Wireless World

ELECTRONICS, RADIO, TELEVISION

JULY 1962

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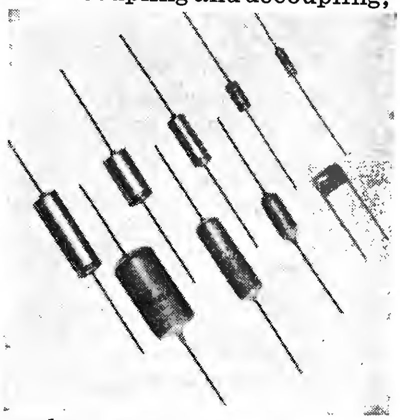
MULLARD MINIATURE CAPACITORS

for modern receivers, recorders and record-players

Mullard miniature capacitors are appearing in ever-increasing numbers in all stages of modern television, radio and audio equipment. They cover the full range of applications, the miniature electrolytics being used for coupling and decoupling, and the polyesters and miniature foil types replacing the older paper types.



Miniature electrolytic capacitors are offered in five can sizes. The largest capacitance available is 640μF rated at 2·5V, and the smallest is 0·32μF at 64V. Polyester capacitors are available in two comprehensive ranges, one covering capacitances from 0·001 to 0·47μF at 400V, and the other from 0·01 to 1·0μF at 125V. Four miniature foil capacitors are available—0·01, 0·022, 0·047 and 0·1μF, the values most commonly required in r.f. and i.f. stages. These groups thus afford excellent cover of the needs of radio and television receivers, tape recorders and record-players, and the new Mullard capacitors represent a notable advance on the older types of component previously used.

AD140—A NEW POWER TRANSISTOR FOR CAR RADIOS

To meet the need for high a.f. gain in transistor car radios, Mullard have recently released their new alloy-junction transistor, type AD140. This new transistor has a high current gain and possesses good linearity and frequency characteristics.

In conjunction with the OC82M miniature driver transistor, the AD140 comprises the new Mullard high gain audio package, type LCR2, which will now be appearing in the newest car radios. The package forms a two-stage class A audio amplifier, capable of delivering an output of 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 the full output. The LCR2 package offers an economic design and ensures an excellent standard of performance. The introduction of the Mullard AD140 power transistor thus constitutes a major contribution to the development of all-transistor car radios.

WHAT'S NEW IN THE NEW SETS

These articles describe the latest Mullard developments for entertainment equipment

Improved method of valve assembly

A new semi-automatic aid to the assembly of the component parts of a valve has recently been introduced by Mullard to the production of a number of their valves. This aid comprises a jig which guides the various electrodes of a valve into the correct locating holes in the bottom mica of the cage structure, thus eliminating the need for manipulation of the components by the operator. The operation of a small press seats the electrodes firmly in the bottom mica, and jaws then clamp the assembled cage in position to facilitate fitting and securing the top mica. The new aid increases the speed at which valves can be manufactured and at the same time reduces the possibility of damage by operators, thus ensuring a much more consistent product with smaller spreads in characteristics.

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Wireless World

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I.E.A. Ascendant

SINCE the demise of the British Industries Fair it has been our habit to deplore the lack of exhibitions in this country on a scale which can be compared with those to be seen in most other European countries. The recent Instruments, Electronics and Automation exhibition at Olympia has entirely changed that mood and has administered a timely tonic on the eve of our possible entry into the European Economic Community.

When, last month, we had to find no fewer than five pages merely to list the exhibitors and to show the position of their stands, it was realized that an occasion of unusual significance, if only for sheer size, was imminent. In the event it proved to be more than that. Of the 91,748 visitors recorded, 6,708 were from overseas, an increase of 67% compared with the figures for the previous exhibition in 1960. Many of the products shown will have been seen previously at Continental exhibitions, but clearly it has been worth while for an increasing number of our overseas competitors, customers and friends to make the journey to see the indigenous product of those British firms who have not exhibited abroad, and to renew and develop contacts with those who have. As readers of this journal are aware, we make a practice of visiting and reporting on most of the European exhibitions and we have no hesitation in saying that the I.E.A. exhibition is now in the front rank of its kind.

It has not always been so and we still recall with embarrassment the expression on the face of a housewife complete with shopping basket and small child who some years ago, had been persuaded to part with her entrance fee by the blandishments of "popular" posters outside the exhibition. Representatives of other industries were no doubt more successful on that first occasion in concealing their utter bewilderment or alternatively maintaining their scepticism about the future of these newfangled ways of going about making, measuring and controlling things.

This year the sightseeing was unmistakably professional and well informed and the sightseers were either technical or managerial or both. Minds had been made up and they were there to discuss prices rather than principles. The boffins and their prototypes were still represented but there was more writing in order books than circuit sketching on the backs of envelopes. The overall impression given by the 4th I.E.A. exhibition is that the industry is consolidated and in a good position to face competition from any quarter.

Lines and Fields

THE International Television Conference organized by the I.E.E. in association with the I.R.E., the Television Society and the British Kinematograph Society is reported elsewhere in this issue. If the attendance did not quite reach the early estimates of the organizers it was nevertheless a very successful meeting, and went far in restoring the prestige of British television in the eyes of overseas visitors who might have gained a wrong impression from the less than adequate support given by the industry as a whole to the Montreux Symposium.

Of the several technical demonstrations seen during the Conference at Savoy Place one of the most thought provoking was the comparison of line and field frequency standards which formed part of Dr. Maurice's introductory lecture on systems standards. In our seat at a distance of about 12ft from one of the 23-in monitor screens we could detect no difference between 405, 625 or 819 lines, but the improvement of 60c/s field and picture frequencies over 50c/s was remarkable. The absence of flicker with interlaced fields and the further removal of horizontal line jitter with full-line sequential pictures seem to us to be a much more worthwhile first objective than any improvement of vertical definition. With the growing need for precision offset working and stable scanning frequencies, independent of the mains, there is no reason why we should not change to 60c/s with interlacing, but the ultimate aim of full sequential pictures would double the bandwidth and must await an extension of wire distribution, Dr. R. G. D. Williams' National Electronic Grid or P. P. Eckersley's centimetric-wave multi-source "floodlighting" scheme.

THE "STENODE"

AN OLD PRINCIPLE REVIEWED IN THE LIGHT OF MODERN TECHNIQUES

By L. A. MOXON,* B.Sc., A.M.I.E.E.

THE principle of the "Stenode Radiostat"[1] developed in 1929 by Dr. J. Robinson was simple; selectivity was provided by a single tuned circuit with a very high Q-factor, and the attenuated audio frequencies restored by tone-correction after detection. Demonstrations were impressive, and a Committee was appointed by the Radio Research Board to "examine and report on the properties of very highly selective receivers." It was concluded[2] that no new principles were involved, but that the combination of high selectivity with tone correction "possesses properties which make it a valuable addition to the available alternatives in the design of receiving circuits." This was 30 years ago and, despite occasional brief mentions in the textbooks, it would seem that no further use has been made of the idea. The article draws attention to several advantages of the "Stenode," which appear to have escaped attention. One difficulty, the need for a high degree of local oscillator stability, is easily disposed of with modern techniques.

An important feature of the "Stenode" is the enhancement of the carrier of an amplitude-modulated signal relative to the side bands. This largely eliminates distortion caused by selective fading[3, 4] and also makes it permissible to suppress one sideband, thereby further reducing the distortion and increasing the effective selectivity; moreover, the crystal-resonator which is favoured for the high-Q circuit can be adjusted to provide about 15-20 dB rejection of one sideband without any additional components. There are, of course, other methods of achieving a similar result, but these involve either complex circuitry or tuning difficulties, whereas the "Stenode" is actually simpler than an "ordinary" receiver, since the selectivity is derived mainly from a single tuned circuit, which makes alignment easier and is particularly attractive from the point of view of the home-constructor. Tone compensation is no problem, the requirement being a constant 6 dB per octave, provided the bandwidth of the selective circuit is less than the lowest audio frequency to be reproduced. Incidentally, most communication receivers fitted with a crystal gate can be converted into "Stenodes" by the addition of one resistance and one capacitance and it is ironical to note that, although the crystal gate originated with the "Stenode,"[2] absence of tone correction has prevented it from being fully exploited for the reception of telephony.

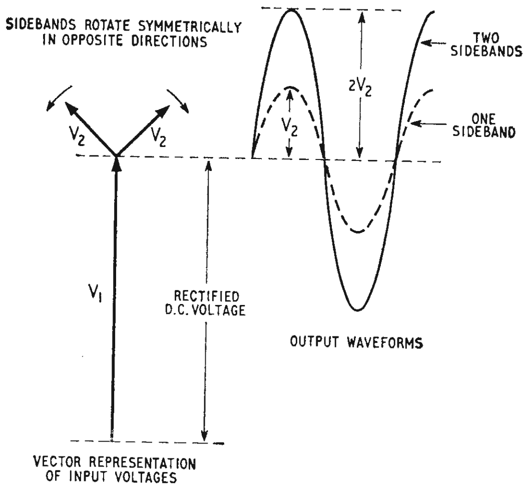

Fig. 1. Operation of a linear detector when the carrier (V_1) is large compared with the sidebands.

The Detection Process

To appreciate the difference between "Stenode" and conventional receivers, it is necessary to focus attention on the detector.

When a carrier and two sidebands are applied to a detector, we have the familiar situation depicted in Fig. 1. In the absence of selective fading the two sidebands come together simultaneously at "top-dead-centre" and cause an increase in the output current of the detector. Half a cycle later they come together again, but pointing downwards so that they decrease the output current. If the detector is linear the increase and decrease are equal and a sine wave is traced out as the vectors rotate. At 90° from the maximum, which is the zero of the modulation cycle, the sideband vectors cancel each other and the output current is unaffected by the modulation. In practice, if the carrier vector is large enough compared with the sidebands, it does not matter whether the detector is linear or not because the portion of the characteristic occupied by the sidebands is short enough for curvature to be neglected. If one sideband is removed, the other traces out a wave of half the original amplitude; notice, however, that the modulation is no longer a sine wave because at the zero of the modulation cycle the input voltage is given by $\sqrt{(V_1^2+V_2^2)}$ which is larger than the proper value V_1. The difference is negligible if V_2 is small compared with V_1, but if, as in Fig. 2, V_1 and V_2 are equal, the downward swing of the modulation envelope is 7/3 times the upward swing and distortion is considerable. Further reduction of V_1 tends to reduce the distortion, the roles of V_1 and V_2 being interchanged, but if more than one sideband tone is present, intermodulation occurs between the two

*Amateur Station G6XN.

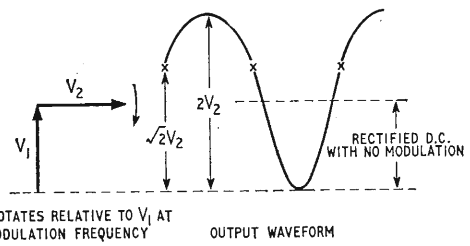

Fig. 2. Distortion of output waveform by a linear detector with a single sideband (V_2) equal to the carrier (V_1). Crosses mark "zero" of modulation cycle. Modulation increases the rectified voltage by 23%.

tones regardless of detector law. With both sidebands present and the carrier reduced by fading, an even worse situation can arise, the fundamental tone being reduced or eliminated and each sideband beating with (a) its opposite number to produce harmonics, and (b) other tones to produce intermodulation products. It can be seen from this that much of the distortion caused by selective fading can be overcome by sufficient accentuation of the carrier, or its replacement by a suitable local oscillation, although it remains possible for destructive interference between the sidebands (due to disturbance of phase-symmetry) to cause waveform distortion as well as holes in the audio response. This in turn can be avoided by eliminating one sideband which, as explained above, leads to continuous distortion unconnected with selective fading unless the carrier has first been adequately reinforced. Under non-fading conditions, elimination of one sideband halves the signal voltage, as noted above, but the bandwidth and therefore the noise power is also halved so that the degradation of signal-to-noise ratio is not 6 dB but only 3 dB. Since removal of a sideband also eliminates any accompanying interference, it is desirable to provide for rejection of either, or neither, sideband.

There are three main ways of reinforcing or replacing the carrier.

(a) Starting with an ordinary communication receiver a local carrier is injected from the beat frequency oscillator, as nearly as possible on the correct frequency, and the beat note between the local carrier and the "real" one, if audible, removed by a high-pass filter. Care must be taken to ensure that the beat does not reach sufficient amplitude, prior to removal, to intermodulate with other tones. Unless one sideband is removed, e.g., by filtering, a low-frequency beat between the sidebands can be avoided only by exact synchronization as in (b) or (c) below. For single-sideband reception of music, the maximum allowable tuning error is only 2 or 3 cycles[8] and very difficult to achieve.

(b) The local carrier is locked in frequency to the incoming carrier using, for example, the "Synchrodyne" method [5] or a phase-lock loop[6].

(c) Instead of inserting a locally generated oscillation, the incoming carrier is reinforced as described in Refs 3, 4, or, more simply, by means of a "Stenode" circuit as described above. The allowable tuning error is then of the same order as the circuit bandwidth.

Provided the carrier applied to the detector is strong enough, beats between the various other tones applied to it will be of negligible amplitude compared with the beats between these tones and the carrier. A square-law detector exercises this discrimination on a "voltage-squared" basis, and a linear detector by the process of modulation suppression or "capture effect," which comes about as explained in Fig. 3. Interference from sources outside the band occupied by the wanted signal can therefore be removed by a low-pass filter after the detector, provided the wanted carrier (after reinforcement) is stronger at the detector than any other component of the signal spectrum. It follows that given sufficient accentuation of the wanted carrier an interfering signal will not produce intelligible interference or capture effects, only sideband splash and possibly a heterodyne whistle which can be filtered out. This may enable the listener to catch a word here and there despite a high average level of interference so that, although the quality of the communication is perhaps very low grade and useless for commercial purposes, it may suffice for an amateur trying to add to his list of countries worked or win a DX contest. Similar remarks apply to capture effect exerted on the wanted signal by noise peaks; this tends to offset the nominal 3 dB loss of signal-to-noise ratio which may result from the sacrifice of one sideband, as discussed above.

Under selective fading conditions, the mean audio level is likely to be more or less constant although individual frequency components including the carrier are fading up and down. Referring to Fig. 1, it is obvious the variation of the carrier, V_1, has no effect on the audio level provided V_1 remains within the linear portion of the detector characteristic and is not allowed to fall to an amplitude below that of the sideband. A further proviso is that a.g.c., if used, must be operated either by the audio signal or by the carrier level averaged over a period which is long compared with the fading period. The sideband amplitude at the detector must of course be large compared with the noise level of the detector which includes hum and microphony; at the same time the carrier, boosted to an average of 20-30 dB

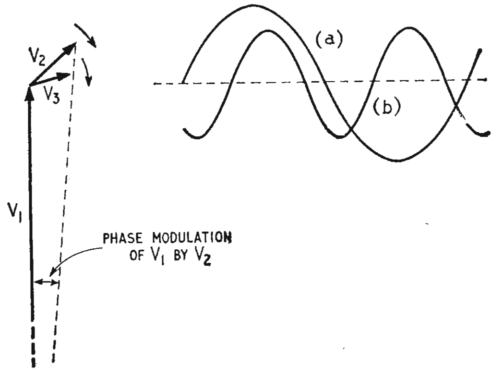

Fig. 3. Modulation suppression in a linear detector. Output waveforms traced (a) by V_2 and (b) by V_3. From the point of view of V_3, V_1 is phase- and amplitude-modulated by V_2. If $V_1 \gg V_2$ the phase-modulation tends to zero, but V_1 continues to change in length by the amounts V_2, V_3 as these vectors rotate. The output contains only d.c. and the sum of the waves traced by V_2, V_3. Remove V_1 and the output then consists of the modulation of V_2 by V_3 as in Fig. 1. V_2 could be a carrier, V_3 one of its sidebands and V_1 a stronger carrier. V_1 therefore suppresses the modulation of V_2.

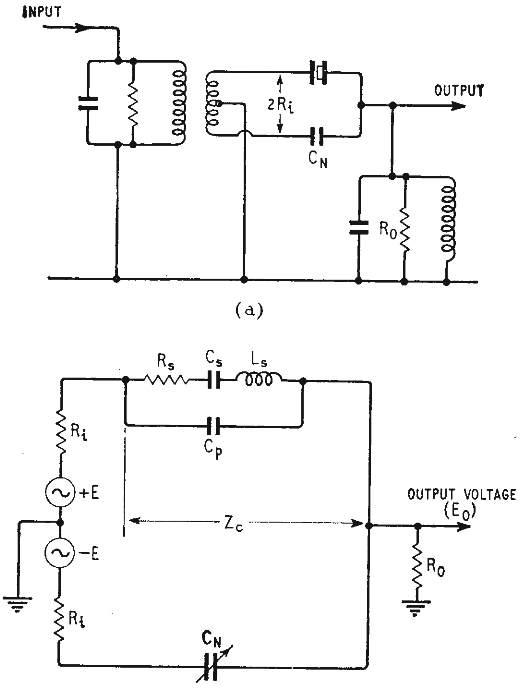

Fig. 4(a). Typical crystal gate. (b) Equivalent network. Z_c = impedance of crystal. For symmetrical response $C_N = C_p$. On tune, output voltage $E_o = ER_o/(R_o + R_i + Z_o)$.

above the side-band level, but subject to fading, requires to be confined within the linear range of the detector; this range must therefore be as large as possible. It follows that the ratio of overload level to noise level of the detector sets a limit to the useful amount of carrier-boost and therefore to the usable Q of the selective circuit. An alternative limitation on Q is imposed by considerations of tuning accuracy and frequency drift. The ultimate design limits still remain to be probed but, in the meantime, a circuit bandwidth of about 100-200 c/s seems a reasonable choice on all counts, and thermionic-diode detectors appear satisfactory at this order of bandwidth.

This limitation makes it inadvisable to rely on a single high-Q circuit for the whole of the required selectivity. At a channel spacing of 3 kc/s a single circuit with a bandwidth of 100 c/s gives an adjacent-channel rejection ratio of 36 dB; more than this would normally be useless because of out-of-band radiation from the interfering transmission, and it is at greater spacings, with relatively powerful interfering signals, that trouble arises. The selectivity of the "Stenode" increases by only 6 dB per octave so that at 24 kc/s spacing the rejection ratio is 54 dB and an unwanted signal need only have a level of 0.5 mV to interfere seriously with a wanted signal of 1 microvolt. Additional tuned circuits are therefore required, but these can have relatively wide bandwidths.

The Selective Circuit

Early references[2] mention a Q of 10,000 obtained by the use of reaction, and the more modern Q-multiplier technique allows a Q of this order to be obtained with reasonably good stability. This allows the use of an i.f. in the 1-2 Mc/s region and leads to a very simple design of receiver for the short-wave broadcasting and amateur bands, but fails to provide any discrimination between sidebands. Fig. 4 shows a typical crystal gate, as used in communication receivers, and this can be adjusted by means of C_N to reject either, or neither, sideband. Fig. 5 shows response curves calculated for a typical 8.2 Mc/s crystal with the object of operating a "Stenode" circuit "in reverse" as a single-sideband generator, and Fig. 6 shows the degree of sideband suppression achieved. Curves for different crystals and other frequencies (assuming appropriate adjustment of C_N) tend to follow the same "universal" shape except for a raising or lowering of the maximum and minimum amplitude levels, depending on the Q of the circuit; this in turn tends to be inversely proportional to the impedance in series with the crystal and is readily adjustable to the required value. In the original "Stenode" circuit there was no attempt to provide a low series impedance, the crystal output being taken directly to the grid of a valve, and to account for the reported impressive performance it must be assumed that the valve had, fortuitously, a low input impedance due to Miller effect and that imperfect neutralization of the crystal resulted in accidental suppression of one sideband.[2]

The sideband rejection indicated by the solid curve of Fig. 6 is perhaps not impressive, but is considered a useful design compromise for inexpensive and easy-to-build receivers. In the better class of receiver one might expect to find the sideband rejection increased by a crystal lattice or mechanical filter of conventional design. A simpler alternative would perhaps be a "double Stenode" employing two separate crystals with staggered rejection notches, and two tone-correction networks

Tone-compensation Circuits

Fig. 7(a) shows the original "Stenode" tone-correction circuit, which provides exact compensation for

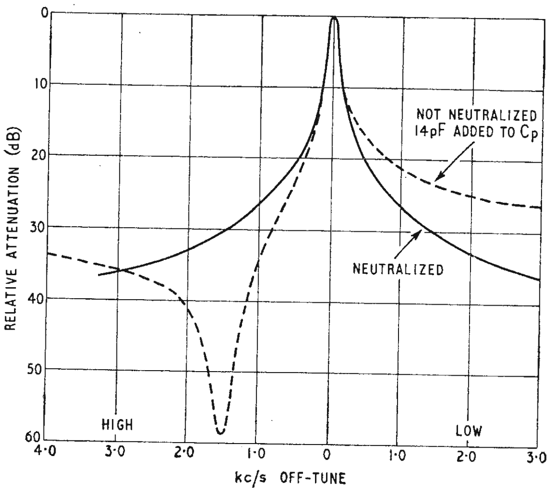

Fig. 5. Response of crystal gate calculated for typical crystal (Ref. 9). f = 8,200 kc/s, C_p = 6 pF, Cs = 0.0074 pF, L_s = 0.051 H, R = 15Ω, $R_i + R_o$ made up to 35Ω.

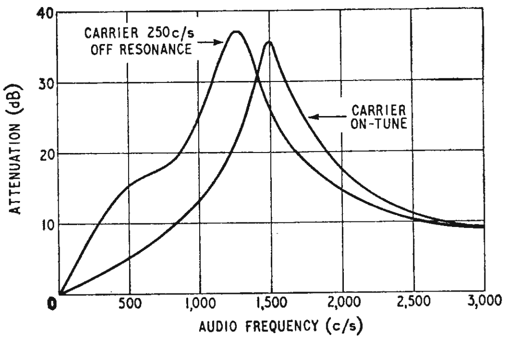

Fig. 6. Attenuation of unwanted sideband by dotted curve of Fig. 5.

the response of a simple resonant circuit. Fig. 7(b) is an alternative which, as shown in Fig. 8, provides less-exact compensation but requires only two resistors and a capacitor and has the further desirable characteristic of tending to suppress frequencies outside the wanted audio range. Assuming some reserve of audio gain, this circuit can be applied to an existing communication receiver fitted with a crystal gate, the parallel resistance being the grid leak or volume control associated with an a.f. stage. Other component values can be used provided the 8:1 resistance-ratio is preserved, the required capacitance being inversely proportional to resistance. The circuit is assumed to be supplied from a source whose impedance is low compared with 0.25 megohms, or whatever value of parallel resistance is used, and correction is obtained ovei the frequency range of 300-3,000 c/s approximately. Correction can be obtained over a wider range, at the expense of gain, by increasing the resistance ratio and choosing a suitable value of capacitance.

The report[2] quoted above points out that the resonance curve of the crystal-gate circuit, even when adjusted for symmetry, does not conform to the ideal shape, and stresses the difficulty of achieving accurate tone compensation. This might be important for high-fidelity reception of a local broadcasting station, but for good intelligibility of speech, and even for acceptable musical reproduction, there is considerable latitude and the circuit values quoted have been found satisfactory for any bandwidth less than about 300 c/s, with or without suppression of one sideband.

Practical Circuits

When resuming amateur radio activities in 1946, the author was attracted by the "Stenode" as a simple answer to the receiver problem. The first venture used one r.f., one i.f. and one a.f. stage with a total of three circuits tuned to the intermediate frequency. Reaction applied to the first i.f. circuit by means of a separate valve reduced its bandwidth to a few hundred cycles, and the circuit of Fig. 7(b) was used for tone-correction. The receiver was completed and made to work in the course of 3 or 4 evenings, without test equipment, at a total cost of about 30s, and gave good service for many years but had one major defect, being easily overloaded by strong signals. At first this was not serious, because the station was located on a steep hillside facing south-west which acted as a "screen" against European signals, whilst favouring the long route to Australia which became the author's main amateur-radio interest. Later versions with improved strong-signal selectivity have taken various forms, including the use of short-wave converters in front of broadcast receivers with reaction applied to the i.f. amplifier. The current model is illustrated in Fig. 9 and employs a crystal gate at 465 kc/s, and double-frequency changing with a crystal-controlled first mixer and a tunable first i.f. covering roughly 3.3 to 4.2 Mc/s. A single 10.5-Mc/s crystal provides coverage of both the 7- and 14-Mc/s amateur bands, and third harmonics of crystals at 5,840 and 8,167 kc/s cater for the 21-Mc/s band, including the adjacent broadcasting band, and the lower end of the 28-Mc/s band. Other crystals and switch positions could, of course, be added for coverage of additional bands as required. The bandwidth of the crystal filter is about 200 c/s but could probably be reduced with advantage to 100 c/s. An alternative 400-c/s bandwidth was provided as well as wide-band non-"Stenode" operation, as it was thought that the 200-c/s bandwidth

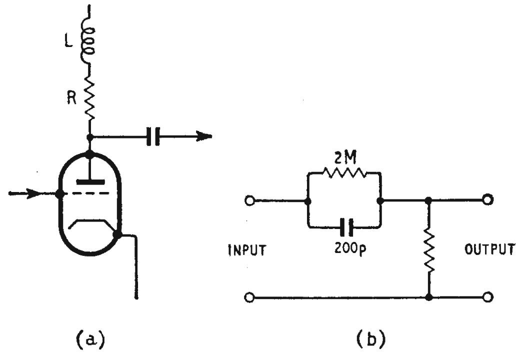

Fig. 7. Tone correction circuits: (a) provides exact compensation for solid curve of Fig. 3 if $L/R = 2\,L_s/(R_s + R_i + R_o)$. (b) provides approximate correction as shown in Fig. 8.

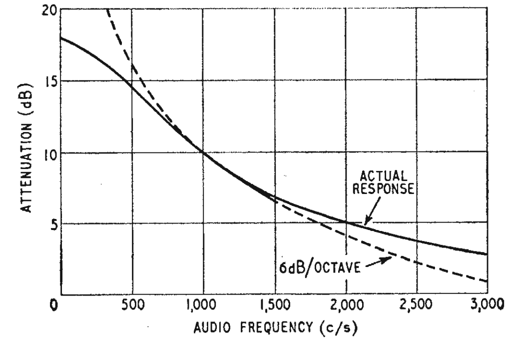

Fig. 8. Tone correction with circuit of Fig. 4.

would slow down the process of searching for signals, and also cause difficulties in receiving unstable signals. With the narrow bandwidth, instability is, of course, much more obvious but it has been found in practical operation that the bandwidth switch always remains in the "narrow" position; this provides signal-signal reception of c.w. signals as well as reception of amplitude-modulated and single-sideband telephony. It is sometimes an

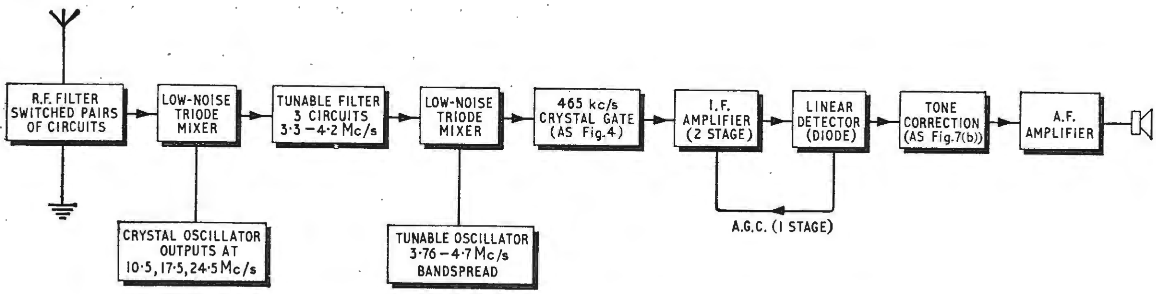

Fig. 9. Simple "Stenode" receiver for amateur DX bands.

advantage to leave the b.f.o. switched on when receiving amplitude-modulated speech, thus providing a stronger and more stable "carrier"; this is possible because the sideband suppression is adequate for prevention of serious interference between the sidebands, and it is interesting to observe the voice pitch varying with tuning as in the case of genuine single-sideband signals. This mode of operation, however, does make tuning appreciably more difficult than with a normal receiver, whereas without the b.f.o., assuming adequate bandspreading, there appears to be no slowing down of the searching process. With amplitude-modulated signals, the oscillator stability required for the "Stenode" is greater than for conventional receivers, but is less than the requirement for single-sideband reception, which is the same for both types of receiver. Crystal control of the first local oscillator and normal good practice[7] in the design of the second local oscillator (i.e., stable components and circuit arrangements which minimize the influence of valve capacitances on the resonant frequency) gives adequate stability for reception of broadcast and all types of amateur signals.

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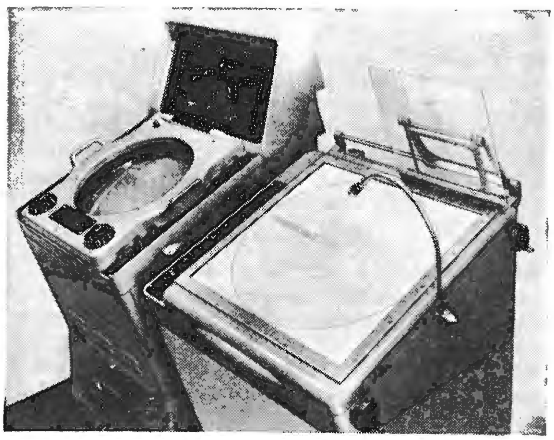
RADAR PLOTTING UNIT

TO eliminate errors and reduce the time required in working out the future relative positions of ships from a true-motion radar display, Decca Radar Ltd. have now introduced Automatic Relative Plotter Type 50 for use in conjunction with their Type TM 969 marine radar.



Complete Decca radar system Type 969/ARP comprising TM 969 true motion radar and Type 50 automatic relative plotter.

The plotting paper lies beneath a glass table on which are engraved range rings and an 18in dia. azimuth circle. Underneath the paper, and pivoted at its centre is an arm which carries a stylus capable of taking up any position along the arm. The position of the stylus is determined by co-ordinates transmitted from the electronic "interscan" range and bearing marker on the radar display, and all the operator has to do is to press a foot switch when the interscan is adjusted on an echo. This imprints a black dot on the plotting paper together with time to the nearest ¼ minute. With average ability an operator can plot up to 20 echoes in a minute. Successive plots at short intervals give instant information of course and speed of all vessels in the vicinity including own ship, from which it is possible to assess, by inspection, if any ships are on a collision course. The conventional, and time consuming method of vector triangulation is unnecessary for confirmation; all that is necessary is to extrapolate the plots of the two (or more) ships to find the CPA (closest point of approach).

An additional transparent plotting surface (called the "Predictor") mounted to give free N-S and E-W movement can be pulled down over the main plot and with a wax pencil the effect of possible alternative plans of action to avoid collision can be rapidly assessed before giving orders for alteration of course or speed.

TECHNICAL NOTEBOOK

Triode i.f. stages—normally disregarded as a possibility because of neutralization difficulties—can be made economically with R.C.A. "Nuvistor" miniature metal envelope valves. A feature of the Nuvistor is its relatively low inductances and capacitances, which, because of the method of manufacture, are kept within close limits from one sample to the next. Angel and Gote of the Radio Corporation of America describe in *I.R.E. Transactions on Broadcast and Television Receivers* (Vol. BTR-7 No. 2) the use of the 6CW4 triode in simply neutralized i.f. amplifier circuits. These give average stage gains of up to 34dB. The simplest system described uses a 3pF (max) trimmer from anode to a feedback overwind on the grid coil; but an alternative arrangement returns the grid coil to chassis through 10pF and has the neutralizing capacitor connected to the common junction of these components.

Myo-electric control of artificial muscles was the subject of a paper by A. Bottomley *et al* at the recent Brit. I.R.E. symposium on Electronic Aids for the Handicapped. In a paralysed muscle, or even in the stump of an amputated limb, electrical activity exists which is proportional to the effort exerted by the subject. In the proposed system, a small servo is used to drive the artificial or auxiliary limb, and takes as its operating voltage the amplified difference between surface potentials at points over the flexor and extensor muscles. The servo amplifier has a time-constant of 100mS which, together with a small amount of back lash, is needed to prevent the system responding to short-term involuntary fluctuations of the signal. Feedback is taken from the output shaft.

High-temperature quartz resonators have been made possible as a result of recent work by Dr. J. C. King of the Bell Telephone Laboratories. He has found that major causes of energy absorption, and thus Q reduction, at high temperatures can be removed from a quartz crystal by subjecting it to electrolysis so as to remove impurities. Also, contrary to previous expectations, an electrolyzed quartz crystal can be made to resonate very stably in this higher temperature range by cutting it at a higher orientation angle than is usual. The frequency at which a quartz crystal resonates depends primarily upon its dimensions and temperature. Fortunately there exists an optimum operating temperature at which slight changes in temperature do not result in very great frequency changes. This is the temperature at which the rate of change of resonant frequency with temperature is zero. Because at this temperature this rate of change of frequency also changes sign, it is known as the "turn-over" point. The temperature at which this turn-over point of a resonator occurs depends primarily upon the angle at which it is cut from a single crystal of quartz: in general, the higher the angle of cut, the higher the "turn-over" temperature. However, it has been generally thought that turn-over points occur only in the temperature range under 250°C. And it has been exceedingly difficult to investigate the possibility of higher turn-over points because ordinary quartz absorbs so much energy at higher temperatures that precise measurements could not be made. These two factors made it very difficult to use quartz as a resonator at high temperatures. Recently, Dr. King impressed an electric field of about 500V/cm across a quartz crystal for a period of about 24 hours at a temperature of 500°C. This caused impurities such as sodium and lithium to be swept out of the crystal. He discovered that as a result of this electrolysis, quartz retains its ability to vibrate with little energy dissipation, even when used at temperatures as high as 550°C. The availability of a low-loss (high-Q) crystal at high temperatures encouraged him to look for turn-over points at temperatures in this higher range. He found that quartz did indeed exhibit turn-over points at various temperatures from 300°C to 535°C, depending upon the angle of cut. The discovery of high-temperature turn-over points (which permit stable frequency operation) and the effect of electrolysis of quartz (which increases its Q at high temperatures) make possible the fabrication of treated quartz resonators for use in high temperature environments. Another important application is also possible. When ordinary quartz is exposed at room temperatures to ionizing radiation such as X-rays, its resonant frequency is altered. To restore it to stable frequency operation it must be annealed at 400°C or more. On the other hand, electrolyzed quartz can be exposed to ionizing radiation without incurring resonant frequency changes by operating it at a sufficiently high temperature such that there is a continual annealing out of these ionization effects. Thus it is feasible to operate electrolyzed quartz resonators in the gamma-ray environment of nuclear reactors or in satellites which must traverse the Van Allen radiation belts.

