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Commentary

THE output of scientific information has been increasing at an enormous rate in the last decade or so, but it has been recognized for some time past that the time available for reading and digesting this ever-growing volume of information is strictly limited and indeed there are many who declare that it is getting less.

The problems associated with the publication of specialized technical information are of great concern to us, and particularly welcome, therefore, is the appearance of a survey* recently carried out at the request of the Department of Scientific and Industrial Research as part of a programme of inquiry into the dissemination to industry of the results of scientific and technological research.

The terms of reference were, broadly, to examine the use made of technical literature by industrial technologists in the United Kingdom, and, because of the wide diversity of industry as a whole it was decided that the most fruitful and most accurate results could be obtained if its activities were confined to the electrical and electronic industry of this country.

A survey of this kind must of necessity be made on a selective basis if it is to be kept within reasonable bounds, and was therefore limited to industrial establishments with between 200 and 1 000 employees and attention was focused on those individuals engaged in research, development and production and who were likely to influence or be influenced by the use of technical information.

Similarly, technical information was confined to that making its appearance in the journals of the relevant professional institutions and to periodicals.

Scientific reports coming from the various research laboratories of the Government and the D.S.I.R., which must constitute a large proportion of the reading matter—how much it is difficult to estimate—are excluded from the survey. Likewise, scientists and technologists in the Government Research Establishments and the Universities are left out.

Nevertheless, with these restrictions of readers and reading matter, the survey seeks to find out who reads what and when.

In the industrial establishments the average reader engaged in research and development, emerges as an individual of 35 years of age occupying his present position for three to four years in the firm where he has spent the last seven to eight years. If engaged in management he is ten years older, although there is no evidence that he has advanced in the hierachy from the research laboratory, but in research and management alike, only one in five appears to have academic or technical qualifications.

What constitutes reading matter is capable of wide interpretation and this accounts for the variety of journals each with its own technical level and content. No single journal can hope to cater for all needs and tastes, but the survey at least indicates a preference and this is for one of medium difficulty containing no reports of fundamental work, but among other things a large number of advertisement pages including a section for appointments vacant.

Wisely perhaps, no attempt is made to establish any order of importance.

Having dealt with readers and reading matter, the survey proceeds to ascertain when for the most part the technical reading is done. Pressure of work in an industrial establishment seems to preclude reading in the firm's time and it is perhaps only in Government Research Laboratories and Universities that the reading and absorbing of scientific information is acknowledged and accepted as "work".

Elsewhere, 'man goeth forth to his work and to his labour until the evening' and reading must be done at home where social and domestic interests compete for his time. Two-thirds of those interviewed do in fact settle down to their more serious reading when the day's work is done.

There seems to be no complete solution to this problem other than the obvious one, although some attempt has been made, particularly in the larger organizations where the requisite facilities exist, to alleviate these conditions by preliminary selection and by the preparation of abstracts, and so on, but if it is still true that "reading maketh a full man" he must not be put on a prescribed diet, but be left to browse at will.

* *"The use of technical literature by industrial technologists." — A report by Christopher Scott on a Survey designed by Leslie T. Wilkins, Central Office of Information.*

A Sine-Wave Generator with Periods of Hours

By G. Klein* and J. M. den Hertog*

By means of an 'inverse-function generator' it is possible to derive a triangular voltage accurately from a sinusoidal one. By applying negative feedback the reverse can also be achieved. Making use of this possibility an ulta-low frequency sine-wave generator was designed for maximal periods of 3½ hours. The distortion is then negligibly small. If a slight distortion is permissible, this period can be increased considerably. An important feature of this generator is the fact that no transient phenomena occur. The inverse-function generator can also be used for various other purposes, one of them being a logarithmic voltmeter covering the range from approximately 10mV to some tens of volts.

(Voir page 376 pour le résumé en français: Zusammenfassung in deutscher Sprache Seite 381)

FOR some purposes it would be desirable if sinusoidal voltages with a very low frequency were available. Especially in the study of mechanical vibration phenomena and in the automatic control field characteristic periods of minutes or even hours may occur. In this connexion it is interesting to investigate what period can still be realized with the aid of electronic components only. A possible lowering of the frequency with the usual phase-shift oscillators[1] (*RC*- or Wien-bridge type), is limited for the following reasons:

(1) With these oscillators the switching on of the apparatus and the changing of the frequency give rise to transient phenomena which take 5 to 10 periods to die out. This would become highly objectionable in the case of long periods.

(2) The amplitude-limiting element required for suppressing the distortion in the simple circuits must have a time-constant which is a few times greater than the longest period, so as to ensure that this element does not correct instantaneously, but takes the average of some periods. With these large time-constants, however, the faster disturbances will hardly be corrected, so that these should be kept as small as possible, thus making extra high demands on the stability of the circuit. These difficulties may be obviated by generating, simultaneously with the desired voltage, another voltage with the same amplitude and frequency, but shifted 90° in phase with respect to the first and by supplying both voltages to a square-law response element (for instance, a thermistor with two heating coils). In this case the amplitude is measured continuously ($V^2 \sin^2 \omega t + V^2 \cos^2 \omega t = V^2$) and the time-constant of the amplitude-limiting element can then be greatly reduced, which is advantageous with a view to the correction of possible disturbances.

The objection stated under (1) remains, however, and therefore sinusoidal voltages have been made by distorting triangular voltages by means of diodes or other non-linear elements. The reason for this is that by using good capacitors, triangular voltages of comparatively long periods can be made without experiencing appreciable difficulties. In this manner good sinusoidal voltages can be obtained. The degree of accuracy is governed mainly by the number of steps in which this transformation is effected and by the constancy of the characteristics of the non-linear elements. A feature of the method described in this article is that the sinusoidal voltage is exactly derived from a triangular one. This is achieved by making use of an inverse-function generator, a device also suitable for other applications. Before giving a description of the sine-wave generator the principle of this inverse-function generator and some of its applications will be dealt with.

Finally, it is noted that the u.l.f. generator described here produces no transient phenomena, except for a short warming-up effect after switching on.

The Inverse-Function Generator

The principal part of the inverse-function generator is formed by a difference amplifier (Fig. 1).

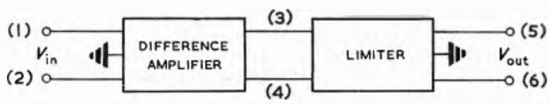

Fig. 1. Basic circuit for inverse-function generator

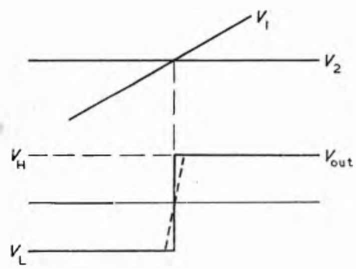

Fig. 2. Voltages at different points in Fig. 1

In principle a difference amplifier only amplifies the potential difference between the input terminals (1) and (2) and not the voltage difference which these points have in common with respect to earth. The degree to which this actually happens is determined by the rejection factor[2], i.e., the ratio between a common voltage difference on (1) and (2) with respect to earth and the voltage difference between these points which produces an equal voltage difference between the outputs (3) and (4). By increasing the amplification to a very high level and by keeping the output voltage between an upper limit V_H and a lower limit V_L by means of a limiter, it can be ensured that the following very close approximation applies (Fig. 2):

$$V_{out} (= V_{5\text{-}6}) = V_H \text{ for } V_{1\text{-}2} \text{ positive}$$

$$V_{out} = V_L \text{ for } V_{1\text{-}2} \text{ negative.}$$

In reality there will be some 'crossover', but by selecting

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the limits closely together and by making the amplification sufficiently large, the influence of this area can in most cases be made negligibly small.

It is now possible to obtain an inverse-function generator from the circuit shown in Fig. 1 in the following way.

Assume the voltage on point (1) to be a periodic function of time, e.g., a repeated exponential function as shown in Fig. 3(a). A voltage V_2 is applied to point 2. The output voltage will now have the shape as shown. The height of the pulses is always $V_H - V_L$. The width Δ can be found from the following calculation

$V_1 = V_r\ e^{-t/RC}$, thus $V_2 = V_r\ e^{-\Delta/RC}$ and

$\Delta = RC \ln V_r/V_2$ or $\Delta = \text{const.} - \text{const.} \ln V_2$

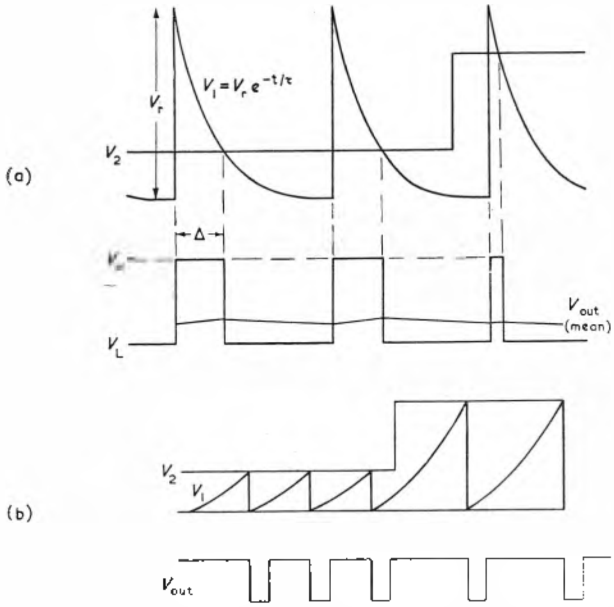


Fig. 3. Principle of inverse-function generator

By taking the mean value of V_{out} the following is thus achieved: Point (1) receives a periodical voltage which is an exponential function of time within the period. The output voltage V_{out} is now proportional to the logarithm of the voltage on point (2).

It will be clear that V_2 need not be a direct voltage, but the highest frequency therein must be small compared with the frequency of the scanning voltage V_1, so that it is always possible to take the average of a sufficient number of periods.

What applies here to a voltage which is an exponential function of time. also applies to other functions of time.

If V_1 is a sinusoidal voltage $V_r \sin \omega t$, V_{out} is determined by:

$$V_{out} \propto \arcsin V_2/V_r$$

This transformation is the basis of the ultra low frequency generator, as will be shown in the next paragraph.

If it is assumed that $V_1 = V_r t^2$, then $V_{out} \propto \sqrt{V_2}$.

Another possibility is that the scanning frequency of V_1 is determined by V_r and that at every flyback a pulse arises whose height and width are independent of V_2 (Fig. 3(b)). In this way the reciprocal of the inverse functions is obtained, e.g.:

$$V_1 = ct \text{ gives } V_{out} \propto (V_2)^{-1}$$
$$V_1 = ct^2 \text{ gives } V_{out} \propto (V_2)^{-\frac{1}{2}}$$

It is thus possible to realize by means of this inverse function generator rather intricate relations between V_{out} and V_2 starting from relatively simple time functions.

By making use of the possibility of making the output voltage proportional to the logarithm of a voltage, a logarithmic valve-voltmeter can be made. In principle this

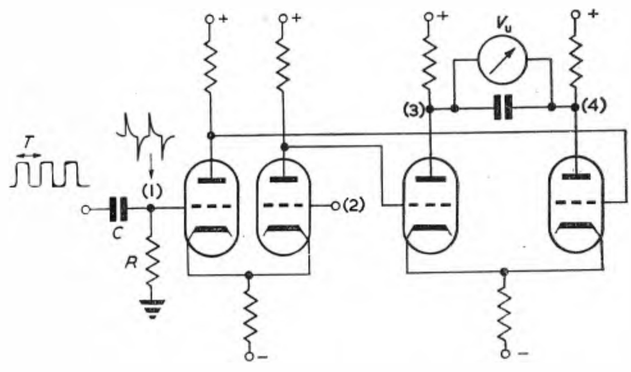


Fig. 4. Schematic of logarithmic voltmeter

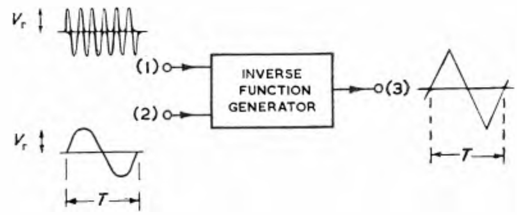


Fig. 5. Sine-triangle transformation

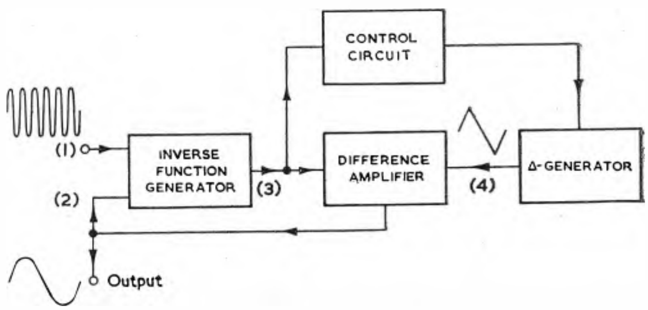


Fig. 6. Principle of ultra-low frequency generator

circuit consists of a conventional, direct-coupled difference amplifier, the output voltage of which is integrated (Fig. 4).

Input (1) receives an exponential voltage which is derived from a square-wave voltage with the aid of a high-pass RC filter. Both positive and negative voltages (V) may be applied to point (2). In this case a voltage which is proportional to $V/|V| \cdot \ln |V|$ is measured between the output terminals (3) and (4).

The amplitude of the square-wave voltage is selected some tens of per cent greater than $|V_2|_{max}$, while the voltage on point (1) must drop to a value which is many times smaller than $|V_2|_{min}$, the smallest voltage to be measured. If the latter condition is not fulfilled, the zero-level of the exponential voltage will change and this will give rise to inaccuracies at the lowest voltages.

