communications " by F. J. D. Taylor at 7.30 at the Winter Gardens.

MANCHESTER
8th. I.E.E.—" Medical electronics " by W. J. Perkins at 6.15 at the Reynolds Hall, College of Science and Technology.

14th. I.E.E.—" Electronic summation metering " by M. L. Done at 6.15 at the Reynolds Hall, College of Science and Technology.

MIDDLESBROUGH
21st. Society of Instrument Technology.—" Some physical methods of analysis " by Dr. G. Jessop at 6.30 at the Cleveland Scientific & Technical Institution, Corporation Road. (Joint meeting with the Inst. of Physics and Phys. Soc.)

NEWCASTLE-UPON-TYNE
6th. I.E.E.—Discussion on " The computer and the electrical engineer " opened by Dr. E. S. Page at 6.30 at the Rutherford College of Technology, Northumberland Road.

8th. Brit.I.R.E. & Inst. of P.O. Elec. Eng.—" Some results of tests at the Goonhilly earth station " by F. J. D. Taylor at 6.0 at the Institute of Mining and Mechanical Engineers, Westgate Road.

20th. I.E.E.—" Storage tubes " by J. C. Firmin at 6.30 at the Rutherford College of Technology, Northumberland Road.

NOTTINGHAM
28th. I.E.E.—" Education of engineers " by Dr. E. R. Laithwaite at 6.30 in the Main Lecture Theatre, T1 First Year Applied Science Teaching Block, Nottingham University.

PORTSMOUTH
15th. I.E.E.—" Test equipment for the Armed Services " by F. W. Jackson, E. Booth and D. F. Cockram at 6.30 at the College of Technology.

SHEFFIELD
29th. I.E.E.—" Some aspects of the use of computers in process control applications " by J. F. Roth at 6.30 at the University, Mappin Street.

SOUTHAMPTON
7th. Brit.I.R.E.—" Solid state switching " by A. C. Savage at 6.30 at the Lanchester Theatre of the University of Southampton.

14th. I.E.E.—" An introduction to programming languages " by M. J. Kingston at 6.30 at the University.

WEYMOUTH
16th. I.E.E.—" Recent developments in components for computers " by W. Renwick at 6.30 at the South-Dorset Technical College.

UNBIASED

By "FREE GRID"

Electronic Snobbery

NOWADAYS we so often hear the adjective "electronic" used when the words "electric" or "electrical" should have been used, that I have been wondering why all this is. I have come to the conclusion that "electronic" has become a snob word, always to be preferred to its humbler relations by people of the type who speak of "perspiration" and shudder at the vulgar word "sweat." These sort of people will always use the adjective "electronic" if it can possibly be worked in to describe a component or piece of equipment.

Ten years ago the International Electrotechnical Commission submitted, for national approval, the following definition of the noun "electronics," which is now included in the British Standards Institution's "Glossary of Terms Used in Telecommunication and Electronics" (BS204):—

> "That branch of science and technology which deals with the study of the phenomena of conduction of electricity in a vacuum, in a gas, and in semiconductors, and with the utilization of devices based on these phenomena." The adjective "electronic" "qualifies that which is concerned with electronics or any device which functions according to its principles."

The conduction of electrons through metallic conductors as in the case of our house wiring, is outside the realm of electronics (just vulgar "electrics" I suppose). If this could be remembered by those who persist in using "electronics" on every possible and impossible occasion it would, I'm sure, save a lot of confusion in the mind of the man in the street.

Problems of Presbyotia

IN the December issue I mentioned that after having had my hearing tested on the G.P.O. Otometer—if that be the correct term—at the Radio Communications Exhibition, I realized how much high-note reproduction I was missing. This loss was due, of course, to the insidious onset of presbyotia which, together with presbyopia, is apt to creep up on us. Even though the Editor implied by his footnote that I might have been worrying unduly by allowing myself to be misled by the hypnotic hyberbole of sales literature, I still think I am losing something at the top of the musical register, as I find I am able to tolerate shrieking sopranos to a greater extent than was once the case.

It interests me to note that a well-known figure in the audio world, namely, G. A. Briggs, has also been getting his hearing tested, as he mentions in his new book, "Audio & Acoustics." He did not, however, take a test in a public exhibition like myself, but went boldly to the sanctum sanctorum of hearing in London, namely, the Institute of Laryngology & Otology.

I was particularly interested in chapter 2 of the book, in which J. Moir, the sub-editor, deals with otological physiology. He has set me wondering whether it would not be possible to do something about that particular manifestation of presbyotia which results in a falling off in sensitivity to the upper musical register as we age. We could tackle the problem of using headphones or a hearing aid fitted with variable treble boost. Unfortunately, a hearing aid, unlike glasses, is taken by some people as a sign of senility. Would it not be possible to build a treble-boost amplifier small enough to push into our auditory meatus—earhole to you? It should even be possible, I think, to interest surgeons in inserting one right inside the ear. After all, it is now possible for surgeons to implant in the body an electronic pacemaker for the heart.

Ultra-Het Sets

I WONDER if any of you can tell me why we speak of super-het receivers, and never of ultra-het ones and yet talk of ultrasonic and not supersonic waves? It is no use telling me that ultrasonic waves are related to sonics or acoustic frequencies whereas superhets are concerned with radio frequencies. A superhet is so called because the beat frequency which we pass through our i.f. amplifiers is beyond the range of audibility or, in other words is a supersonic heterodyne frequency.

The reason for the question in my first paragraph is that I think there must be some subtle difference between the meanings of the Latin words ultra and super of which I am ignorant.

I am not a Latin scholar myself nor have I ever claimed to be. I might possibly have become one but when I was studying Latin, among other things, Kitchener pointed his accusing finger at me in the famous recruiting poster and said that "Your Country Needs YOU." I recall thinking at the time that the country must be in a pretty parlous plight if Kitchener seriously thought my services in his famous army could affect the issue.

However, I decided to trust his word and so laid aside my "Lewis & Short" and my "Liddell & Scott"; but Kitchener got tired of me after a few months, and I found myself in a loathsomely instable ship, hoping that a kindly U-Boat commander would soon end my misery. *Sic transit spes mea docti.*

I do, therefore, ask you who were too young to be beguiled by Kitchener to enlighten my ignorance as to why ultrasonic waves are not called supersonic ones because they are, after all, just as much above audibility as are the supersonic beat frequencies handled by our i.f. amplifiers. No doubt there is some niggling nuance of meaning which makes the two words non-interchangeable.

Queen Victoria's Set

THE letter from Mr. Rowland F. Pocock in the December issue—and also the one in the November number—about the origins of wireless in the R.N. interested me greatly. He certainly seemed to know what he was talking about and took the trouble in his latter letter to make good some omissions in his former one. I wonder if it was the R.N. who fitted wireless to the Royal Yacht *Osborne* and also to the Queen's residence at East Cowes in 1898?*

For the benefit of the younger readers of *W.W.* who may not realize that wireless is so old, I had better explain that Queen Victoria did not have wireless fitted because she was seeking to be amused, which history tells us would have been rather difficult to accomplish. She had the installation fitted in order to keep in touch with the Prince of Wales ($2\frac{1}{2}$ years later, King Edward VII) when he was carrying out a leisurely circumnavigation of the Isle of Wight while convalescing. It seems a pity that the installation did not find its way to the Science Museum. Maybe it did and the curators have it stored away waiting for the opening of the new block.

* Mr. Marconi was requested to set up the land station at Ladywood Cottage, Osborne.—ED.