Capacitors in a new range from Plessey use sheets of paper interleaved by a machine developed from those used to fold cigarette papers into their packets. Metallized paper sheets are folded and interleaved and connections are made by spraying zinc on to the projecting free ends.

Finished interleaved stacks are encapsulated in resin for protection and sealing against the ingress of water. The photograph shows a stack of sheets opened to show the construction. Advantages of the new technique over the rolling process are reduction of self-inductance and greatly increased surface area, giving better heat dissipation. Insulation values of 5,000MΩ/μF are claimed and capacitance values fabricated by this technique range from 0.25μF to 20μF with voltage ratings of 350 to 3,500.

Light-flash sets resistance in a machine for the adjustment of high-stability, high-accuracy, thin-film resistors. Described in *Electronics* for 9 February 1962, by Edwin Tomkins of the Armour Research Foundation, the machine uses a spiral-shaped xenon flash tube placed round the resistor, the whole being contained in a magnesium-oxide reflector. About 1,300μF charged to 4kV is discharged through the tube, and the resulting flash of light, although of only one or two milliseconds duration, raises the temperature of the film to several thousand degrees Centigrade, so that evaporation occurs. Both metal-alloy and carbon-film resistors have been treated in this way, typical results for carbon being a 67.63-Ω resistor raised to 117.7Ω by four flashes. A bridge circuit in which the resistor is measured could control flashing.

INTERNATIONAL TELEVISION CONFERENCE

AS if to make amends for their lack of support at this year's Montreux Television Symposium, British authors were much in evidence at the International Television Conference organized by the I.E.E. in co-operation with the British Kinematograph Society, the Television Society and the American I.R.E. Of nearly 130 papers presented, just over 100 were given by British participants. The Conference was attended by about 550 delegates from 20 countries.

Eighteen sessions, some running concurrently, were held, covering almost every possible aspect of television engineering: system standards, pick-up and display tubes, frequency assignment, recording, standards conversion, medical uses, links, studio and equipment design, industrial and scientific applications, wire broadcasting, transmitters, receivers, colour and space applications.

The Conference was opened by Lord Brabazon, and the introductory lecture was given by Dr. R. C. G. Williams, the chairman of the Conference Organizing Committee, who made some forecasts of possible developments which may take place in television in the next 25 years. He foresaw television as the best means for meeting the desire for literacy in underdeveloped countries and for higher education at university level in more advanced civilizations. An increase in the number of programme channels could be effected in the U.K. by the establishment of a wide-band National Electronic Grid connecting centres of population.

Bandwidth Restriction.—A very interesting paper was presented by Professor Cherry, of the Imperial College of Science and Technology, on the compression of bandwidth in television transmission systems. It was demonstrated that almost no degradation of a 3 Mc/s 405-line picture was visible by halving the transmission bandwidth. For the transmission of black and white drawings, documents or typescript, a bandwidth reduction of 20 to 1 is possible.

Basically the principle of the system suggested is to examine the video waveform continuously and to transmit only those parts of the signal where detail or "edges" are present. Almost all of the complexity of the equipment is at the transmitting end, the receiving apparatus being relatively simple.

This equipment, used in conjunction with the proposed electronic grid, would have great application in the development of the old idea of visual telephones.

A different approach to the visual telephone development was presented by E. L. Byer of the I.T. & T. (U.S.A.). He described the Videx, which is a slow-scan television system utilizing a vidicon and also a direct view storage tube. With this device, it is possible to transmit a 400-line television picture over a 2.7 kc/s telephone channel in 60 seconds. The scene to be televised is scanned by a vidicon camera operating at the slow-scan parameters to produce the narrow-band video signal directly. The received signal is then displayed on an Iatron, at the low rate. Flicker is eliminated, since the Iatron is a storage device, and the entire picture can be stored at high brightness for a period of between one to six minutes after being received.

Pick-up Tubes.—In the session devoted to television camera tubes, two new R.C.A. types were described. The first was a high resolution device (1,200 lines), described by R. G. Neuhauser, *et al.* A new photoconductive surface was developed for this 1½in magnetically deflected and focused tube, to reduce the inherent lag of the photoconductor and compensate for the increased lag which results from the increased capacitance of the larger tube size.

The other tube, also a vidicon (dealt with in a paper by R. G. Neuhauser and J. E. Kuehne), is electrostatically focused and was developed to explore the possibilities of its adaptation to transistor camera equipment. The design objectives were to reduce power consumption and lower production costs in order to widen its field of application. Electrostatic focusing removes the need for a relatively heavy focus coil and thus reduces the overall weight of a vidicon camera.

A completely new device was presented by Takao Ando, of Nippon Electric (Japan). He described an electronic zoom image tube, which makes possible the variation of the size of a reproduced image of an object by changing the magnification of an electron lens in an image convertor tube by altering focus coil currents. The most important problem is to keep the reproduced image focused and correctly oriented, with the minimum of distortion, while the image size is varied.

The principle is as follows: the focusing coil is split into three parts; two are near to the photocathode and the third near the target. Raising of the current through the coils near the photocathode increases the reproduced image size, and adjustment of the relationship of the currents through the first and third parts maintains proper focus.

Recording and Standards Conversion.—Charles P. Ginsburg (Ampex) gave the introductory lecture on television recording and reviewed the present state and the prospects for future improvement in video tape recording. It was hoped, he said, for a much higher area packing density to be achieved, by reducing the speed of the tape. This itself presents problems requiring improved transducer structure, tape quality and wider bandwidth. Experimental machines had been constructed in Japan, the U.S.A. and also in Europe, using the helical scan (or "Omega" wrap) configuration. The advantages are, simpler associated electronics, no head switching required and no noise or frequency banding in the reproduced picture. Greater attention must be paid to time-base stability owing to the fact that the video head scans the tape almost longitudinally (3°-4°) and, therefore, variations of speed of the tape are transferred to the output waveform.

One of the outstanding contributions to the Conference was the group of three papers presented by A. V. Lord, E. R. Rout and P. Rainger (B.B.C.) on standards conversion without recourse to image re-scanning. Convertors now in use all rely upon a television camera on one standard picking up an image of a scene displayed on a picture monitor on another standard. This involves two extra electro-optical conversions in the transmission chain with consequent loss of definition. Where the transfer necessitates a change of field frequency, difficult flicker correction has also to be carried out.

The system proposed does not permit the change of field frequency, but presumably great benefit would be derived for a change between 625- and 405-lines, and *vice versa*. The principle uses what is known as a delay-line interpolator. With a conversion in the line standards of a picture, the position of a particular picture point would be changed due to the difference in scanning rates; however, the subjective position of the picture point may be corrected by displaying also positional information from the next line of the picture. (This necessitates a one-line delay in the apparatus.) The amplitude of the signals from the "previous" and "next" lines are adjusted to give the correct output timing.

Colour Television.—Great interest was shown in the two sessions devoted to colour television, at which 13 papers were presented. Dr. George Brown (R.C.A.) gave some figures of the present amount of colour television broadcasting in the U.S.A. where the N.T.S.C. system was introduced some eight years ago. The National Broadcasting Company transmitted a total of 1,760 hours of colour programming in 1961 and 65 per cent of all programmes will be produced in colour this year. The American Broadcasting Company will also commence colour television transmission this autumn.

A new design of studio colour camera described by Dr. Brown incorporates *four* pick-up tubes. One image orthicon and three electrostatically focused vidicon tubes. The compatible monochrome (Y) signal is derived directly from the image orthicon instead of by matrixing from the colour tubes; this gives improved pictures on black and white receivers, better signal-to-noise ratio and better grey scale. The three vidicon tubes produce the primary colour waveforms which are matrixed to form the N.T.S.C. colour difference signals. Lower bandwidth circuits (2 Mc/s) may be used for the vidicon channels, thus simplifying the problem of registration of the images. The faces of the vidicon tubes are specially cooled to reduce effects due to black current.

G. B. Townsend (G.E.C.) drew attention to the necessity for the correct choice of the "white" balance for a colour television system. Work in the U.S.A. has indicated the choice of the observers there to be for a colour approximating 4,000°K, while in this country the recommendation is for a "less-blue" white of 3,500°K. This is affected by the colour of the ambient light in the viewing room and it was suggested that, for example, the balance could be changed when the transmission occurred after sunset as opposed to during daylight hours.

Some of the latest developments in the Secam system were described by H. Peyrolles (C.F.T., Paris). The chrominance signal is transmitted on a line sequential basis by frequency modulation of the sub-carrier. This makes the signal undistorted by differential phase and gain distortion or poor linearity in the transmission chain. The sub-carrier visibility at the receiver has been reduced by lowering the transmitted level of the sub-carrier. In order to improve signal-to-noise ratio, certain modifications are now used. The f.m. signal is also amplitude modulated proportional to the saturation. No true information is conveyed by the a.m. and it is removed by limiting at the receiver. Pre-emphasis of the high-frequency components of the signal is also used, which makes the dot structure formed by the sub-carrier more uniform and less apparent on the receiver.

Studios and Studio Equipment.—Dr. A. M. Spooner (Associated Rediffusion) presented a general view of television studio design and this was followed by a lively set of papers on studio vision equipment. As far as the programme-producing companies are concerned, it seems that semiconductors and transistors have at last been accepted. Contributions by members of the B.B.C., Associated Television and ABC Television described equipment for switching, mixing, distributing and amplifying video signals which they had designed and constructed themselves.

B. Marsden (Associated Television) described a transistor radio microphone obviating the need for trailing wires, booms and boom operators. The transmission frequencies are in Bands II and III, and special receivers are employed with very low noise input circuitry and a.f.c. ocal oscillator control.

A multi-standard transistor synchronizing pulse generator was described by J. V. Corney and A. Isaacs (Ferguson Radio). The generator was "computer type" logic in the form of binary counters and gating circuits for the derivation of all timing edges and is thus extremely stable in operation. The timing of successive edges is accurate to within 2 nanoseconds.

Space Applications.—The only lady engineer to present a paper was Dr. Nancy Roman of the U.S. National Aeronautics and Space Administration Laboratories. She spoke about three possible space applications of television; satellite tracking, ground-based astronomy and spacecraft instrumentation. An experiment is now being conducted in the U.S. in which a battery of 25 television cameras gives a panoramic view of the whole sky. Ordinates of the position of a satellite are derived and this information is fed to a computer controlling a telescope. In this way the telescope may be moved to within an accuracy of a few seconds of arc, to view the satellite.

It is possible that within a few years, if more sensitive, highly stable and very rugged television equipment can be developed, the photographic-telescope method of observation of stars will be replaced by special closed-circuit television systems. Even now the overall sensitivity of a magnesium oxide image orthicon pick-up tube used in conjunction with a 36-inch telescope is equal to that of photographic plates with the 200-inch Mt. Palomar telescope.

Television pictures from satellites or planetary probes have usually to be restricted in resolution in order to conserve transmission bandwidth. Vidicon cameras are used with a transmission rate of approximately one picture per 30 minutes. It is intended to equip future satellites with the very sensitive magnesium oxide image orthicon cameras, so that in the event of the other direction-finding instrumentation failing, it would be possible to determine the position of the satellite by observation of star patterns.

LETTERS TO THE EDITOR

The Editor does not necessarily endorse opinions expressed by his correspondents

Pay Television

MAY I have the opportunity of developing briefly the argument of this Company's plan for a broadcast pay television service mentioned in "World of Wireless" of your May edition?

The premise on which this plan is based is that the u.h.f. bands are available for new television services.

We propose—

1. That at the start, half the available 48 u.h.f. channels be employed to cover progressively the main centres of population with six new programmes—3 Pay TV and 3 others (not one as stated in your report). The coverage for all 6 programmes obtained at the end of this stage of the plan would be approximately 65% of the population of the United Kingdom and the work involved might well occupy four to five years.

2. That the remaining 24 u.h.f. channels (as yet unallocated under the Company's plan) should be used to extend to near-national coverage three of the abovementioned six programmes. We estimate that this final stage of the plan might be completed in a further five years, or ten years from the start.

3. That the decision as to which three programmes should be so favoured would be based on the public's experience and acceptance of the six programmes in the areas initially covered during the first four to five years.

4. That relay networks, present and future, would continue to perform a useful public service by redistributing broadcast programmes (including Pay TV) in areas of poor reception, and by bringing these programmes to certain other communities which lie, temporarily or permanently, outside the range of broadcast transmitters.

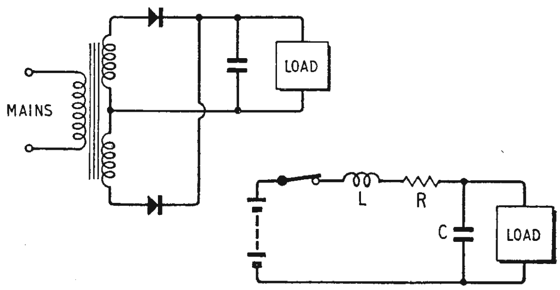
This plan, when completed, would provide five programmes (2 v.h.f.+3 u.h.f.) having a near national coverage with a further three u.h.f. programmes for 65% of the population. It can be seen from this that we subscribe to the principle that the dense regions of population should have a greater choice of programmes than the rest.

L. S. WHITE
British Telemeter Home Viewing Ltd.
London, W.1.

Transistor Power Amplifiers

MR. BUTLER'S letter (May 1962 issue) on the effect of transformer leakage inductance in simple diode and reservoir-capacitor power supplies of the type shown in the accompanying diagram may have left some readers with the impression that this type of power supply is not satisfactory unless special precautions are taken: this is not so. It is true that the transformer leakage inductance together with the reservoir capacitor form a parallel tuned circuit (while the diodes are conducting), which means there is a danger of the output impedance rising at the resonance frequency, but it turns out that the circuit values for this effect to be important are very unlikely to be met in a practical design.

In the simple equivalent circuit of a diode and reservoir-capacitor type of power supply, R represents the total series resistance and is made up of the transformer secondary winding resistance, plus the primary resistance referred to the secondary, and the resistance of the diode. L is the leakage inductance referred to the secondary. The switch represents the action of diodes which connect the transformer to the load for a short time during the peak voltage of the mains input. These diodes conduct only for about 1/10th of the time of one cycle of the mains, so that as far as the effect we are considering (we are not interested in mains ripple) the supply voltage can be represented as a battery. The rest of the time (which is about 9/10ths) the diodes are non-conducting and there is no current flowing through the transformer secondary. The point I wish to make is that the leakage inductance is included in the circuit only for a very short time each cycle. Ideally, the behaviour of the equivalent circuit I have built up should be analysed for a sudden change in the load on the power supply, but unfortunately this is a very complicated calculation. In order to obtain a superficial solution I am going to assume the switch is closed *all* the time (this state of affairs does exist in a power supply with a choke input filter) and argue that if the power supply behaves all right under this condition, it will be even more satisfactory when working in its usual way with the leakage inductance disconnected from the



circuit for most of the time. With this assumption the equivalent circuit becomes simply a battery with a parallel tuned circuit between it and the load. The danger is that a sudden change in the load (as in a class-B amplifier) will "ring" the output voltage of the power supply. It can easily be worked out that the circuit is adequately damped if $R \geqslant \sqrt{L/C}$. Taking practical values from my amplifier design,[1] $R = 0.5$ ohm, $C = 5000\ \mu F$ which makes the maximum permitted leakage inductance 1.25 mH, a value which is unlikely to be exceeded. In addition there is the improvement due to the switching action of the diodes, which has been ignored in order to make the analysis reasonable. As a practical verification of this argument I have artificially increased the leakage inductance of the above example to 10mH (i.e. 8 times the calculated value for adequate damping) and the power supply was still well damped.

With a choke input filter type of power supply this simple analysis is much more accurate and, since L is large, there is a very real danger of the power supply "ringing" at a low frequency. Under these conditions the technique proposed by Mr. Butler can be used but very often needs impracticably large capacitors: even so an improvement can be made with capacitor values which are less than the "ideal" design values.

While writing, there are two additional points I would like to mention about my amplifier design[1]:—

(a) The XA102 type of transistor is no longer made and a good alternative is the S.T.C. type T.K.31.

(b) The safe ambient temperature figures quoted in the article are calculated on the assumption that the amplifier is operated continuously at the power level which gives maximum dissipation in the output transistors (his is about 40% of maximum power output) and an I_{co} value for the transistors which is 3 times greater than the maximum quoted in the data sheets. This factor 3 is thought desirable to provide a safety factor and to allow for I_{co} increasing as the transistors age. Under these conditions the safe maximum ambient temperature of the 10 watt amplifier is 30°C. With no safety factor and the maker's maximum I_{co} value, the maximum permissible ambient temperature rises to 45°C. With no safety factor and a typical I_{co} value, 65°C is when thermal run-away occurs. The last condition has been verified experimentally by raising the ambient temperature until the output transistors actually did fail. The temperature reached was over 60°C which agrees well with the calculated 65°C value.

The point I wish to make is that although transistors with typical I_{co} values are all right up to 65°C (just), nevertheless when allowance has been made for maximum I_{co} values and a safety factor, the safe ambient temperature is down to 30°C. In other words, making allowance for the worst case gives a very much lower safe ambient temperature.

R. C. BOWES

Malvern.

[1] "Transistor Audio Amplifier," R. C. Bowes, *Wireless World*, July 1961, p.342.

Television Recordings

I FEEL obliged to make some comment on the letter in the May issue from Mr. R. B. Green. Criticism seems to be levelled at the quality of videotape recordings and 8mm film, amongst other matters. Videotape is capable of reproducing a picture that is practically indistinguishable from the original if the machine is properly set up.

8mm film is made from the same materials as 16mm and 35mm film, and so the resolution of the film is identical. In fact, 8mm is actually 16mm, double perforated, and slit down the middle after processing. If a good quality camera and lens are used, and if the camera is on a tripod, and if a good quality projector with a good lens is used to project the film, there is no excuse for poor resolution. What, then, gives 8mm film its reputation of being poor in quality? In the first case, most people enlarge it to a much bigger *relative* size than 16mm. The 8mm film frame is slightly less than one quarter of the area of the 16mm frame, and consequently should be enlarged to only one quarter of the screen area. By "blowing it up" as big as the room will allow, one is asking too much, and 16mm would be the same under these circumstances. I can refer Mr. Green to 8mm films that are sharper than some 16mm films I have seen. I feel that he may have been exposed to some amateurish films, taken with the cheaper cameras, with hand-held shots taking the edge off the definition.

However, I agree with him entirely in his observation that the improvement in definition of the 625 line standard is only marginal, and that the change that will be most apparent is the transfer of the line frequency whistle into the less audible portion of the audio range. The nature of my work has enabled me to see American 525 and Continental 625 line videotapes, and his comments are borne out. As to Eurovision, the conversion equipment is constantly being improved, and anyone who saw the first of the International "Come Dancing" programmes must have been impressed by the relative good quality of the Copenhagen pictures. I, with Mr. Green, find the constant variations in successive television programmes annoying, but I feel that the resetting of brightness and contrast when changing from one channel to another is even more annoying, and I heartily wish that the standard was more constant, and adhered to. Unfortunately many of the public are content to be entertained without being selective, and without giving any thought to what they are watching.

Bristol. D. R. WILLIAMS.

Colour Television

THE answer to P. P. Eckersley's question, "Would you pay three times as much to see a film in colour as you would in black and white?" is that there are undoubtedly many who would, if the number of cinemagoers who are willing to pay several times the normal prices to see big-screen colour productions such as "Ben Hur," "South Pacific" and "El Cid," is any criterion.

In the case of colour films shown at normal prices, one may well ask why would the producers themselves go to the expense of colour, if they did not consider it would yield a greater financial return than a black and white movie?

Manchester, 20. A. E. HENSHALL.

TO the Latin tag, *de gustibus non est disputandum*, so ably rendered into English for us by the former chief engineer of the B.B.C., one might well reply, *et sic transit gloria mundi*, since it seems obvious that Mr. Sheffield, of New York (in rapt contemplation of his cathode-ray tube), cannot be well acquainted with Eckersley of 2MT.

Sale, Cheshire. J. M. ARDERN.

Preferred Numbers

SINCE no member of the American Radio-Electronics-Television Manufacturers' Association, who are probably the originators of the preferred numbers to base six, has come forward to answer Mr. A. B. Cooper's plea in your January issue, may I offer him some help?

The rounding-off of the preferred numbers used for electronic components is carried out in the 5% range to give a uniform progression of differences. To save space we may consider the region round 33 and write down

22		24		27		30		33		36		39		43		47
	2		3		3		3		3		3		4		4	
		5				6				6				8		
				11								14				

The apparently logical use of 32 will thus involve a reduction by 1 of all values from 27 to 36, if the differences are to progress uniformly. It is a task which I leave to Mr. Cooper to determine whether the errors thus introduced outweigh the errors to which he draws attention. It seems probable that these issues were explored in detail by the original committee.

The fact that the preferred numbers are logarithms can be regarded as a useful design aid when network solutions are to give preferred values for the components. I examined this question at some length in *Wireless Engineer* (Oct. 1945, Jan. and July 1946). Mr. Cooper may find some interest in the discussion of the appropriate preferred value for π.

London, W.8. H. JEFFERSON.

WORLD OF WIRELESS

Birthday Honours

AMONG the recipients of awards in the Queen's Birthday Honours List are the following:—

Knighthood

Isaac Shoenberg, director of Electric & Musical Industries, "for services in the development of television and sound recording."

Isaac Shoenberg, M.I.E.E., the 82-year-old director of E.M.I., who receives a knighthood in the Birthday Honours List, led the team which developed the 405-line television system used by the B.B.C. since 1936.

C.B.

R. W. Sutton, O.B.E., superintendent, Services Electronic Research Laboratory.

C.M.G.

L. J. Hooper, O.B.E., deputy director, Government Communications Headquarters.

C.B.E.

K. Adam, Director, Television Broadcasting, B.B.C.
F. D. Edwards, managing director, Edwards High Vacuum Ltd.
L. F. Taylor, assistant P.M.G. (engineering), East African Posts and Telecommunications Administration.

O.B.E.

F. Axon, D.C.M., chief engineer, External Services, B.B.C., until recent retirement.
Lt. Col. E. W. Milner, T.D., Royal Corps of Signals, Territorial Army.
F. W. Perks, chairman of Radio Industry Exhibitions.
H. B. Sedgfield, M.B.E., director of research and development, Sperry Gyroscope Company.

M.B.E.

J. E. Haworth, senior executive engineer, Post Office Research Station.
L. C. Hill, manager, Cable & Wireless Ltd., Belize, British Honduras.
G. H. Stephenson, chief project engineer, E.M.I. Electronics Ltd.
I. M. M. Summers, experimental officer, Royal Radar Establishment, Malvern.

I.S.O.

C. J. Cameron, assistant staff engineer, G.P.O.

B.E.M.

W. J. M. Scott, technical assistant class II, Telecommunications Liaison Group, War Office, Berlin.
L. Trout, supervisor, Solartron Electronic Group.

I.R.E. Jubilee

IT was in May 1912 that the Society of Wireless Telegraphy Engineers and The Wireless Institute in America decided to amalgamate and chose the name "The Institute of Radio Engineers" for the new organization. Starting with 46 members it now has nearly 100,000 in all parts of the world.

The May 1962 issue of *Proc.I.R.E.* (Vol. 50, No. 5) commemorates the occasion and, in addition to recording the history of the Institute, contains in its 900 pages of editorial matter no fewer than 113 papers by leading authorities "chronicling the past, assessing the present and interpreting the future" of every aspect of communications and electronics.

We offer our sincere congratulations on the past and present achievements of the Institute, coupled with a special appreciation of the efforts of the authors and of the Editorial Department in producing this outstanding issue of the *Proceedings*.

Murphy Radio.—Following the Rank Organisation's acquisition of Murphy Radio Ltd. the members of the board of Murphy have resigned: they are E. J. Power, chairman and managing director; F. B. Duncan, vice-chairman; H. V. Batchelor, C. R. Casson, K. S. Davies, E. W. Kent and A. P. Power. The new board consists of J. Davis, deputy chairman and managing director of the Rank Organisation, who is chairman; K. Winckles, M.B.E., assistant managing director of Rank; and D. Saward, O.B.E., managing director of the Bush Radio Division of Rank. K. S. Davies, E. W. Kent and W. Ross (secretary) are remaining as members of the management of Murphy Radio and are to "assist in the co-ordination of the activities of Bush and Murphy." It is announced that when this co-ordination is under way it is intended to enlarge the board of directors of Murphy and for a common management board to be set up to guide the activities of the two companies.

Radio Astronomy.—The need for the protection of certain radio frequencies from radiations of man-made origin to facilitate "the reception of extremely low-level electromagnetic radiations of extra-terrestrial origin" was recognized at the Geneva Radio Conference of 1959. The U.S. Federal Communications Commission has now proposed the world-wide allocation of the following bands exclusively (except in two cases) for radio astronomy:—40.66-40.70; 73.0-74.6; 328.6-335.4 (secondary to aeronautical radio-navigation); 1400-1427; 1664.4-1668.4 (secondary to meterological satellites); 2690-2700; 4990-5000; 10680-10700; 15350-15400; 19300-19400; 31300-31500 and 88000-90000Mc/s.

4U1ITU is the call sign of the International Amateur Radio Club, whose first station was opened on June 10th at the International Telecommunication Union's headquarters in Geneva, Switzerland. The aims of the I.A.R.C. are to further international friendship and understanding through amateur radio, to co-operate with all amateur associations throughout the world, and to provide an organization for managing and operating the new transmitting and receiving station.

R.T.R.A. Conference 1963.—Venue of next year's annual conference of the Radio & Television Retailers' Association is Scarborough, Yorks, from May 19th to 22nd. The Association has decided to repeat at Scarborough the type of exhibition held in conjunction with this year's Bournemouth conference, and has signed a contract with C. Rex-Hassan Associates covering its organization for the next three years.

German Hi Fi.—Audio manufacturers and importers in West Germany have formed an association to be known as Deutsches High Fidelity Institut (dhfi) with the object of specifying standards of reproduction of high-fidelity sound equipment and of giving public demonstrations of high-quality reproduction. The address of the secretary is H. Ticho, Rüsselsheimer Str. 22, Frankfurt/Main.

Radio Control.—The Post Office recently issued the 5,000th licence for the radio control of models. Since the Model Control Licence was introduced in 1954 licensees have been permitted to use the bands 26.96-27.28 Mc/s and 464-465 Mc/s. From next January the higher band will be altered to 458.5-459.5 Mc/s. The cost of a licence is £1 for five years, and applications must be sent to the Radio Services Department, Radio Branch, G.P.O., St. Martin's-le-Grand, London, E.C.1.

Illegal use of sound radio and television sets without a licence resulted in about 13,000 successful prosecutions by the G.P.O. in 1961, stated the Postmaster-General, Reginald Bevins, in answer to a question raised recently in the House of Commons about how much revenue is being lost to his Department by "pirates." He said the Post Office was continuously trying to track down cases of this sort by way of detector vans and so on, but obviously it was not possible to say how many people are still evading the licence fee.

Sierra Leone's first television station is expected to begin regular programme transmissions early in August. 625-line pictures in Band I to what is commonly called C.C.I.R. standards will be transmitted from the station which is sited at Aberdeen, near Freetown. Microwave equipment will be used to link the studios at New England with the transmitter. Total equipment has been supplied by Pye T.V.T. Ltd.

Austria.—About 70% of Austria's output of television sets now have 23in screens. Of last year's total production of 95,000, about 5% was exported. The 1962 limit for the import of television sets is 3,500. The import quota for broadcast receivers is 15,000 which is considerably below last year's export figure of 36,000 out of a total production of 240,000.

Television Society Council Elections.—Four new council members of the Television Society elected to fill vacancies caused by retirement in rotation are: P. L. Mothersole (Mullard), E. G. Rowe (Thorn-A.E.I. Radio Valves & Tubes), G. B. Townsend (G.E.C.), and Dr. R. C. G. Williams (Philips).

The Television Society of Australia has become associated with the U.K. Television Society and arrangements have been made for a mutual exchange of papers and information. The membership of the U.K. Society is around 1,300 and that of the Australian some 400.

Valve and Semiconductor Guides.—A reference source to the structure of the British electronic valve and semiconductor industry, published in booklet form by the B.V.A. and V.A.S.C.A., broadly classifies 48 types of valves, tubes and other devices and gives the names of the firms which make each type listed. Another V.A.S.C.A. publication, "Record of Semiconductor Outlines' (7s 6d; overseas postage 1s extra) contains 43 drawings indicating the space which should be allowed in equipment for the devices and also gives other features of importance to interchangeability. Both booklets are available from V.A.S.C.A. headquarters at 156 Oxford Street, London, W.1.

R.I. Club.—The total membership of the U.K. Radio Industries Club is now 2,270. Of this number 916 belong to the parent organization in London, the next largest membership being Scotland with 290. The latest provincial club is the East Midlands, formed during the past year, which has a membership of 118. The 1962/63 president, in succession to Ernest Brown, of Brown Brothers, is Guy Fountain, chairman and governing director of Tannoy Products.

Radiation Hazard?—"Fylingdales Workmen to be 'Screened'"—headline in *Daily Telegraph,* June 13th.

Electronics and the Blind.—At a congress held in New York from June 18th to 22nd "to further scientific development to aid the blind" a number of papers were presented by delegates from the U.K. and Dr. W. Grey Walter of the Burden Neurological Institute, Bristol, took a leading part. At one of the sessions on sound recording H. John F. Adam, of the Royal National Institute for the Blind, gave details of the tape cassette system of "talking books" and, at another session Dr. Maxwell B. Clowes, of the N.P.L., gave some design criterior for a blind reading aid.

Asdic.—Twelve of the 25 contributions to the symposium on Sonar Systems being held in the University of Birmingham from July 9th-12th are by authors from overseas—U.S.A., Canada, Germany, Italy and Norway. The conference is being sponsored jointly by the Brit.I.R.E., the Institute of Physics and Physical Society, and the Electrical Engineering Department of the University. Registration forms (fee £8) are obtainable from the Brit.I.R.E., 9 Bedford Square, London, W.C.1.

R.S.G.B. Golden Jubilee.—July 5th, 1963, marks the fiftieth anniversary of the formation of the London Wireless Club from which grew the Radio Society of Great Britain. During the period June 30th to July 6th next year the Society will be holding various functions including a jubilee dinner at the Connaught Rooms, London, on July 5th.

R.S.G.B.'s annual amateur radio exhibition, more familiarly known as the Radio Hobbies Show, is to take place this year nearly a month earlier than usual and at a new venue. Dates are October 31st to November 3rd, inclusive, at the Seymour Hall, Seymour Place, near Marble Arch, London, W.1.

T.E.M.A. Officers.—The 1962/63 chairman of the Telecommunication Engineering and Manufacturing Association is W. G. Patterson, M.B.E., divisional director and general manager of the Telecommunications Division of A.E.I. The new vice-chairman is C. Riley, O.B.E., director and general manager of the General Electric Co. (Telecommunications) Ltd.

The Electrical Research Association in its annual report for 1961 states that it is breaking with the tradition of being essentially a "heavy" electrical engineering industry research association and is expanding its activities in the electronics field. It reports a steady build up of electronic work and that in 1961 12% of the Association's research activity was of direct importance to the electronics industry and a further 6% of indirect interest. A ratio of 50:50 would more nearly represent the present balance in industry, states E.R.A.

H.P. Deposits Cut to 10%.—Television sets, sound radio receivers, tape recorders and record reproducing equipment are among a wide range of goods for which the minimum initial hire purchase and credit sale deposit was reduced on June 5th from 20 to 10%. The three-year maximum repayment period remains the same.

Northern Polytechnic.—Among the short, advanced, evening courses offered by the Dept. of Electronics and Telecommunications at the Northern Polytechnic, London, is one on the engineering aspects of sound recording and reproduction and another on colour television engineering. The college also offers a five-year part-time day or evening course in preparation for the electronic servicing certificate recently introduced by the City and Guilds of London Institute and the Radio Trades Examination Board. The Polytechnic's full-time diploma course in electronics and telecommunications provides for complete exemption from the Brit. I.R.E. graduateship examination.

"**Teaching by Television**" is the title of one of the three British Association Granada Lectures on communications in the modern world which are to be given in the Guildhall, London, in October. The speaker will be Yoshinori Maeda, general managing director of the Japan Broadcasting Corporation. Tickets for this lecture on October 16th and for those on the 9th ("New discoveries in the cliffs of the Dead Sea shores"), and 23rd ("The language of economics"), are obtainable from Granada TV Network, Golden Square, W.1.

Audenshaw Periodicals Service, run largely by sixth formers of Audenshaw Grammar School, Manchester, organizes the despatch of secondhand magazines to schools and colleges overseas where they are so badly needed. Readers wishing to donate their copies of *Wireless World* are invited to send a postcard, giving their name and address and details of what magazines they can despatch, to The Audenshaw Periodicals Service, Audenshaw Grammar School, Audenshaw, Manchester, who will supply labels and postal instructions.