The highest voltage that can be dealt with by normal difference amplifiers is a few tens of volts. If the amplification is sufficient the lowest voltage is determined by the drift of the amplifier which, with some care, can be reduced to less than 1mV. This limitation will be indeed decisive for l.f. and d.c. amplification. In the case of h.f. amplification a smaller overall amplification will be the limiting factor, as the 'crossover' shown in Fig. 2 will become a substantial fraction of the total duration of the pulse and can no longer be neglected. It is therefore possible for a l.f. logarithmic voltmeter to cover the range from 10mV to 50V without any particular trouble. True, this range is relatively small (3·7 decades), if compared with the logarithmic current meters based on the logarithmic relation between current and voltage of diodes in the retarding field region, but these cannot readily be made suitable for measuring voltages in the millivolt range.

Ultra Low Frequency Generator

Principle

If a sinusoidal voltage with a sufficiently high frequency is applied to one input (1) of an inverse-function generator (Fig. 5), the output voltage (3) will depend on the voltage on (2) according to an arc-sine function. Expressed in a formula: If $V_1 = V_r \sin \omega t$ and $V_2 = V_2$ then $V_3 = V \text{ arc} \sin V_2/V_r$. Assuming V_2 to be a sinusoidal voltage with a low frequency compared with that of V_1, but with the same amplitude (V_r), the time dependence of V_3 will be as shown in Fig. 5: a triangular voltage, the amplitude of which is determined by the limits V_H and V_L of the inverse-function generator, but whose frequency is equal to that of V_2. In this way a sine-triangle transformation is effected. The reverse is now achieved by means of negative feedback (Fig. 6).

Because of the negative feedback to point (2), point (3) is forced to follow a triangular voltage on point (4). If this triangular voltage has the correct amplitude corresponding to the one shown in Fig. 5, a sinusoidal voltage with the amplitude of the h.f.-sinewave on (1) and the frequency of the triangular voltage will be present at point (2). Correct adjustment of the amplitude of the triangular voltage on (4) is ensured by the fact that the voltage on (3) determines the points of reversal, as will be shown in the description of the circuit. In the following paragraphs the various parts will be described in greater detail.

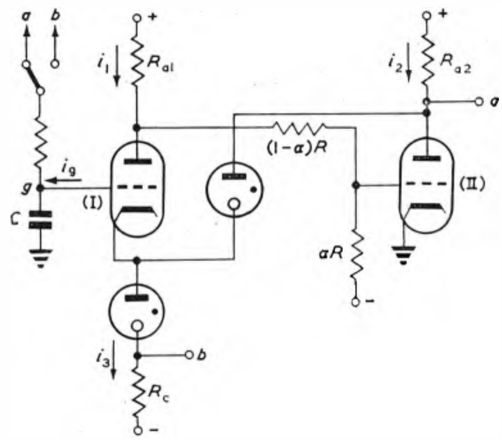


Fig. 8. Basic circuit of triangular voltage generator

Inverse-function Generator

The diagram of the inverse-function generator used is shown in Fig. 7. It consists of a two-stage difference amplifier. In the first stage a cascode circuit is used. Together with a large differential cathode-resistor (V_3) this circuit guarantees a reasonably high rejection factor. For the circuit proper a relatively low rejection factor suffices, but a high rejection factor reduces the demands made on the stabilization of the supply-voltages.

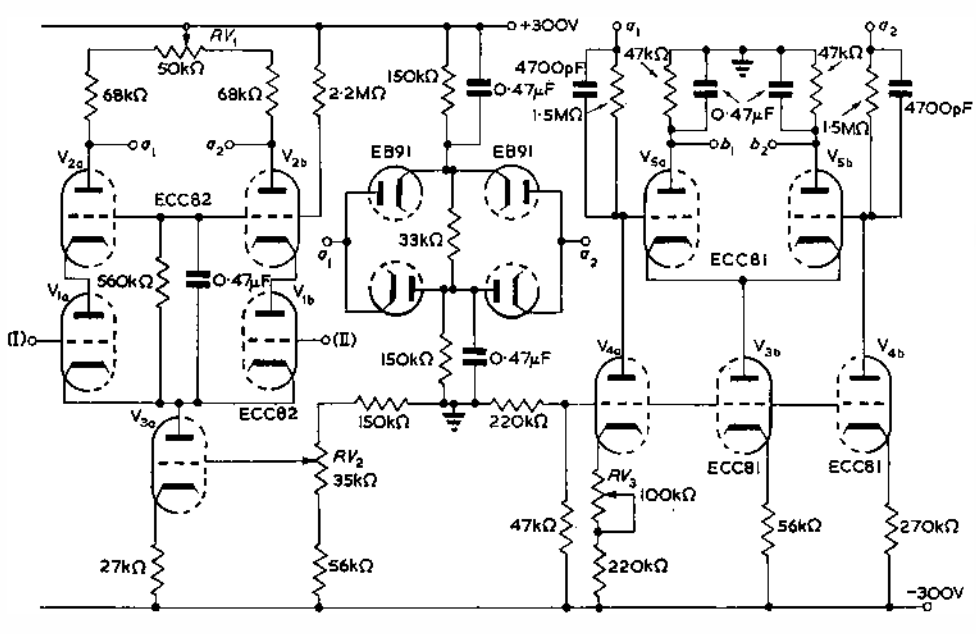
The voltage fluctuations on the anodes of this stage (a_1 and a_2) are limited by means of the EB91 diodes. The anodes are connected with the grids of the second stage by means of the potentiometer circuit consisting of a 1·5MΩ resistor and 4 700pF capacitor in parallel, in series with an artificially increased resistor, V_4. This potentiometer circuit permits of a considerable drop of level without any loss of amplification. In view of the connexion to the other equipment it was desirable to connect the anode resistors of the second stage to earth.

The smoothing is effected by the capacitors parallel to these resistors. The total amplification of this inverse-function generator is not particularly high, since the values selected for the input signals to I and II may be relatively high (some tens of volts), so that a sufficiently high degree of accuracy can already be attained at fairly low amplification levels. RV_1 and RV_3 are used for balancing the two stages while the correct level for the anodes a_1 and a_2 can be obtained by means of RV_2.

Triangular Voltage Generator

It is not very difficult to produce triangular voltages with a period of a few minutes. It becomes increasingly difficult, however, to extend this period to a couple of hours. In principle such a voltage

Fig. 7. Inverse-function generator used in u.l.f. generator



will be generated by having a capacitor charged by a constant current. The limiting factors are:

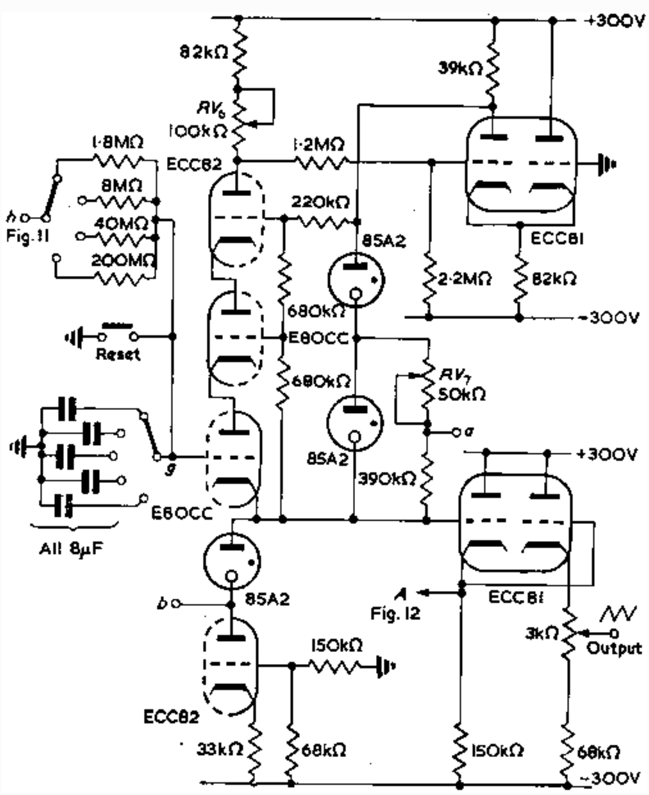
(1) Leakage of the capacitor: for obtaining these long periods a large capacitance will be preferred (some tens of microfarads), so as to make the demands on the other determining factors not too exorbitant. For good capacitors of this value mounted in the apparatus, leakage resistances corresponding to RC values of more than 10^5sec were found, so that in the case of periods of a few hours (10^4sec) this factor would not necessarily be limiting.

(2) The constancy of the charging current: as one preferably wants to generate a reasonably high voltage, the circuit must be such that the charging current is independent of the voltage on the capacitor.

(3) The capacitor must be connected to the grid of an amplifier valve. The grid current of this valve should preferably be very small throughout the entire voltage range.

The circuit diagram is shown in Fig. 8. The points a and b follow point g accurately, but on a d.c. level which is approximately 85V higher or lower than that of g. By connecting g to one of these points via a resistor the capacitor C is charged or discharged. A rough calculation (in which the internal resistance of the stabilizer tubes is neglected and a high amplification factor for the triodes and a high R_c value are used) gives the following result: a follows g, consequently $\Delta i_2 = \Delta V_g / R_{a2}$. Δi_1 and Δi_3 are very small, thus Δi_2 must be supplied by valve V_2, which requires a voltage variation $\Delta i_2 / S_2 = \Delta V_g / S_2 R_{a2}$ on the grid for this purpose. (S_2 = transconductance of valve II). This voltage variation requires $\Delta i_1 = V_g / S_2 R_{a2} \alpha R_{a1}$, which is achieved by creating a potential difference between the grid and the cathode of V_1, viz. of $\Delta V_g / S_2 R_{a2} \alpha S_1 R_{a1}$, a and b follow g but for the fraction $1/S_1 R_{a1} \alpha S_2 R_{a2}$, which is a few

Fig. 9. Complete circuit for triangular voltage generator



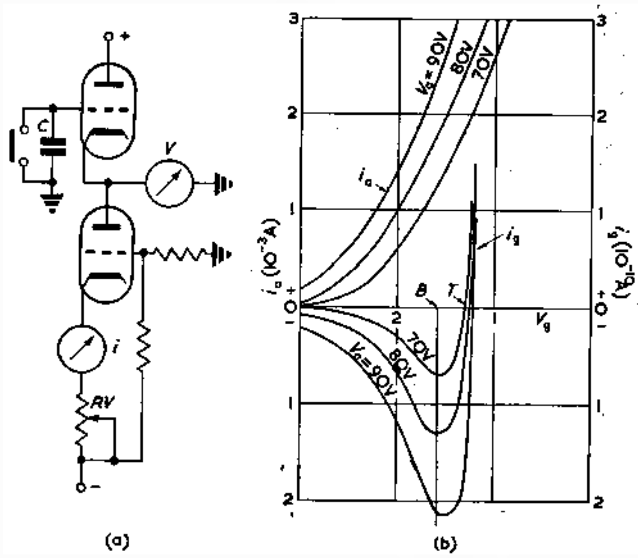


Fig. 10 (a) Circuit used for the measurement of grid-current

Fig. 10 (b) Anode-and grid-current of triode E80CC versus grid potential for different anode voltages

thousandths at most in the circuit used. This calculation is permissible because R_c is indeed many times greater than R_{a2} and, moreover, because V_1 in the circuit used is a triple cascode. This was done for the following reason:

A simple calculation shows that the grid current i_g of V_1 must be small. If the capacitance is assumed to be 40μF and if the voltage sweep is 50V, the resulting value is 2mC which must be supplied or carried off within half a period. For the longest period (approximately 12 500sec) this means a current of about 0·3μA. The grid current should therefore be preferably smaller than 10^{-9}A over the whole voltage range, a requirement which is not met by most valves without special provisions. In the circuit (Fig. 9) a triode E80CC is used in such a manner that its working-point remains unchanged, through the entire voltage range. This is achieved by means of the double cascode arrangement. The working-point is now so selected that the grid current is small. Fig. 10 shows a few characteristics for the triode E80CC measured in the arrangement represented by Fig. 10(a). By choosing a working-point at T the grid current is made zero, but in this point small changes in the supply voltages can cause a large grid current. Therefore it is better to choose the working-point at the left of B. The grid current is then of the order of magnitude of 10^{-10} A, which is sufficiently small.

The working point of the valve is adjusted by means of potentiometer RV_6 which determines the current through the cascode. The voltage difference $V_a - V_g$ is made equal to $V_g - V_b$ by means of RV_7, so that the leading and trailing edges of the triangle have the same slope.

The measured results were as follows:

For ΔV_g = 50V (from −25 to +25V) it was found that,

$\Delta(V_g - V_b) = 74 \,.\, 10^{-3}$V and $\Delta(V_g - V_a) = 45 \,.\, 10^{-3}$V.

The point h is connected to a or b with the aid of relay A which forms part of the control circuit of the triangle voltage generator (Fig. 11). The direction of the triangular voltage must be reversed at the moments when the anodes of the second stage of the inverse-function generator have reached earth potential; in that case one of the two halves of this second stage has become completely non-conductive, which corresponds to one of the extreme positions.

The control circuit, consisting of two equal parts, ensures that relay B or C is actuated at the moment when the anode b_1 or b_2 (see Fig. 7) has reached earth potential. Contacts on this relay so operate relay A that h is connected to the correct point (a or b). The contacts of the relay are represented in the drawing in non-energized position. The right moment of changing over is adjusted by means of potentiometer RV_9. A delayed changeover means that the inverse-function generator leaves its range of control.