Gliding Instrumentation.—Lt. Cdr. R. Brett-Knowles, R.N., of H.M.S. *Collingwood,* is to undertake the duties of Instruments Development Co-ordinator for the British Gliding Association. He will act as a "clearing house" for new ideas and projects in the fields of instruments, batteries and radio (in conjunction with the Association's radio co-ordinator, Sgt. John Williamson, of the R.A.F. Radio School, Yatesbury).

Radio Amateurs' Exam.—As already announced, a second Radio Amateurs' Examination will be held this year. This has been arranged for the evening of November 2nd. A list of 40 colleges at which the exam can be taken has been issued by the City and Guilds of London Institute, and application to sit the examination must be received by the college concerned not later than October 1st. The fee is 30s.

Our cover picture this month makes use of pictures provided by Wayne Kerr (instrumentation) and the Esso Petroleum Company (automation in oil refining).

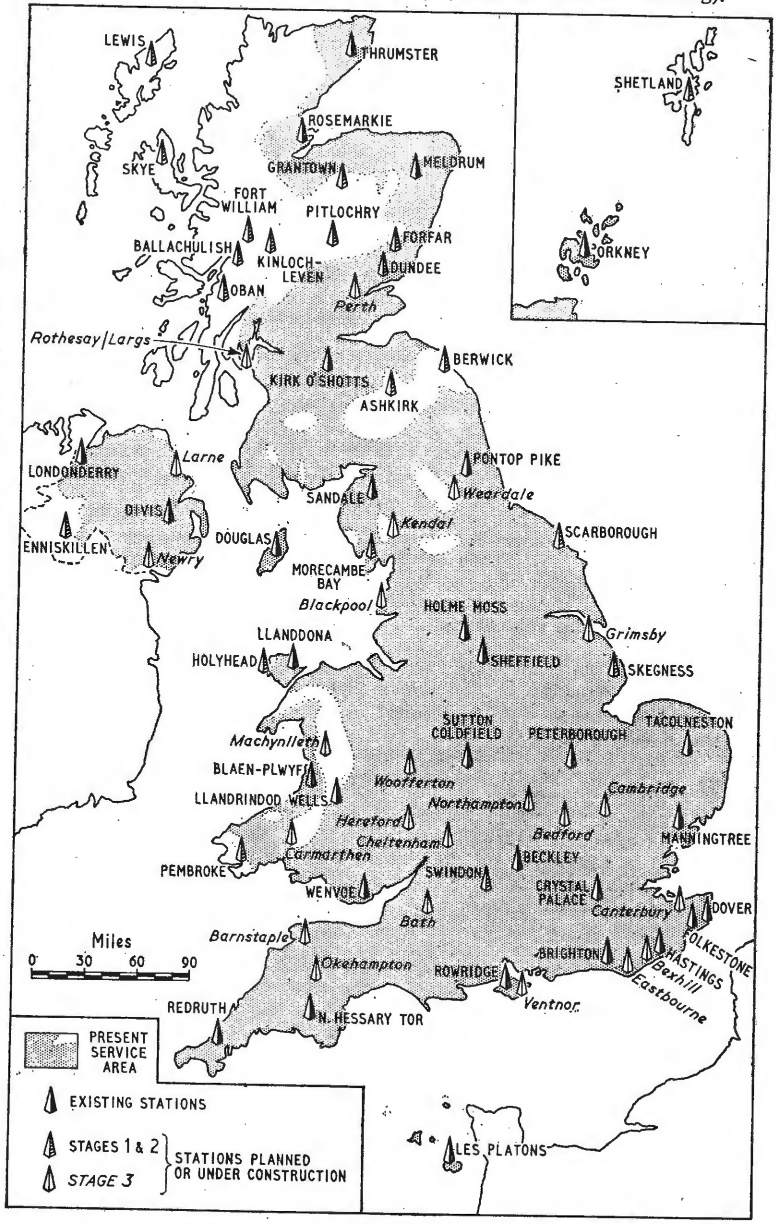
23 NEW TV STATIONS

B.B.C. Extends Coverage

Stage 3 of the British Broadcasting Corporation's plans for improving and extending their television coverage in the U.K. calls for an additional 23 low-power satellite television stations. The Postmaster-General has indicated his approval in principle for stations at Barnstaple, Bath, Bedford, Bexhill, Blackpool, Cambridge, Canterbury, Carmarthen, Cheltenham/Gloucester, Eastbourne, Grimsby, Hereford, Kendal, Larne, Machynlleth, Newry, Northampton, Okehampton, Perth, Rothesay/Largs, Ventnor, Weardale, and Woofferton.

All the stations will use very low-power "translators," which receive the programme from an existing station and relay it on another channel. The B.B.C. plan to build further stations in later stages of their scheme. Some of them will need to be of higher power and to have more elaborate equipment. In particular, further stations in the Highlands and Islands of Scotland can be planned only when the stations already authorized for this area in Stages 1 and 2 are in operation and their effective range has been established.

Thirty transmitters now broadcast the B.B.C.'s television service, with a further 20 stations planned, or under construction in Stages 1 and 2. The B.B.C. state that Stage 3 will not delay the completion of Stages 1 and 2, and it is hoped to complete all three Stages by the end of 1964, when the service will be available to 99.4 per cent of the population. Stage 3 also calls for 18 further v.h.f. sound radio stations the majority of which will be co-sited with television transmitting stations.



(*Map: Crown Copyright Reserved*)

Personalities

Sir Harold A. Wernher, Bt., G.C.V.O., T.D., has become deputy chairman of the Plessey Company of which Sir Allen Clark is chairman and managing director. The appointment of **John A. Clark** as joint managing director is also announced. Michael Clark and A. E. Underwood continue as deputy managing directors. Sir Harold, who is chairman of Ericsson Telephones, joined the board of Plessey on the merging of the two companies and Automatic Telephone and Electric Company last year.

George S. Taylor has resigned from the board of Gas Purification and Chemical Company and its subsidiaries which include Grundig (Great Britain), Wolsey Electronics and Grundig Works (Northern Ireland). He joined the British offshoot of the West German Grundig company as sales director on its formation ten years ago. Prior to that he had been, for some years, with Whiteley Electrical. He was chairman and managing director of both Grundig (Great Britain) and Wolsey Electronics.

R. S. Roberts has resigned from the board of Wolsey Electronics Ltd. His association with the company dates from 1955 when he acted as a consultant. In 1957 he was appointed executive technical director, and a year later joined the board. Mr. Roberts is principal lecturer in the Northern Polytechnic's department of electronics and telecommunications.

Donald Scott, for the past seven years an assistant engineer-in-chief with Cable & Wireless, has been appointed deputy engineer-in-chief in place of the late **A. H. Harris** who died in February. Mr. Scott joined the Eastern Telegraph Company in 1919 and transferred to C. & W. on its formation in 1929. Since joining the E-in-C's department in 1948 he has been responsible for the day-to-day operation of the company's cable and radio services. **Richard W. Cannon,** who joined C. & W. in 1941 at the age of 17, is appointed an assistant engineer-in-chief in place of Mr. Scott.

H. J. Leak, founder and managing director of the company bearing his name, has been elected president of the British Sound Recording Association. He succeeds **P. J. Walker,** managing director of the Acoustical Manufacturing Company, who has completed his second term of office.

R. O. Seccombe has joined Mullard Ltd. as deputy service manager. Mr. Seccombe had been with Murphy Radio for 25 years, and for the last 13 was service manager. He is succeeded at Murphy's by **J. Alan Hutton.**

P. D. Saw has joined Contronics Limited, of Blackdown, Hants., as technical director. He was, until recently, chief designer and development engineer of the Electronics Division of Tyer & Company, of Guildford. He will be concerned initially with the application of solid-state circuitry to industrial control systems.

N. G. Worster, A.M.I.E.E., has joined Avo as chief engineer. For the past four years he has been chief development engineer of Measuring Instruments (Pullin), prior to which he was with S. Smith & Son (England).

T. K. Hemingway, author of the contribution on the bootstrap follower in this issue, graduated in electrical engineering at Manchester University in 1953 since when he has been with English Electric. He is primarily concerned with the design of transistor circuits and systems for use in guided weapons.

D. B. Weigall, M.A., M.I.E.E., is the B.B.C.'s new chief engineer, external broadcasting, in succession to **F. Axon,** D.C.M., Assoc.I.E.E., who has retired but whose services are being retained in an advisory capacity. Mr. Axon joined the Corporation in 1941, in what was then the overseas and engineering information department, of which he became head in 1951. Two years later he was appointed to the post from which he now retires. He was responsible for much of the modernization of the B.B.C.'s short-wave installations, both in this country and overseas. Mr. Weigall, his successor, joined the Corporation as a student apprentice in 1933. He has twice been seconded to other organizations. From 1940 to 1942 he was chief engineer of the Malaya Broadcasting Corporation and from 1943 to 1946 he was technical adviser on broadcasting to the Ministry of Information. From 1948 to 1961 he was in the planning and installation department where he was latterly head of the transmitter equipment section.

J. W. Soulsby, chief radio officer of the British India Steam Navigation Company's *Uganda*, has been re-elected for his eighth consecutive term of office as chairman of the Radio Officers' Union. He joined the Marconi Marine Company in 1918. The Union's vice chairman is **J. G. Salveson,** flying radio officer with British European Airways which he joined soon after demobilization from the R.A.F. in 1946.

OBITUARY

N. J. Chanter, M.Sc., D.I.C., A.R.C.S., A.M.I.E.E., manager of Mullard Transmitting and Microwave Valve factory at Waddon, Surrey, since 1958, died in hospital on May 16. Mr. Chanter, who was 46 years of age, was previously for 12 years head of the Microwave Valve Division at Mullard Research Laboratories, during which period he was responsible for the development of many new technical devices and techniques applicable in the fields of radar and communications. Mr. Chanter studied physics at the Royal College of Science and before joining the company was engaged in the development of radar systems.

Dr. phil. Siegmund Loewe has died at the age of 77. He studied under Prof. Slaby and worked with Graf Arco in Telefunken. In 1921 he founded his own firm in Berlin which became known as Radio AG D.S. Loewe and later under its present name of Loewe Opta AG. Dr. Loewe's name will be associated, by older readers of this journal, with the first sputtered metal film resistors and with multi-stage RC-coupled valve amplifiers in a single glass envelope. He was a pioneer in the development of television, and in collaboration with M. von Ardenne produced commercial cathode-ray receivers for the opening of the German television service in 1935.

The sudden death of **T. S. Woodget** occurred on May 25. He was 49. As reported in the last issue, Mr. Woodget had only recently been appointed to the board of M.O. Valve Company after 28 years' service.

Frederic J. Boardman, chief inspector of the Bush Radio Division of the Rank Organization, has died at the age of 56. Mr. Boardman joined Bush at Chiswick in 1945 after serving in the Aeronautical Inspection Directorate.

J. K. Starnecki, chief engineer and head of development at W. G. Pye & Co., Cambridge, died on May 15

I.E.A. Exhibition Report

NEW DEVELOPMENTS FROM BRITAIN AND OVERSEAS

This year's I.E.A. Exhibition was notable for its size and for the sheer quantity of new exhibits. No fewer than 550 firms were showing, over 100 from overseas. Only in one or two fields were new trends discernible: refinement of older techniques was the principal development. Rise times are shorter, bandwidths wider, levels more constant and even buttons no longer need pressing. Computers compute faster, and one firm's equipment has even started to delegate authority—a sort of arch-organization-man.

We have tried to compress into the following account an outline of those items which members of the Wireless World *editorial staff judged to be of general interest. Quite obviously it has not been possible to include all those details of a specification which a potential customer would need.*

To assist readers who may require fuller details of particular instruments, we shall be happy to put them in touch directly with the manufacturers if they will fill in the application forms which are to be found in the front section of this issue.

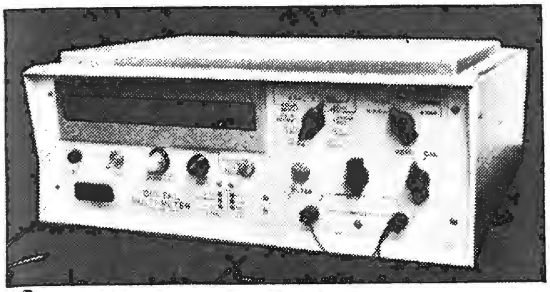
MEASURING INSTRUMENTS

Frequency Measurement. By far the greatest step forward in the field of frequency measurement and generation has been the frequency synthesizer. At least four of these instruments were shown, all having comparable performances, which can be summarized as follows: frequency measurement over the range a few tens of kilocycles to over 1000 Mc/s at an accuracy of a few parts in 10^8, frequency generation from either zero or about 20 Mc/s to over 1000 Mc/s at the same accuracy, and stability which is governed by the stability of either an internal standard or a received standard from M.S.F. or W.W.V.

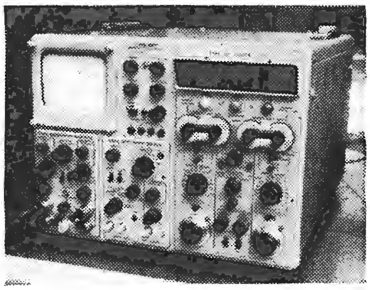
In the Telemax-Southern TD-1 Frequency Meter, the internal standard is a 5 Mc/s, 4 parts in 10^9 crystal oscillator, and measurement is possible up to about 3 Gc/s. The mode of operation of these instruments, which was described fully by R. Brown in *Wireless World* for November 1961, depends on continuous frequency division and mixing, and results in a form of control which is effectively digital in accuracy. For frequency measurement, either an interpolation oscillator may be used after the ultimate frequency division stage or a counter unit may be employed, in which case human reading error is not a term in the result.

The only rival to the heterodyne technique of measurement used in these instruments is the digital counting process and two rather predictable trends have become apparent here. The speed of counting is increasing rapidly, and is now at about the 100 Mc/s mark, while at the other end of the range, several small, low-priced counters are making their appearance, with no frills and a crystal stability of a few parts in 10^5 or 10^6. Typical examples are the Venner TSA3334 and Racal SA520, both transistor instruments. Both cater for frequency and period measurements, with multi-period-average switching, the Venner counter having a 10 kc/s test facility. The top counting speeds are 1.1 Mc/s and 300 kc/s respectively.

The high-speed instruments are exemplified by the Rochar 60 Mc/s counter timer and the Racal SA518 100 Mc/s instrument. Both of these are really 10 Mc/s counters with a high-speed, non-displaying divider at the "front end." The Racal SA513 divider is interesting in that it consists of a transistor toggle followed by a divide-by-five tunnel-diode circuit. An unusual feature of the General Radio 1130-A counter is the display. The eight counting decades can be split into two sets,



Blackburn Electronics digital multimeter, which affords measurement of R and C, alternating voltage and direct current and voltage, at a maximum speed of 3 readings/sec.



Digital readout is feature of Tektronix 567. Adjustable limits are provided, coloured lamps indicating whether measured value is in or out of limited zone.

one providing the counting function, the other being used as a storage and display unit. While the first four decades count, the second set display the result of the previous count, any change in reading being accomplished in 100μsec. The "spots-before-the-eyes" sensation is thereby greatly reduced, and, as the significance of the four storage decades is variable, accuracy is not sacrificed.

Phase measurement is added to the range of facilities provided by the Hewlett-Packard 524 counter by the 526D Phase Unit. The two signals are fed to trigger circuits which form gate pulses separated by the phase difference of the signals. The counter is then gated, and counts 0.1μsec units. Measurements may be carried out on signals in the range 1 c/s to 20 kc/s at an accuracy depending on the ratio of the unknown signal and the time units. A fixed frequency multiplier, tuned to 1.44 Mc/s, is available to enable measurements on 400 c/s signals to be direct reading in tenths of a degree.

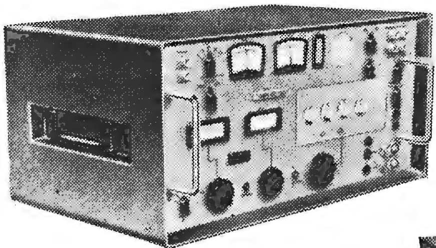
Waveform Display. Sampling oscilloscopes and transistorized instruments are the areas in which new developments are appearing. General laboratory instruments of the valve type, covering, say, 10 Mc/s to 60 Mc/s, proliferate, and progress in this region is directed towards compactness and reliability, with noticeable efforts being made to apply a more realistic formula relating works cost and selling prices.

Digital read-out may strike one as a shade odd when applied to an analogue device such as an oscilloscope, but when pulse techniques are employed to provide sampling, as in the Tektronix 567, the whole process of measurement requires a second look, and digits are the logical result. The basic oscilloscope has an equivalent rise-time of 400psec (bandwidth 0-875 Mc/s) and will display amplitude and time between selected and brightened points on an in-line read-out. Voltage measurements are carried out by an analogue-to-digital converter using the variable-comparator ramp method, 1 Mc/s clock pulses being counted during the gating period. Time is measured by counting the number of sampling pulses occurring between selected points on the trace. Upper and lower limits may be set up, appropriately-coloured lights being operated if these are exceeded.

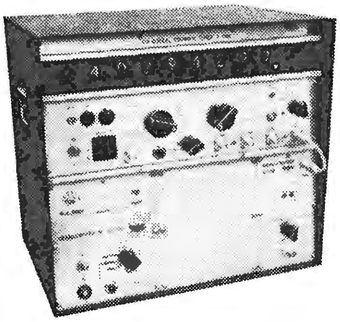
Transistors are used exclusively in the Dumont 766 oscilloscope. The basic instrument contains no circuitry connected with either x or y co-ordinates, these functions being contained in two transistorized plug-in units. The y amplifier bandwidth is 25 Mc/s, and a comprehensive time-base unit is available. A novel feature is the combined x and y shift control which is in the form of a joystick.

General-purpose oscilloscope development is well represented by the Telequipment D55A. This is a double-beam instrument with two identical y amplifiers of 0-15 Mc/s response and 100mV/cm sensitivity. Two time-base generators are used, either of which may be coupled to either beam. Alternatively, one time-base being a slow one, it is possible to use one to strobe the other. For use when examining a television signal, a pulse output is provided to brighten the part of the picture being studied.

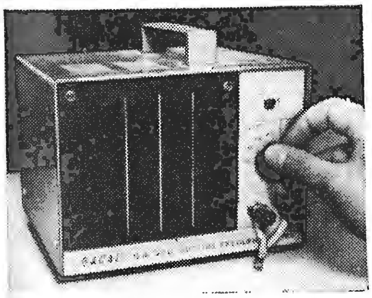
Oscillographic recording continues to be made simpler, and the new Philips PM9300 photographic arrangement is probably the most sybaritic yet seen. It consists of a special Rolleicord camera, using either ordinary 120 roll film (24 exposures 2.8×6cm) or a Polaroid-Land back and cassette. The camera is suitable for 10 or 13cm oscilloscope screens, and all necessary hoods and supports are provided.



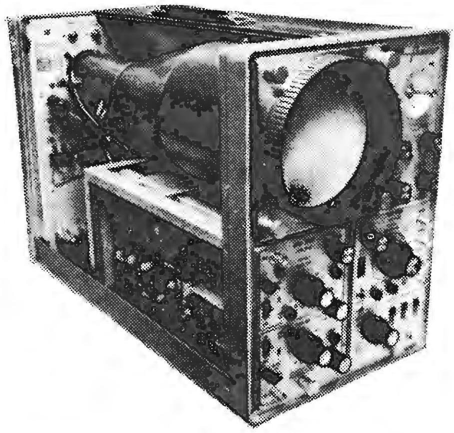
Left: Frequency meter and synthesizer TDI exhibited by Telemax-Southern.



Right: 60 Mc/s counting combination by Rochar.



Left: 300 kc/s counter from Racal, for general purpose frequency and time measurement at low cost.



25Mc/s oscilloscope from Dumont, which uses transistors exclusively.

Amateur photographers will be delighted to hear that the Rollei is perfectly good for normal work.

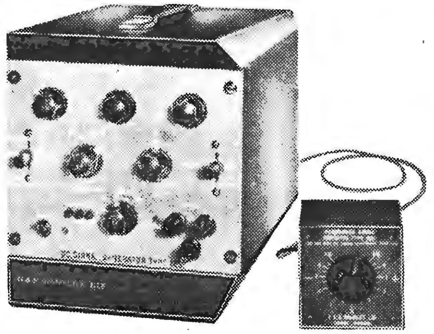
For larger, permanent records of high-speed waveforms, the Moseley 101 Waveform Translator performs a sampling process to reduce the frequency response required to that of an *x-y* plotter. A slowly-varying ramp waveform is compared with the time base voltage, a pulse, slightly delayed on the last, being produced each time the two signals are in coincidence. The pulse is used both to sample the *y* signal and to *z*-modulate the oscilloscope tube, thereby indicating the point of sampling. The Translator is useful in its own right whenever a waveform containing high frequencies must be handled by equipment with a low frequency response.

Distortion in a transmission system is caused if the gain or phase characteristic of the system is at all dependent on the amplitude of the input signal. In the N.T.S.C. colour television system, chrominance information is conveyed by the amplitude of a high-frequency signal superimposed on the picture luminance waveform and blanked at line frequency. If the system were non-linear in gain or phase, the colour signal would be in error by an amount depending on the instantaneous amplitude of the luminance signal. Wandel and Goltermann have introduced a distortion meter, the VZM-1, which simulates the N.T.S.C. signal by means of a sawtooth at line frequency blanked by sync pulses, with the high frequency superimposed. The composite signal is applied to the system under test, and the output amplified, the high-frequency chominance signal being extracted. This is now examined by oscilloscope for linearity and phase variations in comparison with a reference signal.

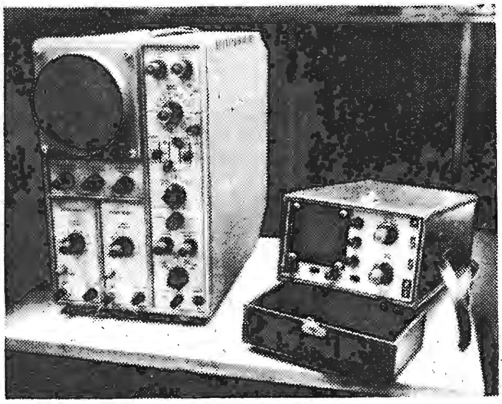
The three functions of distortion, voltage and relative power measurement are performed by the L.E.A. (Laboratoire Electro-Acoustique) Qualiscope E.H.D.20. The fundamental frequency contained in the input signal is rejected by a continuously-variable RC filter which works between 20c/s and 25kc/s. The remainder is indicated on a meter calibrated in per cent total harmonic distortion and is also displayed on a c.r.t. where the shape of the remaining signal, when plotted against the input signal, is a guide to its composition. When the meter is in use for power or voltage measurement, the c.r.t. can be used for frequency measurement by the Lissajous method.

Pulse generators are developing in two directions—towards more varied combinations of polarities, pulse groups and simultaneous pulses, and towards extremely short single pulses. The first group finds application in the testing and simulation of radar and other systems, while short pulses are required for the testing of computer switching and wide-band devices. Marconi Instruments exhibited one of each kind—the double pulse generator TF1400 and the nanosecond pulse generator TF1389. The TF1400 uses conventional techniques to obtain pulses with rise times of 30nsec, together with double pulsing and secondary pulse facilities, while the TF1389 employs the coaxial line discharge process to provide pulses with a rise-time of less than 500psec. A coaxially mounted mercury wetted relay contact is driven by a sinusoidal signal at up to 350c/s, discharging a length of coaxial cable and forming the pulse. The pulse width is determined by the length of cable used, and provision is made for pulse lengths of 2·5, 5, 25, 50 and 100nsec; different length pulses are obtainable by using external cables. 600W of peak pulse power is given.

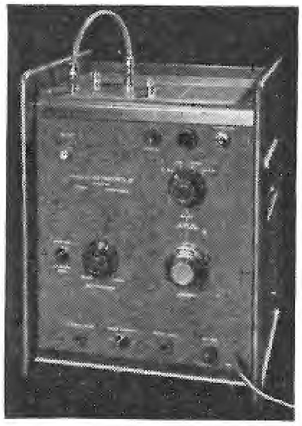
Automatic measurement of complex ratios for performance testing of any a.c. system where the transfer function can be specified in terms of complex voltage ratio of less than 6·25:1 is provided by the Wayne Kerr-Gertsch CRB-3. The acceptance of the concept of ratios rather than absolute voltage values has enabled the bridge technique to be adopted, with its inherent accuracy. The input impedance is 10kMΩ, which virtually eliminates any worries of "measurand" loading. In-phase and quad-



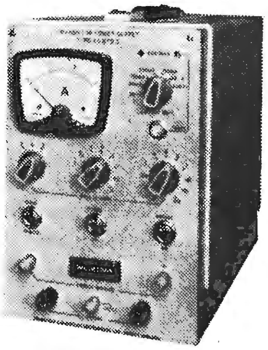
Source of precisely-controlled voltage for calibration and backing-off purposes from G. & E. Bradley. Square waves are also available at 1 c/s or 50 c/s. Resolution is 0.2% from a few millivolts to 500V.



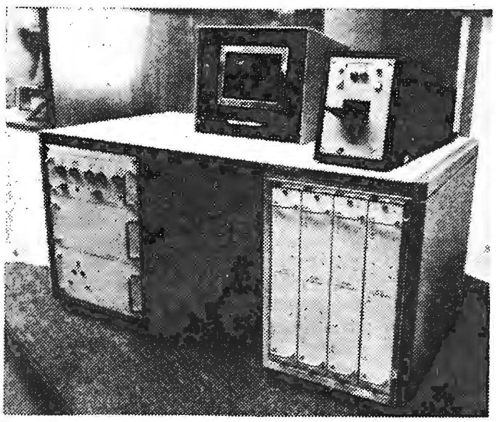
Two new oscilloscopes by Telequipment. On the left, the D55A dual-beam instrument, with delaying sweep, with the S31 transistorized portable instrument at the right. Y-bandwidth of the S31 is 0-3 Mc/s and it uses a 4kV p.d.a. tube.



Nanosecond pulse generator for 0.5nsec rise times, by Marconi Instruments.



AS870-3 stabilized power-supply by Solartron. Load can be connected across remote sensing terminals to avoid loss in output lead.



Noise-spectrum analyser shown by Solartron gives complete print-out of spectral density in the range 1 c/s-10 kc/s in 2 seconds. Display is log-log and 17-in tube provides continuous display of spectrum.

rature signals derived from the reference signals are added and used to drive the common of a null amplifier, the input of which is the output of the unit under test. An alternating relay programmes inputs from the decades of in-phase and quadrature ratio transformers to a phase-sensitive detector. In the output of the detector is a polarized relay which, depending on whether the bridge is over or under balance, is open or closed. This relay controls the clock pulses to the decades, and as each decade reaches one position over balance, the pulses are connected to the finer decade, while the original decade retracks one step. The process continues until all decades have been scanned, when R_x and jR_y may be read from an in-line display.

Power-supplies using transistors as the variable series impedance are rather more vulnerable to overload conditions than those with valves in this position. The effect of a short circuit or low-resistance at the output is so expensively fast that fuses are very little use. Overload protection circuits are therefore required, and vary from the "bang-bang" type to fully proportional protection. In the Solartron AS870.3 and AS757.3 stabilized units, a demand for more current than can reasonably be expected is detected by a transistor switch, which applies a fixed voltage to the series emitter-follower base. The current output is thereby limited to a value set by the fixed voltage divided by the value of a series resistor in the emitter. If the load persists in its demands, the output voltage falls, and the change is fed back to the series transistor in such a way as to decrease the current through it, which prevents the dissipation of excessive amounts of power. The Solartron instruments have terminals for the connection of sensing leads from the load itself, so that the voltage drop of power carrying leads is avoided.

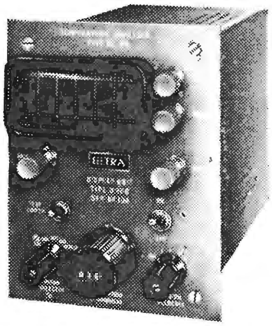
An 80V stabilized supply by J. Langham Thompson uses silicon controlled rectifiers in the a.c. feed to the mains transformer primary. Variations of the output voltage determine the mark: space ratio of a pulse generator output, which is used to adjust the conduction angle of the s.c.r's. A series transistor is used for fine stabilization, and here again remote sensing is provided for.

INDUSTRIAL ELECTRONICS

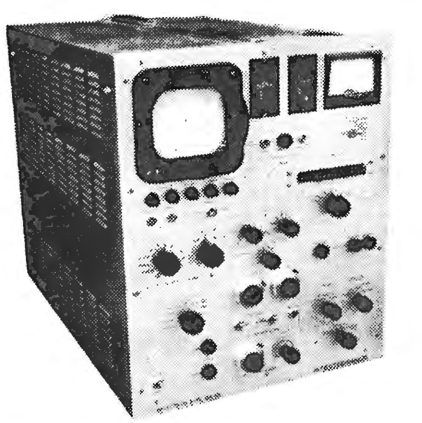
Proximity and Thickness.—Several interesting applications and methods of capacitance measurement were shown. For example in the Burndept Sensikator proximity detector the capacitance at the probe forms part of a tuned circuit connected to the third grid of a heptode whose first grid is fed from a high-frequency (23-Mc/s) oscillator. With this arrangement capacitance changes in the tuned circuit cause much larger changes in the heptode anode current. These changes are differentiated in a CR network before being used to trigger a flip-flop. The differentiation ensures that only rates of change of capacity above a certain value are finally registered and so makes this detector very suitable for counting objects moving on a conveyor belt, since it will not be affected by relatively slower random movements of the belt. Another proximity detector made by the same company—the BE 238—responds directly to small changes in the capacitance, which in this case is connected in the anode circuit of a crystal-controlled Miller-Pierce oscillator. Controls are provided for tuning the anode capacitance to the critical point at which any slight increase causes abrupt cessation of oscillations. Lippke showed how both the thickness and moisture content of paper can be measured from the capacitance it gives between two sets of measuring plates. If, as in their Supertest 712, these plates are set so that the paper nearly fills the space between them the capacitance gives directly the paper dielectric constant and thus its moisture content. The paper thickness can be measured—as in their QG-6—by spacing the plates further apart, for in this case it can be shown that fluctuations in the paper dielectric constant have less effect on the measured capacitance than thickness changes.

Displacements of less than a micro-inch can be resolved with the Ferranti Micro Comparator. An inductive bridge measuring circuit is used whose four elements are rigidly attached to the probe. Damage to these elements due to rough usage is avoided by providing a shear point on the probe so that this breaks off first.

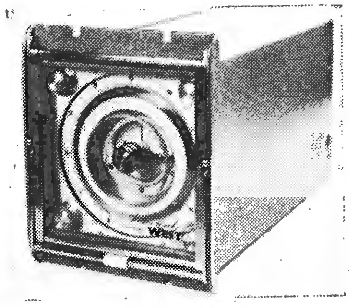
Flowmeters based on Faraday's



Ultra temperature analyser.



Intertechnique transistor multichannel pulse height analyser.



West "Viscount" three-term temperature controller.

principle of electromagnetic induction were shown by Alto and by Kent. The liquid—which must be at least slightly conducting—flows in an alternating transverse magnetic field. This sets up (at right angles to both the field and flow direction) an alternating e.m.f. in the liquid which is linearly proportional to the rate of flow and applied field. Advantages of this system of flow measurement are that the instrument does not impose any restriction on the flow, and that it is not affected by irregularities in the flow profile or changes in viscosity, density or consistency. In the Kent flowmeter the a.c. output from the flow tube is compared (after amplification) with an a.c. reference derived from the magnetic field exciting current: this comparison eliminates errors due to variations in the supply voltage or frequency. The comparison is carried out by means of a self-adjusting potential divider consisting of a pair of thermistors differentially heated by the out-of-balance signal. The dividing ratio actually set up (which is proportional to the flow) is measured by feeding a d.c. reference to the divider and separating out the divided d.c. from the a.c.

Metal Detection.—A ferrous detection system shown by Thorn uses the ferrous material to increase the mutual coupling between two coils and thus initiate oscillations in a suitable circuit. An advantage of this system is that it does not depend on the speed of the ferrous object and can thus be used to count rotations at very low speeds.

Force-balance Methods.—A frequently-used method of measurement employs the force-balance principle. In this system the quantity to be measured is converted into a force which is applied to a pivoted beam. The beam is rebalanced by the force between a current-carrying coil and the field due to a permanent magnet or second coil (one of which is attached to the beam), the rebalancing current then providing the required measurement. An unusual force-balance system is used by Pullin in their Unibloc. In this case any change in the quantity to be measured is used to impart a corresponding rotary torque to a shaft. This causes a rocker attached to the shaft to make contact with one of two terminals and so causes one of two corresponding uni-directional synchronous motors to rotate a second shaft. A cam on this shaft then repositions the ends of two tension springs attached to the first shaft so that the rocker is rebalanced between the contacts and the motor is switched off. The time taken to rebalance the rocker then gives the required measurement. This time is converted into a number of stepping pulses by means of three switches actuated by cams on the motor-driven shaft: these pulses are then fed to a three-phase stepping motor whose rotation is used to finally indicate the quantity being measured. This system can be adapted very simply for control purposes by using the rocker arm to energize a control lever motor.

Data Logging.—Of the multi-channel data-logging and alarm systems shown one of the more elaborate was the Blackburn Electronics "Adonis", since this also offers limited computing facilities in Boolean algebra. Mobile data-logging equipment specially for process-control feasibility studies has been developed both by Ferranti and A.E.I.

Although looking rather like oscilloscopes, the Intertechnique Models SA20 and SA40 (distributed by Miles Hivolt) are actually transistorized multichannel pulse height analysers for nuclear detectors. The slowness and information wastage of systems in which the various energies are scanned in turn are avoided by storing all the pulses simultaneously. The amplitude of each pulse is first converted by a RC discharge circuit into a proportional time interval: during this interval the pulses from an oscillator are counted to convert the pulse amplitude finally into digital form. This determines the channel in which the pulse is stored in the magnetic core memory. The contents of the whole memory can be viewed on the built in c.r.t. or read out using an external recorder. Automatic programming of various read out and storage cycles is possible. Removal of background by means of subtraction storage is another available facility. In two special operation modes the amplitude converter is disconnected and all pulses counted between times set up by external generators: these times being chosen to give decay period and time of flight measurements.

In the Ultra UE90 temperature analyser 2,000 samples per second can be taken of up to 40 thermocouple outputs for display on a c.r.t. Adjustable calibration pips allow exact measurements to be made and the reference voltage is compensated for changes in ambient temperature so that cold-junction compensation is not necessary.

Data Transmission by Telephone.—Two unusually sophisticated methods of error detection and correction were noted in f.s.k. binary data transmission systems shown by S.T.C. and by Bendix Ericsson. The latter used the Hagelbarger system (see *Bell System Technical Journal*, July 1959, p. 969) in which check bits derived as the sums of all pairs data bits spaced a certain distance apart are transmitted alternately with the data bits. On reception the data and check bits are separated out and the message bits added in similar sets of spaced pairs to appropriate check bits. If the sums for the two cases containing a particular data bit are both odd this bit is an error and can be corrected. This system will detect and correct practically all errors other than those caused by long bursts of noise. S.T.C. used a much longer word length than usual (240 bits), to which is added only 12 parity bits using a cyclic code (see *Proc. I.R.E.*, Jan. 1961, p. 229). This reduces errors by a fact of about 2^{12}.

The G.P.O. is developing a f.s.k. modulator/demodulator for rental.

Process Control.—In most cases only a single quantity was controlled by feedback of a signal depending on the error deviation, its derivative (with respect to time), and its integral (three-term control). Such control is provided by Fielden in their type A units by a simple double-triode twin cathode-follower circuit connected via two CR networks to a d.c. amplifier fed from the deviation signal. The two resistors in these networks can be used to adjust the derivative and integral action times, and control of the proportional bandwidth is obtained by a potentiometer between the earthy ends of the cathode resistors. The differential output between the two cathode followers is fed back from the potentiometer slider to the d.c. amplifier input; the current output of this amplifier then provides the required control signal.

Power control by means of silicon-controlled rectifiers is usually carried out by firing them for a fraction of a complete cycle depending on the error signal. Unfortunately this does not give a linear control and the power-factor varies with the error signal. Both of these disadvantages are avoided in West's "Viscount" three-term temperature controller by always firing the SCR's at zero phase and controlling the power by omitting the required proportion of complete cycles rather than fractions of every cycle.

A power input controller shown by English Electric (Type A42FT) consists of a watt-hour meter having an additional perforated disc positioned between a lamp and a phototransistor. As power is consumed, the perforated disc rotates and interrupts the light to the photocell. This produces current pulses which are amplified and counted down electromechanically until the required energy has been consumed.

Among the fixed-programme controllers shown was one for the intriguing application of industrial knitting (shown by Bendix Ericsson). The appropriate pattern is fed in on a punched card for storage, and the machine control signals read out in sequence via solenoids. In the English Electric controller the programme is set up in the ferrite core store by means of input switches which are activated by a human operator as he carries out a normal programme.

A "building brick" system in which the individual bricks may be whole computers has been introduced by Elliott. This is called ARCH (standing for Articulated Computer Heirarchy) and is intended for building up process control systems in which computers are interconnected in a chain of command (see p. 269 of our June issue).

Predictive feed-forward control from models representing the process and fed from the same inputs is being investigated by A.E.I. A suitable general mathematical model is chosen whose co-efficients are adjusted by a computor to minimize the deviation of its performance from that of the process (for various perturbations of the input variables).

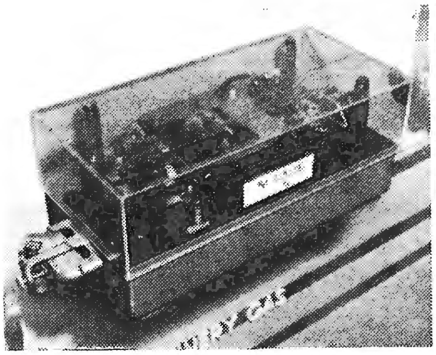
Computers.—An unusual type of analogue computer—the Analac A110—was shown by C.S.F. This measures quantities in terms of high-frequency alternating (472kc/s) rather than direct currents and voltages, and mathematical transformations are carried out by symmetrical passive LC networks. Since losses are very low, amplifiers are not needed. This increases reliability and reduces both the errors and the cost of the machine.

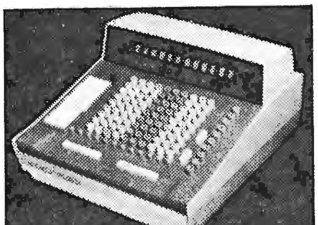
Because of the ability of the new International Systems Control TRW-530 process control computer to carry out several parallel elementary operations in the same pulse interval, it would be possible to specify more than 6,000 distinct orders for this computer. Using the corresponding order code would be prohibitively expensive both in terms of computer logical circuits and of the time required for the programmer to master such a code. To meet this problem only those orders (such as multiplication and division) which are universally employed are provided as wired logic. Further orders can be stored in the computer memory, but in general the programmes are made up of more elementary instructions (e.g., shift one place, transfer registers) rather than conventional orders. This increases programme complexity but allows full advantage to be taken of the high speed of the computer.

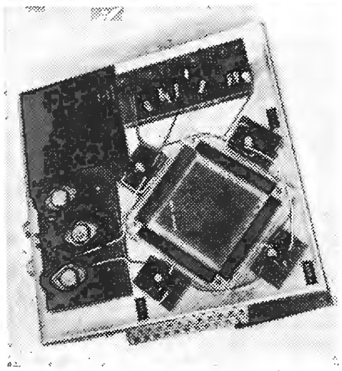
A current-balance computing element—the ER92—was shown by Evershed and Vignoles. In this a pivoted beam carrying coils at each end is subjected to torques produced by the interaction between signal currents in these coils and magnetic fields (which may be produced by permanent magnets or by further signal currents in external fixed coils). A vane attached to the beam forms part of a differential capacitor connected to give variable coupling between an r.f. oscillator and phase-sensitive bridge rectifier. The rectifier output passes through another coil attached to the beam and interacts with the field of a permanent magnet so as to rebalance the beam. The rebalancing oscillator current then mathematically depends on the various signal currents according to how their coils are interconnected.

While not strictly within our field, it is interesting to note that springs, levers and pneumatic valves can be used to carry out mathematical operations: a spring and lever module for multiplying and dividing was shown by Foxboro-Yoxall and a complete pneumatic simulator for educational purposes was shown by VEB Carl Zeiss, Jena (represented by Scientific Instruments).

Small computers—generally for educational purposes—are now being increasingly manufactured and a kit is even available (Daystrom Heathkit Model EC-1). A feature of the Short educational computer is that the amplifiers, coefficient, and other units have their circuits engraved on them so that when they are plugged into the computer board to set up a problem, the appropriate circuit diagram for that problem is automatically displayed. The Sunderland general-purpose analogue computer incorporates a test genera-



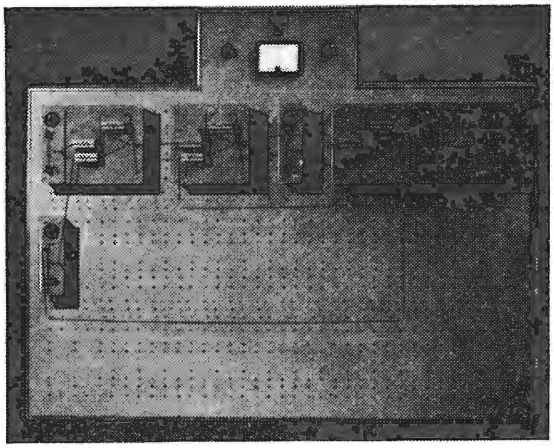




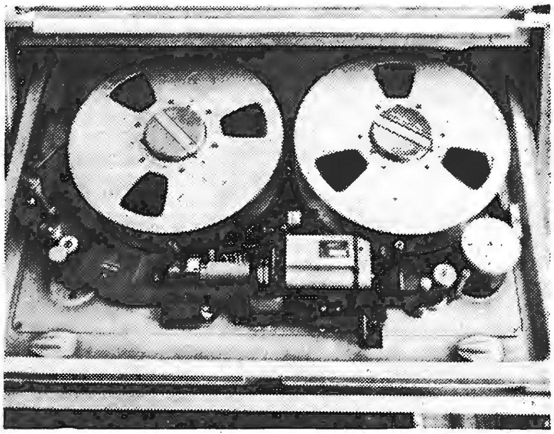
Above: Example of a small computer is the Sumlock Comptometer Anita (A New Inspiration to Arithmetic) desk calculator using Hivac cold-cathode tubes.

Above left: Evershed and Vignoles current-balance relay computing element.

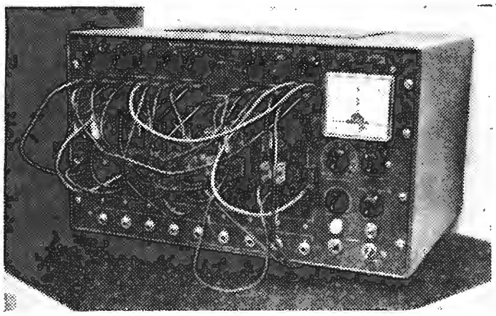
Left: Memory section for a small desk:calculator shown by Mullard.



Short educational computer.



Ampex wideband instrumentation recorder showing rotating heads.



Daystrom Heathkit educational analogue computer kit made up.

tor for providing the sine, square and ramp signal required for complete systems analysing.

Logic Building Bricks.—An increasing number of manufacturers are now offering such "bricks" for switching, control and computing purposes. (Incidentally it is becoming very difficult to draw clear lines between these three types of use in spite of their generally increasing complexity.) Nearly all of these units used transistor/resistor or transistor/diode logic circuits, but one exception was the use of magnetic cores (with multiple windings) by Di/An controls (distributed by Scientific Furnishings). Mullard had a comprehensive exhibit of equipment using their Norbit or Combi-elements, of which an intriguing example was Betsie (Bets Settlement Investment Engine) which, besides calculating winnings on simple types of bets, can also deal with more complicated bets with names like Yankee, Patent and Round Robin.

Instrumentation tape recording.—Tape transport systems employing interesting methods of securing constant tape tension were shown by E.M.I., Ampex and Epsylon. In the Epsylon MR120 recorder feelers which bear on the outer edge of the tape on the reels are mechanically linked to the take-up and supply motors. These motors are of the constant torque type and rim drive two discs attached to the spool axles. As the radius of the tape on the spool varies, the mechanical linkage from the feelers bearing on the outer edge of the tape causes the motors to move along radii on the discs attached to the spool axles. This causes the torques actually applied to the spools to vary with the radius of the tape on them so that the tape tension is held constant. In the Ampex FR600 the tape guides have holes in them through which air is pumped, a transducer sensing the air pressure at the outer guides so as to correct for any tension differences. Tape ends and breakages are also sensed pneumatically. This air cushioning system also reduces tape wear and edge curl. Edge curl and consequently tape skew is reduced in the E.M.I. TD3 and TD4 range of recorders by reducing the length of each guide actually in contact with the tape by giving it a pointed rather than curved cross-section. Constant tape tension is secured by passing the tape over two spring-loaded compliance arms linked to carbon-pile resistors in series with the take-up and supply motors.

A system now frequently employed for giving a fast uniform start consists of making the tape drive a perforated wheel situated between a lamp and phototransistor. For a fast start the tape drive is at first put into fast wind and only when the correct tape speed (as sensed by the p.r.f. of the phototransistor output) is reached are the capstan pinch rollers engaged. In addition, in the E.M.I. TD3 and TD4 range these rollers are not engaged until the capstan has accelerated to its correct speed—this condition being sensed by the sudden rise in the voltage across the hysterisis motor phase splitting capacitor as synchronism is reached.

The rotating head system (providing tracks across rather than along the moving tape) used by Ampex in their video recorders has been adapted by them to provide a wide bandwidth (4Mc/s) also in their models AR-300 and FR-700 instrumentation recorders. An additional head records three tracks in the normal way along the tape near its edge. Two of these can be used to provide auxiliary information with a 15kc/s band width, the third is recorded with a monitor signal which is used to accurately control the capstan speed on playback. The pressure of the tape on the rotating heads is controlled by a female guide which in the FR-700 on replay is servo controlled to still further reduce any residual timing errors. Since the rapidly rotating heads heat the tape, a heated guide is provided to raise the tape temperature to 60°C before it reaches the rotating heads. This avoids sudden changes in tape temperature (and consequently dimensions) at this critical point.

A tape head with the "write" portion in the same gap as the "read," and separated from it by only 0.002-in, was shown by Magnetic Products. Reducing the spacing between the read and write gaps allows a greater information packing density to be achieved.

(*Continued on page* 321)

—Vortexion quality equipment

The W.V.B. recorder has an additional amplifier and head with provision for "before" and "after" record monitoring while the recording is in progress, and this also has echo facilities.

The W.V.A. recorder has provision for a plug in stereo head and can be supplied with this and stereo playback pre-amplifiers with equalisation each having an output of 1 volt from a cathode follower. This is type W.V.A./S.

A heavy mumetal shielded microphone transformer is built in for 15-30 ohms balanced and screened line, and requires only 7 micro-volts approximately to fully load. This is equivalent to 20ft. from a ribbon microphone and the cable may be extended to 440 yds. without appreciable loss.

The 0.5 megohm input is fully loaded by 18 millivolts and is suitable for crystal P.U.'s, microphone or radio inputs.

The playback amplifier may be used as a microphone or gramophone amplifier separately or whilst recording is being made.

The meter fitted for reading signal level will also read bias voltage to enable a level response to be obtained under all circumstances. A control is provided for bias adjustment to compensate low mains or ageing valves.

The power output is 4 watts heavily damped by negative feedback and an oval internal speaker is built in for monitoring purposes.

THE VORTEXION W.V.B. or W.V.A/S

are eminently suitable for making a high quality recording almost indistinguishable from the original since these models have facilities for monitoring the recording actually put on the tape with only a fraction of a second delay.

By this means, when for any reason the signal is distorted or not as required, the result of the recording on the tape can be heard almost instantly, and adjustments can be made until the results are as required.

Many types of music today have the treble boosted considerably, and may result in greater power being recorded at high frequencies than at middle frequencies, an overload of the tape at high frequencies gives a mushy quality with lots of hiss and background noise.

Adjustment to the bias level while listening to the result is useful in this connection especially where the brand of tape and the bias setting for it are not exactly known.

Again if clean treble recordings at $3\frac{3}{4}$in. are of prime importance it is now recognised that no other method is quite so effective in achieving this as reducing the bias slightly while listening to the results. The meter reading of the new bias setting for the particular tape used may be noted for future use.

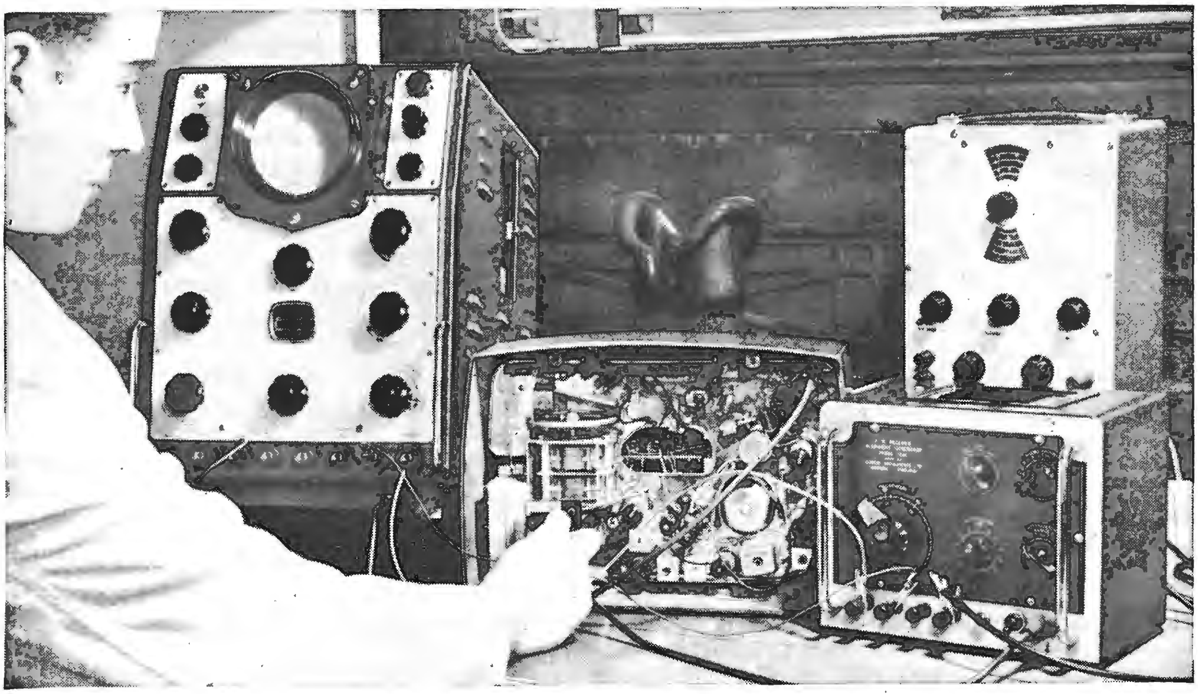
VORTEXION LIMITED, 257-263 The Broadway, Wimbledon, London, S.W.19

Telephones: LIBerty 2814 and 6242-3. Telegrams: "Vortexion, Wimbledon, Lon."

COSSOR 1035 Mk III

PLUS F.M. receiver alignment generator

Offered together for only £110



Two of Cossor's precision instruments are now available at radically reduced prices. They are the successful Oscillograph 1035 Mk. III and the invaluable F.M. Receiver Generator 1324. A decisive move by Cossor makes these two instruments available together for £110 (deferred terms: £32 deposit and 6 monthly payments of £13.10.0) or separately for £99 and £12.12.0 respectively.

MODEL 1035 Mk. III

- DOUBLE BEAM
- BANDWIDTH 7 Mc/s
- SENSITIVITY 30 mV/cm
- DIRECT TIME AND VOLTAGE CALIBRATION
- INCORPORATED TV FRAME SYNC. SELECTOR
- ROBUST AND RELIABLE

MODEL 1324

- COMPACT, EASY TO HANDLE
- DRIVEN FROM OSCILLOGRAPH
- FREQUENCY COVERAGE 7.5 Mc/s TO 27.5 Mc/s AND 87.5 Mc/s TO 107.5 Mc/s CONTINUOUSLY VARIABLE
- R.F. OUTPUT 5 µV TO 50 mV
- 1 Kc/s SINE-WAVE VOLTAGE OUTPUT VARIABLE UP TO 8 VOLTS FOR A.F. TESTING

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TELEVISION

Slow-scan television for the transmission of video information over telephone lines was noted at the "Physical Society" Exhibition in January, and since then Cawkell have advanced a step further. In the original system, the information as received was displayed directly on a small storage tube. Recently, however, barrier-grid storage tubes have been used for the standards conversion process at both transmitting and receiving ends of the chain, with the advantage that conventional high-speed television channels can be operated, with normal television monitors. In cases where the connection is not direct, the signal can be used to modulate a sub-carrier.

Colour television at low cost for the non-technical operator was shown by Nottingham Electronic Valve. The system works on a 405-line standard with 100 fields and $33\frac{1}{3}$ frames per second. The bandwidth of the system is 6 Mc/s and colour is obtained by colour discs in camera and monitor. The picture is viewed through a magnifier to give a similar size to that provided by a 14-in tube.

Completely transistorized camera has been developed by E.M.I. and is called the Type 8. A very low cost instrument, the Type 8 is obtainable to work on 405 lines, 525 lines 60c/s, and 625 lines with positive or negative modulation; interlace is random. The camera can be powered by either mains or 12V batteries.

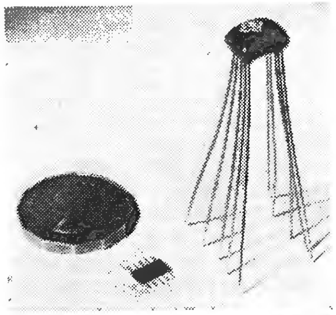
Recording.—Ampex were showing various electronic editing facilities. The reproduced video signal must first be locked to the signal to be "spliced" to avoid "rolling" or "tearing" at the joins. This is done by means of Ampex's Inter-Sync system. Their Electronic Editor is activated by the first video frame synchronizing pulse following the cue signal, the splice being actually made in the following guard band between video tracks. The Electronic Editor provides the required on and off delayed timing pulses to record and erase heads to allow both for the spacing between the activating pulse and the following guard band, and for the spacing between the record and erase heads, as well as for the delay between the activating pulse and the time at which a record head begins a line. In another form—Editec—the splicing times can be programmed automatically.

COMPONENTS

Now that the I.E.A. and R.E.C.M.F. exhibitions are held in alternate years there is always some overlap in both shows, and valve, semiconductor and component manufacturers were this year demonstrating applications of their products at Olympia.

Mullard showed examples from the wide range of their technical advice service including the EC88 grounded-grid triode operating at 960 Mc/s, the AUY10 transistor (4.5 watt) for high-speed core driving and h.f. transmitters, and the low-noise AFZ12 for amplification up to 200 Mc/s. Brimar (Thorn-A.E.I.) demonstrated the performance obtainable with the ECC804 high-slope triode pentode in video amplifiers used to drive the high-sensitivity Sylvania-Thorn SE4D and SE5F cathode ray tubes.

Recently introduced semiconductor devices introduced by Brush Crystal (Clevite) include a field-effect valve analogue OC800, and a series of mesa transistors for r.f. and i.f. amplification.

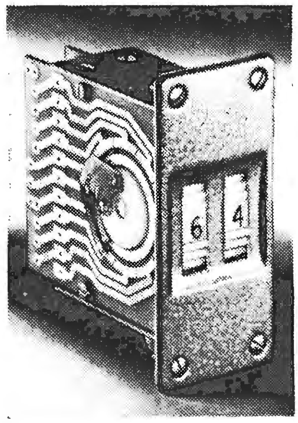


Texas Instruments Series "51" semiconductor networks for use in printed circuits or welded stacks.

Not only the components themselves, but also integrated circuit networks continue the trend towards miniaturization. Texas Instruments have recently started the production of a range (Series "51") of encapsulated silicon solid-circuit computer logic elements with dimensions $\frac{1}{4}$in $\times$ $\frac{1}{8}$in $\times$ $\frac{1}{32}$in. Transistors, diodes, resistors and capacitors are formed by a masking technique and up to 20 elements may be incorporated in each unit. Circuit miniaturization by thin film techniques was also demonstrated by Plessey and by the Royal Radar Establishment who were pioneers in this work.

The volume/performance ratio of capacitors continues to increase as the result of research in dielectrics as exemplified by the T.C.C. "Dritan" and Hunt "Duolectric," the latter in the metallized paper and film type WF197 giving up to 80% reduction in volume for the higher voltage ratings compared with conventional paper and foil types. Gulton Industries, who have developed very thin (flexible) ceramic sheet dielectric materials, were showing micro-miniature (0.085in $\times$ 0.085in $\times$ 0.015in) capacitors suitable for automatic insertion in printed circuit boards. Resistors, too, are approaching vanishing point, as exemplified by the Rsx resistors marketed by G. A. Stanley Palmer, and by the Erie Type N1 ceramic-insulated high-stability type. Another Erie product which took our eye was the "fusible" wirewound resistor. Connection is made by a soldered joint to a spring which can be rejoined if the resistance overheats and opens the circuit.

To conclude, as considerations of space determine that we must, we would draw attention to the following components, which do not fit into any of the broad topics so far discussed: AMP wire and cable connections in such range and variety as to constitute almost an industry in itself; Bulgin multi-legend signal indicator lamps; Burgess M5/T series metal clad micro switches with conduit entry; Painton edgewise "Thumbwheel" switch banks employing printed circuit techniques which may include resistance elements if required; Plessey Type TLA miniature solenoids for 20-24V d.c. supplies; Telcon Metals thin foils which can be produced down to 0.0001in in beryllium copper and in stainless steel, magnetic alloys, tantalum, zirconium, etc., and alphabetically last but by no means least the infinite variety of "pins and things," glass seals and the "components of components," which are the speciality of Wire Products and Machine Design Ltd.



Painton 10 position Thumbwheel switches.

BOOTSTRAP FOLLOWER CHARACTERISTICS

FREQUENCY RESPONSE AND D.C. STABILITY EXAMINED

By T. K. HEMINGWAY,* B.Sc.

IN designing a high input-impedance amplifier, one of the most commonly used circuit arrangements consists of a cathode or emitter follower modified by a feedback arrangement, which contrives to make the grid or base resistor appear to be many times its actual value.

A recent article[1] which described the thermionic valve version, pointed out certain disadvantages of the circuit but did not discuss the question of d.c. stability.

The following notes attempt to show that, first, a particular advantage which the circuit is often believed to have is illusory; secondly that there is a very simple alternative giving much better performance; thirdly that a method often used to overcome the d.c. stability problem (especially in the similar transistor circuit) brings with it further complications.

Performance of the circuit. The circuit is shown in Fig. 1 and consists of a conventional cathode follower with the additional feature that the grid leak R_{g1} is returned to a " tap " on the cathode load instead of a fixed potential. The conventional arrangement is shown for comparison in Fig. 2.

The advantage claimed for the circuit for Fig. 1 is that the input impedance is several times the value of R_{g1}.

This is correct, for the signal appearing across $R_{g1} = v_{in} - v_k = [v_{in} - v_{in}\, R_{L1}/(R_{L1} + 1/g_{m1})]$, so that the signal current is $(v_{in}/R_{g1})\ [1 - R_{L1}/(R_{L1} + 1/g_m)]$ and the input impedance is therefore

$$g_{m1}\, R_{L1}\, R_{g1},\ (1/g_{m1} \ll R_{L1})$$

This is, however, no real advantage because R_{g1} is limited to the maximum permissible value for grid cathode resistance quoted for the valve. This value

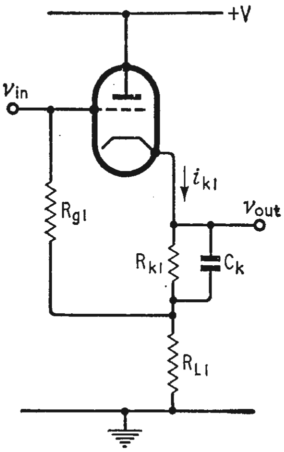


Fig. 1. Bootstrap follower circuit, which is basically a conventional cathode follower with additional feedback.

is arrived at by the consideration that grid current i_g causes a potential drop $R_{g1}i_g$ which gives the valve an unintended and uncertain bias which must be kept much less than the intended bias. The penalty of ignoring this condition is that since the bias is then unknown, so is the cathode current and therefore the d.c. level of the cathode. This fact is generally realized and R_{g1} kept to about one megohm which might typically result in an input impedance of twenty megohms.

The author's contention is that such an impedance is much better obtained by using the conventional

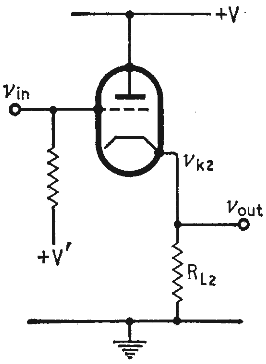


Fig. 2. Conventional cathode follower.

circuit for Fig. 2 with R_{g2} equal to twenty megohms. This does not violate the " R_{gkmax} " condition, as a simple comparison will show, provided one remembers that the important condition is the stability of the d.c. levels in the circuit with time and using different valves.

Firstly, assume no grid current; then in Fig. 1, $v_{k1} = i_{k1}\ (R_{L1} + R_{k1})$ and $v_{gk1} = i_{k1}\ R_{k1}$, i.e. v_{k1} depends on the value of i_{k1} which in turn depends on the valve characteristics and the value of R_{k1}. Without knowledge of the particular valve type to be used v_{k1} cannot be predicted to any accuracy (even $\pm$ 50 volts!). In Fig. 2 on the other hand $v_{k2} = v_{in} - v_{gk2}$; v_{gk} being the bias necessary to pass a value of i_{k2} equal to v_{k2}/R_{L2}. Thus, provided $V' \gg 0$, then for all small valves $v_{k2} \approx V'$, and this will be correct to within $-0+5$ volts.

Now assume a grid current i_g into the grid. In Fig. 1 this causes a decrease in v_{gk1} of $R_{g1}i_g$ which causes a reduction in cathode current of $g_{m1}R_{g1}i_g$ and a fall in cathode voltage of $g_{m1}R_g i_g R_{L1}$. In Fig. 2 the same grid current i_g causes a grid voltage fall of $R_{g2}\ i_g$ and a cathode voltage fall of about the same.

The conclusions are therefore that Fig. 2 is much

* English Electric Aviation Ltd.

superior in d.c. stability with no grid current and the effect of grid current on the two circuits is the same when $R_{g2} = g_{m1}R_{L1}R_{g1}$. Since this is precisely the condition which results in the two input impedances being equal it follows that it is much better to obtain a given input impedance by the method of Fig. 2 rather than Fig. 1.

Fig. 1 has many other disadvantages which have already been proved mathematically in the article already referred to. These are mainly that the output impedance depends on the source impedance and is high except when the source impedance is low—in which case a high input impedance is unlikely to be required; and that the input impedance depends on the load and on the valve characteristics. Neither of the above applies to the conventional circuit of Fig. 2.

Dangerous remedy for the d.c. stability problem. Once it is realized that one may safely use a much higher grid leak in a conventional cathode follower circuit than in an earthed cathode amplifier a method springs to mind whereby one should be able to achieve an ultra-high input impedance with a thermionic valve or a fairly high input impedance with a transistor without sacrificing d.c. stability, this arrangement being particularly attractive to the transistor circuit designer.

The idea is shown in Figs. 3 and 4 which illustrate the valve and transistor circuit respectively. C_2 is made large enough to couple substantially all the cathode or emitter signal back to the tapping point at the junction of the two bias resistors R_1 and R_2. Thus the signal appearing across R_1 is small and so R_1 appears large in the same way as did R_g in Fig. 1, its apparent value being dependent upon the g_m of the valve, or the $r_e+r_b\ (1-\alpha)$ of the transistor, R_L, R_2 and R_1.

Although these circuits suffer from most of the disadvantages of Fig. 1 they have the attraction that since the feedback is coupled via a capacitor, d.c. stability is unaffected and therefore (R_1+R_2) can be for example 20 megohms in Fig. 3 and several kilohms in Fig. 4, the actual maximum value in the transistor circuit being dependent upon the leakage current and the environmental temperature.

Thus in Fig. 3 an input impedance of 200 megohms is easily obtained with $R_1 = R_2 = 10$ megohms and $g_m\ (R_1 // R_2)=20$, where // indicates that R_1 and R_2 are in parallel. In Fig. 4, a value of 100kΩ with

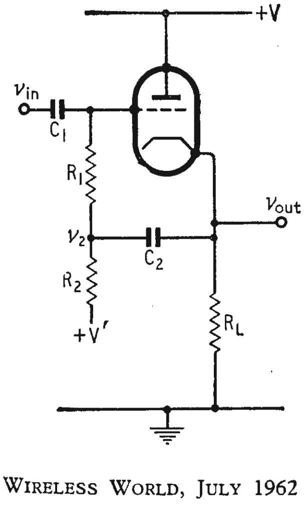


Fig. 3. Blocking capacitor enables high input impedance to be obtained while retaining the d.c. stability of the circuit of Fig. 2.

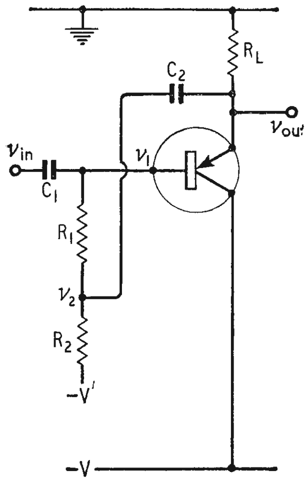


Fig. 4. Transistor equivalent of Fig. 3.

$R_1=R_2=5k\Omega$ and $(R_1// R_2)/r_e+r_b\ (1-\alpha)=20$ can be obtained even with germanium transistors at temperatures up to 50°C, and it is this latter application which is finding increasing use.

Further modifications, incidentally, make it possible to increase the input impedance much more and with silicon transistors values of Z_{in} of 1,000 megohms are being obtained here on production units.

There is however a hidden danger in these very attractive circuits which will only become clear as a result of analysis.

A sine wave analysis is given in the Appendix, for the simple case where the gain of the amplifier is exactly unity.

Examination of the expression for v_{out}/v_{in} reveals that the gain has a peak (exceeding unity) near the frequency where the squared term in the denominator vanishes. This frequency is given by $f = 1/2\pi\sqrt{R_1 R_2 C_1 C_1}$ and the peak gain by:

$$\sqrt{1+\frac{R_1 R_2}{(R_1+R_2)^2}\cdot\frac{C_1}{C_2}}$$

These expressions are approximate only, as f appears in the numerator also.

This effect is most marked when C_2/C_1 is large: this happens in practice when using piezo-electric crystals as accelerometers, microphones or pick ups, when C_1 is represented by the source impedance and is omitted as a separate component. C_1 is then of the order of 500pF and if $C_2 = 0.01\mu F$, $R_1 = R_2 = 10k\Omega$, the peak gain is then $\sqrt{6}$ at a frequency of 8 kc/s. Without this effect the low frequency 3dB point would be about 1.5 kc/s.

It will be seen then that the effect is quite marked and it can occur at an important part of the frequency range.

Cure for the 'peaky' input impedance circuit. A watertight cure which does not at the same time lose the desired performance is difficult to suggest. However, careful design of circuit values bearing the equations given above in mind can usually render the phenomenon harmless.