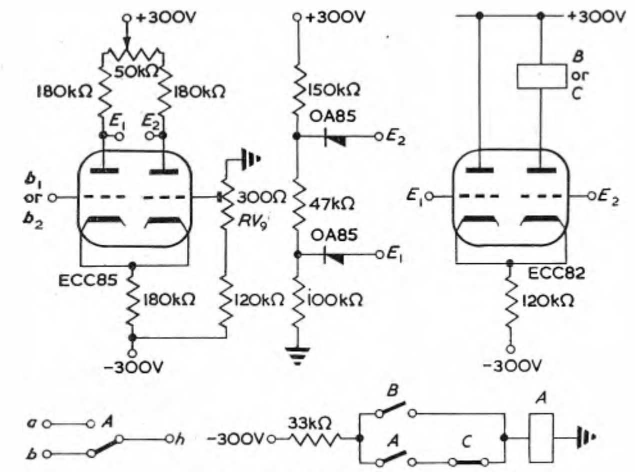


Fig. 11. Control circuit

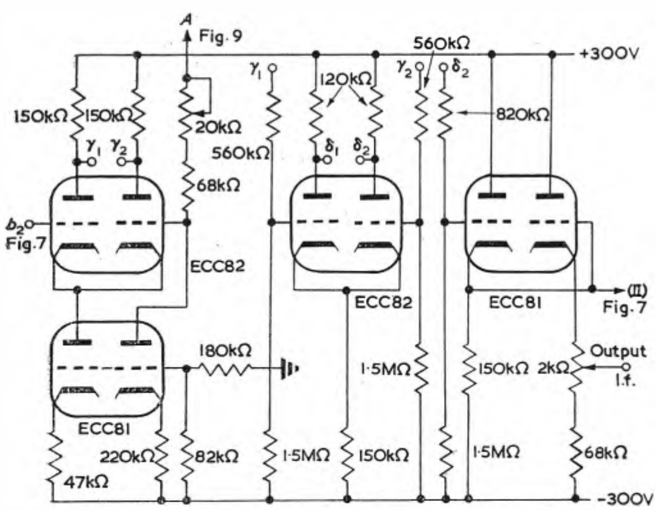


Fig. 12. Feedback amplifier

A slightly premature changeover, however, only means that the sinewave retains its peak value for slightly too short a time.

Other Parts

The diagram of the difference amplifier used for the negative feedback is shown in Fig. 12; it is a two-stage amplifier, one input of which is connected to b_2—one of of the outputs of the inverse-function generator—while the other input is connected to the output of the triangular voltage generator. The sinusoidal voltage on (II) is applied to the output via a cathode-follower.

The diagram of the auxiliary oscillator supplying the voltage for input (I) of the inverse-function generator is given in Fig. 13. It is an oscillator of the Wien-bridge type, in which the amplitude is limited with the aid of a miniature thermistor.

The output voltage was approximately 18V r.m.s. This is also the amplitude of the l.f. sinusoidal voltage. Though the frequency constancy of such an oscillator is quite good, this is no requirement for the circuit in question, as the frequency of the auxiliary voltage determines neither the frequency nor the amplitude of the l.f. sinusoidal voltage.

The schematic of the power supply for the entire apparatus is shown in Fig. 14. Besides a stabilized positive and negative voltage of approximately 300V each, a stabilized heater voltage is also supplied for some valves. The positive and negative supply voltages are obtained by first generating a stabilized voltage of 600V and then stabilizing its negative side at a level of -300V with respect to earth. This can be done in this case, as most of the current passes between the ± 300V and not to earth.

The stabilized heater voltage is obtained by including a variable load in series with the load; the value of this variable load is determined by the adjustment of the EL41 valves. The reference element used[3] is a saturated DL66,

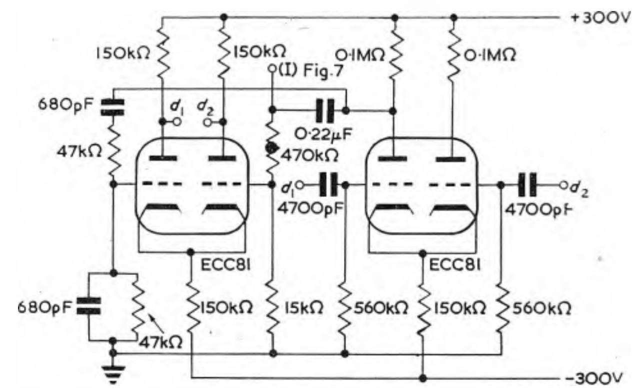


Fig. 13. Auxiliary oscillator

the anode current of which depends on the temperature of the filament. This circuit thus stabilizes the effective value of the heater voltage, which is in fact the requirement.

Results

The apparatus yields sinusoidal (and, of course triangular) voltages with periods from 20 to 12 500sec variable in 20 steps. Fig. 15 shows the reproduction of the output voltage for one of the longest periods.

An amplitude constancy better than 1 per cent is attained owing to:

(1) The good amplitude constancy of the auxiliary oscillator (by placing the thermistor in a copper block the influence of the rapid fluctuations in the ambient temperature were eliminated);

(2) The stabilization of the supply voltages. It was found that for 10 per cent changes in the mains supply the heater voltage of some valves, especially in the triangular voltage generator and in the inverse-function generator had to be stabilized by about a factor 30, while a stabilization of approximately 250 for the positive and negative voltages is desirable. The supply voltage used fully meets this requirement.

The output signal was 50V peak-to-peak.

Conclusion

From the foregoing it follows that the ultimate limitation is formed by the leakage of the capacitor in the triangular voltage generator. If it is a matter, however, of generating a voltage at one single frequency only, good

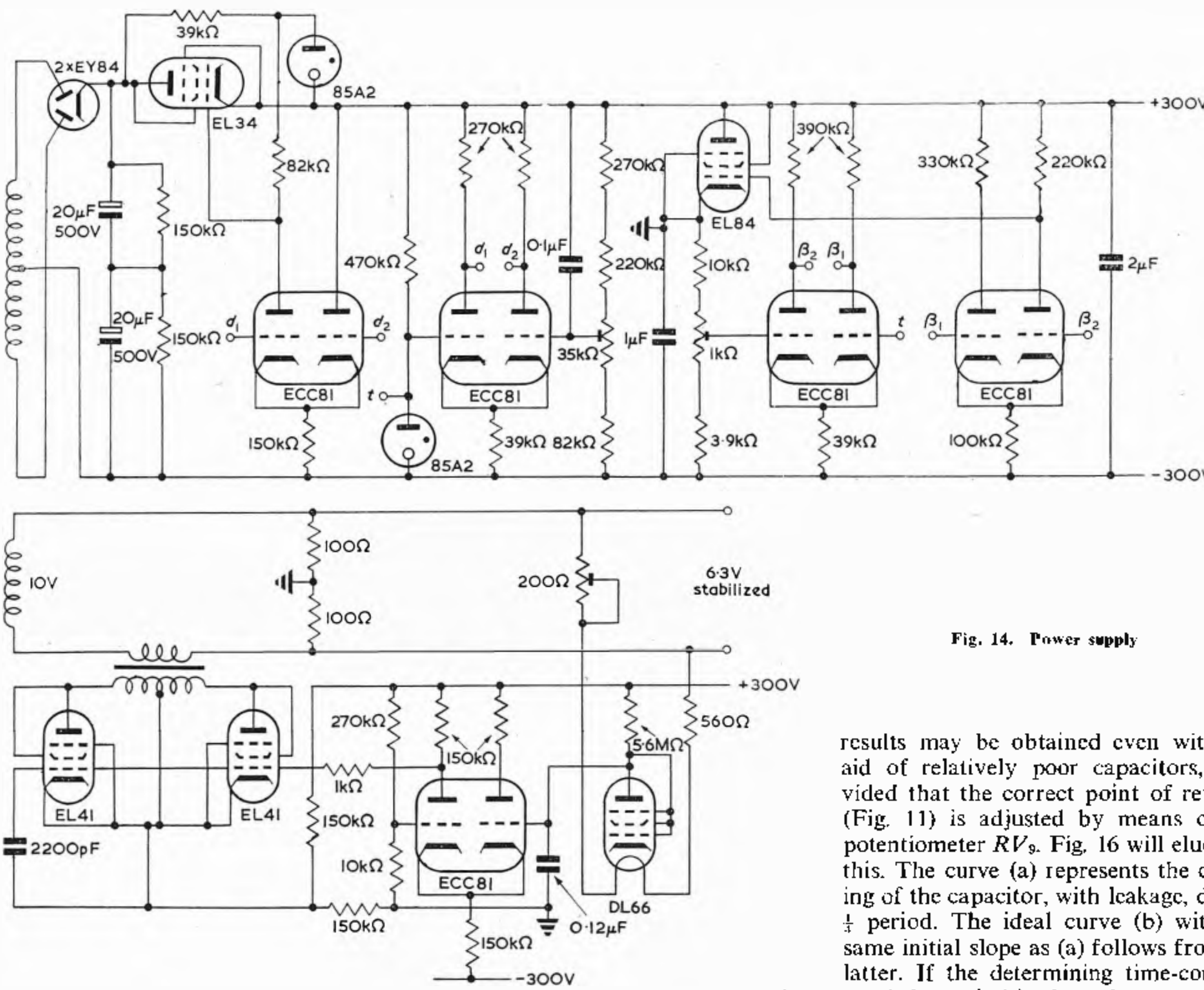


Fig. 14. Power supply

results may be obtained even with the aid of relatively poor capacitors, provided that the correct point of reversal (Fig. 11) is adjusted by means of the potentiometer RV_9. Fig. 16 will elucidate this. The curve (a) represents the charging of the capacitor, with leakage, during $\frac{1}{4}$ period. The ideal curve (b) with the same initial slope as (a) follows from the latter. If the determining time-constant for curve (a) is τsec and the period is Tsec, the corresponding output voltages can be described as follows:

$$V_{out(a)} = V_r \sin K\,(1 - e^{-t/\tau})$$

$$V_{out(b)} = V_r \sin\,(Kt/\tau), \text{ in which } K = 2\pi\tau/T.$$

In this equation it has thus been assumed that the point of reversal of (a) coincides with that of (b), so that it is determined by the moment when (b) and not (a) reaches the point of reversal. The relative difference between the two is therefore:

$$\frac{\sin K\,(1 - e^{-t/\tau}) - \sin\,(Kt/\tau)}{\sin\,(Kt/\tau)}$$

For the first approximation an extension of the progression yields: $t/2\tau\ [1 - (2\pi^2/T^2)\,.\,t^2]$ which function has a maximum for approximately $t = T/8$ and then assumes the value 4·5 T/τ per cent, so that τ need only be equal to $5T$ to reduce the distortion to less than 1 per cent. With some precautions it is possible to obtain periods of tens of hours in this way. The question is, however, whether there is any need of such long periods.

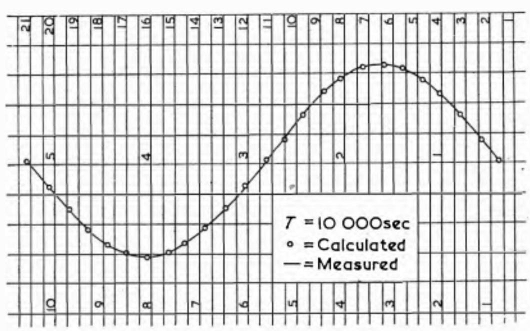
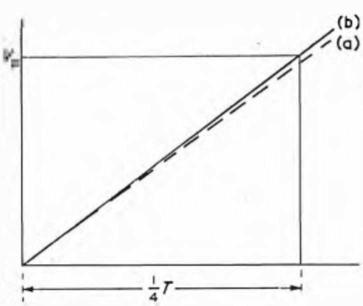


Fig. 15. Recording of output voltage

Fig. 16. (a) Finite RC time (b) Ideal case



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Automatic Tracing for Gas Cutting Machines

By J. S. Cheverton*, B.Sc., P.Eng., A.M.I.E.E.

The equipment described in this article has been designed to obviate the need for guiding a gas cutting machine by hand or the need for expensive metal templates. The equipment consists, essentially, of an optical sensing head which forms part of a closed loop servo system and by its means intricate patterns can be cut from the guidance provided by a simple line drawing. The equipment can be attached to existing gas cutting machines.

(Voir page 376 pour le résumé en français: Zusammenfassung in deutscher Sprache Seite 381)

'LINATROL' automatic tracing equipment is designed and built to eliminate either the tedious task of guiding a gas cutting machine by hand, or the very expensive metal templates which are required for mechanical followers.

The equipment consists essentially of the line tracer head and its associated electronic equipment, and is designed for attachment to any regular type of gas cutting machine. It will became apparent by the following, that this system is ideally suited to gas cutting applications, but is nevertheless based upon a very flexible design principle.

General Background

In a typical gas cutting machine the left-hand table consists of the sheet of steel which is to be cut, according to the pattern or template which is placed on the permanent right-hand table. By means of a pantograph arrangement a follower circumscribing the pattern contour causes the gas torches to repeat that pattern and thus to cut out the required shapes in the steel. The constant torch speed necessary to produce smooth cutting is provided by a motor-driven tracking wheel which is steered across the template table either by a human operator as he guides the tracing wheel along suitable guide lines or by some mechanical arrangement of template and tracing wheel.

These two steering systems both have distinct inherent disadvantages:

(1) The human operator introduces human errors, and limitations.

(2) The mechanical templates are expensive to make and store and may be extremely heavy and cumbersome.

The Linatrol steering system does not require expensive templates, it is automatic, extremely accurate, and drift free. The line tracing head is an integral component of a closed loop servo system which will allow the cutting of intricate patterns from a simple line drawing. This drawing may be any combination of a dark and a light colour between which the tracing head can discriminate.

The main elements of a Linatrol tracing system are:

(1) A tracing head which is coupled to the tracking wheel of the template following section of the gas cutting machine. This unit incorporates:

(a) Optical sensing head
(b) Servo steering motor, with a tachogenerator
(c) Gears

(2) An electronic servo amplifier

(3) Switch controls.

Basic Operation

The basic component of the control equipment is the tracing head, which is driven across the template table by the tracking wheel drive. The tracing head is designed to follow a pattern consisting simply of a line drawing, by generating a steering signal. This signal is produced by the optical sensing device and is then fed to the servo amplifier. The amplifier provides the correct impedance matching, phase shifting and amplification that is required to operate the servo steering motor. This motor maintains the optical sensing device over the line of the pattern at all times by providing the correct steering to the tracing wheel. The tachogenerator is simply used to provide stabilization to the servo system, as in normal closed loop servo practice.