In particular, in order to keep the peak gain low, C_2 should be no larger than necessary. Since an increase in C_2 lowers the peak frequency it is a temptation to increase its value so that the peak occurs below the lowest signal frequency expected. This is dangerous as a sudden change of input will produce a "ring", at this low peak frequency, of high amplitude (as peak gain is high). Even if subsequent circuits do not pass this frequency, overloading can easily occur and distort signals immediately following.

An alternative method is to insert a parallel resistor-capacitor network between the output terminal of the high impedance circuit and C_2, so that feedback is reduced at low frequencies. Another approach is to insert in the following amplifier stage a CR network giving lower gain at low frequencies.

Use for the 'peaky' high input impedance circuit. Although most industrial applications of piezo-electric devices (e.g. vibration measurement) require the following amplification to be constant over the frequency range, a base boost characteristic is often desirable in audio work with crystal microphones and pick-ups.

This can be designed using the equations of Section 3, C_1 being omitted as a separate component and given a value equal to the source capacitance of the pick-up. A practical limit to the amount of boost possible at very low frequencies is set by the consequent values of R_1 and R_2, the total of which must not exceed that value which gives a tolerable d.c. drift.

Conclusions. The often-used cathode follower circuit of Fig. 1 in either its valve or transistor form has a number of disadvantages, most of which have already been pointed out. This article has proved it to have another fault, namely its poor d.c. stability in comparison with the more conventional arrangement of Fig. 2.

An attempt to overcome this particular fault by the practice, common in transistor circuitry, of inserting a blocking capacitor in the feedback path, is shown to lead to a peak response having gains much greater than unity at an important part of the frequency spectrum.

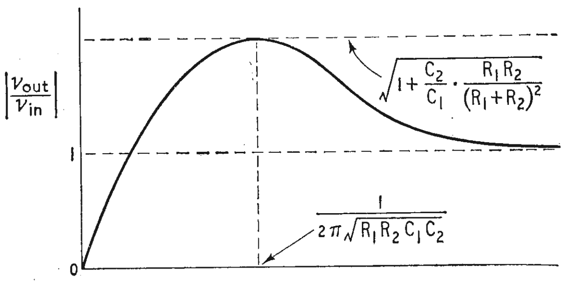
Although primarily intended as a warning of the consequences of this quite usual practice, the article suggests a cure and also a use for the peaky response, whose frequency and amplitude are shown to be predictable.

APPENDIX

Assume that $v_{out} = v_1$

then $$\frac{v_{out}-v_2}{R_1} + \left(v_{out}-v_2\right) j\omega C_2 = \frac{v_2}{R_2}$$

i.e., $$\frac{1/R_1 + j\omega C_2}{1/R_1+1/R_2+j\omega C_2}\, v_{out} = v_2 \quad \ldots\ldots\ldots\ (1)$$



Also $$\left(v_{in} - v_{out}\right) j\omega C_1 = \frac{v_{out}-v_2}{R_1} \quad \ldots\ (2)$$

from (1) and (2), $$\frac{v_{out}}{v_{in}} = \frac{j\omega C_1}{j\omega C_1 + \dfrac{1}{R_1+R_2+j\omega C_2R_1R_2}}$$

$$\therefore \left|\frac{v_{out}}{v_{in}}\right| = \sqrt{\frac{1+\left(\dfrac{\omega C_2R_1R_2}{R_1+R_2}\right)^2}{1+\left[\dfrac{1-\omega^2R_1R_2C_1C_2}{\omega C_1(R_1+R_2)}\right]^2}}$$

This expression has a maximum value near to $\omega^2R_1R_2C_1C_2 = 1$, i.e.,

$$f_o = \frac{1}{2\pi\sqrt{R_1R_2C_1C_2}}$$

and $$\left|\frac{v_{out}}{v_{in}}\right|_{max} = \sqrt{1 + \frac{C_2}{C_1}\cdot\frac{R_1R_2}{(R_1+R_2)^2}}$$

REFERENCE

1. G. W. Short, "The Bootstrap Follower", *Wireless World*, January and February 1961.

Books Received

An Introduction to Servomechanisms, by F. L. Westwater and W. A. Waddell. In an effort to bring the subject within the grasp of Higher National Certificate students, the mathematics are kept to the essential minimum, and do not go beyond linear differential equations. The second part is even less mathematical and deals with the theory by means of frequency-response methods. Transfer function analysis is discussed, and attention is paid to the problem of stability. Pp. 191; Figs. 146. English Universities Press Ltd., 102 Newgate Street, London, E.C.1. Price 15s.

British Standard 2111: Part 1: 1960. Fixed Wire-wound Resistors for Use in Telecommunications and Allied Electronic Equipment. Part I. General Requirements and Test. Pp. 17. British Standards Institution, Sales Branch, 2, Park Street, London, W.1. Price 10s.

Fernsehempfang im UHF-Bereich, by F. Mohring. This 134-page book will be found a mine of information on the design of u.h.f. television tuners by any engineer who has a working knowledge of the German language. A chapter on propagation and the design of aerials and a note concerning the servicing of u.h.f. equipment add worth-while background information. Published by Ing. F. Mohring's company, Loewe-Opta AG, Kronach, Industriestr 1, Germany, copies are available free of charge.

High Quality Sound Reproduction, by James Moir. This is the second edition of a widely accepted work. The whole field of sound engineering is covered at a level which is fitted to both engineer and amateur, the more esoteric mathematics being confined to appendices. Since the first edition was published, emphasis has shifted to stereophony, and this is reflected in this latest edition. Pp. 660. Chapman & Hall, 37, Essex Street, London, W.C.2. Price 75s.

Acoustical Techniques and Transducers, by M. L. Gayford. In the reproduction of sound, the electro-mechanical processes at either end of the chain are probably less well-understood by the majority of engineers than the purely electronic functions. This book remedies the situation and describes the principles underlying most of the transducers concerned with the recording, broadcasting and reproduction of sound. Stereophonic transducers are dealt with, and room acoustics are discussed. Pp. 372. Macdonald & Evans, Ltd., 8, John Street, London, W.C.1. Price 50s.

Transistor Inverters

NEGATIVE RESISTANCE APPROACH TO THE COMMON COLLECTOR CIRCUIT

By THOMAS RODDAM

IF you examine the literature on transistor inverters you will find that the authors describe how you can operate the transistors in a push-pull inverter in the common emitter, common base or common collector mode. The common collector mode has the advantage, they will tell you, that you can earth the two collectors. Then, often in the tiny print reserved for the escape clauses of hire-purchase contracts and motor-car guaranties, they reveal that the circuits are not really common collector circuits at all. I have tried, therefore, in this extension of two earlier articles,[1] to see what a real common collector inverter system would be like. It turns out to be interesting and probably useless: the uselessness made me dismiss it rather shortly but I suspect that because of its rather special features it may, in fact, have special uses.

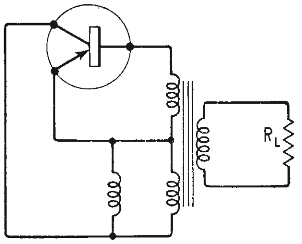


Fig. 1. With the link earthed, this basic common collector circuit reverts to the common emitter configuration.

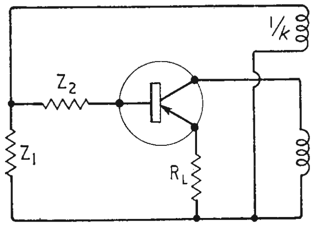


Fig. 2. Common collector circuit with current feedback taken from the collector.

The essence of the common collector circuit, regarded as an amplifier, is that the input is applied between collector and base and the output is taken between emitter and collector. If we convert the circuit to an oscillator by feeding back part of the output to serve as the input we have a choice of feeding back either the load voltage or the load current. It is a trivial exercise to show that if we feed back the voltage across the load there is no functional difference between this circuit and the circuit described in the previous sections. We connect a wire from a different point in the system to earth, but that is all. This can be seen by examining Fig. 1 in which a link is shown connecting equipotential points on the emitter and base windings. Earth this link and we have the common emitter circuit.

There is nothing particularly interesting about this circuit with voltage feedback. It has some constructional advantages, which are well known: it has some disadvantages when used with timing circuits in the base because the voltage swing across the base-collector terminal pair is relatively high. The designer can balance the pros and cons for himself. Our business must be with the circuit using current feedback.

Here we are breaking fresh ground. Systems have been described in which both voltage and current feedback were used, but it has been clear that the current feedback was regarded as an added modifier, that the circuit operated basically on the voltage feedback with its behaviour changed quantitatively but not qualitatively by the current feedback. We must now examine the system in which all the feedback is current feedback.

In any approximations we make when discussing transistor circuits the most common assumption is the thoroughly inconsistent one that as $\alpha \rightarrow 1$ so $\alpha/(1-\alpha) \rightarrow k$, a finite number. We are making this assumption when we say that it does not matter whether we feed back emitter current or collector current. For a simple analysis it is, I think, best to take the feedback from the collector side of the transistor because then we do not have to consider the effect of the impedance of the feedback system in producing voltage feedback. The circuit with which we have to deal then takes the form shown in Fig. 2. This looks very like the circuit previously discussed and the resemblance can, if the draughtsman chooses, be very close. This would be deceptive, however, for the appearance of the load in the emitter lead of the transistor has a dominating effect on the behaviour of the circuit.

To analyse the circuit we draw it in the form shown in Fig. 3, in which we have broken the load connection so that we can look in. We can immediately write down the equation:

$$v_1 - R_L i_e - Z_2 i_e(1-\alpha) - Z_1(1-\alpha+k\alpha)i_e = 0 \quad \ldots \quad (1)$$

from which we derive

$$\frac{v_1}{i_e} = R_L + (1-\alpha)Z_2 + (1-\alpha+k\alpha)Z_1.$$

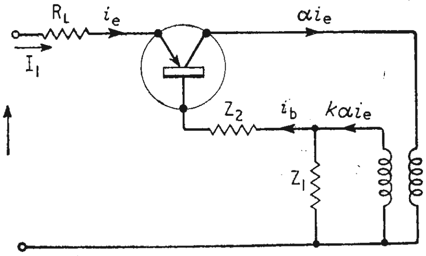


Fig. 3. Fig. 2 redrawn for analysis.

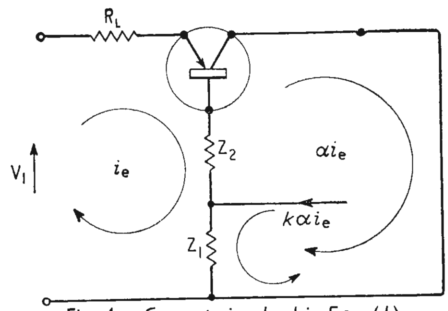


Fig. 4. Currents involved in Eqn. (1).

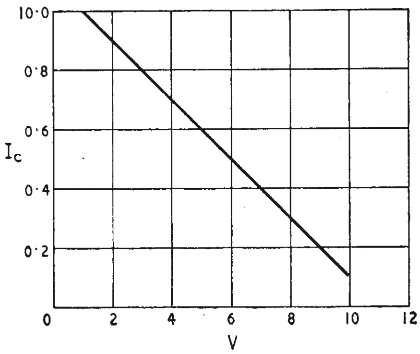


Fig. 5. Negative resistance part of the characteristic. Without its extremities this is similar to the common emitter curve.

The transistor and its feedback network thus appear as a resistance R in series with R_L, and we have

$$R = (1 - \alpha) Z_2 + (1 - \alpha + k\alpha) Z_1.$$

It is convenient to rearrange this slightly, giving

$$R = (1 - \alpha)(Z_1 + Z_2) + k\alpha Z_1.$$

As all experimentalists know, the sign of k is governed by chance and as one of Damon Runyon's characters pointed out, Life is five to four against. (These odds are not official.) We can therefore make k negative and we find that if we do so R will become negative when

$$|k| > \frac{Z_1 + Z_2}{Z_1} \cdot \frac{1 - \alpha}{\alpha}.$$

It may be more convenient to write this as

$$|k|\ \beta > (Z_1 + Z_2)/Z_1.$$

Since we are trying to keep all our inverters in one basket, the negative resistance basket, this condition seems to be just what we want. We have a combination of a load resistance and a negative resistance system just, we think hopefully, as we had before. Let us make some simplification to get the feel of this. We might reasonably examine what happens if $\alpha = 1$, when $R = kZ_1$.

For the sake of having some number we can take $Z_1 = 100\Omega$ and $k = 0.1$ so that $R = -10\Omega$. A typical transistor might then give us the characteristic shown in Fig. 5, a straight line joining the point (1V, 1A) to the point (10V, 0.1A). This is, so far, very much the same as the negative resistance part of the characteristic shown as Fig. 5 in Part 1 of Reference 1. When we get to the ends of this line, however, the transistor current gain begins to fade away and we no longer have any justification for taking $(1 - \alpha) = 0$. We can take another approximation to serve our purposes:

$$-R = |k|\ Z_1 - (Z_1 + Z_2)/\beta$$

which shows that as β becomes smaller the numerical value of the negative resistance becomes less until when, for our particular example, $(Z_1 + Z_2)/\beta = 10$ the value of R is zero.

The overall result is to produce the characteristics shown in Fig. 6. The shape of the top branch needs a fuller analysis than I am prepared to give it at the moment: the really important thing is that the characteristic is of the S form and not the N form and the system is therefore open-circuit stable and short-circuit unstable. It will only take up one of the extreme positions when we have $R_L < |R|$, and these extreme positions are either the cut off position or a position fixed by the top branch of the characteristic. Obviously this can at first be just a bottomed state in which the diode line will set the condition. The base current, however, cannot exceed $(V_{supply}/k)/Z_2$ because this is the value obtained neglecting all other terms and allowing the whole of the supply voltage to appear across the feedback transformer. There must, therefore, be a limit set to the emitter current by this base current and it is this assumption which is used to produce the rather flat section of current limitation.

With a carefully chosen load line we have no problems but it will be seen that as we make R_L smaller we shall start to intersect the characteristic in a region of high dissipation. This is not really surprising if we look at matters in a slightly different way. The inverters we have considered previously give us out a voltage limited system, feeding back the output voltage until the transistor can give no more. This type of circuit will give out a standard current. We are feeding it from a voltage source, however, so that we take in, with small load resistances, a power $V_{supply}\ I_{max}$ and yet only deliver $I_{max}^2\ R_L$ to the load. The transistor must dissipate the rest. It is this effect which seems to limit the utility of this connection, for although it is open-circuit stable and can thus be brought by suitable biasing to a safe rest point the short-circuit behaviour will usually demand a good deal of extra cooling to be provided above the amount needed for normal operation.

So far in this study of the circuit we have not considered how it is to be turned into an oscillator. We know that the basic situation is that the load resistance intersects the system characteristics at three points and that we can arrange for the stable point to be when current is flowing. We may expect that just as in the more usual inverter we shall be able to unlatch the system by moving either the load line or the negative resistance characteristic. The early inverter, you will remember, used the

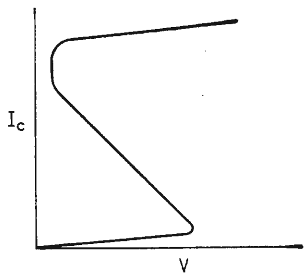


Fig. 6. Complete open-circuit stable characteristic.

inductance of the output transformer to swing the load line round until the total voltage/current ratio fell below the value of the negative resistance: that was with a short-circuit stable system. Here we have an open-circuit stable system and we want the volts/current ratio to increase with time. What we need as our determining element is therefore a capacitance in series with the load which will give us the rotating load line shown in Fig. 7.

When this load line is applied to the characteristic of Fig. 6 we shall get a square current waveform and a voltage jump followed by a linear run up to unlatch: this is just the dual of the familiar square voltage and trapezoidal current waveform of the classical inverter. If we could get a saturable capacitance of suitable size which, after a prescribed number of amp-seconds would become a virtual open-circuit, we should be able to produce the dual of the inverter with a saturable collector transformer.

In the development of more conventional inverters we have seen that it is advantageous to leave the load line where it is and to move the negative resistance characteristics. I am not so sure that this is true of this type of inverter, in which the load line is moving towards a position of reduced transistor dissipation. We can see, however, that there are two easy ways of moving the negative resistance characteristics towards a lower value of $|R|$. We can either reduce Z_1 or increase Z_2. So far these have been assumed to be pure resistances, but we can obviously include reactances in these terms. To make Z_1 fall as time passes we must put an inductance in parallel with the resistance, a matter very easily done since it is simply a question of taking into account the magnetizing current of the feedback transformer. We have the choice between the steady movement of a linear inductance and the sharp switching action of a square-loop core. We can make Z_2 increase with time by incorporating a series capacitance. It will be noted that these elements are the duals of those used in the common emitter circuit.

So far the discussion has been concerned with the skeleton circuit which must be covered with flesh and decently clad before it can be regarded as a practical system. Nowadays I suppose we should start with the push-pull oscillator with the output transformer connected from emitter to emitter. In our example, with $Z_1 = 100\,\Omega$ and $k = -0.1$ the impedance reflected back to the primary of the feedback transformer is $1\,\Omega$ and might be regarded as a tolerable addition in the emitter line. We can then connect both collectors to the cooling fin and get a circuit configuration something like that in Fig. 8. The other versions of the push-pull circuit are fairly easy to write down.

The single-ended inverter based on this principle will need to have the dog-leg load line associated in our previous experience with a diode and a capacitance. It will be clear that in place of the charged capacitance we shall here need to use an inductance carrying current and that the small inductance needed to get the high initial impedance for a conventional single-ended inverter to strike becomes in this system a small shunt capacitance. I do not propose to go into details about this until I have found time to do a full design study and to arrange for a practical investigation of the effect of stray elements. I see little hope of being free to do this in the near future.

Elaborations of the circuit would seem to be possible. The effect of some negative feedback of the load voltage in encouraging a swing to a point where dissipation is not so serious is one avenue. Positive voltage feedback will, I think, give a more square current waveform but introduces dangers of mode changing. The use of this arrangement with a filter in the load circuit is another aspect which at this point can be mentioned merely as a subject for further study.

The real question is whether the circuit has any practical value. My own first reaction was that the

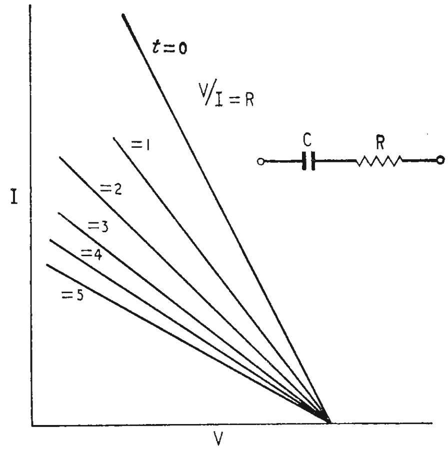


Fig. 7. Series CR circuit and its impedance graph, with t varying.

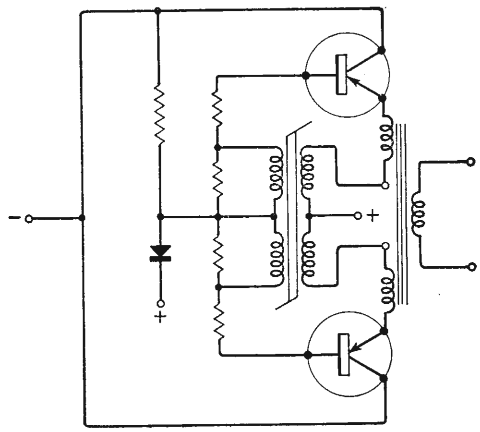


Fig. 8. Typical form of push-pull common collector inverter. The diode and its series resistor are commonly used to encourage the oscillator to start.

danger of high transistor dissipation made it too risky to use but I am not altogether convinced of this. If we have, as is so rarely the case, a current supply we can bias the system to a well-bottomed point and rotate our load line about this, rather than about the point near cut-off. The transistors of a push-pull arrangement will then appear in the circuit in series: perhaps we should start by a study of a bridge or half-bridge system.

If we can get round the practical difficulties we shall find in this circuit a very useful tool. It would appear to offer us a system which converts a constant voltage supply to a constant current supply. There is a whole host of applications here, from the operation of various forms of discharge tube to the supply of current to electromagnets when the current drift due to coil heating can cause difficulty. We have a new device, the constant current diode,[2] which can be introduced as Z_2 to give us the stability which the use of Zener diodes in modifications of Jensen's circuit is claimed to produce.

All this tends to be rather speculative but until we can try matching the circuit to an application this must, I think, be inevitable. Usually we have an application looking for a suitable circuit and we can put in numbers to make our ideas concrete. Here all I can add is: passed to you for action!

REFERENCES

1. "Transistor Inverters—A Single View," *Wireless World*, January and February, 1962.
2. "A Semiconductor Current Limiter," R. M. Warner *et al.* *Proc.I.R.E.*, Vol. 47, No. 1, January, 1959

AIR TRAFFIC CONTROL PROPOSALS

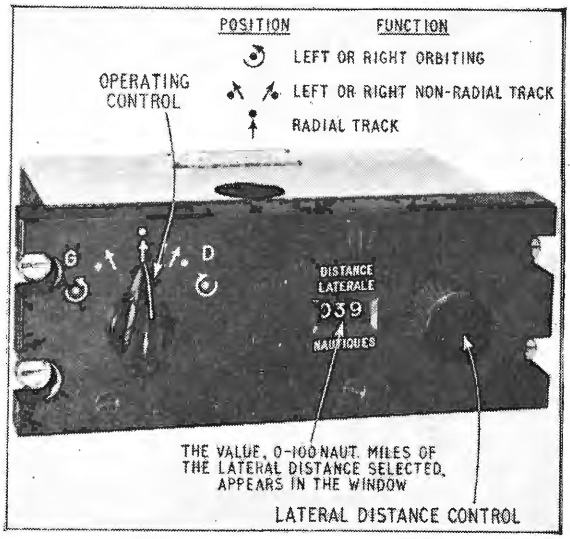
GROUP OF MANUFACTURERS PUT SCHEME TO EUROCONTROL

STANDARD Telephones and Cables and their European associates L.M.T. (France) and S.E.L. (Germany) have suggested that Eurocontrol's requirement for a navigation system (to be in operation by 1965) for the airways over Europe can be met by modifications to the existing equipment and installations to be made in the near future. The proposals cover, in the main, VOR/DME, which was declared a standard navigation aid by ICAO in April 1960.

S.T.C. say that unmodified DME will give better accuracy, in 95 per cent of the cases, than Eurocontrol's requirement of ± 1.5 nautical miles in 200, but that VOR will require improvement to meet the 1° bearing demand.

It is proposed that VORAC—a version of VOR using ten beacon lobes superimposed on the basic cardioid pattern—would meet this in 95 per cent of the cases; but bad sites can cause considerable errors in one or more directions. S.E.L. have developed a wide-aperture Doppler direction—indicating addition to the extra airborne equipment that is required for VORAC.

Military TACAN (which uses a nine-lobe superimposed pattern) can also provide acceptable accuracy and the total of 290 TACAN beacons that will be installed by 1965 would give sufficient cover. So an airline operator has the choice of either adding to his existing VOR equipment or installing TACAN alongside his existing DME (VOR and TACAN combined become VORTAC).



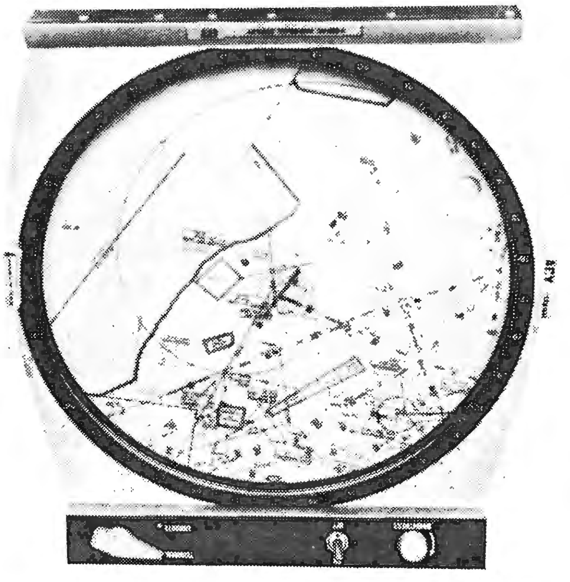
VORDAC track computer which weighs only two pounds.

The group have called the improved VOR "VORDAC" (V.h.f. Omnidirectional Range/Distance measuring equipment for Air Coverage).

The 100,000 VOR receivers at present in use would give, without modification or addition, the accuracy obtained now; but with a small extra unit the full potential of VORDAC would be realized. Another point about VORDAC is that the "cone of silence" blind-spot over the beacon is reduced in size.

A simple track computer in the aircraft would enable a map display (already developed) to be provided; this would show the aircraft's position on the map by the intersection of radial and spiral lines whose positions are controlled by outputs from VORDAC. For Eurocontrol, this map unit would cover a 90-mile diameter circle centred on a beacon and can carry up to 20 maps filed according to the flight plan. Also data transmission could be used to relay to the ground the aircraft's position.

Beacon cover envisaged in the proposal would demand modification of about 35 existing DME beacons and installation of new ones but as no new land (other than that provided for already) will be necessary the capital cost would be that of the equipment alone, estimated at about £1½m.



VORDAC pictorial display unit modified from VORTAC. This can hold 20 maps.

FUNDAMENTALS OF FEEDBACK DESIGN

7.—TRANSFORMERS

By G. EDWIN

ANY discussion of systems using negative feedback will have a slightly unreal air as long as an attempt is made to keep it simple, for simplicity can only be achieved by excluding any adequate consideration of transformers. The ideal transformer is itself not a problem, since it only alters the voltage level and thus what we have called the gain: it is pedantic and misleading to insist that in the sort of problem we are considering the decibel is only a power ratio. The problem begins with the ideal non-ideal transformer, an interesting device which can be made, at any rate for use in some parts of the circuit. New problems arise with the non-ideal non-ideal transformer, a system which is sometimes produced by a more sophisticated design.

In our context here a transformer is a wide-band system. We may at some later point come back and discuss narrow-band circuits, but for the moment the vital task is to discover how to deal with the output transformer of a normal low-frequency amplifier. The author has used exactly the same method in the megacycle range but it is exceptional to require amplifiers of very wide relative band here. The reason why this requirement of a wide band is made is quite simple: we wish to consider the upper and lower band limits quite separately, leaving the task of reconciling the two ends to the designer of the physical transformer.

The low-frequency response of the transformer is always considered first, because it is this which fixes the size of the transformer and establishes the framework within which the high-frequency design will take place. At low frequencies, of course, the transformer is equivalent simply to a combination of an ideal transformer of the same ratio $n:1$ which brings the secondary load resistance R_s over to the primary as a resistance n^2R_s, and the primary inductance which appears in parallel with this resistance. This combination, with its valve, has a standard $[1 + j\Omega]$ amplitude and phase response which has its characteristic frequency at $\omega_0 L/n^2R_s = 1$ if we are using a pentode, or at $\omega_0 L/R_{11} = 1$, with $R_{11} = 1/((n^2R_s)^{-1} + \rho^{-1})$ if we are using a triode of impedance ρ.

In designing for stability we merely include this as one of the response-determining factors which we must juggle about. Because it is very much easier to increase the size of the coupling capacitances elsewhere in the amplifier than it is to increase the inductance of the transformer, the usual thing is to fix the inductance from the required low-frequency response and shift the other characteristic frequencies to suit. Several factors must still be watched.

Even with a push-pull output stage there will be some net d.c. in the transformer. This will make it necessary to consider the use of air gaps in the core and we shall have the whole sequence of problems of resistance, flux limitation and the rest. Obviously the lower the inductance the fewer the turns: the fewer the turns the fewer the ampere-turns and the smaller the gap, and so on. We must, however, watch the tolerance on this inductance. On the basic design what will be the range of inductance which we can expect and will the amplifier be stable at both limits? With a signal imposed, and perhaps unbalanced d.c. in the class-B case, how will the inductance vary over the cycle? Will the amplifier swing into an unstable zone? Here we see the distinction between the ideal transformer, with $L \rightarrow \infty$, the ideal non-ideal transformer, with L a defined constant inductance having losses which are either zero or easily expressed as a single network resistance, and the non-ideal non-ideal transformer with its uncertain inductance varying over the signal cycle. This is one part of the problem, a problem which is best solved by designing for very good margins in the region in which the transformer response is the controlling factor.

The other part of the problem is more subtle and is often overlooked. In a typical design the response with feedback will remain flat down to perhaps one-quarter of the frequency at which the basic amplifier begins to roll-off. In the most economical design, therefore, although the response is nominally flat down to, say, 10 c/s, the output transformer may be 3dB down at 40c/s. This 3dB drop is due to the fact that the load presented to the output valve has fallen below its optimum value: to put it another way the output valve is now required to supply a good deal of magnetizing current as well as the load current. The result is that as the valve is limited in its current swing the amount of power which can be delivered to the load is limited at a level where the overall frequency response is still flat. Some designers are prepared to pay the necessary price and use high inductances, getting stability by using one of the CR circuits to cut off at a substantially higher frequency. This solution has the effect of transferring the problem to the amplifying stage immediately before this band restricting stage, for the voltage swing here will be increased in proportion to the amount by which the gain would have dropped without feedback. Provided that the restriction is at the input end of an amplifier it is usually not difficult to make this a safe solution. The choice of the transformer inductance is a matter which requires very careful consideration and it is necessary to relate it to the complete performance of the amplifier. Stability is almost the least of the problems.

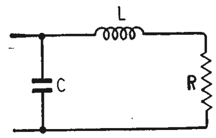


Fig. 34. Equivalent network (at high frequencies) for a transformer.

When we turn to the high-frequency end of the response we are faced by a new problem. It will be assumed that we are considering output transformers and that we are taking our feedback from the output. From the primary, or from the secondary? The behaviour of a transformer at the upper end of its frequency band can be examined in terms of the equivalent network of Fig. 34. If we take feedback from the primary of the transformer we can say that we are controlling the response at the input terminal of this network, so that in series with the load we shall have the leakage inductance L. This is not exactly correct, but it will do for the moment. The effect is to give a $[1 + j\Omega]$ response outside the feedback loop to the overall response, due to the leakage inductance. Inside the feedback loop we still have a $[1 + j\Omega]$ response due to the capacitance, of course. As long as the effect of the leakage

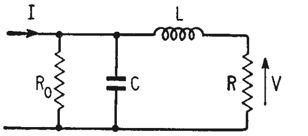


Fig. 35. Equivalent network (at high frequencies) for an output transformer fed from a valve of impedance R_0.

inductance is permissible in the overall performance this is undoubtedly the easiest way of arranging matters. The transformer is, in a sense, only half inside the feedback loop and is only half as troublesome.

When we take into account the impedance of the valve we have for the equivalent circuit the arrangement shown in Fig. 35. It is not too difficult to proceed to derive the expression.

$$\frac{I}{V} = \frac{R + R_0}{RR_0}\left[1 + j\omega\left(\frac{CR_0R}{R_0+R} + \frac{L}{R_0+R}\right) - \omega^2\frac{LCR_0}{R_0 + R}\right]$$

In the pentode case the frequency dependent term, the part in the square brackets, reduces to

$$[1 + j\omega CR - \omega^2 LC]$$

This is fairly easy to handle and will be treated first. Let us write $\omega_0{}^2LC = 1$, so that we can reduce the problem to a normalized form, with $\Omega = \omega/\omega_0$,

$$[1 + j\Omega R\sqrt{C/L} - \Omega^2]$$

We now want to find $|I/V|$ and express it in decibels, and we also want the phase angle (θ).

$$20 \log|I/V|$$
$$= 10 \log [1 + \Omega^2(CR^2/L - 2) + \Omega^4]$$
$$\theta = \text{arc tan } [\Omega R \sqrt{C/L}/(1 - \Omega^2)]$$

In the region where $\Omega < 1$ the amplitude response is roughly constant. We can take a special case of $CR^2/L = 2$, and we have then the form $[1 + \Omega^4]$, which will be 3dB down at $\Omega = 1$ and will fall 12dB/octave at large values of Ω. If we want a straight-line approximation we can do just as we have done before, take the response as flat up to $\Omega = 1$ and then twice the slope of the single reactance characteristic.

Suppose, however, that $(CR^2/L—2)$ is not zero, but is some quantity k. The response function is now of the form $[1 + k\Omega^2 + \Omega^4]$. It is by no means difficult to plot this function or rather 10 log $[1 + k\Omega^2 + \Omega^4]$, as a set of graphs for different values of k. The task is made rather easier by performing some simple transformations first. Let us write $W = 1/\Omega$, so that $(1 + k\Omega^2 + \Omega^4) = (1 + k/W^2 + 1/W^4) = (1 + kW^2 + W^4)/W^4$. The response function is then $10 \log (1 + kW^2 + W^4) - 10 \log W^4$.

We now begin the construction of Fig. 36 by plotting $10 \log (1 + k\Omega^2 + \Omega^4)$ in the region $\Omega \leqslant 1$ This is done for the four values $k = 1, 0, -1$ and -1.5 and shows how the shape depends on the factor k. At the point $\Omega = W = 1$, we can draw the 12dB/octave asymptote, which is the form $10 \log W^4$. In the region $\Omega > 1$ the response is the alegebraic sum of the $(1 + kx^2 + x^4)$ form already plotted (which gives the mirror image of the curves we have just drawn in the left-hand side of the graph and which we can dot in without more calculation) and the 12dB/octave asymptote. Below the set of curves the complete process is shown for $k = -1.5$.

The importance of this transformation trick is that it reduces the amount of labour involved, so that we can contemplate calculating the response without too much trouble. For the case of $k = -1$, for example, we draw up the table

$\Omega =$	1	0.7	0.5
$\Omega^2 =$	1	0.5	0.25
$\Omega^4 =$	1	0.25	0.0625
$1 + \Omega^4 =$	2	1.25	1.0625
$-\Omega^2 =$	-1	-0.5	-0.25
$1 - \Omega^2 + \Omega^4 =$	1	0.75	0.8125
$10 \log(1 - \Omega^2 - \Omega^4) =$	0	1.25	0.9

Slide-rule accuracy is quite enough, because these curves are to be added to others from other parts of the amplifier, where we shall probably use 3dB/cm as our scale.