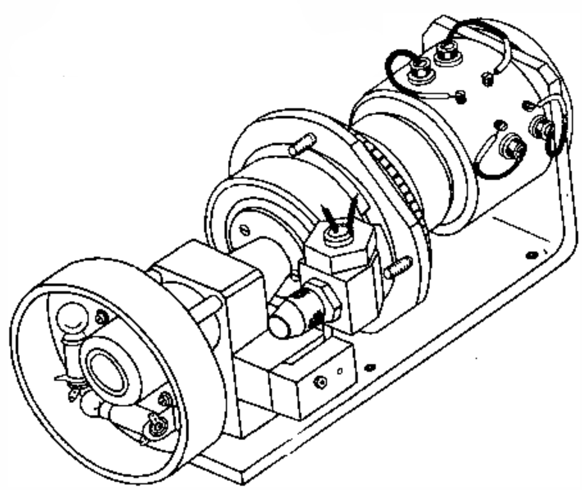


Fig. 1. Optical sensing head

The Tracing Head

The optical sensing device consists of two main parts—an upper section, and a lower section. (See Fig. 1.)

The lower part is rigidly mounted to the frame of the tracing head and has mounted within it a bi-convex lens of suitable focal length, so positioned that it throws the image of a small portion of the pencil line pattern to be traced on to the photocell. The area of the pattern which includes that portion which is focused on to the photocell, is illuminated by four small lamps, equally spaced around the lens mount, and above which is fitted a reflector.

The upper section of the optical assembly houses the photocell, which is made to vibrate, and carries four slip rings for completing the necessary electrical connexions. The photocell is attached to the lower end of a rigid bar, to the upper end of which is fixed a small permanent U-shaped magnet with its poles facing away from the photocell. The rigid bar is balanced vertically within the optical assembly by being permanently assembled at its centre

* *Canadian Westinghouse Company Limited.*

of gravity to a horizontal straight flat torsion spring which is clamped at each end to the optical assembly. The axis of the spring is perpendicular to a line through the poles of the magnet (see Fig. 2). Immediately above the permanent U-magnet and in very close proximity to it, are mounted the poles of an energized E-magnet so that the poles of both magnets lie in a common vertical plane. The coil of the E-magnet is energized at 60c/s in order to produce an alternating field which in turn forces the U-magnet from side to side and so sets the photocell vibrating about its mean position.

The direction of the oscillations of the photocell, in relation to the direction of travel of the drive wheel, is such that the image of the line of the pattern is scanned perpendicularly. The photocell is set off centre from the vertical axis of the optical system so that it scans slightly ahead of the position on the pattern immediately below. If, as the drive wheel moves the optical system across the pattern, the optical axis does not remain exactly above the line of the pattern, an error will result such that the photocell does not scan the image of the line symmetrically. This assym-

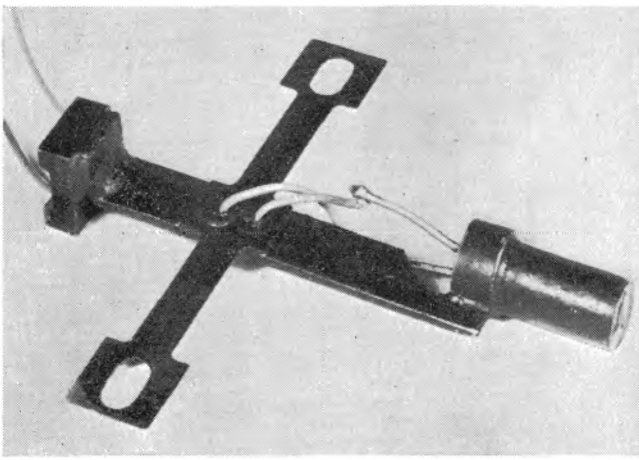


Fig. 2. Vibrator arm

metry causes the photocell to produce specific electrical signals for left and right errors, i.e. dependent upon whether the optical axis moves to the left or the right, of the line being traced. These signals are amplified and used for operating the steering motor.

At the lower end of the optical sensing head there is fitted an optical position indicator. This allows the operator to readily position the optical unit of the tracing head over any particular mark on the pattern. This positioning device consists of a lamp and a lens so adjusted as to project a small spot of light on to that point of the pattern which is focused on to the sensing head photocell. The lamp and lens are built into a small projector unit and are not used during regular tracing.

The servo steering motor is for two phase, 60c/s operation, and it incorporates a 60c/s tachogenerator. It is coupled by gears to both the optical sensing device and to the vertical column carrying the drive wheel. This gearing produces approximately a 25:1 step down from the motor to both the drive wheel column and to the upper section of the optical assembly which houses the vibrating or scanning photocell.

Operation of the Servo Steering System

The vibration of the scanning photocell is such that when the optical axis is immediately over the line of the pattern, the photocell has focused upon it in turn, equal amounts of light. Since the photocell vibrates at 60c/s, this results in a photocell signal at twice line frequency, namely 120c/s. (See Fig. 3.)

When the line of the pattern is displaced relative to the centre of vibration of the scanning photocell, this cell has focused upon it in turn, two different amounts of light. This results in a photocell signal containing line frequency whose phase, relative to that of the line voltage, depends upon which side of the line on the drawing the centre of vibration is displaced. (See Fig. 4.) This error signal at line frequency is phase adjusted and amplified and used to supply the control winding of the two-phase servo motor whose other

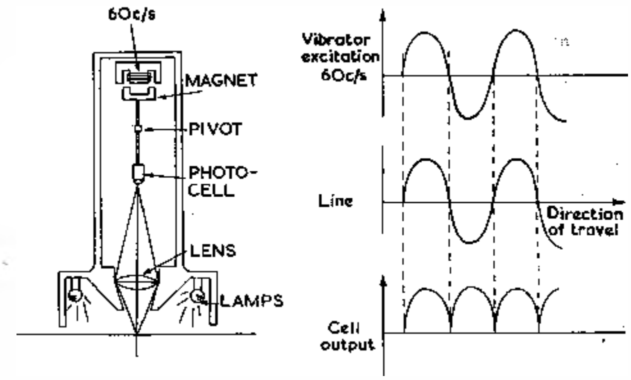


Fig. 3. 'On line' photocell waveforms
(Left) Tracing head
(Right) Locus of point seen by cell during travel (line below cell)

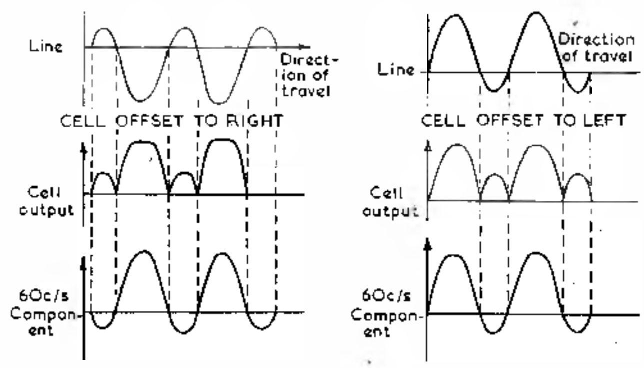


Fig. 4. 'Off line' photocell waveforms
(Left) Out of phase with excitation supply
(Right) In phase with excitation supply

winding is supplied directly from the line. This motor is geared to steer the tracing head in such a way that it will always reduce the error between the lines of the pattern and the vertical axis of the optical scanning device. Thus, while the driving motor moves the entire tracing head across the drawing, the steering motor maintains the scanning head directly above the line.

The offset of the photocell, which causes it to scan the pattern slightly ahead of a point immediately below the cell, provides phase advance to the closed loop steering servo mechanism. This technique assists in stabilizing the system, and also eliminates steering direction ambiguities at sharp corners on the pattern

The use of an all a.c. servo system for automatic steering, prevents the possibility of the equipment responding to changes of light, voltage, or any expected variable, other than the pattern.

Electronic Control Unit

The electronic control unit houses the steering amplifier and an automatic stopping relay device. This unit is built into a steel enclosure which contains all the necessary circuits, Fig. 5.

The output from the sensing head photocell is fed to the steering amplifier where it is amplified for controlling the steering motor.

The main amplifier is a simple a.c. unit having several stages of pre-amplification and ending with a push-pull power stage which is matched with a transformer to the steering motor control winding. The pre-amplifier includes a filter to extract the 60c/s component of the photocell signal. This filter has the effect of producing the required phase shift to cause the motor to have the correct phase relationship between its two fields—i.e., +90° or −90° depending upon the error signal in the servo system.

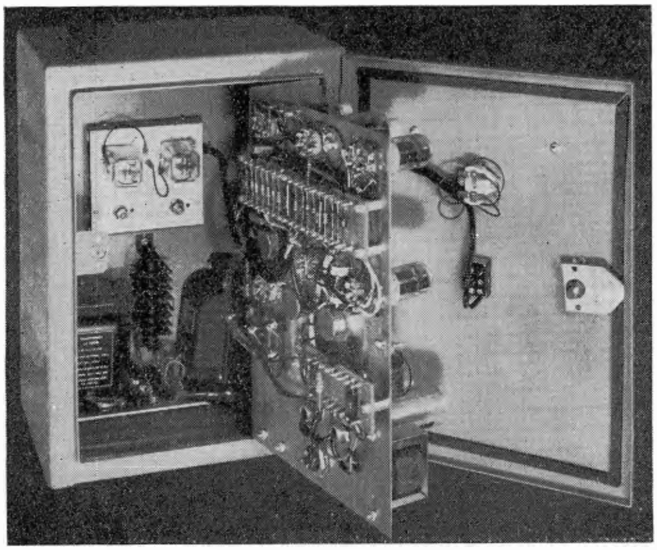


Fig. 5. The electronic control system

Safety Relay

Within the electronic unit is a relay which will switch off the drive motor in the event of the tracer losing the pattern line during a cut.

This relay is controlled by an a.c. amplifier driven from the unfiltered photocell signal which is used for the steering control. The contacts of this relay may be used to control the drive motor as well as solenoid type gas valves for the torches. Thus, this relay device is a safety system which may be used to automatically switch off the entire gas cutting machine in the event of the tracer losing the line of the pattern or alternatively reaching the end of the line.

During tracing, the photocell signal includes a continuous a.c. signal which is normally a mixture of 60c/s and 120c/s. When the optical sensing head sees no line, negligible a.c. signal is produced by the photocell. Since only the a.c. signal will cause the safety relay to hold in, an overriding switch is generally required. This switch would be held until tracing had commenced for any one cut.

Switch Controls

The switch controls may be mounted on the gas cutting machine or connected remotely by cable. Switches are provided for:

Manual-off-Automatic
Steer Left
Steer Right
Drive

These controls may be used for positioning the tracing head at the correct place on the pattern and then starting the tracing device for cutting. The manual position on the head control switch will permit hand steering or the use of a radius bar, if this should be required.

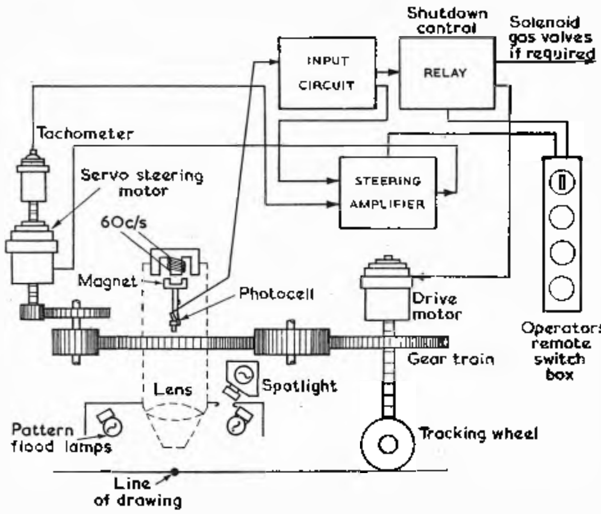


Fig. 6. The complete system schematic

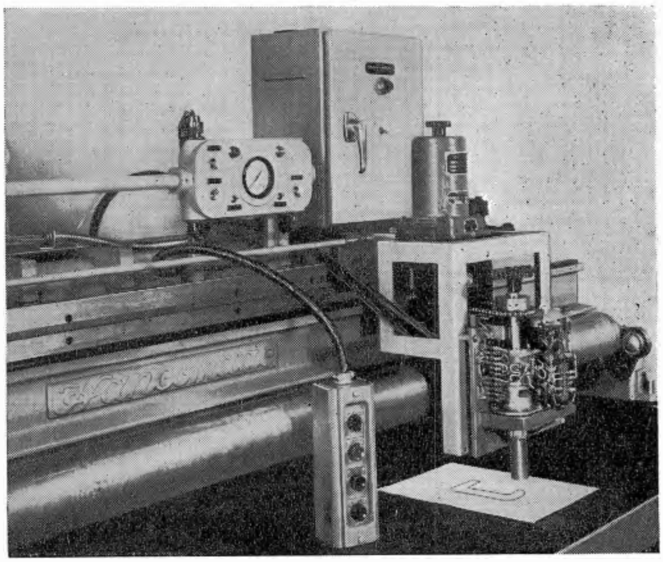


Fig. 7. A typical Linatrol tracing head

In order to show the drawing and to reveal the interior of the cabinet, both the floodlight assembly and the cabinet cover have been removed.

The 'drive' control simply overrides the automatic stopping relay. The 'steer left' and 'steer right' switches control 60c/s signals taken from the electronic unit power transformer. These signals are injected into the amplifier to remotely steer the tracing head when full automatic steering and tracing is not in operation.

A complete system schematic is shown in Fig. 6 which includes all major and minor system components. A typical Linatrol tracing head built on to a manual tracing unit is shown in Fig. 7, without the dust covers.

In this case the tracing wheel, which is steered by the 'Linatrol' equipment does not run on the tracing table and therefore over the drawing. The drive from the tracer wheel to the carriages is through a roller system patented by

Hancock & Co. (Engineers) Ltd. The advantages of this method of driving are obvious.

Above the framework on which the 'Linatrol' head unit is mounted will be seen the standard tracer made by Hancock & Co. which is used to propel the movement of the carriages with the steering, of course, being controlled by the 'Linatrol' steering servo.

Operation

The travel speed of the drive motor is adjusted to a value to suit the thickness of the material to be cut. With the power switched on and the controls set for 'automatic' the tracing head is positioned for use by means of the switch controls and the spotlight device.