When we turn to the calculation of the angle

$$\theta = \text{arc tan}\left[R\sqrt{\frac{C}{L}} \times \frac{\Omega}{1 - \Omega^2}\right]$$
$$= \text{arc tan}\left[R\sqrt{\frac{C}{L}} \times \frac{W}{W^2 - 1}\right]$$

we see that at $\Omega = 1$ we have 90° phase shift and symmetry about the point $\Omega = W = 1$, $\theta = 90°$, so that again we need only calculate the diagram for the region $\Omega < 1$. We have $CR^2/L - 2 = k$, so that $R\sqrt{C/L} = (2 + k) = k'$. Once we have plotted the

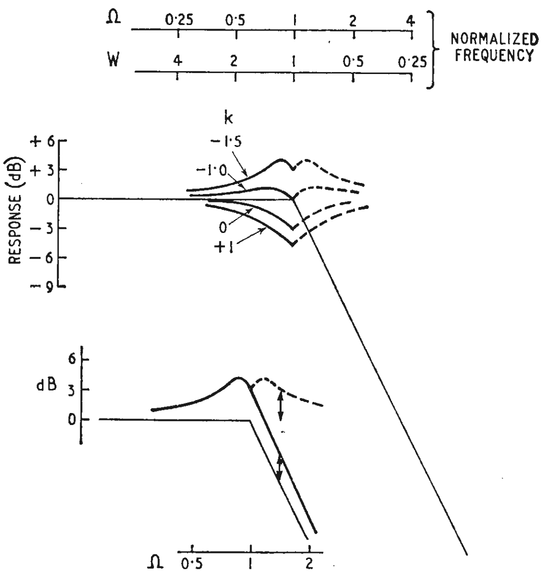


Fig. 36. Plot in dB of $10\log(1+k\Omega^2+\Omega^4)$ for $\Omega \leqslant 1$ and derivation of plot of $10\log(1+kW^2+W^4) - 10\log W^4$ where $W = 1/\Omega$ — the normalized amplitude response of an output transformer fed from a pentode.

graph for $k' = 1$ the rest is very easy, because we can regard the other curves as compressions of this. Making a table:

$\Omega =$	1	0.7	0.5	0.25
$\Omega/(1 - \Omega^2) =$	∞	1.375	0.677	0.267
arc tan $\Omega/(1 - \Omega^2) =$	90°	54°	34°	15°

Having plotted this in Fig. 37, let us now add the curve for $k' = 2$.

$\Omega =$	1	0.7	0.5	0.25
$2\Omega/(1 - \Omega^2) =$	∞	2.75	1.33	0.53
$\theta =$	90°	70°	53°	28°

These show the way in which as k' gets smaller the phase characteristic becomes steeper and we can find ourselves with an amplitude response which is actually above the middle frequency level combined with a phase shift well above 90°. Fully plotted curves of this kind appear in many standard texts,

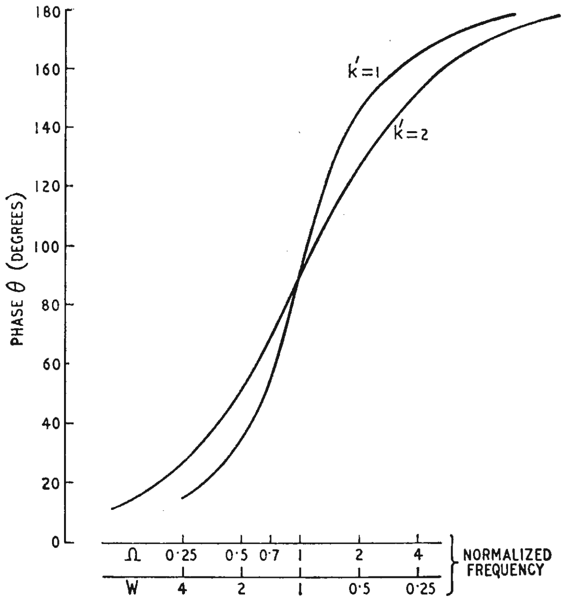


Fig. 37. Plot of arc tan $[k'\Omega/(1 - \Omega^2)]$ — the normalized phase response of an output transformer fed from a pentode.

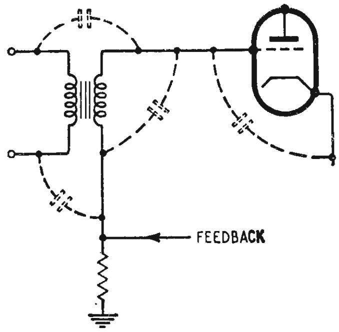
but it is usually just as quick to calculate them for the few points needed as to look them up and correct the scales.

A step back, and we see that by some rather more complicated substitution we can use these curves for the more general form, with a finite source impedance.

Once the physical size and the number of turns on the transformer are fixed, as they are by the low-frequency requirements, there is not too much which can be done about the leakage inductance and stray capacitance. This is a rather sweeping statement, but although the use of better core materials is one way of improving matters it is really just part of the process of carrying through a painful reappraisal of the behaviour at both ends, balancing swings against roundabouts.

Transformer designers without much experience of feedback amplifiers may be tempted to use one of the methods of subdividing the winding which are well-known for reducing leakage inductance and self capacitance. It is difficult to give a proper appraisal of these methods, which often lead to very satisfactory

Fig. 38. Input transformer circuit showing various stray capacities.



results but which involve a certain amount of risk. Not infrequently it is found that the subdivision of the windings, by introducing a complex system of internal leakages and capacitances, leads to a transformer response of correspondingly complex form. This can be disastrous, because the overall network can give quite large phase shifts with little major change in amplitude response in the region where the local resonances occur.

For most applications the design is carried to this point and it is established that the high-frequency cut-off will be out of the danger area. As long as this can be done we may add capacitance across the primary of the transformer to give a more gentle roll-off, or add a CR step circuit. At higher power levels this may not be too easy, simply because in steady-state tests with sinusoidal signals of high frequencies there is a good deal of energy dissipated in the resistor. Capacitor voltage ratings are also troublesome and it is almost impossible to get a capacitor manufacturer to recommend a type of say 0.001 μF capacitor for 500V r.m.s. of music.

Complicated as this procedure may seem, we are by no means finished. Even when the feedback is taken from the primary of the transformer we may find that we must reappraise again. Many amplifiers are required to work into a variable load and indeed it is often these in which the feedback must be taken from the secondary side. Altering the load resistance will alter the response, so that we shall need to determine the position of the upper and lower characteristics for a range of loads. Normally we deal only with the fully-loaded case and with the case when no load is applied at all, but we watch to see that we have not merely skipped round a danger point. Worst of all is an amplifier feeding a cable network to which a number of loads are attached. This can give us an almost pure capacitive loading to the amplifier when the loads are individually switched off. Systems of this kind require special study and are well beyond the scope of this survey. A typical treatment would be to use internal feedback loops to

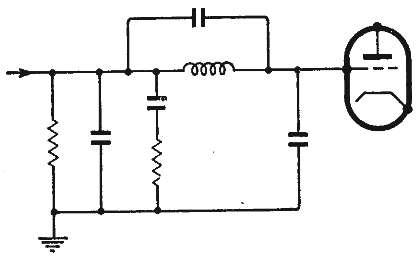


Fig. 39. Equivalent network for circuit of Fig. 38.

shape the response very rigidly so that the wildest changes associated with the transformer would be tolerable in the overall feedback loop.

Quite a different transformer problem is that associated with the input transformer. Neglecting transistor circuits, the input transformer appears inside the feedback loop only when feedback is to be brought back to the input grid, in the circuit shown in Fig. 38. The leakage inductance and various capacitances now appear in the circuit, giving a network of the kind shown in Fig. 39 in which even the source impedance plays a part. There is no simple and direct correlation between the capacitances in Figs. 38 and 39, for Fig. 39 is simplified to make it look like a filter structure, as well as to show the appearance of the source impedance in the network. This circuit may become unstable when the input is open-circuited. This problem can only be regarded as suitable for analysis in the most sophisticated amplifier designs. It is necessary to know that it exists so that it can be avoided whenever possible and treated experimentally where it cannot be escaped.

It will be obvious that this discussion of transformers has been as inadequate as its length would suggest. The transformer is a complex circuit element and all that can be done here is to indicate which of its characteristics are particularly related to our main problem. Frequently the amplifier design will be tailored to the completed transformer and where this is necessary the amplitude characteristics are easily measured. It is not too difficult to determine the 90° point in the top-end characteristic. From this information a matching process with the curves will give a reasonable approximation to the phase response so that the remainder of the circuit can be designed.

Commercial Literature

Variable electromagnetic pump for gases and light oil is marketed by Edwards. Called the "Reciprotor", a magnetic vibrator operates the piston to give flows up to 1.8ft³/min, 22in(Hg) vacuum and 10.7lb/in² pressure. Leaflet from Edwards High Vacuum Ltd., Manor Royal, Crawley, Sussex.

Industrial valves produced by Associated Electrical Industries are listed in a new catalogue from A.E.I.'s Radio and Electronic Components Division, Industrial Valves & Cathode Ray Tubes Department, 155 Charing Cross Road, London, W.C.2. Also included are equivalents and CV lists.

Tuning capacitors and their drives, trimmers and ceramic stand-off insulators of diverse sizes and ratings are listed in Wingrove & Rogers "Polar" general catalogue. Wingrove & Rogers Ltd., Domville Road, Liverpool 13, Broadway Court, London, S.W.1.

Ultrasonic testing apparatus is described in a catalogue from Ultrasonoscope, which also gives a treatise on testing methods. Ultrasonoscope Co. (London) Ltd., Sudbourne Road, Brixton Hill, London, S.W.2.

"Electrical Contacts", a booklet from Johnson Matthey, reviews the art of contact making and lists stock alloys and sizes. Copies from Johnson Matthey & Co. Limited, 73-83 Hatton Garden, London, E.C.1.

Storage tubes of the flood-gun direct-viewing type are described in a booklet from English Electric together with practical circuit information for their operation. English Electric Valve Co. Ltd., Chelmsford, England.

Connectors for ribbon wiring are detailed in a leaflet from Belling & Lee Ltd., Gt. Cambridge Road, Enfield, Middlesex.

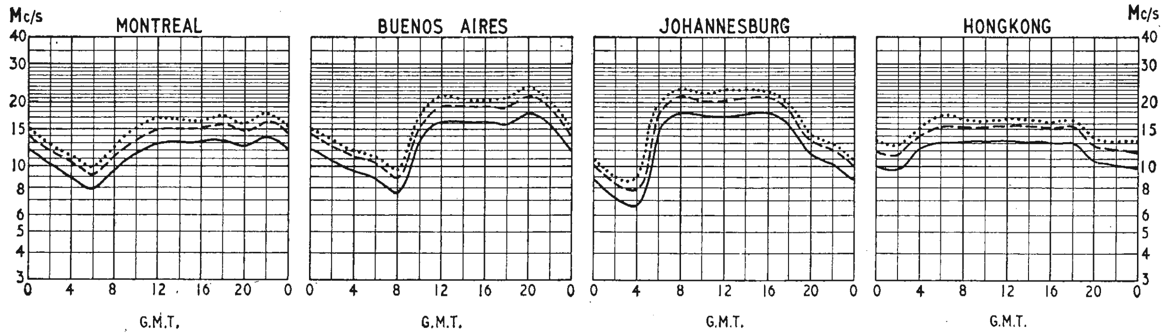
Dispersions are described in a booklet issued by Acheson Colloids Limited, P.O. Box No. 12, Prince Rock, Plymouth, Devon. Dispersed substances include graphite and molybdenum disulphide in colloidal and semi-colloidal form, whilst carriers may be water, oils, resins, glycerine or esters.

Hay bridge for measurement of Q and L of iron-cored components with or without d.c. flowing is made by Furzehill. Type B810A operates from 25 to 3,000c/s and has companion P350 magnetizing supply and G4068 10W a.f. generator. Leaflets from Furzehill Laboratories Ltd., 57 Clarendon Road, Watford, Herts.

100-watt SSB mobile or static radio-telephone that consumes only 7W on "receive" is described in Redifon's booklet on their GR410. The set uses transistors extensively and provides for operation on four spot frequencies between 3 and 18 Mc/s upper or lower sideband. May be remote-controlled. Redifon Ltd., Broomhill Road, London, S.W.18.

SHORT-WAVE CONDITIONS

Prediction for July



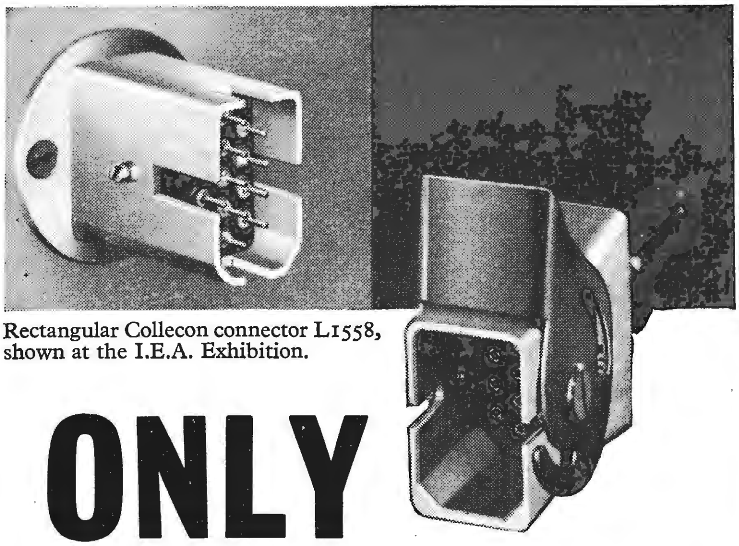
THE full-line curves indicate the highest frequencies likely to be usable at any time of the day or night for reliable communications over four long-distance paths from this country during July.

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

•••••••••• FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE FOR 25% OF THE TOTAL TIME

— — — PREDICTED MEDIAN STANDARD MAXIMUM USABLE FREQUENCY

——— FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE ON ALL UNDISTURBED DAYS



Rectangular Collecon connector L1558, shown at the I.E.A. Exhibition.

ONLY "Belling-Lee" "COLLECON" and "CAMLECON" CONNECTORS

offer all these advantages

- **Sockets individually adjusted to mating pins after engagement.** *(this eliminates all risk of having a poorly mated pole, always a hazard with a conventional multi-pole connector.)*
- **Unusually low insertion and withdrawal forces.**
- **Negligible contact wear.**
- **Very high contact pressure.**
- **Low and constant contact resistance.**
- **Low noise under vibration, shock, and acceleration conditions.**
- **Every pin locked into its socket, preventing accidental disengagement.**

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"BELLING-LEE" NOTES

No. 42 of a series:

"Camlecon" and "Collecon" Connectors

The connectors featured on this page are so novel in conception that we thought it might be interesting, particularly to new readers, to make them the subject of our notes. The principle employed was described in our advertisement last month (if you missed it, send for descriptive leaflet), and represents probably the most significant advance in mating connectors since the first plug-and-socket was invented. To appreciate what has been achieved, however, it is necessary to understand the fundamental problems which confront designers of these components.

Ideally, the entire surface of the plug pin should make contact with the inside wall of its socket, but no machined surface is free from irregularities (it only requires a high enough magnification to observe this), and, in practice, contact is only made at a number of points. These can be increased in area and number by applying pressure, but this usually results in greater frictional wear during mating and unmating, besides raising the forces required for insertion and withdrawal. On the other hand, if contact pressure is light, large variations can be expected under conditions of acceleration, shock and vibration, and this gives rise to "noise."

Increasing the resilience increases the number of points of contact when pressure is applied, and various ingenious methods of doing this have been devised, of which the "O.Z." principle is outstandingly successful. However, this improvement can be entirely lost if either surface becomes accidentally distorted, which can easily happen in a multipole connector without being noticed. Incidentally, the provision of resilience is also a convenient way of compensating for machining tolerances.

A solution to all these problems would be to adjust each socket to its mating pin and increase the contact pressure *after* engagement, and this is precisely what is done in "Camlecon" and "Collecon" connectors. The sockets are closed up on their pins after they have been fully mated, so that contact pressures are balanced against the resultant thrust exerted by the pins on the walls of their sockets. This means that variations in the dimensions of mating piece parts (which are made to normal tolerances), as well as any subsequent distortion, are compensated, and contact is assured. Contact pressures may differ from pole to pole, but are always very high and therefore contact resistance is low and sensibly constant.

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Differential Equations—

—and how to avoid them

By "CATHODE RAY"

THIS is really part 4 of a series. So I don't guarantee it will be utterly clear to anyone who joins now, without some previous initiation. A full cumulative recap would leave little if any room for further development, so all I can do is hopefully scatter a few clues.

The object of the exercise was to introduce a method of circuit analysis that has come into considerable vogue, especially in America. Whether or not one makes practical use of it, one can hardly fail to get a clearer view of how circuits respond to signals—or, to use a more general word, to excitation. Sometimes one is interested in the response at the terminals where the excitation is applied, in which case it depends on the impedance or admittance (in one word, *immitance*) between those points. But the examples we have been considering are the usually more interesting ones in which the response is elsewhere, so that an input and output can be distinguished. The ratio of response to excitation, if both magnitude and phase are taken into account, is known as the transfer function.

We studied the simplest kinds of first-order transfer functions—those in which the circuit comprises only one resistance and one reactance. Then last month we went on to a simple second-order example, with R, C and L all in series. We noted the values of ω or f that made the whole transfer function zero (" zeros ") and those making it infinite (" poles ") and marked them by noughts and crosses respectively on a " complex plane ". The resulting diagram is helpful for plotting curves of magnitude and phase angle against frequency (frequency characteristics).

This procedure admittedly saved no time or effort. But if in the intervening weeks you have been practising like mad you will, I hope, be able to support my claim that familiarity with pole-zero diagrams enables one, merely by looking at them, to get a good idea of the corresponding frequency characteristics. You may even have reached the point where the scheme begins to pay dividends. In case you did not, I attempted to encourage survivors to stay with me by announcing at the end that the idea was not restricted to the pure sine-wave signals we had been assuming, but was valid for a whole group of forms—the exponential—which can be made to include most of the important shapes.

Now an essential fact to grasp is that elucidation of electrical circuits (and their many analogues in mechanics, acoustics, etc.) is based entirely on the solving of differential equations. Those who, like me, approach differential equations with grave misgivings and an entire absence of confidence, may feel that grasping a nettle would be more congenial. That is one reason (whether we know it or not) why we are so reluctant to consider any other waveform than sinusoidal. Rather than tackle other sorts direct we run round the problem by splitting them up, *au Fourier*, into possibly an infinite series of sine waves. The underlying explanation is that the sinusoidal waveform is the only periodical one that is unaffected by differentiation and integration. Consequently all trace of those processes can be concealed so completely that most people are unconscious of their coming into the matter at all. Everything seems to be done by ordinary algebra.

So much is this so that it may be necessary to substantiate my statement that differential equations are basically essential. The only exceptions are circuits with absolutely unvarying currents and voltages; Ohm's law is enough for them. But they are of no interest to us at all because they are incapable of conveying information (in its widest sense). Directly there is variation with time, inductance and capacitance enter the picture, and the relationships between current and voltage are necessarily differential equations:

$$v = L\frac{di}{dt} \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$i = C\frac{dv}{dt} \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

See what this involves us in with our last month's simple circuit (Fig. 1) if we don't conveniently assume the waveform of v_i is sinusoidal. It is easy enough to find v_0 if we know the current flowing through R, but there's the rub. We are at once faced with

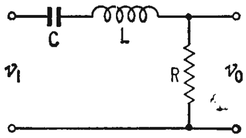


Fig. 1. A simple series LCR circuit once more as an example.

$$v_i = iR + L\frac{di}{dt} + \frac{1}{C}\int i\,dt \quad \ldots\ldots\ldots \quad (3)$$

where v_i is a given function of t. And that is likely to be the terminus for most of us, for most functions of t.

Yet this equation (3) is tantalizing, for it does look rather like the familiar formula we would use if v_i were sinusoidal:

$$V_i = I\left(R + j\omega L + \frac{1}{j\omega C}\right) \quad \ldots\ldots\ldots \quad (4)$$

from which I is easily found, given V_i and the circuit values and frequency. How was this (4) got for us?

The simplicity we associate with sinusoidal excitation is really due to it as a particular case of the wider class of exponential functions of time. These are unique in coming out of differential equations more or less unscathed. The simplest of them is e^t:

$$\frac{d}{dt}e^t = e^t \quad \ldots\ldots\ldots\ldots\ldots \quad (5)$$

Since differentiating it has no effect, the same applies to integration. More generally

$$\frac{d}{dt}Ae^{at} = aAe^{at} \quad \ldots\ldots\ldots\ldots \quad (6)$$

from which follows

$$\int Ae^{at}dt = \frac{A}{a}e^{at} \quad \ldots\ldots\ldots\ldots \quad (6a)$$

Now the graph of e^t (Fig. 2) is not even periodic, much less smoothly sinusoidal; it has no *wave*form at all, so the fact that the sine wave is a particular example of it may not be instantly obvious. The only effect of a multiplier such as a in (6) is to vary the steepness of the curve in Fig. 2. At least, that is true of any " real " number. But let us make the exponent (i.e., the index or power) " imaginary " by prefixing it with j. To make it more general we can put in a multiplier or coefficient; ω is most used because, although it could stand for any parameter, in practice we are interested in the cycle frequency f,

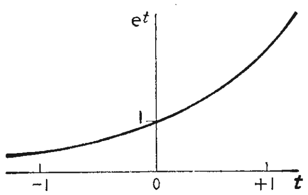


Fig. 2. Graph of e^t plotted against t. It has the unique property that the slope of the curve (i.e., de^t/dt) at any point on it is equal to its own value, e^t.

or (to simplify it mathematically) the radian frequency $2\pi f = \omega$. And so we have the much-used expression $e^{j\omega t}$.

At first sight this looks complete nonsense. But in " e " (April 1960) I showed that we were not forced to accept it in blind faith as an arbitary symbol to convey a certain meaning; we could logically arrive at that meaning graphically or otherwise, using ordinary mathematical processes. It would take too long to go through it all again, so I'll just repeat that $e^{j\omega t}$ is a quantity represented by the polar co-ordinates $1\underline{/\omega t}$. In effect, then, it is a spoke, one unit long, rotating at the rate of $\omega/2\pi$ revolutions per second, or ω radians per second, as indicated in Fig. 3.

The connection between this and sine waves is now clear, because the projection of such a spoke on the " real " axis represents by its length the cosine of the angle ωt attained by it after any time t, and its projection on the " imaginary " axis is similarly sin ωt. This is expressed by Euler's identity:

$$e^{j\omega t} = \cos \omega t + j \sin \omega t \quad \ldots\ldots\ldots \quad (7)$$

The anticlockwise rotation in Fig. 3 signifies by mathematical convention an increasing positive angle. So an increasing negative angle is represented by clockwise rotation, implied by $e^{-j\omega t}$. In Fig. 4 both are shown together, and obviously

$$e^{-j\omega t} = \cos \omega t - j \sin \omega t \quad \ldots\ldots\ldots \quad (8)$$

Adding these two " spokes " vectorially by " completing the parallelogram ", and then dividing by 2, or doing the equivalent by solving the simultaneous equations (7) and (8), we get

$$\cos \omega t = \frac{e^{j\omega t} + e^{-j\omega t}}{2} \quad \ldots\ldots\ldots \quad (9)$$

$$\sin \omega t = \frac{e^{j\omega t} - e^{-j\omega t}}{2j} \quad \ldots\ldots\ldots \quad (10)$$

By applying (6) to these we get

$$\frac{d}{dt}\cos \omega t = -\omega \sin \omega t \quad \ldots\ldots\ldots\ldots \quad (11)$$

$$\frac{d}{dt}\sin \omega t = \omega \cos \omega t \quad \ldots\ldots\ldots\ldots \quad (12)$$

Lots of people who have never got so far as (9) and (10), or even e, may be quite familiar with (11) and (12), which can quite easily be found directly, without bringing in the rather occult $e^{j\omega t}$. Was this invented just to look clever?

Well, if you try using (11) and (12) to solve a differential equation—(3) will do for a start—I think you will find the direct and simple approach not so easy after all, even with the sinusoidal waveform. The apparently more involved route via exponentials not only covers a wider variety of signal forms; it is simpler to apply and more effective.

This is not a textbook on the subject, so I'll only outline the process. You rewrite the equation in exponential form. The obvious thing is to use (9) or (10) as it stands, substituting the double exponential for the usual cos or sin form of current and voltage. But while that would be perfectly correct, there is a simpler way. The (9) and (10) form may suggest to us the upper and lower sidebands in a radio transmission, each limited to half the amplitude of the carrier wave. Just as it was realized that either sideband contains all the information, making it uneconomical to transmit both, so it has been found that one $e^{j\omega t}$, as a unit " phasor", multiplied by the peak value of voltage or current, sufficiently represents the sinusoidal signal throughout the working, and there is no difficulty in interpreting the final result.

So i becomes $Ie^{j\omega t}$, di/dt becomes $j\omega Ie^{j\omega t}$, d^2i/dt^2 becomes $(j\omega)^2\ I\ e^{j\omega t}$, and $\int i\ dt$ becomes $Ie^{j\omega t}/j\omega$ (plus a constant of integration if need be).

Applying this to (3), for example, we get (4), since $e^{j\omega t}$ cancels out. So now, provided we can handle j,

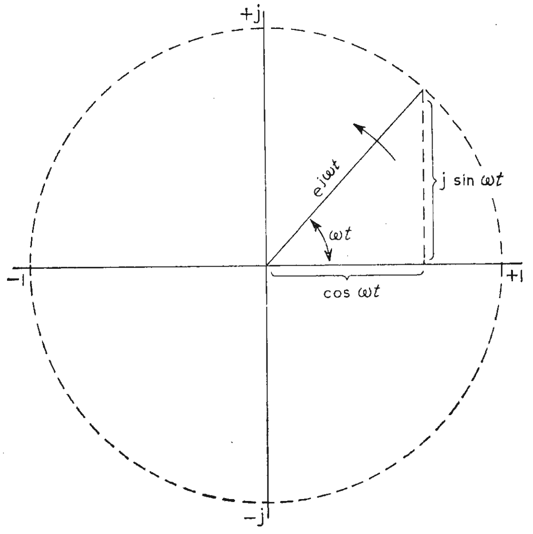


Fig. 3. If the exponent t is multiplied by an "imaginary" quantity, say $j\omega$, the exponential function is found to generate sinusoidal waves.

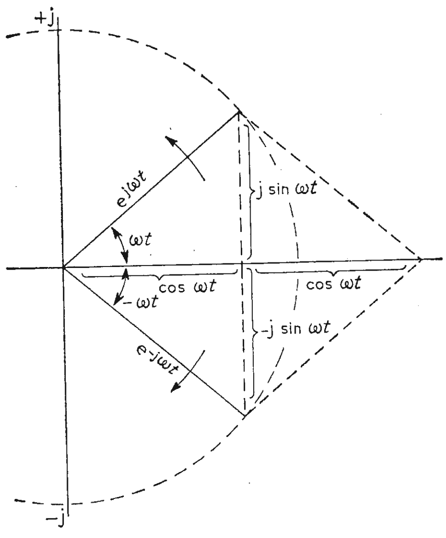


Fig. 4. How 2 cos ωt can be split up into $e^{j\omega t}$ and its conjugate, $e^{-j\omega t}$.

we have nothing more than a slight extension of Ohm's law. And that is one way of avoiding differential equations—by using the results of someone's pioneer efforts. Many people who are familiar with inductive and capacitive reactances, $j\omega L$ and $1/j\omega C$, as members of the Impedance Club along with the sole founder member, R, and can do a.c. circuit calculations on that basis, are unaware of how the $j\omega$ and $1/j\omega$ parts came into it. They may be surprised to find that they are traces of the differentiating and integrating processes involved in solving circuital differential equations by means of imaginary exponential functions. (Sounds most impressive!) Because one assumes a sinusoidal waveform, which can be expressed in terms of the exponential $e^{j\omega t}$, differentiating it (as is necessary when L is encountered—eqn. (1)) changes this to $j\omega\ e^{j\omega t}$; in short, simply multiplies it by $j\omega$; and integrating it (as is necessary for finding v when C is encountered—eqn. (2)) similarly divides by $j\omega$. And that is how the forbidding-looking differential equation (3) can be replaced by the simple algebraical extended-Ohm's-law one, (4). The relationship between one sinusoidal current or voltage and another in any linear circuit is given by an algebraic equation with $j\omega$ as (possibly) variable and R, L and C as constants.

As we have seen in previous instalments, a first-order circuit (R and L *or* C), gives an equation with only the first power of $j\omega$; a second-order circuit equation is a quadratic in $j\omega$; and so on. The number of answers in the solution of the equation is equal to the order.

For the reason (among other and even better ones) that response to excitation is relatively easy to calculate when it is sinusoidal, this particular shape has become so common in all branches of electrical technology that its use is assumed unless the contrary is stated. So when we have become proficient in a.c. calculations on that basis we may be full of confidence. If this is so, there will be the unfortunate necessity for bringing our balloon into sharp contact with the point of the fact that perfectly pure sinusoidal a.c. is never used! If one considers (as is appropriate in *Wireless World*) the communications branch of electrical engineering, one finds that it depends entirely on some kind of modulation, even when the unmodulated form is sinusoidal. And although the object of the power branch is to supply as nearly as possible pure and continuous a.c., it has to be switched on some time. The type of differential equation solution we have noted, and the algebraical short cut founded on it, are not enough.

The books on differential equations have a name for the solution just mentioned; the "particular integral". It indicates the steady-state response in a circuit. They go on to show that this is only part of the solution; there is another, which they call the "complementary function". It covers any transients that may emerge. In the early days one could often manage to ignore these, but with increase in speeds of signalling they have become less and less ignorable.

Fig. 5(a) shows a sinusoidal voltage v and the current i that would result if v had already been switched on for a long time to a series circuit consisting (let us say) equally of resistance and inductive reactance, Fig. 5(b). Even the most elementary book on a.c. will tell us that i will lag by 45° or $\pi/4$ radians—one eighth of a cycle, anyway. Now one of the essential features of an inductive circuit is that current can't begin to flow in it instantaneously. A voltage has to act for a finite time to get it going. So the state of affairs depicted in Fig. 5(a) can't spring into existence immediately the switch is closed, unless that happens at precisely one of the moments, such as t_1, when the current is passing through zero.

You may perhaps be surprised that it does so then, when a voltage 70.7% of the peak value is suddenly applied. Reactance and resistance in this circuit being equal, however, 70.7% (or $1/\sqrt{2}$) of peak v is exactly the regular peak value of the voltage across L, which naturally occurs at the moment when, owing to current being zero, there is no voltage across R. At t_1 the conditions are therefore exactly the same as if the switch had been closed all along. The only "memory" the circuit has is due to storage of energy in L, and by choosing a moment when that energy is nil we make sure that previous history (i.e., switch "on" or "off") has no influence on history then beginning.

Consider next what is happening (the switch being still closed) at t_2—or the same phase in any other cycle. The current is at its peak, so momentarily is neither increasing nor decreasing. Consequently there can be no voltage across L. The

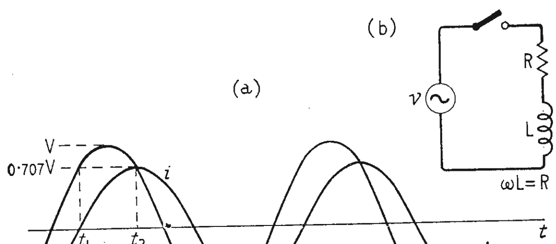


Fig. 5. (a) Steady state of current and voltage in the circuit (b) when the switch has been left closed.

whole applied voltage is busy driving current through R. We note again that it is 70.7% of the peak v. Because the current is at its peak this is obviously the peak voltage across R. The fact that it is equal to the peak voltage across L (quarter of a cycle earlier) is of course a result of our having chosen for simplicity to make resistance and reactance equal.

If we had happened to switch on at t_2, the conditions just described, and shown in Fig. 5(a), couldn't possibly have come into existence at once. An instantaneous rise in current from zero to peak value would necessitate an infinitely large applied voltage. In actual fact the situation is momentarily the same as at t_1. In order to provide the right amount of opposition to the applied voltage there must be growth of current in L equal to that shown at t_1. But instead of the voltage rising, as at t_1, it is falling. So the rise of current is short-lived.

Without working out the differential equation in full (and unless you have done it before, or are a mathematical genius, that takes time) you might think it hopeless to try to determine exactly how the current varies from t_2 on, when that is the switch-closing moment. Presumably in time it catches up and swings into regular phase relationship with the voltage, like a late arrival joining a marching column; but how long does it take?

There is no need for either a display of mathematical erudition or a furrowed brow, if we are familiar with the well-known build-up and die-away curves in LR and CR circuits, and remember that because the circuit is linear the principle of superposition holds. That is to say, the total current due to two or more causes operating at the same time is equal to the sum of the currents due to the causes separately. Our second choice of switching time can be put on the same footing as the first if we imagine that the current had previously been brought up to peak value by a battery equal in voltage to that of the a.c. supply at t_2. In effect, then, two sources are switched simultaneously. One is v, which (because the initial current, due to the other source,

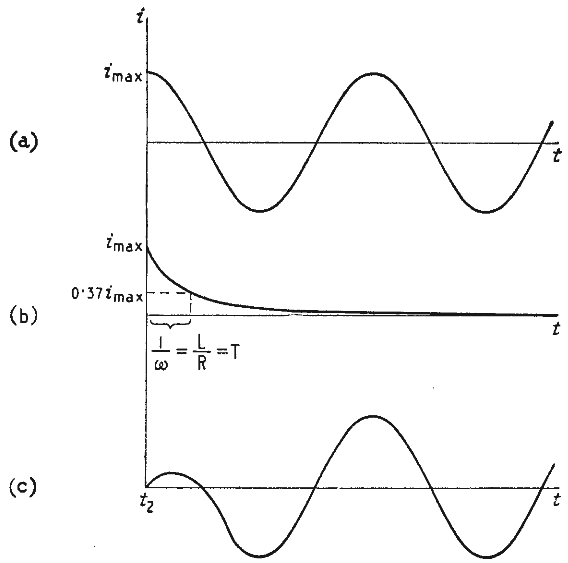


Fig. 6. The current curve (c) when Fig. 5(b) is switched on at $t=t_2$ can be found by subtracting a transient (b) from the "regular" waveform (a).