Tracing may be commenced by setting the tracing head up over a pattern lead-in line. Alternatively the head may be adjusted so that when it moves its path will intercept the pattern at approximately 30°.

The 'inch' button is pressed to override the safety relay, and the drive motor will start. When the optical head reaches the line, it will follow the line automatically. In this condition it is not necessary to continue to press the 'inch' button, since the safety relay is actuated from a signal caused by the existence of the line, as mentioned above.

Automatic shut down upon completion of the cut may be readily accomplished. There are two methods which may be adopted to provide this, the choice depending upon the operator. Firstly, a gap may be placed in the pattern contour—this must be of sufficient width to prevent the tracing head from coasting over the gap and starting up again. Secondly, the operator may cover the pattern contour with a blank card at the point where machine shut off is required. This latter system is the most flexible as it does not restrict the point at which the tracer would be required to intercept, and lock on to the pattern, at the start of the cut.

Patterns

The tracing head will follow a line which is crossed by another line perpendicular to the first. This facility permits the cutting of a series of patterns in one continuous operation provided that the cutting action of the torch is not impaired by the gap which it may have to cross. This technique has proved very successful on steel up to ½in thick.

The preparation of patterns is very simple provided that the lines drawn are distinct, clear, and even. A draftsman's 'H' pencil makes an excellent line on a good grade of heavy white paper.

It is quite possible to add operator's notes to the pattern in red pencil without interfering with tracing. This is because the photocell in the tracing head is very sensitive to red, and thus cannot see red pencil on white paper.

Conclusion

'Linatrol' equipment built on to a gas cutting machine has shown how gas cutting techniques can be improved. It is no longer necessary for an operator to laboriously steer a manual tracing unit. Alternatively, it is no longer necessary for a tool room to go the expense of preparing complicated metal, wood or strip templates for a mechanical follower. With 'Linatrol' equipment, a pencil drawing will enable steel to be smoothly gas-cut to intricate shapes with an accuracy of 0·010in and at less cost than by any other method.

The foregoing has described the operation of 'Linatrol' equipment for use on 60c/s supplies. Automatic steering may be achieved equally well on 50c/s supplies, by adjusting the frequency sensitive components for the lower frequency.

Acknowledgments

The author's thanks are due to the Canadian Westinghouse Company Limited for permission to publish this article and to Hancock & Co. (Engineers) Ltd, London, who are now producing a gas cutting machine using this equipment, for permission to publish Figs. 5 and 7. This article is based on a paper read at the I.R.E. Canadian Convention and which was published in the Convention Record for 1958.

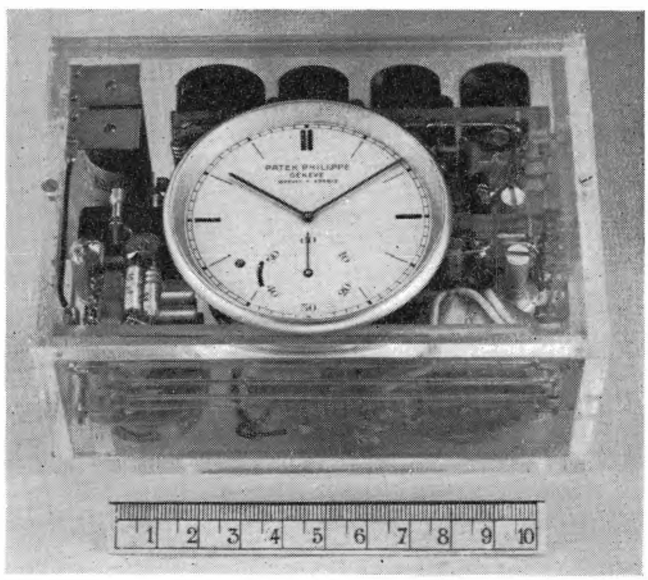
A Miniature Quartz Clock

Patek Philippe, Geneva, have produced what they claim to be the smallest quartz clock in the world. The total volume of this unit, including an accumulator which provides for 70 hours' operation, is $830cm^3$.

A 10kc/s quartz crystal is used as the primary frequency standard and the temperature compensation is such that it provides an accuracy of $\pm 1 \times 10^{-6}$ over a 24-hour period in the temperature range 0°C to 50°C.

The crystal frequency is divided down by 600 to provide an input of $16\frac{2}{3}$c/s to the amplifier which provides the power to drive a synchronous micro-motor which has been specially made by Patek Philippe and which has overall dimensions of 20mm diameter by 34mm height.

The complete clock measures 134 × 94 × 66mm, it employs 16 transistors and has a total power consumption of 15mW at 1·25V which may be supplied from the built-in accumulator or from solar cells etc. The overall accuracy of the clock is 0·1sec in 24 hours and, in order to gain maximum accuracy from the clock there exists, on the seconds dial, a small black patch with a white slot which when hidden by the hand permits an objective reading.



The miniature quartz clock

A Transistor Characteristic Curve Tracer

By J. F. Young*, A.M.I.E.E., A.M.Brit.I.R.E.

A Dekatron is used to develop a stepped voltage controlling the base current of the transistor under test. At each step a half sinusoidal voltage is applied to the transistor and the resulting collector current is plotted against voltage on an external oscilloscope. A series resistor provides the current signal and limits the transistor dissipation. The unit can also be used to plot the characteristics of normal or of Zener diodes.

(Voir page 377 pour le résumé en français; Zusammenfassung in deutscher Sprache Seite 382)

WHILE simple tests of transistors are often adequate for audio work, more comprehensive testing is required for switching transistors. Simple tests giving the current gain of a switching transistor are useful, but additional information such as bottoming voltage, turnover voltage, reverse leakage current and slope resistance is also required. The simplest method of presentation of such information in a readily digested form is as a set of characteristic curves of collector voltage against collector current.

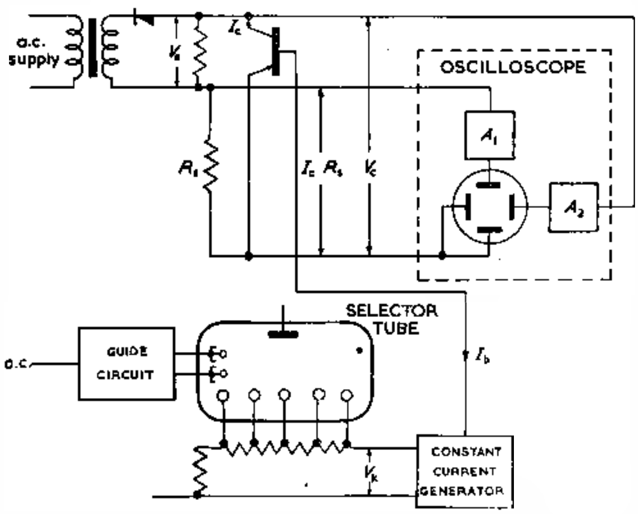


Fig. 1. General arrangement of tester

Such curves are extremely tedious to take and plot manually. A single curve of collector voltage against collector current at a given value of base or emitter current can be displayed on an oscilloscope without difficulty[1]. However, some form of switch is necessary if a complete family of characteristics is to be displayed[2].

The Basic Arrangement

Most transistors available in this country at the present time are of the pnp type, and these mainly are used in the earthed emitter configuration. Consequently a simple device capable of displaying a set of characteristic curves for a pnp transistor connected with earthed emitter is quite useful, and the added complexity which would be required in order to test any transistor in any connexion is hardly worthwhile. While it is possible to use a rotary switch, such as a uniselector[3,4] to vary the base current, it is preferable to use an electronic switch so that the equipment is silent in operation[5,6,7]. A Dekatron cold-cathode counting tube can be used to provide a stepped voltage wave and this can be used in conjunction with a constant voltage to constant current convertor to provide a stepped base current. At each step the collector to emitter voltage can be varied while it is plotted on the face of a cathode-ray tube against collector current. A block diagram of such a tester is shown in Fig. 1.

Pulses derived from the a.c. supply are supplied to the guides of the Dekatron selector, which consequently steps

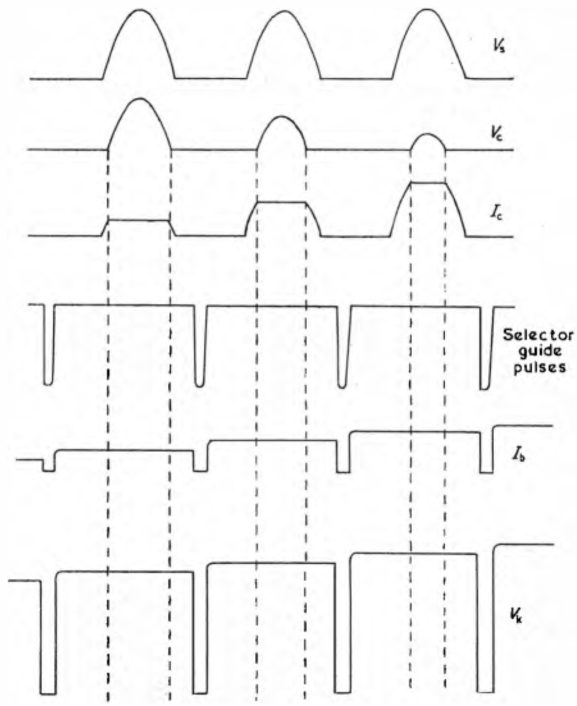


Fig. 2. Waveforms associated with tester

round from cathode to cathode. As it does so the output voltage V_K changes in steps because of the progressively increasing resistance in the successive cathode circuits. This stepped voltage is used to control a constant current generator which supplies the base current of the transistor.

The collector and emitter of the transistor are connected in series with a resistor R_s to a half wave rectified supply V_s. On the assumption that the transistor characteristics are as shown in Fig. 3, the collector current I_c waveform will be as in Fig. 2, a flat-topped wave. The waveform of collector voltage will therefore be $V_s - I_c R_s$, the top part of a sine wave.

The resulting display on the oscilloscope is as shown in Fig. 4. The ends of the curves lie along a line of negative slope equal to R_s and passing through the peak value of V_s on the V_c axis. If the face of the tube is calibrated, such quantities as current gain, collector slope resistance, turnover value and reverse leakage current (at $I_b = 0$) can be obtained. The effects of temperature variations can be seen

* *The General Electric Co. Ltd., Witton.*

directly. Photographs can be taken if permanent records are required. For test purposes the display can be compared with a Perspex template of standard curves.

Resistor R_s is required in the transistor circuit for two purposes; firstly as a shunt to provide a voltage proportonal to collector current and secondly in order to limit the transistor dissipation. A suitable averaging time for the dissipation rating is probably about 20msec or one cycle if a 50c/s supply is used. It is therefore sufficient to determine the mean dissipation over one cycle, find the value of I_c corresponding to the maximum possible dissipation and hence calculate the value of R_s required to limit the maximum dissipation to the permitted figure. In Appendix 1 it is shown that the maximum mean dissipation occurs at

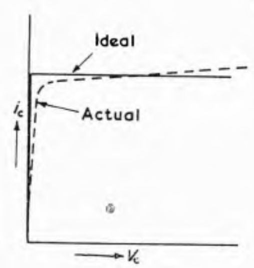


Fig. 3. Transistor characteristics

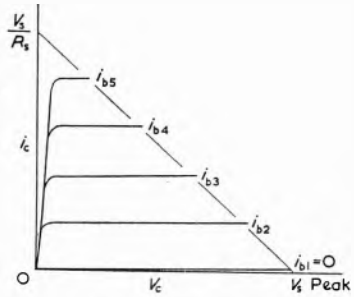


Fig. 4. Oscilloscope display

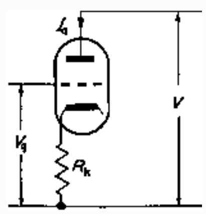


Fig. 5. Basic form of constant base current generator

a value of

$$I_c = (V_{s(peak)}/R_s) \times 0{\cdot}4$$

the maximum dissipation is:

$$W_{max} = 58\ (V_{s(peak)})^2/R_s)\ \text{mW}$$

From this equation the required value of R_s for any supply voltage and permissible dissipation can be found.

Since a supply voltage switch must be fitted, it is possible to fit another switch having settings given by the dissipation rating. The two switches together can then determine the value of R_s to be used. An alternative method, using simpler switches but less convenient and less safe to use because a calculation must be carried out, is to have a simple 'resistor value' switch as well as a 'supply voltage value' switch. Whichever method is used, about 14 different resistors from 3·3Ω to 50kΩ will be sufficient for use with most low and medium power transistors.

The basic form of the constant base current generator is shown in Fig. 5. Analysis of this arrangement shows that:

$$I_k = \frac{\mu V_g + V}{r_a + (\mu + 1) R_k}$$

where μ is the valve amplification factor, and r_a is the valve anode resistance. Thus the effective impedance looking at the anode is $r_a + (\mu + 1) R_k$ (see Fig. 6), which can be very high if μ is appreciable. The valve thus behaves as a high impedance, constant current source while not requiring an excessive supply voltage.

Since very small values of base current might be required, and the value of μ for a valve is not usually known at low current values, it was necessary to carry out tests under these conditions. These indicated that operation would be satisfactory at currents as low as 10μA using one-half of a B309 double triode as shown in Fig. 6.

The base current of the transistor under test is changed in steps by variations of V_K produced by the Dekatron. The basic current range is changed by switching-in various values of cathode resistor.