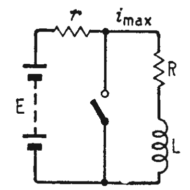


Fig. 7. The transient shown in Fig. 6(b) can be generated in this circuit by closing the switch.

is i_{max}) establishes steady-state Fig. 5(a) conditions at once, as shown separately in Fig. 6(a). The other is a d.c. source causing a sudden reduction in applied voltage from $v_{max}/\sqrt{2}$ to zero. This has the usual exponential die-away form, determined solely by the initial and final current values (i_{max} and 0 respectively) and the time constant of the circuit, L/R. In this example, where $R = \omega L$, it is $L/\omega L, = 1/\omega = 1/2\pi f = \tau/2\pi$, where τ is the duration of one cycle. So at this fraction of a cycle after t_2 the transient current is $i_{max}/e, = 0.37 i_{max}$, and we can plot it and sketch the curve, Fig. 6(b).

Fig. 6(a) being the total current if there had indeed been both sources, and (b) the current due to the fictitious source alone, the current due to v alone, which is what we actually get, is (a) minus (b), shown at (c).

In this example the transient is very transient and normal service is soon established. But if R were much smaller relative to L, the time constant and therefore the transient would be correspondingly longer. Of course, theoretically they are all infinitely long, but for practical purposes the transient is negligible after about 5 time constants. If R were zero, the transient corresponding to Fig. 6(b) would be continuous d.c. and the current due to the wholly alternating voltage would never alternate!

The starting amplitude of the transient is equal to what the current should have been (according to Fig. 5) at the moment of switching on, and the time taken to die away to a given percentage of that amplitude depends only on the ratio of L to R. So it is easy enough to adapt Fig. 6 for any other switching phase, and all without anything to do with differential equations.

Or is it? I have been ticked off before for seeming to frighten people away from maths by creating for it what is nowadays called the wrong image. And now my title is a wide-open invitation to a further reproof. But, like film titles, mine is a misleading one, just to get people inside. This is the moment to reveal that, just as lots of people run reactances rapidly off their slide rules, untroubled by a single thought of the differential-equation particular integrals responsible for the forms being ωL and $1/\omega C$, so thousands of ex-radar-mechs. know all about currents and voltages building up and dying away to the extent of 37% in L/R or CR seconds, without realizing that this information is the complementary-function part of the solution of the differential equation for the circuit concerned.

A circuit to produce the transient part only of Fig. 6(c) could be as shown in Fig. 7, where E is sufficient to pass i_{max} through $R+r$. I have included r solely out of consideration for the feelings of the battery when the switch is closed in order to generate the transient. It takes no part in that process in so far as it concerns our original circuit, R and L.

From the time $t = 0$, at which the switch is closed, the situation in the closed circuit comprising R and L is expressed by this differential equation, based on Kirchhoff's voltage law:

$$iR + L\frac{di}{dt} = 0 \ldots\ldots\ldots\ldots (13)$$

plus the information that $i = i_{max}$ at $t = 0$. (13) can be rearranged as

$$\frac{di}{dt} = -\frac{R}{L}i$$

If we turn back to eqn. (6) which is a quite general result, proved in any book on the calculus, we see it is identical in form, Ae^{at} being represented by i, and a by $-R/L$. So we conclude that i, the transient current in Fig. 7, is specified by

$$i = Ae^{-(R/L)t}$$

To find what A is, we fill in the known value of i at $t = 0$, viz., $i_{max} = Ae^0 = A$.

And because L/R is what we call the circuit time constant, T, the final form of our equation is

$$i = i_{max}e^{-t/T}$$

If we plot i against t according to this equation we get Fig. 6(b), just the same as if we followed the rules handed out by the radar instructor to other ranks (officers are supposed to solve the differential equation).

This is such a very easy differential equation that it can be done as shown, making use of the standard form given here as (6), from any list of differential coefficients. In less simple circuits this procedure wouldn't work, but there is a more generally available one which does, and incidentally is another way of dodging differential equations. In one form—poles and zeros—we have already been using it.

We obviously have several loose ends left to be woven into the fabric, and I can visualize the Editor, like the judge in " Perry Mason ", looking anxiously at his watch or its equivalent (an electronic computer that tots up the number of printed pages it will run to?) and asking how much longer I'm going to be. When I tell him, he'll certainly call for an adjournment; for one thing, we've still not got around to those odder exponential signal forms. Meanwhile, if you're new to all this you might care to amuse yourself by working out exactly what happens when the switch in Fig. 5(b) is *opened* at some moment when current is flowing.

INTERNATIONAL TELECOMMUNICATIONS

WORK OF THE U.I.T. AND ITS CONSULTATIVE COMMITTEES

THE opening in May of the new Headquarters of the International Telecommunication Union in Geneva by U-Thant, the acting secretary-general of the United Nations, affords an opportunity to review the work of the U.I.T.—to use the initials of its French title.

Founded in 1865 as the International Telegraph Union by twenty States, its title was changed to the present one in 1932 and its members now total 117. The purposes of the Union as defined in the Convention are —" to maintain and extend international co-operation for the improvement and rational use of telecommunication of all kinds; to promote the development of technical facilities and their most efficient operation with a view to improving the efficiency of telecommunication services, increasing their usefulness and making them, so far as possible, generally available to the public; and to harmonize the actions of nations in the attainment of those common ends."

The four " permanent organs " of the Union are the General Secretariat, the International Frequency Registration Board, the International Telegraph and Telephone Consultative Committee (C.C.I.T.T.) and the International Radio Consultative Committee (C.C.I.R.). The General Secretariat is responsible for organizing the Plenipotentiary Conference (the supreme authority which meets every five years or so) and is the liaison between the telecommunications administrations of the member countries. It is at this conference that the International Telecommunication Convention and the regulations governing the operation of the radio, telephone and telegraph services throughout the world are revised. The last Plenipotentiary Conference was held in Geneva in 1959 and the next is planned for 1965 (the Union's centenary year) in Switzerland.

The I.F.R.B., created in 1947 at the Atlantic City conference, consists of eleven " independent radio experts " (all from different countries) who are elected at an Administrative Radio Conference. The work of the board consists primarily of investigating and substantiating claims to the use of specific frequencies by member countries. It it is found that the use of the frequency will not cause harmful interference to other stations, it is then recorded on the Master International Frequency Register. Some idea of the work involved will be gained from the fact that an average of 1,700 frequency assignment notices are received by the board each week. Another major task of the I.F.R.B. is the preparation of the seasonal h.f. broadcasting schedules.

Since 1957 the C.C.I.T.T. has taken the place of two consultative committees, one covering telegraphy and the other telephony. This committee and the C.C.I.R., set up in 1927, study (through special study groups) and issue recommendations on the technical and operating problems in their respective fields.

All members of the I.T.U. can participate in the work of these consultative committees together with representatives of certain organizations operating telecommunication services, as for instance the marine radio companies and broadcasting organizations. Each consultative committee holds a plenary assembly every few years—the last such C.C.I.R. meeting was held in Los Angeles in 1959 and the next is scheduled for January 1963 in New Delhi.

With the advent of space communication, the Union is faced with a new responsibility and is calling a special conference in 1963 to go into the question of techniques and regulations.

Information on the Union's work is given in the monthly *Telecommunication Journal* which is now available in separate English, French and Spanish editions from the I.T.U. headquarters, Place des Nations, Geneva, Switzerland.

PLOTTING TRANSISTOR CHARACTERISTICS

PRACTICAL GUIDANCE FOR THE STUDENT USING SIMPLE EQUIPMENT

By A. T. FERGUSON*

THE introduction of transistors into the syllabus for examinations will result in many schools and colleges performing experiments whereby the characteristics of a transistor may be determined. A search through text-books and manufacturers' literature will give general information about methods of procedure but, with one exception, little detail; valve-voltmeters are mentioned at random and the demand for these must give great joy in many quarters. The method described here shows how the different characteristics may be obtained with equipment that is normally available in a school laboratory. The objective is to enable students to conduct experiments that will lead to an understanding of the principles involved in the application of the transistor; this is to be done with equipment that the student is already familiar with and understands. The obvious types of transistor to use initially are those that are most readily available, and low power audio frequency transistors are most suitable. Common emitter operation only is considered here but the methods outlined can be readily applied to other configurations.

Meter Resistance: For voltage/current characteristics of a valve the circuit used is arranged as shown in Fig. 1. With normal instruments the volts drop across the milliammeter is negligible in comparison with the voltage indicated on the voltmeter. In the case of transistors this is no longer so and a method of correction has to be applied. The magnitude of the correction is determined from the resistance of the current meter and it is desirable to know just what this is. The range of currents to be measured for the different transistor characteristics will vary from a few microamps to about 10 mA for the type of transistor considered here. The resistance of a 0-250μA instrument is generally about 300 ohms, whereas if a multi-range instrument is used the resistance will be much greater. For example, an Avometer Model 8 has a resistance of 2,500 ohms on the range 0-50μA and 1,700 ohms on the range 0-250μA. The resistance of a 0-10mA instrument will be between 3 and 15 ohms; again, for comparison, an Avometer Model 8 has on this range an internal resistance of 50 ohms; the Model 7, 10 ohms. The resistance of the meter in no way interferes with the

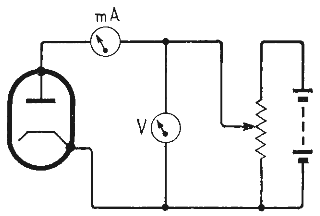


Fig. 1. Circuit for valve characteristic measurement.

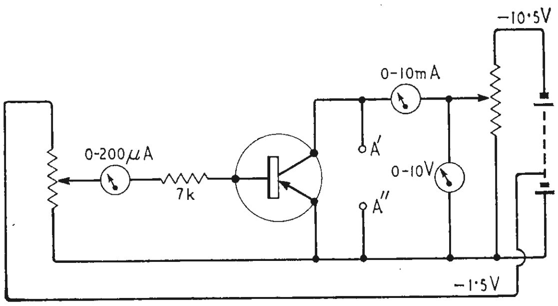


Fig. 2. Measurement of output characteristic at high collector voltages, using ordinary potentiometer.

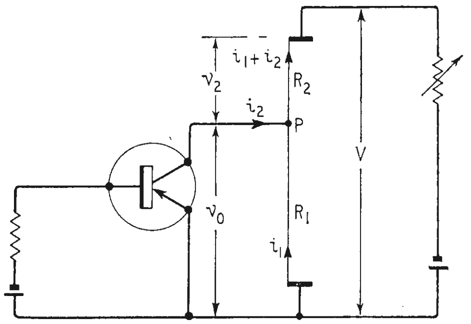


Fig. 3. Principle of slide wire circuit.

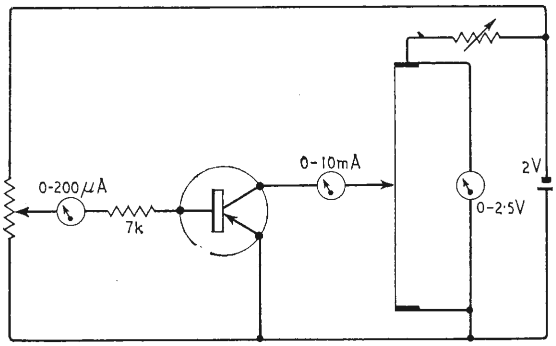
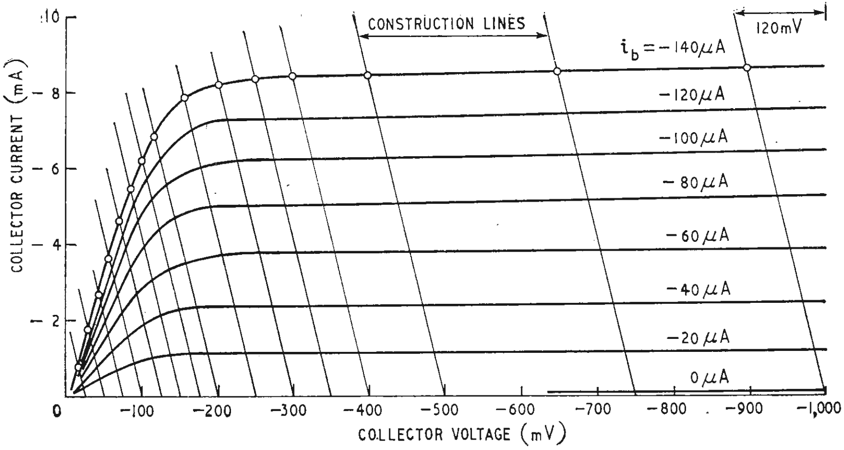


Fig. 4. Practical circuit using slide wire.

*Lecturer, South Shields Marine and Technical College.



(a)

Fig. 5. (a) Output characteristic. "Load lines" allow for resistance of collector current milliammeter. (b) specimen set of readings at 140μA base current.

COLLECTOR VOLTAGE (mV)	−25	−50	−75	−100	−125	−150	−175	−200	−250	−300	−350	−400	−500	−750	−1,000
COLLECTOR CURRENT (mA) $i_b = -140\mu A$	−0·8	−1·8	−2·6	−3·6	−4·6	−5·4	−6·2	−6·8	−7·9	−8·2	−8·3	−8·4	−8·4	−8·5	−8·6

(b)

accuracy of the results but it must be known. If it is not indicated on the instrument it must be measured.

Output Characteristics, 1 to 10 Volt Range: The circuit used is shown in Fig. 2. If a high resistance voltmeter, say 20,000 ohms per volt, is used it will be connected across A′ A″. In these circumstances the meter, V, will not be required, as the emitter-collector voltage is indicated directly, no correction being necessary. If a 1,000Ω/V meter is used it will be connected as shown and the procedure is as follows.

The readings of collector current for different values of collector voltage are tabulated for given values of base current, including the open-circuit base condition. Axes with convenient scales are prepared on graph paper and each point along the abscissa corresponding to a voltage at which current was measured is marked; from each of these points a line with a slope equivalent to the resistance of the milliammeter is drawn in pencil. This should be done by laying off one line accurately and drawing the others parallel to it; it should take about two minutes to do this. The co-ordinates are marked off along sloping voltage lines and horizontal current lines. When the characteristics have been drawn the pencil construction lines may be erased, but it is a good idea to leave the slope of these indicated at some point. It will be possible in many cases to disregard the correction and plot the co-ordinates directly. Whether or not this is so can be determined by drawing one construction line and considering the amount of correction indicated by it.

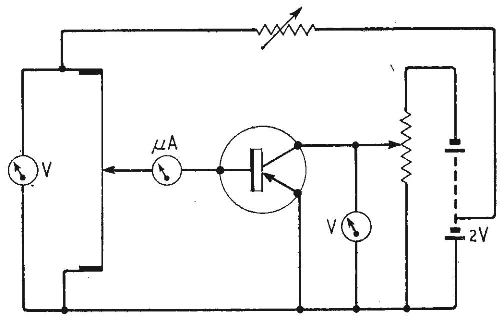
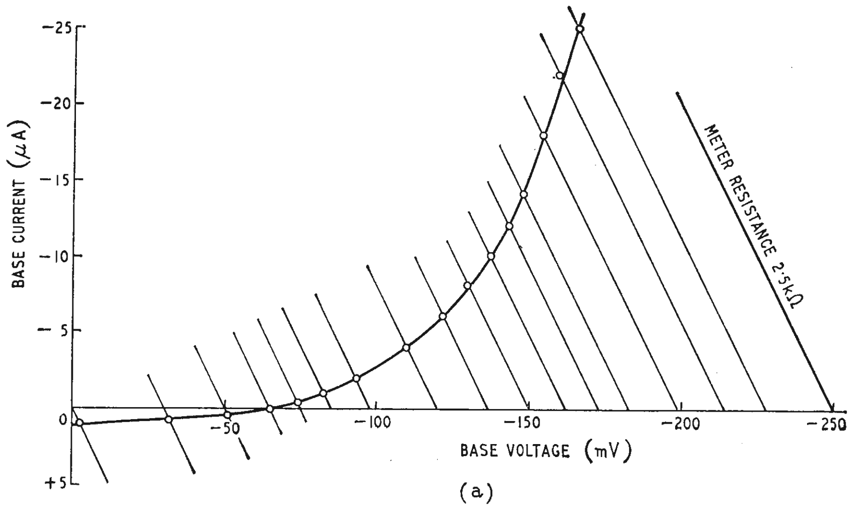


Fig. 6. Circuit for input characteristic measurement.

Output Characteristics, 0 to 1 Volts. To obtain low voltages a slide-wire potentiometer is used. The bridges and potentiometers supplied to schools are normally fitted with 24 s.w.g. wire, which has a resistance of approximately 2 ohms per metre, so that with one volt across the bridge the current will be approximately 500mA. Referring to Fig. 3, P is the sliding contact on a slide-wire potentiometer, R_1 and R_2 being the values of the resistance between P and the ends of the potentiometer.

$$V = i_1R_1 + (i_1 + i_2)R_2$$
$$v_0 = i_1R_1$$
$$\therefore \frac{V}{v_0} = 1 + \frac{(i_1 + i_2)R_2}{i_1R_1}$$
$$\frac{V}{v_0} - 1 = \frac{R_2}{R_1}\left(\frac{i_1 + i_2}{i_1}\right)$$
$$\therefore \frac{V - v_0}{v_0} = \frac{v_2}{v_0} = \frac{R_2}{R_1}\left(\frac{i_1 + i_2}{i_1}\right)$$

Hence, if i_1 is large in comparison with i_2, v_0 is practically proportional to the length of wire comprising R_1. If the bridge is rewired with 20 s.w.g. constantan wire a current of approximately 1.4 A is needed for one volt across one metre of wire, and the accuracy of the voltage indication in these circumstances will compare favourably with that obtained on a valve-voltmeter. For very low voltage measurements the voltage across the wire is reduced.



BASE CURRENT (μA)	1	0·75	0·5	0	−0·5	−1	−2	−4	−6	−8	−10	−12	−14	−18	−22	−25
BASE VOLTAGE (mV)	0	−30	−50	−65	−75	−85	−98	−120	−137	−150	−162	−173	−183	−199	−214	−228

(b)

Fig. 7. (a) Input characteristic. "Load lines" allow for resistance of base current microammeter. (b) Specimen set of readings.

The sliding contact must be arranged so that it cannot be detached from the potentiometer.

The circuit is illustrated in Fig. 4. A lead-acid accumulator is used for the supply as this would normally be available in a school laboratory, and it provides a source that is free from fluctuation. Before readings are taken the resistance of the milliammeter is noted and a table is prepared for the observations. Readings of collector current are taken for different values of base current, the collector circuit voltage being set at one value and then altered after the range of base currents has been covered. In this way the number of adjustments necessary to obtain a set of readings is reduced. The voltage across the potentiometer is maintained by adjustment of the variable series resistor, the voltage would generally be kept at one volt but can be reduced to cover very low voltages.

Fig. 5(a) shows a group of characteristics obtained in the manner described; the resistance of the milliammeter used was 12 ohms and, consequently, the voltage drop across it with a 10 mA current would be 120 mV. This gives the slope of the construction lines which are shown. To clarify the method, the readings noted for a base current of 140 μA are given in Fig. 5(b).

In the circumstances where the collector voltage is zero, the collector being effectively connected to the emitter, a small reverse collector current will flow. This current will become smaller as the collector voltage is increased, and will be zero with a collector voltage of about 8 millivolts. Increasing the collector voltage thereafter results in a collector current in the normal direction. Because of this effect the characteristics do not pass through the origin, but the extent by which they do not may be too small to be indicated on some of the scales used when plotting the characteristics.

Transfer Characteristic: The information required to plot this is obtained from the output characteristic curves by reading off the corresponding values of base and collector current for a fixed value of collector voltage.

Input Characteristic: This is taken with the circuit shown in Fig. 6, the collector voltage being kept at −4.5 volts. The base current will undergo a reversal and it will be found convenient to employ a "reverse movement" switch on the meter, or a centre-zero instrument. The resistance of the microammeter is noted and the readings of base current are tabulated for differing values of base circuit voltage as the latter is increased from zero. After suitably scaled axes have been chosen construction lines are drawn from the voltage axis, the slope of the lines corresponding to the internal resistance of the microammeter, and current values are plotted along these; the result is shown in Fig. 7.

Television Engineering. Volume Four. General Circuit Techniques (2nd edition) by S. W. Amos, B.Sc. (Hons.), A.M.I.E.E., and D. C. Birkinshaw, M.B.E., M.A., M.I.E.E This B.B.C. engineering-training manual deals with the circuit techniques used in television, both from the points of view of specialized video-frequency work and the timebase side. Since publication of the first edition in 1958 development has occurred in the circuits used, particularly in the line-timebase stage, and, to keep pace with this advance the authors have revised their book. In particular, the chapter on line-deflection circuitry has been extensively modified to bring it up to date and changes have also been made in the sections dealing with counter circuits and frequency division, delay lines and field-scan output stages. With ten more pages (278) than the previous edition, the second edition still costs 35s (36s 2d by post). Published, by arrangement with the B.B.C., by Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1.

Nands and Nors and Sheffer Strokes

NAMING STATIC SWITCHING CIRCUITS

By J. F. YOUNG, C.G.I.A., A.M.I.E.E., A.M.Brit. I.R.E.

AT the present time a confusing number of strange new words is appearing in the electronics literature, producing riddles like, "When is a NOR not a NOR?—When it's a NAND!". Problems like this are no joke, they are very real problems which arise in the rapidly expanding field of transistor static switching. New names for old circuits seem at first sight to be coined on the principle of "A rose by any other name". While there are no doubt very good reasons for the present mix-up, they are not too clear. Since it is not easy to understand why there is such confusion, it is interesting to investigate how it has come about.

In the post-war years, with the expansion of the computer industry, electronic engineers became accustomed to turning words like AND, OR and NOT into circuitry. Now this was not exactly a new process, because for some years telephone engineers had been thinking along similar lines in the design of their relay switching circuits. Electronic circuitry was being used in computers mainly because relays were too slow. However, as the reliability of electronic equipment improved, many engineers began to wonder whether it might be worth while using electronics to replace relays even for low-speed applications, such as industrial switching. The chief advantage would be the absence of moving parts, hence the idea became called "Static Switching". There was, and still is, considerable controversy on the question of whether or not static switching is worth while, but while this continues static switching is being used in increasing numbers of industrial installations.

History of Static Switching Systems

Early forms of static switching used magnetic amplifiers of various types, since magnetic amplifiers had proved their reliability both in military and in industrial applications. Unfortunately, magnetic amplifiers are expensive to produce, so that static switching schemes tended to cost two or three times as much as their equivalent relay schemes. It was usual to have a number of different types of unit, each type capable of performing certain limited logical operations. The number of differing types of unit which had to be produced helped to increase production costs.

At the time when magnetic amplifier static switching was first spreading, the transistor was becoming a commercial proposition. As the reliability of the transistor began to be proved, engineers realized that here was a device which showed promise of being useful for static switching. The small size, reliability and low (and falling) cost of transistors brought hope of producing transistor static switching systems having advantages over magnetic amplifier schemes. It is interesting to note here that the company which had produced the first commercial magnetic amplifier static switching units later introduced the first all-transistor scheme. While changing from magnetic amplifiers to transistors it was desirable at the same time to reduce the number of different types of unit which had to be manufactured. This was accomplished by the introduction of the NOR system[1], which went to the extreme by requiring only combinations of one type of unit to perform all logical functions.

The circuit of a NOR unit using only resistors and a transistor is shown in Fig. 1. The circuit is designed so that if any one of the inputs is taken sufficiently negative, the transistor will conduct even if all of the other inputs are connected to the zero line. If, however, all of the inputs are connected to the zero line, the transistor will cut off and its collector will be negative. Now if we regard a negative voltage as a signal, we can say that the transistor gives a (negative) signal at its collector only if none of the inputs have a (negative) signal applied. In other words, an output signal is obtained only if neither a NOR b NOR c NOR d NOR e have input signals. The reason for the use of the name NOR for the circuit is now obvious. By correct design of the circuit it can be arranged that a transistor collector can provide sufficient output to feed the inputs of several other units, so that the units can be used in combination.

A simple illustration of the versatility of the NOR arrangement is given in Fig. 2b, which is the NOR equivalent of the relay circuit of Fig 2a. Here it is required to produce an output when button C is pressed at the same time as either A or B buttons. The output signal is then to persist until both buttons A and B are pressed simultaneously. The NOR

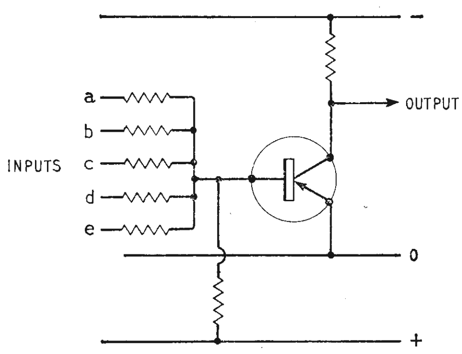


Fig. 1. Transistor-resistor "NOR" circuit.

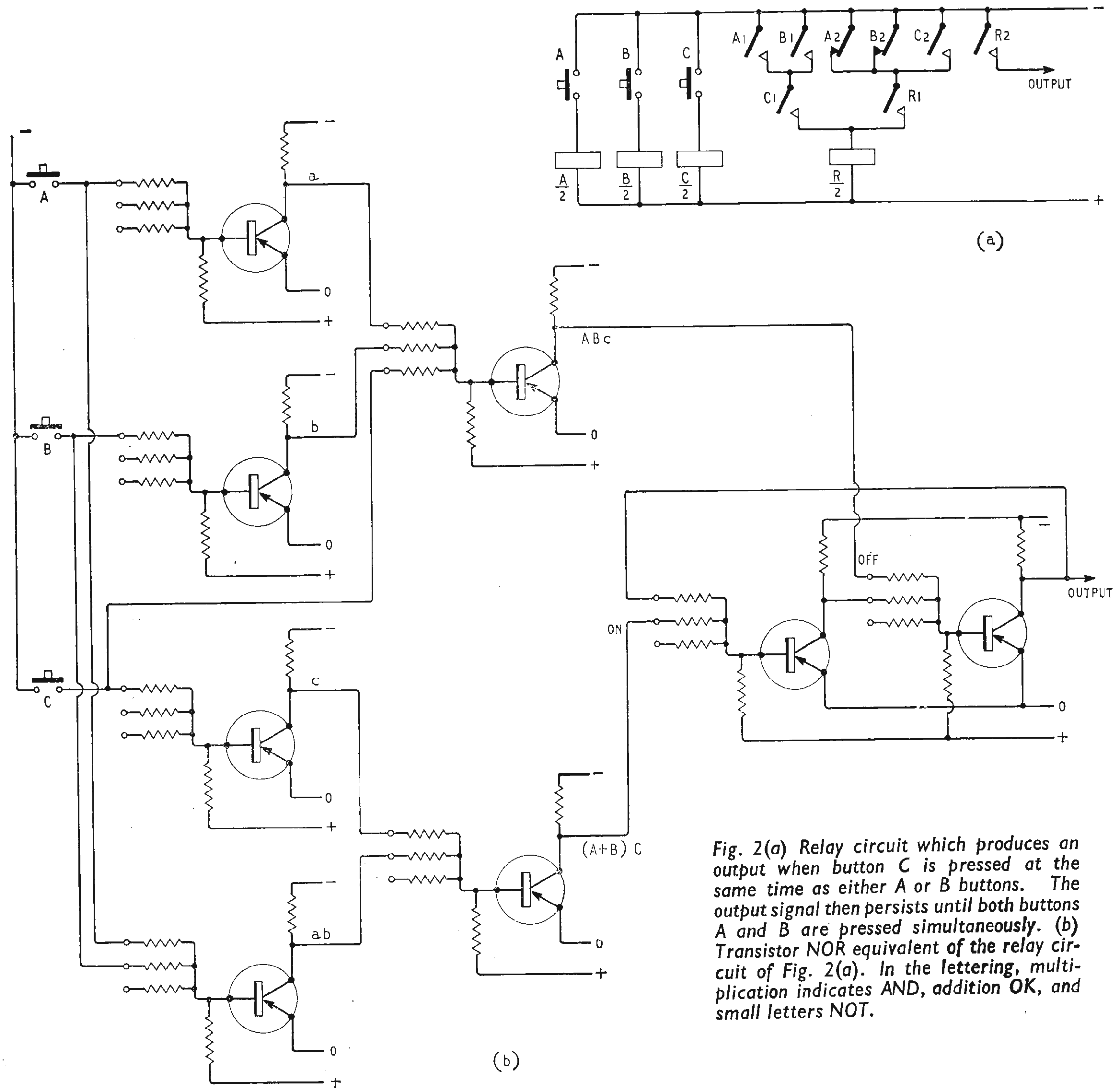


Fig. 2(a) Relay circuit which produces an output when button C is pressed at the same time as either A or B buttons. The output signal then persists until both buttons A and B are pressed simultaneously. (b) Transistor NOR equivalent of the relay circuit of Fig. 2(a). In the lettering, multiplication indicates AND, addition OK, and small letters NOT.

units can be seen to be used to obtain AND, OR, NOT and MEMORY functions.

A little confusion was introduced even in the early days of transistor static switching because it was realized that if n-p-n transistors were used instead of p-n-p transistors, a NOR system using positive rather than negative signals would result. However, this was a minor problem compared with later events.

Alternative Names

It is quite possible to use the circuit of Fig. 1, but to regard the condition when the collector is bottomed as producing an output signal. For convenience this will be referred to as a positive voltage signal to differentiate it from the cut-off condition when the collector voltage is negative. If we think in terms of these positive signals, we can see that a (positive) output is obtained only when one of the inputs is NOT supplied with a positive signal, i.e., when one of the inputs is negative. In other words, a (positive) output is obtained only if there is NOT a (positive) input at a AND at b AND at c, etc. For this reason, the circuit has sometimes been called a NOT-AND or NAND circuit. Unfortunately, the circuit diagram is exactly the same as that of the NOR unit, the only difference being the "normal" polarity of signal used. This difference exists only in the mind of the observer. Yet another name which has been applied to the same circuit when used with positive signals[2] is "Sheffer Stroke" (after H. M. Sheffer, the author of a paper on Boolean algebras published in 1913). In addition, making matters more difficult, the circuit has sometimes been drawn upside-down in order to have the positive terminals at the top with p-n-p transistors.

So far we have only been dealing with one circuit which has been given several different names depending on how it was used (or drawn). This would be bad enough, but some engineers, and the writer must plead guilty to being one of them, have

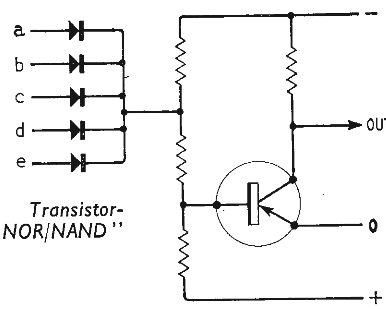


Fig. 3. Transistor-diode "NOR/NAND" circuit.

applied the same names to a different circuit. There are various advantages to be gained from the use of diodes rather than resistors at the inputs to a transistor switching circuit, as shown in Fig. 3. In this case the transistor cuts off and its collector becomes negative if any one input is positive (connected to the zero line), otherwise the transistor conducts and its collector is positive. Consequently, if we think in terms of positive signals, a (positive) output signal is obtained only if there are no (positive) input signals, and we have a NOR circuit. However, Fig. 3 has also been called a NAND circuit, and this is perfectly valid if negative signals are considered since a (negative) output is obtained only if not all of the inputs are present (negative). The same circuit has also been referred to as an AND unit[3], but we will leave consideration of this until later. If we now redraw Fig. 3, first upside-down and then in both ways but using n-p-n transistors with the diodes reversed, the confusion is almost complete.

Variable Polarity Logic

The confusion is not quite complete because there is another way of thinking about the action of these circuits which some people, including the writer, have found useful when designing logical schemes. In the discussion so far, it has been assumed that a standard polarity of signal, either positive or negative, would be used throughout a given system. We have only considered the conditions under which a particular polarity (say positive) will be obtained at the output when the inputs are considered to have, or not to have, the same polarity (say positive). Once the "normal" polarity of signal has been selected, the logical function which will be obtained from a given type of circuit is fixed, and this will determine the logic which is used in the design of complete systems using combinations of that circuit. If we decide to think in terms of negative signals with Fig. 1, we can design a system using NOR logic. On the other hand, if we decide to think in terms of positive signals using the same circuit, we can design the same system using NAND logic. As mentioned above, the difference exists only in the mind.

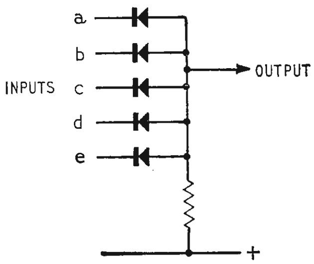
	INPUTS −	INPUTS +	
	NOR	AND	− OUTPUT
	OR	NAND	+ OUTPUT

Left: Fig. 4. Matrix of uses of circuit of Fig. 1 in terms of input and output polarities.

	INPUTS −	INPUTS +	
	NAND	OR	− OUTPUT
	AND	NOR	+ OUTPUT

Right: Fig. 5. Matrix for circuit of Fig. 3.