It will be noted from the waveforms of Fig. 2 that the Dekatron discharge is changed from one cathode to the next at the end of the half cycle during which voltage is applied to the transistor. The base current therefore has

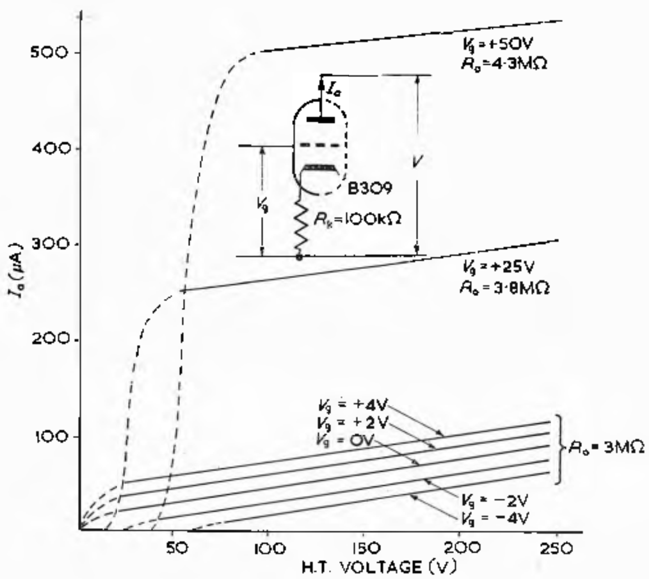


Fig. 6. Characteristics of constant current generator (B309 double triode)

at least one-quarter cycle in which to settle down before collector voltage is re-applied.

The Dekatron rotation can be stopped if required and the discharge can then be stepped around manually to any required cathode. The base current corresponding to that particular step can then be measured, while the curve corresponding to this step remains on the screen.

Dekatron Circuits

A simple Dekatron circuit to produce a stepped voltage waveform is shown in Fig. 7. The cathodes are connected in pairs, cathode 1 to cathode 6, cathode 2 to cathode 7 etc. The pairs of cathodes are connected to series resistors as shown, so that a five step output voltage is produced ten times per second if a 50c/s supply is used. While an oscilloscope display reappearing ten times per second has a certain amount of flicker, it is not too objectionable. If the cathodes are connected individually, rather than in pairs, to series resistors so that a stepped voltage waveform with a repetition of five times per second is produced, the resulting oscilloscope display is difficult to view. Interlacing of the traces gives little improvement. The disadvantage of the connexion of the cathodes in pairs is that the individual cathodes have slightly different characteristics, so that two cathodes connected together do not produce identical waveforms on alternate display cycles. This produces a slight pairing effect in which the individual lines of the display split into two. It is possible to compensate

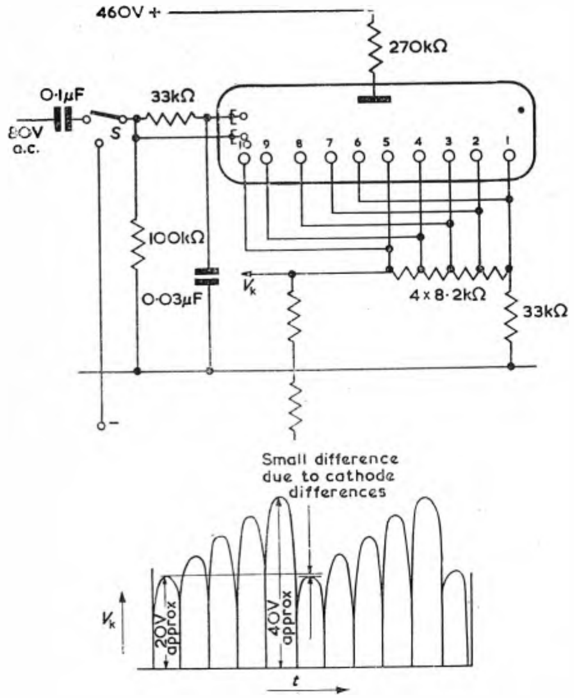


Fig. 7. Dekatron circuit to produce a stepped voltage waveform

for this, but since the pairing is not wide enough to be objectionable compensation is not worthwhile.

Since the Dekatron is not required to count, but is rotating continuously, a simple sine wave phase shift guide drive circuit as shown in Fig. 7 might be expected to be satisfactory. However, as shown in the waveforms of Fig. 7, there is some feed-through of the guide voltage to the cathodes, so that the required flat-topped cathode waveform is not obtained. A simple pulse drive circuit as shown in Fig. 8 can give greatly improved results. Here one-half of a B309 double triode is used to develop a negative going pulse on the occurrence of positive peaks of the applied 50c/s grid waveform. The guides are normally biased to 50V positive and the usual integrating guide drive is used.

The base current produced by the constant current generator, and hence the voltage produced by the Dekatron, must be constant during the negative half cycles of the supply voltage which are applied to the transistor collector. In order to ensure that the base current has time to settle down before the commencement of the negative half cycle, the drive voltage for the Dekatron is phase shifted by about thirty degrees leading at the triode grid input circuit. The grid drive voltage is 17·5V r.m.s.

For manual stepping, or inching, of the Dekatron discharge, the Dekatron guide input is disconnected from the triode anode and it is shorted to earth. This produces a single negative driving pulse. An open position on the inching switch removes the pulse drive and makes it possible to display a single characteristic curve at fixed base current.

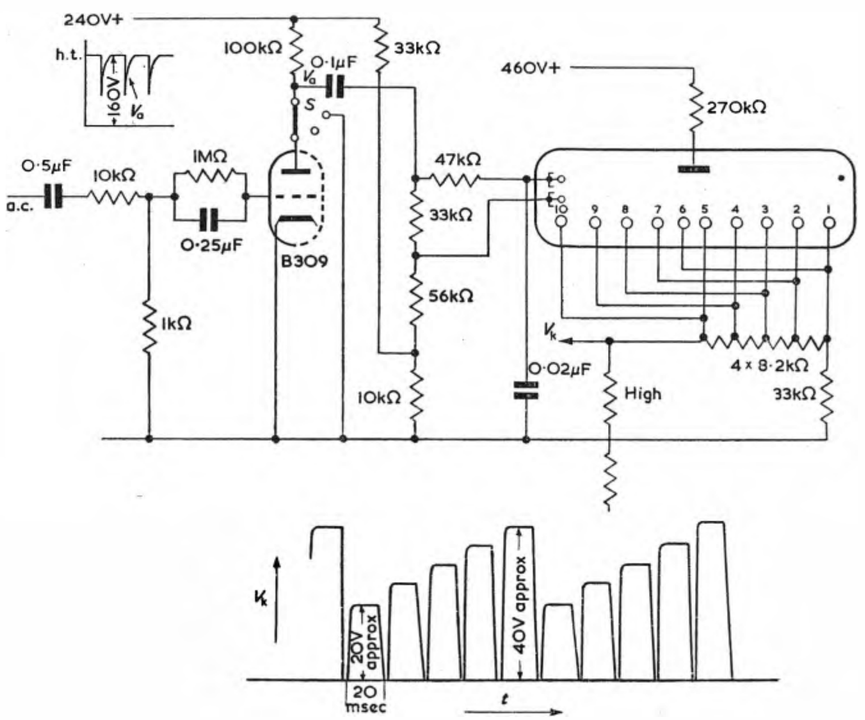
The Complete Unit

The circuit of a complete transistor curve tracer based on the principles given above is shown in Fig. 9. The Dekatron selector tube runs at about an 800μA anode current supplied from the whole of the secondary of the supply transformer via a half wave rectifier. The capacitor input filter used gives a ripple of less than 0·2V peak-to-peak. The Dekatron cathodes are connected to series resistors as described above. In order to drop the output cathode voltage to a suitable level to feed the grid of the constant current valve, a high impedance potentiometer chain is connected from the output cathode to a neon stabilized 60V negative line. The current taken by this potentiometer, plus the burning current of the NT2 neon tube, total less than 1mA, so a good degree of smoothing of the 60V line is possible. The ripple on this line is less than 50mV peak-to-peak, and this is further attenuated by the potentiometer chain. The base current of the transistor under test is supplied from the anode of the constant current generator V_3. The nominal value of base current supplied is adjusted by the 500kΩ potentiometer in the grid circuit, while the step magnitudes are determined by the cathode resistors switched in by S_2. This switch is calibrated in change of base current per step from 3μA to 3mA.

A link is provided in the base circuit so that an external meter can be connected to read base current if required. When this is done, the rotation of the Dekatron is stopped by S_1 so that the base current is steady and not stepped. The discharge can then be inched around so that the base current can be metered at each step. Alternatively, if required, a resistor can be inserted instead of a meter and the voltage across this resistor can be displayed on an oscilloscope with or without continuous stepping of the Dekatron. Care is needed in the wiring of the grid circuit of the constant current generator in order to avoid stray pick up, since the grid circuit impedance is high. However, it has not been found necessary to screen this circuit.

The Dekatron guide pulse generator V_3 is supplied from a centre-tap on the mains transformer T_1. The half wave

Fig. 8. A simple pulse drive circuit



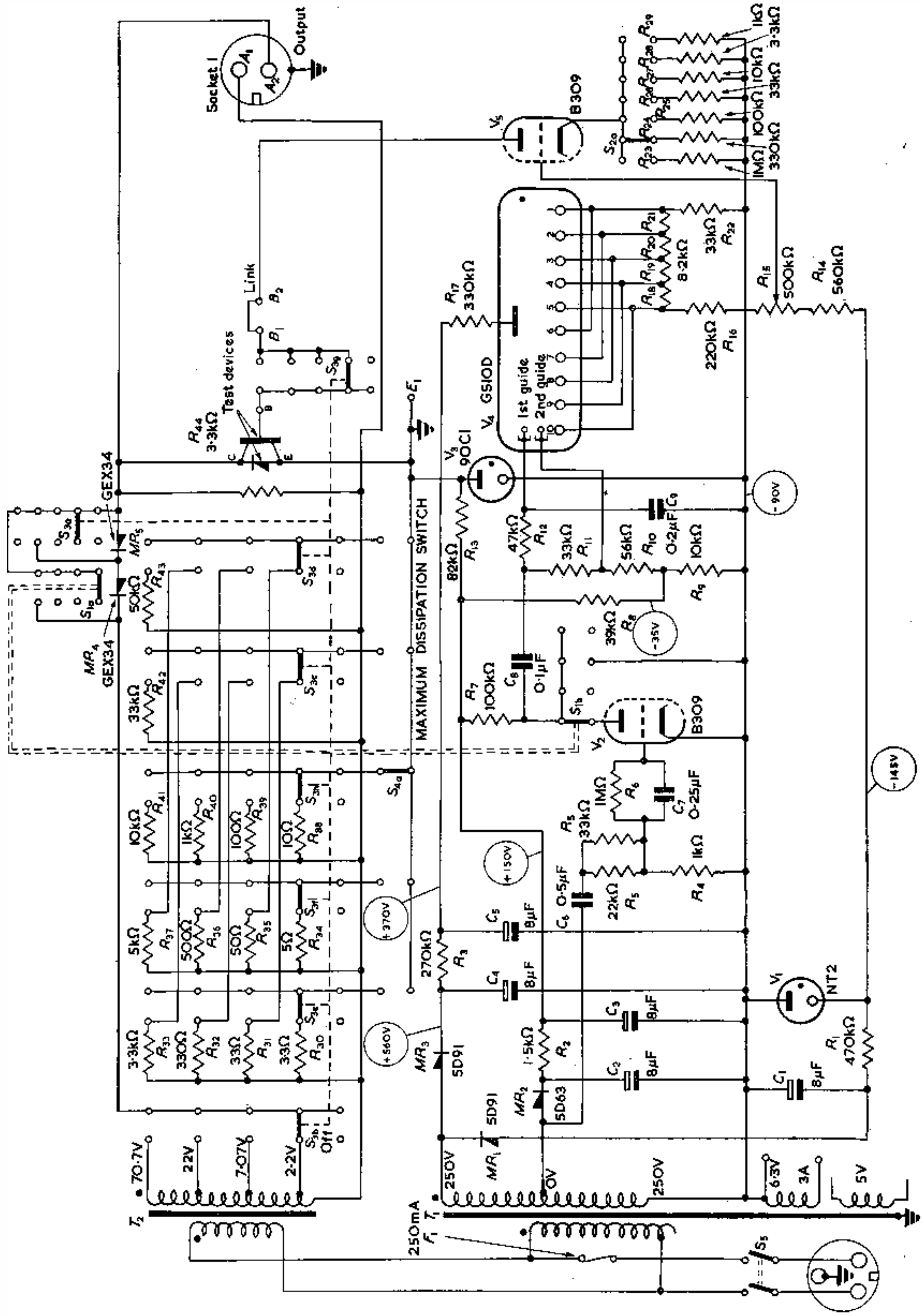


Fig. 9. The complete transistor curve tracer

rectifier also supplies a 90C1 stabilizer tube, the ripple level here being about 0·65V peak-to-peak. The emitter of the transistor under test is connected to the positive of this 90V supply, which is earthed.

A separate tapped transformer T_2 is used to supply the collector of the transistor under test. A half wave rectifier is connected in this supply so that only negative half cycles are normally applied to the collector. However, this rectifier can be shorted by switch S_1 if single forward-reverse characteristics of transistors or diodes are required. Complete families of forward-reverse transistor characteristics cannot be obtained by this method since there is no suitable time interval during which the base current can be switched from one value to the next. Switch S_1 gives:

(a) A family of forward characteristics.

(b) A single forward characteristic.

(c) An inch position which rotates the Dekatron discharge one place and so increases the base current by one step.

(d) A single reverse-forward characteristic.

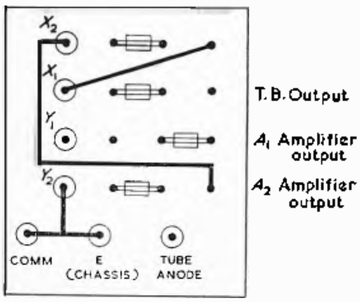


Fig. 10. Connexions to the oscilloscope

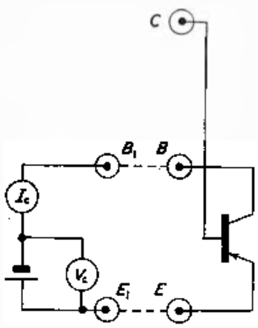


Fig. 11. Method of obtaining current-base voltage curve

The transformer voltage tapping switch S_3 and the maximum dissipation switch S_4 together determine the value of the collector series resistor. This ensures that if the maximum permissible transistor dissipation is set on S_4, it will not be exceeded at any voltage setting of S_3. The resistor values are shown in Table 1. Since the transformer winding resistance and the rectifier forward resistance are neglected, and since the transistors will normally be tested at room temperature, it will usually be safe to test transistors at up to twice the maximum rated dissipation. It is shown in Appendix 1 that the calibrated maximum dissipation of S_4 also applies to single curve tracing for Zener diodes. Normal semiconductor diodes tested well below turn-over voltage will be operated at much less than the maximum dissipation indicated on S_4.

Oscilloscope Connexions

The curve tracer is normally used in conjunction with a 1049 oscilloscope. The connexions to the oscilloscope are shown in Fig 10. One deflexion amplifier is used for horizontal deflexion and the other for vertical deflexion. The screened output leads from the curve tracer carry the voltage and current signals to the amplifier terminals on the front of the oscilloscope. The A_1 amplifier is used for the current signal, being coupled at the side panel of the oscilloscope to the Y_1 deflexion electrode as usual, so that the current deflexion is vertical. The voltage signal is connected to the A_2 amplifier, the output of which is coupled to the X_2 deflexion electrode via an extra link as shown in Fig. 10. The X_1 deflexion electrode is linked as shown to the shift potentiometer socket on the side panel (which is usually connected to the X_2 electrode). The voltage deflexion is therefore horizontal. The Y_2 electrode is linked to the common line as shown so that the second beam is deflected from the screen and cannot interfere with the display. The horizontal voltage deflexion and vertical current deflexion give a display which can be compared directly with most published common emitter characteristics.

When S_1 is open and the collector voltage is half wave rectified, only the forward characteristics of the device being tested are displayed. During the whole of the positive half cycle of the supply voltage, deflexion voltages are absent and the beam stays at the origin of the display. This causes an objectionable bright spot to appear at the origin. However, this spot can be reduced in brilliance quite easily by use of the intensity modulation feature on the oscilloscope. If the intensity modulation switch is set to the internal mains frequency position, the beam current is reduced in alternate half cycles and the bright spot at the origin is reduced in intensity. For this measure to be effective the mains supplies to the curve tracer unit and to the oscilloscope must be phased correctly. If it is found that the spot is brightened and the rest of the display is dimmed it is only necessary to reverse the supply leads to the curve tracer to obtain correct phasing for reduction of spot brightness.

The resistor values shown in Table 1 have been chosen to suit the switched A_1 amplifier gain ranges on the oscilloscope. The shift control on this amplifier is calibrated 0 to 1 and 0 to 3. Consequently if resistors having values such as 33Ω, 50Ω and 100Ω are used, collector currents can be measured on the calibrated shift control directly, or, in the case of the 50Ω, by multiplication by two. The value of collector voltage can be determined from the calibration of the A_2 amplifier, multiplied by 1·15 to allow for the fact that the X plates are used for deflexion. To find the grounded emitter current gain of a transistor at any operating point, the family of characteristics is moved vertically by the distance between two curves by adjustment of the calibrated A_1 shift control on the oscilloscope. The current gain is then easily determined from the base current step value and the A_1 shift control calibration. Terminals labelled C, B and E are provided for the collector, base and emitter of the transistor under test. When diodes are tested they are simply connected between terminals C and E. Extra terminals B_1, B_2 and E_1 are also provided. Terminal B_1 is normally linked to B_2, but this link can be removed for insertion of a milliammeter or shunt to measure base current. Terminals E_1 and B_1 can be used as shown in Fig. 11 to obtain a display of the base current-base voltage curve of a transistor. This is a diode characteristic and is often important in switching applications of transistors. To obtain this characteristic the base of the transistor is connected to the C terminal, the emitter to the E terminal and the collector to the B terminal. The link

TABLE 1

Series Resistor Values

PEAK SUPPLY VOLTAGE V_s	MAXIMUM DISSIPATION (mW)				
	12	17·5	50	100	200
3.1	50Ω	33Ω	10Ω	5Ω	3.3Ω
10	500Ω	330Ω	100Ω	50Ω	33Ω
31	5kΩ	3·3kΩ	1kΩ	500Ω	330Ω
100	50kΩ	33kΩ	10kΩ	5kΩ	3·3kΩ

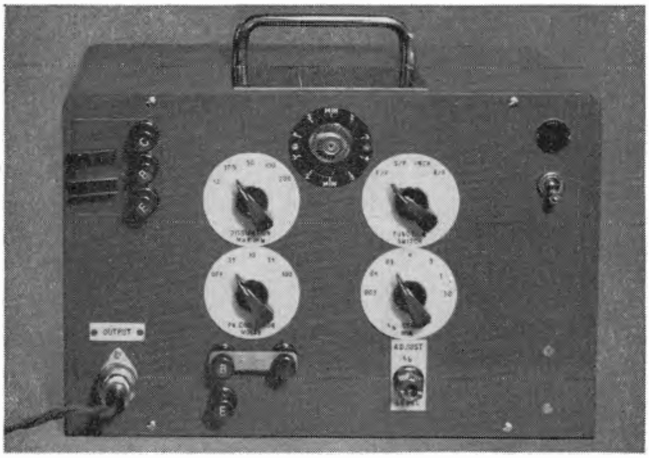


Fig 12. The complete instrument

between B_1 and B_2 is removed and an external d.c. collector supply is connected from E_1 to B_1.

Construction

The construction of the device is quite conventional, being in a 12in by 8in by 8in instrument case as shown in Fig. 12. The Dekatron is mounted on a bracket on the main chassis so that it can be seen through an escutcheon on the front panel. The escutcheon is specially engraved with two sets of numbers from 1 to 5, so that the number of the base current step in use can be read when the discharge is being inched around. Since the cases of several of the electrolytic capacitors used are 90V negative to the chassis, these capacitors are mounted on a paxolin sub-chassis and their cases are taped with p.v.c. for safety. While the original model curve tracer had extensive screening compartments further experiment has shown these to be unnecessary and screening is not now fitted.

Typical displays obtained with the curve tracer are shown in Fig. 13. The slight hysteresis effect which has been encountered by other workers in this field[3,4,6] only appears when families of curves are displayed and it is not normally troublesome. This applies also to the slight pairing effect caused by differences in the pairs of Dekatron cathodes connected in parallel. This latter effect could be eliminated, and the accuracy of the tracer could be improved if the series cathode resistors of the Dekatron were replaced by Zener diodes. The constant voltage characteristic of these would ensure a flat topped, stepped cathode waveform of accurately controlled amplitude. However, since the complete unit is so inexpensive, the addition of Zener diodes would at present cause an appreciable percentage increase of cost. A further addition to the basic instrument which might prove useful, would be the provision of means for plotting calibration lines on the display during the resting half cycle.

Because the device is small it is possible to keep it near to the oscilloscope with which it is used and have it ready for operation in a very short time. In practice it has proved to be extremely useful for general testing of semiconductors and some such device is almost indispensible for work on switching semiconductors. Where a large number of transistors of a particular type are to be tested, it is worthwhile making a Perspex template of standard characteristic curves with which the display can be compared. While the accuracy of the device is not high, the information obtained from it is most useful.

Acknowledgements

The author wishes to thank the General Electric Company Ltd, for permission to publish this article, and Mr. H. W. C. Pilling for his valuable work during the development and construction of these equipments.

Appendix I

It is assumed that the transistor collector current-collector voltage characteristics are ideal as shown in Fig. 3. The half wave rectified sine wave shown in Fig. 14 is applied to the transistor in series with a resistor R_s. At the beginning of the half cycle the supply voltage causes insufficient current to flow in R_s to enable any voltage to appear across the transistor. The whole of the supply voltage therefore appears across the resistor R_s and the current is $\frac{V_s \sin \omega t}{R_s}$. When the current reaches the knee of the transistor curve, the transistor maintains the current at this value regardless of the voltage across it. The voltage across resistor R_s therefore remains constant and any further increase of supply voltage appears across the transistor. At the end of the half cycle the reverse operation takes place. The transistor current waveform is flat topped and the voltage waveform is the top of the supply voltage waveform as shown in Fig. 14.

If the angle at which the knee of the characteristic is reached is A, then since the waveforms are symmetrical about $\pi/2$, the transistor mean dissipation over the cycle can be found by integration between A and $\pi/2$.

The transistor voltage at any instant is

$$V_c = V_s \sin \omega t - I_c R_s$$

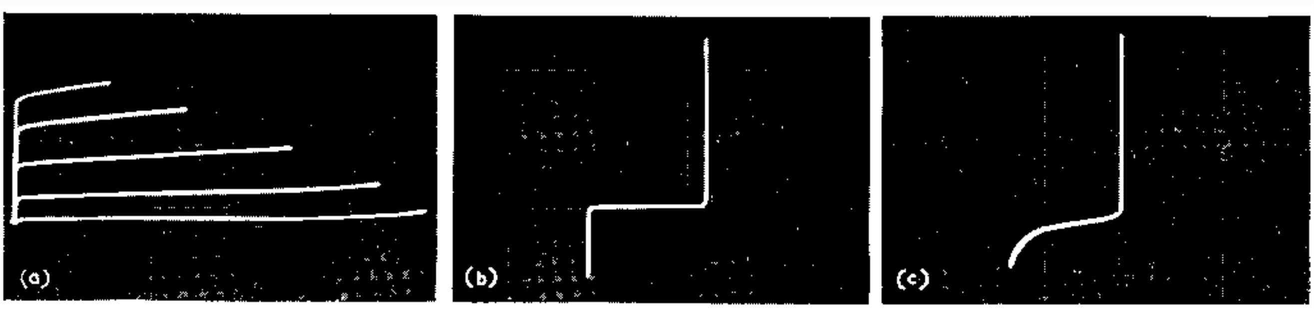
The instantaneous power dissipation is therefore

$$V_c I_c = V_s I_c \sin \omega t - I_c^2 R_s$$

Now

$$I_c = \frac{V_s \sin A}{R_s}$$

Fig. 13. Typical displays obtained with the curve tracer



hence

$$V_c I_c = \frac{V_s^2 \sin A \sin \omega t - V_s^2 \sin^2 A}{R_s}$$

The mean power dissipation over one cycle is therefore

$$W = (1/\pi)\int_A^{\pi/2} \frac{V_s^2 \sin A \sin \omega t - V_s^2 \sin^2 A}{R_s}\, d(\omega t)$$

$$= \frac{V_s^2}{2\pi R_s}[A - (\pi/2) + \sin 2A + [(\pi/2) - A] \cos 2A]$$

Hence, to find the value of A giving maximum power, differentiate with respect to $2A$

$$\frac{dW}{d(2A)} = \frac{V_s^2}{2\pi R_s}[\tfrac{1}{2} + \tfrac{1}{2}\cos 2A + [A - (\pi/2)] \sin 2A]$$

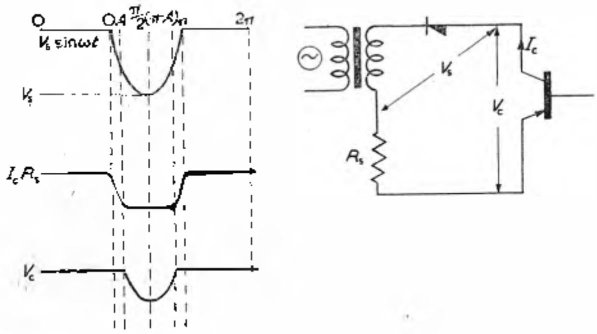


Fig. 14. Half wave rectified sine wave applied to the transistor

From this it is found that the power dissipation of the transistor is a maximum when $A = 23°15'$

whence $I_c R_s = 0{\cdot}4\, V_s$

also the maximum power is

$$W_m = \frac{58 V_s^2}{R_s} \text{ milliwatts.}$$

If the voltage and the maximum permissible dissipation are specified, then one must have

$$R_s = \frac{58 V_s^2}{W_m}$$

If a 50c/s supply is used, and if 20msec is a reasonable averaging time, the expressions given can be used to determine a safe value of R_s.

Appendix 2

The Zener diode characteristic is assumed to be ideal as shown in Fig. 15. The sine wave shown in Fig. 16 is applied to the Zener diode in series with a resistor R_s. At the beginning of the reverse half cycle the supply voltage causes only a small current to flow in the diode, so the drop across R_s is negligible and the whole of the supply voltage can be considered to appear across the diode. When the supply voltage exceeds the Zener diode turn-over voltage V_t, the diode carries current and further increases of voltage appear across the resistor, the current being $\dfrac{V_s \sin \omega t - V_t}{R_s}$. At the end of the half cycle the reverse effect takes place. During the conducting half cycle it is assumed that the voltage across the diode is small so that the dissipation can be ignored.

The Zener diode voltage waveform is flat topped and the current waveform is the top of a sine wave $\dfrac{V_s \sin \omega t}{R_s}$ as shown in Fig. 16. If the angle at which the knee of the characteristic is reached is A, then as for the transistor, it is sufficient to integrate between A and $\pi/2$.

The diode current at any instant is

$$I_t = \frac{V_s \sin \omega t - V_t}{R_s}$$

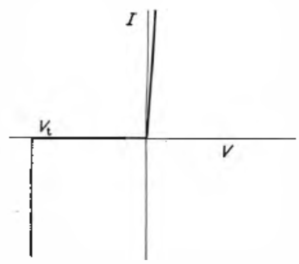


Fig. 15. Ideal Zener diode characteristic

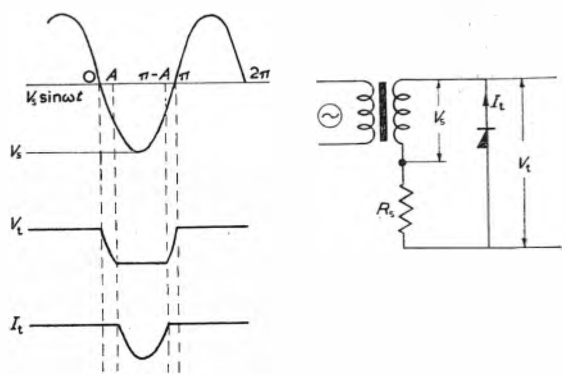


Fig. 16. Zener diode waveforms

The instantaneous power dissipation is therefore

$$V_t I_t = \frac{V_t V_s \sin \omega t - V_t^2}{R_s}$$

now $V_t = V_s \sin A$

hence

$$V_t I_t = \frac{V_s^2 \sin A \sin \omega t - V_s^2 \sin^2 A}{R_s}$$

This is the same expression as was obtained for the transistor, and a given resistor value will therefore give the same dissipation for a transistor or for a Zener diode at a given supply voltage.