Now it is not at all essential to accept these restricted modes of thought when designing a system using a particular type of unit. Why fix a "normal" polarity of signal at all? It sometimes simplifies matters if the input and output polarities are thought of as different, e.g., "What combination of negative inputs will produce a positive output?". To illustrate this, if the circuit of Fig. 1 is considered as giving a positive output signal, and we determine what combination of negative input signals will give an output, it will be seen that a (positive) output is obtained when a (negative) input signal is applied to either a OR to b OR to c, etc., and Fig. 1 becomes an OR circuit. On the other hand, if the output is thought of as negative and the inputs as positive, a (negative) output is obtained only if (positive) input signals are applied to a AND to b AND to c, etc., and Fig. 1 is an AND circuit. Another example has been noted above, where it was mentioned that the circuit of Fig. 3 has been



Right: Fig. 6. Diode "AND" circuit.

	INPUTS −	INPUTS +	
	OR	NAND	− OUTPUT
	NOR	AND	+ OUTPUT

Left: Fig. 7. Matrix for circuit of Fig. 6.

referred to in the literature as an AND circuit[3], as indeed it is if we think in terms of negative input and positive output signals.

When using a single type of unit to design complete switching systems, it is sometimes advantageous to free one's mind from the fixed-polarity mode of thought and to arrange for the correct polarity of inputs in order to obtain AND and OR functions. If a table is constructed showing the uses of Fig. 1 in terms of input and output polarities, we obtain:—

INPUT POLARITY	OUTPUT POLARITY	FUNCTION
NEGATIVE	NEGATIVE	NOR
NEGATIVE	POSITIVE	OR
POSITIVE	NEGATIVE	AND
POSITIVE	POSITIVE	NAND

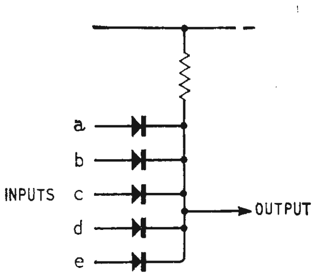
This table can be put in matrix form as shown in Fig. 4, while the corresponding matrix for the circuit of Fig. 3 is given in Fig. 5.

Once one has accepted this concept of a variable-polarity logic and one has released one's mind from the limitations of fixed-polarity logic, one is prepared to accept the use of the usual simple diode AND circuit to obtain other functions than AND. For example, the matrix for the fixed-polarity positive-signal diode AND circuit of Fig. 6 is given in Fig. 7, while the circuit and variable-polarity matrix of a positive-signal diode OR circuit are given in Figs. 8 and 9 respectively.

It can now be seen that each of the four circuits given above can give any of the four functions AND, OR, NOR and NAND if variable-polarity logic is used. This raises the question of whether or not it is possible to build complete logical systems using only, say, the circuit of Fig. 8. It is not possible to achieve this because firstly some form of power amplification is required and secondly phase inversion is necessary if variable-polarity logic is to be used at all in practice. However, as is known, the circuits of Fig. 1 and Fig. 3, which incorporate both power amplification and phase inversion, can be used to construct complete systems. It is often possible to sketch out a system using the English terms AND, OR and NOR and then, by using variable-polarity logic, to substitute the circuit of, say, Fig. 1 for the various functions. This is an alternative to the conversion of the system requirements into the NOR or NAND form by the use of Boolean algebra. The variable-polarity approach can simplify the first attempt at the design of a scheme, though it may be necessary to eliminate redundant elements later.

Matrix Classification

The variable-polarity approach to the design of switching systems might not suit all engineers. However, the variable-polarity matrices do give a clue to a classification of transistor static switching circuits which can help to overcome the necessity, in order to make quite clear just what is meant, for using terms like "fixed-polarity negative-signal resistor-transistor NOR circuit". The circuit of Fig. 1 gives a positive output if any one input is negative, whereas that of Fig. 3 gives a negative output if any one input signal is positive. It is therefore possible to refer to Fig. 1 as a "Positive output for ONE Negative input" or a "P1N" circuit, and to Fig. 3 as a "Negative output for ONE Positive input" or an "N1P" circuit. Under this convention, a version of Fig. 1 using an n-p-n transistor would be an N1P circuit, and it would carry out the same logical functions, and have the same variable-polarity matrix as the circuit of Fig. 3. Using this form of classification, any circuit which gives the matrix of Fig. 7 becomes an N1N circuit and a circuit giving the matrix of Fig. 9 is a P1P circuit. This classification can be obtained from the matrix by looking at the output and input polarities corresponding to the OR function on the matrix. An alternative is to write down all possible combinations of input polarities and the resulting output polarities as shown in Fig. 10, when the classification becomes obvious by inspection. There have been proposals to design the circuit of Fig. 1 so that not one, but two or more inputs must be negative in order to bottom the transistor[4]. Such a design would be a P2N circuit in the classification discussed above.



Left: Fig. 8. Diode "OR" circuit.

	INPUTS −	INPUTS +	
	AND	NOR	OUTPUT −
	NAND	OR	OUTPUT +

Right: Fig. 9. Matrix for circuit of Fig. 8.

INPUTS A B C	OUTPUT P1N	N1P	N1N	P1P	P2N
+ + +	−	−	+	+	−
+ + −	+	−	−	+	−
+ − +	+	−	−	+	−
+ − −	+	−	−	+	+
− + +	+	−	−	+	−
− + −	+	−	−	+	+
− − +	+	−	−	+	+
− − −	+	+	−	−	+

Fig 10. Classification of circuits from input and output polarities.

We can now see one reason for the confusion of names which has arisen in the field of static switching by examining a typical matrix, say that of Fig. 4. A circuit described by this matrix can be used to obtain any of the four functions shown in the matrix, the function obtained depending on how we define the "Normal" input and output polarities. Consequently, it is not really satisfactory to name such a circuit after any one of these four functions, even if we substitute some other name for another particular function (e.g. for NAND). The fact that the designer of a unit prefers to use one or another particular form of mathematical logic to design complete schemes is no longer sufficient justification for limiting the description of the unit to only one of its possible logical functions, unless the input and output polarities are also stated each time the description is used. If we do not try to keep circuit descriptions apart from semi-mathematical terms, the confusion of names will increase. In this connection, it should perhaps be mentioned that the classification of circuits based on their matrices which has been discussed above is an attempt to shed some light on the present position, not an attempt to throw a few more names into an overflowing melting pot.

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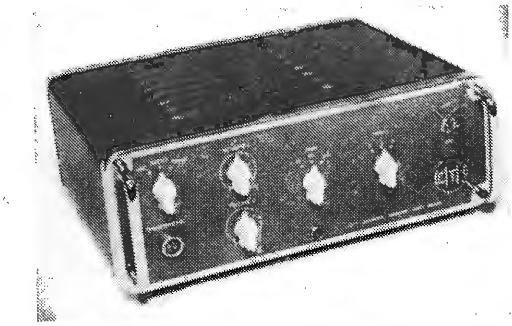

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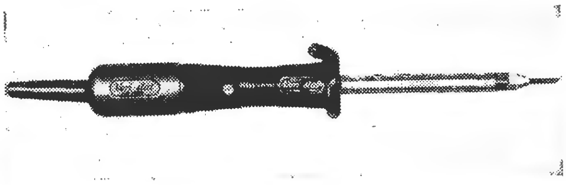
Front Fixing Control Knob

FRONT fixing by collet tightening screw is a feature of the range of control knobs now marketed by A. F. Bulgin & Co. Ltd., Bye-Pass Road, Barking, Essex. The tightening device is concealed by a clip-in plastic cap, which is available in a range of colours—as are the knobs themselves, although these are normally in black Bakelite. The type numbers are K460-K465.

Thermostatically Controlled Soldering Iron

WEIGHING only 1¾oz, the latest type of thermostatically controlled iron from Cardross Engineering Co. Ltd. is ready for use 20sec after switching on. The element is rated at 50W and is available for various voltages between 12 and 240. Bit sizes are $\frac{1}{32}$, $\frac{1}{16}$ and $\frac{3}{32}$in in diameter.

The thermostat control maintains a constant bit temperature, which can be set to suit the job to be done. The high rating of the element means that many joints can be made rapidly without the bit-temperature falling. The life of the bit and element should be prolonged as the temperature is not allowed to rise when the iron is removed from the work. The retail price of the



Cardross Engineering thermostatically-controlled soldering iron.

iron is £2 15s and it is made by Cardross Engineering Co. Ltd., Levenford Works, Woodyard Road, Dumbarton.

Right-angle Cable Plug

ACCESS to the inner conductor is provided in the Sealectro Conhex r.f. right-angle plug. The entry jack is intended for a 0.04in pin and is p.t.f.e.-insulated. The plugs are available in 50Ω or 75Ω types, from Sealectro Corporation, Hersham Factory Estate, Walton-on-Thames, Surrey.

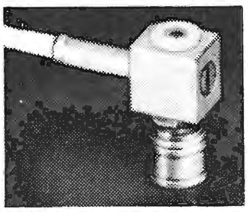
Plug-in Transformers

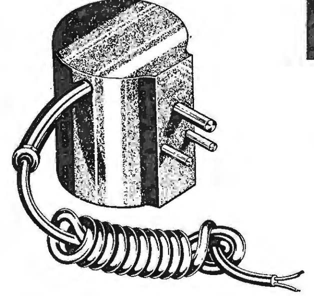
HOW often, when using a low-voltage appliance fed from the mains by a separate transformer, does the resulting multiplicity of cables and plugs cause confusion, apart from the inconvenience of having yet another "box" taking up valuable bench space or waiting to be fallen over on the floor?

A transformer combined with a mains plug is a particularly convenient way of overcoming all the snags. This is a new product from the Nelson Engineering Co. Ltd., Netherfield Road, Nelson, Lancs.

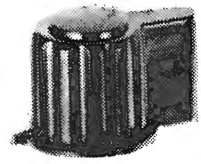
Units rated at up to 60VA are available moulded in epoxy resin housings, with standard plugs for insertion in mains sockets; a lead is fitted on the low-voltage side,

Right: Sealectro Conhex right-angle connector. The test jack is opposite the plug termination.





Nelson plug-in transformer fitting 5-A three-pin socket.



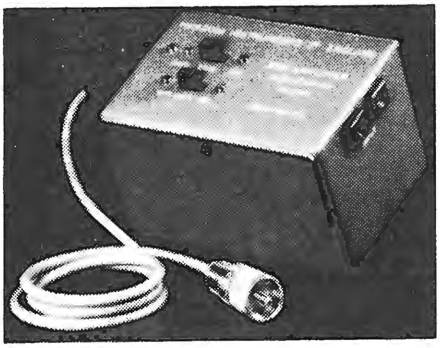
Bulgin collet-fixing control knob, Type K462.

for connection to the appliance. Another type has a moulded hook for hanging on the wall near the socket outlet.

Prices range from £3 12s and a variety of voltages and plug-pin combinations are catered for.

Oscilloscope Pre-amplifier

A VOLTAGE gain of 10 or 100 over the range 3c/s-100kc/s is provided by the Marconi Instruments TM6591 oscilloscope pre-amplifier, which is battery powered. The use of semiconductors avoids the masking of low-level phenomena by hum, and 200μV wave-

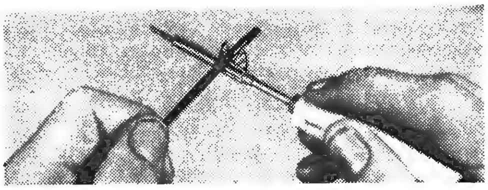


Oscilloscope pre-amplifier by Marconi Instruments.

forms from low-impedance sources may be examined. A leaflet is supplied by Marconi Instruments Ltd., Longacres, St. Albans.

Simple Heated Wire-stripper

PRIMARILY for use on Antex soldering irons, but equally useful on other irons with bits in the region of 0.25-in diameter, the Antex wire-stripper consists of a



Antex cable-cover stripper mounted on soldering-iron bit. Wire is pushed into the V-nick and rotated.

simple V-shape cutting nick in a steel strip that is formed to slip on to the soldering iron bit. Costing 1s, the stripper is effective on thermoplastic cable coverings.

Anglo-Netherland Technical Exchange Ltd., 7/8, Idol Lane, London, E.C.3.

Capacitors and Resistors

ALSTON Capacitors Ltd. have recently introduced a range of silvered-mica capacitors, moulded in high-temperature polythene that meet the acceptance tests for H.1. grading prescribed in specification DEF 5132. Alston Capacitors, recently acquired by Alma Components Ltd., make their range AG in values between 100pF and 1500pF in up to $\pm 1\%$ tolerance and ± 1pF from 10pF to 100pF. The temperature coefficient is less than 60 parts/10^6/°C and voltage ratings are 350 and 750V (d.c.). Type AH is similar electrically, but in a larger case, and values range from 470pF to 0.01μF.

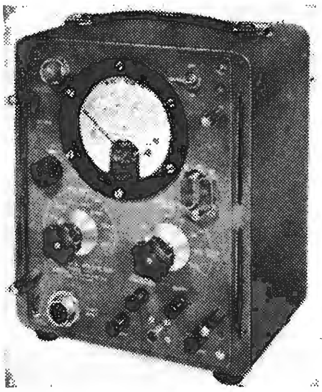
A new Alma Components product is a range of positive-temperature-coefficient resistors designed for the provision of temperature compensation with the high coefficient +0.45%/°C. The resistors are sealed and values range from 5Ω to 2.5kΩ.

Alston Capacitors Ltd., and Alma Components Ltd., 551 Holloway Road, London, N.19.

True R.M.S. Voltmeter

MEASUREMENT of receiver noise is facilitated by the Cossor Instruments Model 1453. A gain-stable wide band amplifier feeds a vacuo-junction, which then indicates on a 3½ in meter. On ranges up to 10V f.s.d., the response is within ± 0.6dB of true r.m.s. values from 50c/s to 10Mc/s at 20°C, and on the higher range is 1.5dB down at 10kc/s. Input impedances of 75Ω to 1MΩ are provided, and a high-pass filter can be used

Cossor R.M.S. Voltmeter Model 1453.



for mains hum elimination. The instrument is made by Cossor Instruments Ltd., Cossor House, Highbury Grove, London, N.5.

Light-weight Ultrasonic Flaw Detector

WEIGHING only 28lb the Ultrasonoscope Mk. III Flaw Detector incorporates circuits for the suppression of echoes from grain boundaries so that fault signals are thrown up in high relief. A switch provides for the use of a single probe for transmission and reception or for separate probes; the frequency range is 1.5 to 5Mc/s. The display tube is five inches in diameter and a camera adaptor is available for the recording of results. Ultrasonoscope Co. (London) Ltd., Sudbourne Road, Brixton Hill, London, S.W.2.

Ultrasonoscope Mk. III ultrasonic tester.

News from Industry

G.E.C. Head Office, formerly at Magnet House, Kingsway, London, W.C.2, has now been moved to Greycoat House, Greycoat Place, Victoria, S.W.1 (Tel.: Sullivan 3411). Housed there are the accounts, cashiers, central publicity, estates, personnel, public relations and share and transfer departments, together with the economics unit, overseas operations division and deputy secretary. The directors of the G.E.C., company secretary and company controller are at the Offices of the Board, situated in Glen House, Stag Place, Victoria, S.W.1. Central marketing, export accounts, government and railways department, house engineers and overseas administration are located at Kemble House, Kemble Street, Kingsway, W.C.2 (Tel.: Temple Bar 8000). Enquiries regarding sales and service of G.E.C. products should continue to be made to the appropriate subsidiary company.

S.T.C. has formed a new electro-mechanical division at Harlow, Essex, to make and market a wide range of products, including telecommunication relays and microphones. D. A. Lush has been appointed divisional general manager and A. C. Carter is marketing manager for the new division, which will take over S.T.C.'s present quartz crystal factory in Harlow when the crystal division moves into a new factory later this year.

Grundig announce that in view of the expansion of their interests which now includes the production and sale of components as well as radio and TV receivers, tape recorders and electronic measuring instruments, the name of the firm, formerly Grundig Radio-Werke G.m.b.H., has been changed simply to Grundig-Werke G.m.b.H. (Fürth/Bayern, Germany).

Telegraph Condenser Co. Ltd.—Group trading profit for the year to December 31st last amounted to £674,560 which compares with £701,737 for 1960. Net profit, subject to taxation and appropriations, is some £25,000 lower. W. C. Handley, chairman, reports that overseas trading during 1961 broke all previous records and went a long way towards offsetting the reduction in home demands. He said the company's partnership with the American Sprague Electric Company was proving of great mutual benefit.

Ever Ready Co. (Great Britain) Ltd. announce that the consolidated net profit for the period from February 26th, 1961, to March 3rd, 1962, after all charges, including taxation, amounted to £1,764,356 compared with £1,706,526 for the previous year. The net profit before taxation amounted to £3,362,268 compared with £3,075,458.

Cambridge Instrument Apprenticeship Schemes are detailed in an illustrated brochure, which has been produced by the company for the guidance of young men contemplating a career in the instrument industry. Information on the types of apprenticeship available is given in the brochure, which also sketches the history of the company and describes some of the instruments it makes. Copies of the brochure are available on application to the Cambridge Instrument Co. Ltd., 13 Grosvenor Place, London, S.W.1.

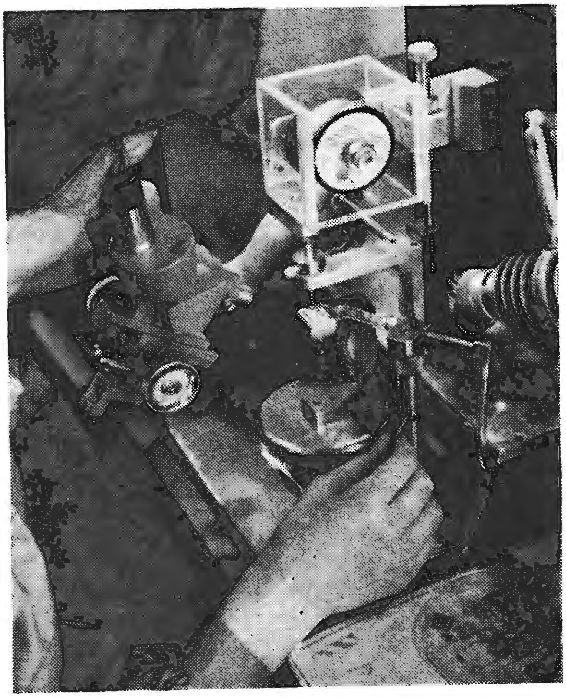
A delayed sound reinforcement system has been installed in the new Coventry Cathedral by Pamphonic Reproducers Ltd. The system, known as D.S.R., eliminates unwanted echoes by delaying the output from each loudspeaker by a fraction of a second so that the final sound from all loudspeakers is synchronized with the arrival of the original sound.

Hewlett-Packard is to expand its marketing organization in the U.K. as from January 1st next by setting up a new sales and service department at its Bedford factory. The company has appointed Dennis P. Taylor as marketing manager, and is also planning to expand its manufacturing sources. Mr. Taylor is to spend several months with the American parent company at Palo Alto, California, before taking up his duties at Bedford. He was previously sales manager of Solartron's Data Processing Division. Livingston Laboratories, who have represented Hewlett-Packard in the U.K. for the past seven years, will continue to offer sales and service of the wide range of Hewlett-Packard electronic instruments to industry.

Microdot electronic components, including miniature and sub-miniature r.f. connectors, together with a wide range of measuring devices (strain gauges, temperature transducers, and r.f. test and telemetry equipment) manufactured by Microdot Inc., of South Pasadena, California, U.S.A., are to be marketed in the U.K. and Australia by Belling & Lee Ltd.

Microwave instruments, including MTI radar test sets, pulse jitter and stability testers, and encapsulated microwave components, produced by Laboratory for Electronics Inc., of Boston, U.S.A., are to be marketed in the U.K. by James Scott (Electronic Engineering) Ltd., 68 Brockville Street, Glasgow, E.2 (Tel.: Shettleston 4206).

Semiconductor networks, *consisting of a complete circuit element—diodes, resistors and capacitors—produced out of silicon by the basic diffusion process, are being manufactured at the Bedford factory of Texas Instruments. These units, which cost between £34 and £41 each, measure 1/8 x 1/4 x 1/32 in. The operator is shown bonding gold wires to an "S.C.N." with the aid of a microscope.*



Livingston Laboratories have set up a new organization to meet the call for an advisory service in the specialized field of control engineering. Basic modules of great flexibility are coming forward in increasing numbers for use in building complete systems which include sensory elements, operational electronics and actuating units. In addition to supplying these products from the world's leading manufacturers, engineering facilities will be available to adapt, supplement or provide systems to meet the needs of industry. The new organization, known as Livingston Control Ltd., has premises at Retcar Street, London, N.19 (Tel.: Archway 6251).

Patients' communications systems in Harlow New Town Hospital to the value of £20,000 are to be supplied by Hadley Telephone & Sound Systems Ltd., of Smethwick, Staffs. Equipment to be installed includes the Hadley Call Nurse patient-to-nurse visual and sound signalling system. This comprises a hand-held multi-service unit which provides at a touch a micro-speaker and nurse calling push-button, a radio programme selector switch, volume control and an over-bed light switch. Hadley are also to equip the hospital with a television aerial system for ward viewing.

A new marine service depot in Glasgow for Decca Radar Ltd. and Decca Navigator Company has been opened at 4 Shuna Place, N.W. This new principal sales and service depot for Scotland, is managed by C. P. Jones, and is responsible for all Decca sales and installations in new tonnage at shipyards on the Clyde, as well as for services to general shipping on the Clyde, Forth, and in other parts of Scotland.

Specialized electronic chemicals of defined purity are described in a new illustrated booklet on "Baker Analyzed" reagents (including semiconductor, emission, ferrite and thermistor chemicals) manufactured by the American J. T. Baker chemical company. Sole U.K. distributors are Omni (G.B.) Ltd., of 35 Dover Street, London, W.1 (Tel.: Hyde Park 9451), from whom copies of the booklet may be obtained.

Telemetry equipment, designed in conjunction with the Signals Research Development Establishment, and manufactured by the Military Radar Group (Manchester) of the A.E.I. Electronic Apparatus Division, was used in a recent firing of a Skylark high altitude research rocket in trials at the Woomera Range in Australia. The rocket was successfully fired to a height of over 80 miles and the instrumentation head subsequently recovered.

A Navigational and Instrumentation Division has been formed by Winston Electronics Ltd., Shepperton, Middx., a subsidiary of the Dynamics Corporation of America. It is initially concerned with a new airborne digital computer and factory production instrumentation.

Sunderland Harbour's existing port services are to be supplemented by a two-channel v.h.f. radio-telephone system, which is to be supplied by the Marine Department of A.E.I.'s Telecommunications Division, Woolwich, London. The new equipment will be installed by A.E.I. at the Pilot House and will enable ships to obtain pilotage and port information directly.

Polyshrink, a shrink-on PVC sleeving which diminishes in diameter by up to 30% when heated, and other plastics sleeving for the electrical and electronic industries, is to be marketed by Hayward Turbine Plastics Ltd., of Chiltern Avenue, Woodside Road, Amersham, Bucks., (Tel.: Amersham 2101), a newly formed subsidiary company of Hayward Turbine Engineering Ltd., of Acton.

Tectonic Industrial Printers Ltd., manufacturers of printed circuits and components, have moved to new premises at Cirtec Works, Frederick Place, Oxford Road, Wokingham, Berks. (Tel.: Wokingham 1150).

M.I.P. in India.—Measuring Instruments (Pullin) Ltd. have just completed arrangements for most of their range of voltmeters and ammeters to be made under licence in India by the newly formed Measuring Instruments (Private) Ltd., of Bombay. Managing director of the new venture, which is not a subsidiary of the U.K. company, is J. Chablani, who has recently completed an intensive study of M.I.P.'s manufacturing and assembly methods at the Acton works.

American type valves and semiconductors to Air Registration Board requirements are now available from Walmore Electronics Ltd., of 11-15 Betterton Street, Drury Lane, London, W.C.2, who are now approved suppliers. Walmore state that they have stocks of types in regular demand and spares can be supplied with A.R.B. release notes.

OVERSEAS TRADE

Storm-warning surveillance radar, to cover the inhabited areas of the north-eastern coast of Australia threatened by tropical cyclones, is being supplied by Cossor Radar & Electronics Ltd. Weighing over eight tons, part of the radar equipment will be installed on Saddle Mountain in N. Queensland. From there data will be received via a 7-mile microwave radio link to other portions of the equipment installed at Cairns Airport. The radar has a nominal range of 240 miles and facilitates observation and tracking of storm centres, whose characteristic cloud patterns can be seen on a P.P.I. display. Iso-echo facilities will enable the densities of clouds and precipitation to be assessed.

A 2,500-mile tour of Western Europe is at present being undertaken by E.M.I. Electronics' mobile demonstration unit. The route is Holland-Germany-Switzerland-Italy-France-Belgium with the aim of showing E.M.I.'s latest electronic equipment, including closed-circuit television, to universities, technical high schools, factories and atomic energy commissions.

Malayan Microwave Link.—Equipment operating in the 6,000 Mc/s s.h.f. band is to be supplied by the General Electric Co. Ltd. for a broadband radio communication system in Malaya between Penang and Gunong Kledang, near Ipoh, with an intermediate repeater station at Maxwell's Hill.

Two Canadian railway companies have placed orders worth about $450,000 with Automatic Telephone & Electric Company for transistor telephone and broadcast channelling equipment for use on existing radio carrier circuits between Moncton-Halifax-Sydney and Moncton-Quebec-Montreal.

Westrex Co. Ltd., of Cricklewood, London, N.W.2, have supplied sound recording—reproducing equipment and picture projection equipment for the Radio Eireann Newsreel and Film Centre in Dublin.

Singapore's international airport at Paya Lebar is to be equipped with Decca DASR-1 surveillance radar. This long-range 10-cm system utilizes two 800-kW transmitters feeding two aerials (one for high cover and the other low cover) mounted back to back.

Two microwave radar links for incorporation into Norway's defence system as part of the N.A.T.O. Infrastructure programme, are to be supplied to the Royal Norwegian Air Force by Marconi's Wireless Telegraph Company under a £500,000 contract.

A repeat order from the Royal Danish Navy for radar equipment to the value of about £90,000 has been received by Decca Radar Ltd.

CLUB NEWS

Barnsley.—The last meeting of the Barnsley and District Amateur Radio Club before the summer recess will be a visit to the Holme Moss television transmitter of the B.B.C. on July 13th.

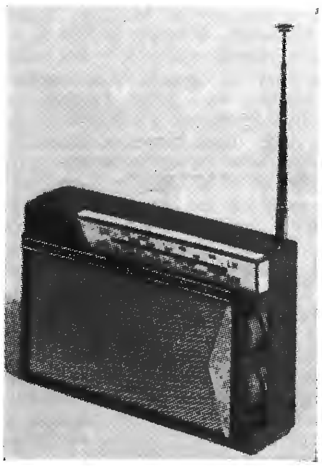
Bradford.—"160 metre SSB-QRP" is the title of the talk to be given by D. Millard (G3OGV) to members of the Bradford Radio Society at 7.30 on July 24th. The club headquarters are at Cambridge House, 66 Little Horton Lane, Bradford, 5.

Eccles.—At the meeting of the Eccles and District Radio Club on July 24th D. Atter (G3GRO) will talk on amateur communication receiver design. The club meets each Tuesday at 8.0 at the Congregational Mission Church, King Street, Eccles.

Erith.—GB3ENT, the transmitter of the North Kent Radio Society, will again be operated from the Borough of Erith's annual show at the Erith recreation ground on August 6th.

Sidcup.—G. Stone (G3FZL) will talk about v.h.f. operation at the June 26th meeting of the Cray Valley Radio Club which will be held at 8.0 at the Station Hotel.

Malmö Shortwave Club.—The U.K. representative of the Malmö Shortwave Club, which was formed in 1948, has sent us particulars of the club which issues "Malmö DX-aren" monthly. Details are obtainable from G. Traynor, 52 Kilbarchan Road, Johnstone, Renfrewshire, Scotland.



Fidelity "Floret" receiver shown in the photograph uses a complementary pair of transistors (n-p-n and p-n-p) to enable the driver and output transformers to be eliminated. Direct coupling is also used between the driver and output stages. Cross-over distortion is greatly reduced with this circuitry, allowing longer use of the batteries. Another unusual feature of this receiver is that the driver base bias (which is derived from the emitters of the output transistors) can be adjusted to equalize the outputs from these transistors.

UNBIASED

By "FREE GRID"

Quantum Telegraphy

AN interesting discussion appeared in the March issue of the *Proceedings of the I.R.E.* concerning the origin of the application of the word "radio" to what we still call wireless.

The use of the word "radio" to describe communication by means of electromagnetic waves, is far older than that of "wireless" if we permit ourselves to go ouside the spectral band governed, in this country, by the Postmaster General. We have all heard of the photophone whereby a beam of light, originating at the transmitting end, was allowed to fall on a piece of selenium at the receiving end. This light was waggled by a mirror attached to the diaphragm of a microphone, causing variations in the resistance of the selenium.

It appears that in place of Bell's word photophone to describe this device, Mercadier in 1880 used the word "radiophone." Of course, the word "radio" was used before that but not, apparently, in connection with communications. Thus in 1875 Crookes used the word radiometer to describe the little rotating device often seen even today as an attention-attracting gimmick in the window of a chemist's shop. However, it appears that it was not until 1907 that the word radio was used in the U.S.A. to describe communication by means of Hertzian waves.

To my mind the strangest part of the whole business is that since about 1917, according to *Proc. I.R.E.* correspondents, the Americans have been using the word "radio" to describe c.w. communication as distinct from the wave-group system radiated by spark transmitters, which they continue to call "wireless." Spark transmission has ceased to be used nowadays but the Americans seem still to use the word "wireless" when they wish to refer to it.

I have used the word "strange" in connection with this, and what I mean is the utter inconsistency of a nation, so wedded to Latin-derived nomenclature in words like escalator, preserving an Anglo-Saxon word like "wireless" when there is a ready-made Latin-derived word to hand which is so very apt. I refer to "quantum," a completely common-place word in scientific circles.

To me it seems that Planck might have coined the word specially to describe spark telegraphy where the waves, and the energy they carry, do indeed come in bunches or "quanta," in contrast to the smooth undulations of c.w. For a nation which discards the word "lift" in favour of "elevator," it seems almost a crime not to turn "wireless telegraphy" into "quantum telegraphy." For the sake of harmony with the word "radio," which is, after all, merely the ablative of the Latin word "radius," "quanto" the ablative of "quantum," would naturally be used.

Stereo Thermophony

I READ with great interest the Editor's remarks in the May issue about the present position of stereophony. He seemed to deal with matters in such a careful word-choosing manner that I realized he was being as meticulous as one of H.M. judges summing up the evidence for a jury which might not possess his own deep knowledge of the technicalities of the matter under consideration.

In fact, his words seemed to me so like the careful summing up of a judge that I half expected him to conclude by inviting us to retire and consider our verdict. But at the last moment, just as he had finished his peroration, it seemed as though Mr. Briggs rushed into court—as he did into *W.W.'s* correspondence columns —with fresh evidence.

Mr. Briggs is not the first person to notice what he tells us about but perhaps nobody could have put the matter so succinctly as he when he states that a warm concert hall—80° F or so in the U.S.A.—causes the strings to sound smooth and silky, and the brass to sound strident. But in a chilly British concert hall, some 15° F coooler, the very reverse holds true. This effect can only be described by the word dysphony, or should we call it the Briggs Effect.

To try to overcome this effect by building an electrical heater into a Stradivarius would be unthinkable, but we could cool the hall down to euphonic brass level, and then dress the strings players in electrically heated suits to produce local thermal ambience; but that would be useless as it is the temperature of the whole volume of air between orchestra and audience which is the vital factor.

We could put the strings in one hall and the brass in another, or even have a separate room for each orchestral instrument, the conductor's figure appearing on a large closed-circuit TV screen in front of each player. Each room could then be adjusted to a special optimal temperature. A battery of loudspeakers —one to each orchestral instrument, or two for a stereo—would face the audience; surely a loudspeaker manufacturer's dream of Elysium.

Unfortunately this elaborate arrangement would simply leave us "as you were." Even if loudspeakers were abondoned and each member of the audience wore headphones, the air between diaphragm and eardrum would soon warm up and thus be right for strings and wrong for brass. The only remedy would seem to be a bone-conduction hearing-aid unit, thus cutting out air entirely as a sound-conducting medium.

Frankly the whole problem is beyond me, and I must leave it to be solved by some of you sonic savants.

Per Mare Ad Astra

I MUST apologize to the Borough of Southend-on-Sea and to the R.A.F. for marrying the first and last parts of their respective mottoes to give me a title for this note. The reason for this title is that I have been re-reading Hancock's "Wireless at Sea; The First Fifty Years," and have been struck by his remarks about the number of wireless operators who have reached positions of eminence.

It is not very surprising to find that ships' operators—or radio officers as they are called nowadays—attain high positions (mainly administrative) in the wireless companies which employ them. I suppose every reader has heard of David Sarnoff, the famous chief of the Radio Corporation of America. Other well-known figures include Sir Ernest Fisk, one-time managing director of E.M.I., and R. Ferguson, until recently managing director of Marconi Marine.

However, *Wireless World* is, after all, a *journal* and so it is not surprising that we should be interested in operators who have become well-known figures in the world of print. At once, there comes to mind H. F. Smith, who served for many years as Editor of *W.W.* Passing from excelsus to excelsior we come to Sir William Haley, the one-time director-general of the B.B.C. who is now Editor of *The Times.*

There are many other examples of success in the world of printers' ink, but this is not so strange when you recall the excellent journalistic training which a sea-going operator of 40 or 50 years ago automatically received. As I related in our 25th anniversary number one of the most important duties of an operator was to see that the news bulletin was on the captain's breakfast table.

Sometimes in those days of relatively restricted ranges, it was well-nigh impossible to read the signals of the transmitter sending the bulletin. This meant that the operator* was forced back on his own resources. He soon learned what sort of news tickled the palates of his readers, and surely the ability to do that is the very stuff of which a good journalist is made.

* Why the third person?—ED.