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A Miniature Electroencephalograph Telemeter System

By D. C. Gold* and W. J. Perkins*, M.Brit.I.R.E., A.M.I.E.E.

A telemeter system is described which enables the electrical activity of the brain of a normal free and unrestrained cat to be recorded. The voltage picked up by an electrode fixed into the skull is amplified sufficiently to modulate a transmitter carried on the cat's back. The transmissions are received and applied to a cathode-ray display unit or a tape recorder.

(Voir page 377 pour le résumé en français: Zusammenfassung in deutscher Sprache Seite 382)

THE effect on behaviour of many recently developed drugs has frequently been studied in the cat and an instrument was required that would record the electrical changes in the brain of a non-anaesthetized cat during these changes in behaviour. The normal pattern of electrical activity in the cat's brain is changed as its behaviour alters, but these changes in the electrical pattern will not be a true representation if the behaviour is in any way interfered with, as for example by the cables normally required to connect the electrode in the brain to the amplifying and recording apparatus. This can be overcome by the use of a radio link but in order to permit free movement of a cat weighing between 9 and 11 lb, the equipment carried by the cat should not weigh more than 9oz.

The electrical activity to be recorded is such that an overall frequency response of 2c/s to 2kc/s is required. Instead of the electrical pattern recorded by a conductor on the surface of the head, which is the integrated picture of the activity of many thousands of nerve cells, it was required to observe the activity of only a few. In order to do this a conductor with a very small conducting tip of the order of 2 to 6 microns has to be used and in these experiments was held in position by a Perspex holder fixed permanently into the skull. The type of micro-electrode has been described by Dowben[1] and Rose[1]. The signal developed between this electrode and an indifferent electrode, such as a length of wire inserted beneath the skin of the scalp, varies between 10 and 250μV. This type of electrode has an impedance as high as 5 to 10MΩ and, in order to reduce interference picked up in the input circuit of an amplifier, a balanced circuit was required. This was obtained by recording the differential voltage between the micro-electrode and the indifferent electrode, using a second similar length of wire as a common reference point. Any current allowed to flow in a micro-electrode of this size produces a very high current density in the tissue in the neighbourhood of the tip and this can interfere severely with the activity of the individual nerve cells. It was therefore necessary to design an input circuit in which the current was less than 10^{-10}A.

In order to give the physiologists the opportunity to discover, initially, whether the electrical activity of a few cells could be satisfactorily recorded in a freely moving animal, it was thought desirable to produce a unit that would require the minimum development and would enable the main physiological and instrumentation requirements to be given preliminary study.

* *National Institute for Medical Research.*

The transmission of very low frequency signals requires a stable carrier frequency, as with either frequency or amplitude modulation, changes in carrier frequency can be confused with low frequency biological signals. A probable future requirement, the recording of the standing potential of the cells, would certainly require crystal control of the

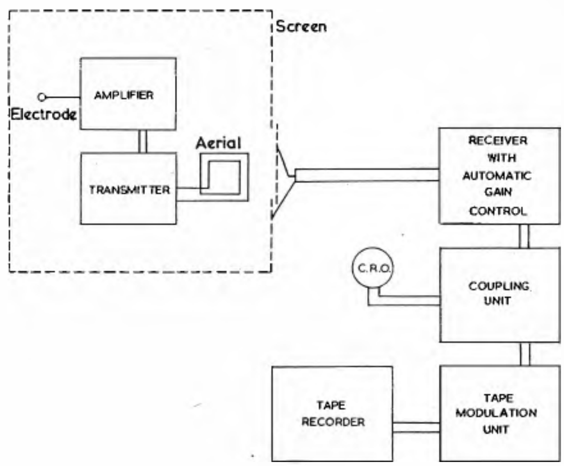

Fig. 1. Basic multiple channel d.c. recording system

carrier, but for a frequency modulated system this would mean more complex circuits than with amplitude modulation, and hence additional weight. Thus it was decided to use a 6·8Mc/s crystal oscillator as the carrier for an amplitude modulated system. The problem of amplitude variation produced by movement of the animal was reduced by confining the animal to a cage 4ft by 3ft by 2ft and by suitable adjustment of the time-constant of the automatic gain control in the receiver.

It was necessary to use valves for the input stage because of the high input resistance and input current limitation and, as the output power required for adequate signal strength was of the order of 20mW, it was decided to use battery valves throughout. The complete system is shown in Fig. 1.

The Transmitter[3] (Fig. 2)

The valves chosen were DF66's for the amplifier (V_1, V_2, V_3 and V_4), a DF72 for the oscillator (V_5) and a DL75 for the output stage (V_6). The batteries used for the h.t. were two Ever-Ready type B157, giving 60V with small physical size and a weight of 1·8oz. Although these were slightly over-run, two six hour experiments were possible before they reached a limiting end point. For the l.t. two 1·3V mercury cells (Mallory RM1R) were used giving approximately the same life.

Because of the common cathode connexions using battery valves and a common battery, it was not possible to use a conventional rejection ratio circuit with common cathode resistor for the input stage. With the circuit of V_1, V_2 phase rejection is obtained by feeding a proportion of the output from V_2 to the screen of V_1, the phase relationship being such as to assist when the input grid signals are in anti-phase and to oppose when they are in phase.

For small input signals the output of V_1 is given by

$$E_o = [\mu_1 e_{g1} + \mu_s e_s]\ \frac{R_1}{R_1 + r_{a1}}$$

and

$$e_s = \frac{\mu_2 R_2 e_{g2}}{R_2 + r_{a2}}$$

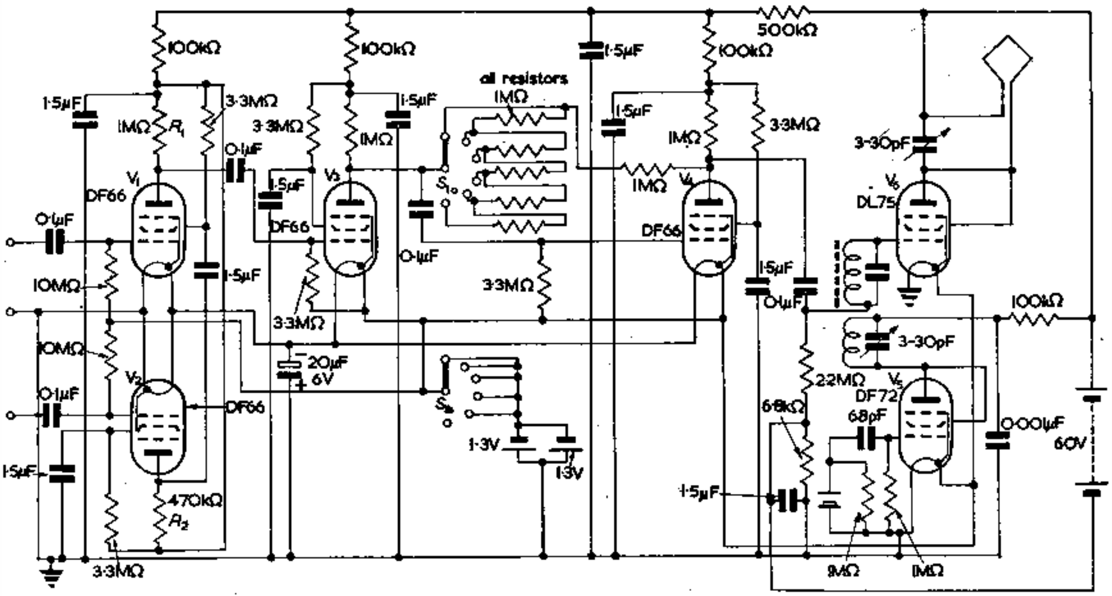

Fig. 2. Modulator and transmitter

where μ_1 and μ_2 are the amplification factors of V_1 and V_2

r_{a1} and r_{a2} are the a.c. resistances of V_1 and V_2

e_{g1} and e_{g2} are the input signals of V_1 and V_2

R_1 and R_2 are the anode loads of V_1 and V_2

e_s is the a.c. voltage applied to the screen of V_1

and μ_s is the amplification factor of V_1 for a signal applied to the screen.

Thus, assuming equal input signals to both valves, the gain

$$\frac{E_o}{e_{g1}} = G = \left[\ \mu_1 \pm \frac{\mu_s \mu_2 R_2}{R_2 + r_{a2}}\right] \frac{R_1}{R_1 + r_{a1}}$$

The best rejection ratio is obtained when

$$\mu_1 = \frac{\mu_s \mu_2 R_2}{R_2 + r_{a2}}$$

then

$$R_2 = \frac{\mu_1 r_{a2}}{\mu_s \mu_2 - \mu}$$

and for this condition with equal anti-phase signals the gain is

$$\frac{E_o}{2e_{g1}} = G = \frac{\mu_1 R_1}{R_1 + r_{a1}}$$

Thus the adjustment of a given pair of valves for best rejection ratio, $\frac{\text{(anti-phase gain)}}{\text{(in-phase gain)}}$ is obtained by control of R_2 only. To save space and to avoid the noise level caused by a miniature potentiometer, a fixed resistor of the correct value was used. The input was connected to the grids of V_1 and V_2 through a capacitor of 0·1μF using a 10MΩ grid leak. V_3 and V_4 were conventional amplifier stages with the gain controlled by feedback from the anode of V_4. Due to the high value of anode loads and the compact construction, stray capacitance significantly affects the frequency response. For example, the frequency response was affected by the gain control and, at the minimum gain, was extended to 10kc/s. The oscillator was a tuned anode, crystal grid circuit mutually coupled to the grid circuit of the output valve V_6. This valve was grid modulated by the output from V_4, approximately 0·5V being required to give sufficient modulation. To produce an undistorted output signal the maximum gain of the modulator was approximately 10^4. The input power to V_6 was 40mW, the current drain on the batteries being about 1mA. The anode circuit of the power amplifier was tuned and the coil wound in a loop connecting the two parts to form the aerial.

Mechanical Details

To allow the cat freedom of movement such as rolling on its side, the unit was constructed in the form of a saddle with the modulation amplifier and l.t. batteries in one side, the transmitter and h.t. batteries in the other and the loop aerial between (Fig. 3). The cases were made of 24 s.w.g. aluminium which, in addition to being robust, gave some measure of screening to the modulator. Each case was 3in long, 2½in wide and ⅞in deep and weighed 0·9oz with its hinged lid, the overall weight of the whole unit complete with batteries being 8·5oz. The under-sides of both cases were lined with rubber to prevent slipping and an elastic strap passed under the body held the cases in position. It was found necessary to fasten the unit to a collar to prevent it slipping backwards to the hind legs. To facilitate changes of gain during an experiment, the gain control was brought out through a slot in the case. The micro-electrodes were connected to the amplifier by a short length of light coaxial cable.

Receiver

An RCA AR88 communications receiver was used with the time-constant of the automatic gain control increased,

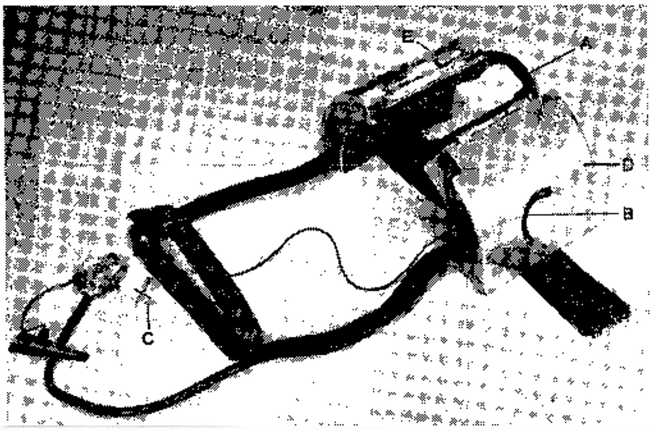

Fig. 3. The transmitter

A Aerial
B Gain control
C Micro-electrode
D Modulator
E Transmitter

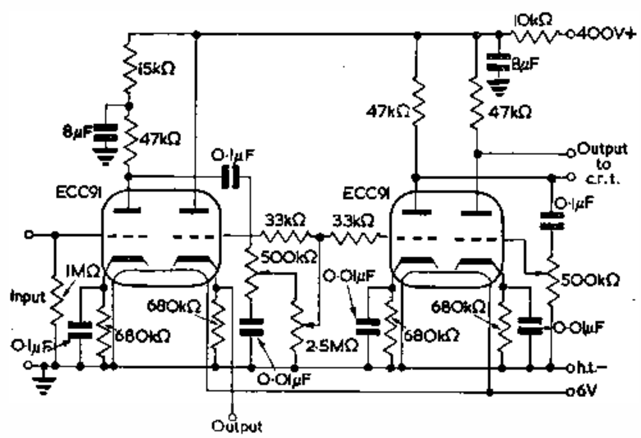

Fig. 4. Coupling unit

to reduce the effect of cat movement. A square of ¼in mesh copper netting (2ft by 1ft) which formed the centre of the roof of the cake was used as the receiver aerial and connected by a coaxial cable to the grid of the r.f. amplifier.

The output from the receiver detector was fed to a coupling unit (Fig. 4). The first stage of this unit was a voltage amplifier with a cathode-follower output for feeding a frequency modulated tape recorder unit and the second stage provided a paraphase output for driving a cathode-ray tube. A variable low-pass filter was also included to cut out unwanted high frequency signals. At maximum gain settings on both modulation amplifier and receiver, the noise level was equivalent to a 10μV signal input to the modulator amplifier and this level could be reduced by increasing the high frequency attenuation.

Results

Comparative tests were carried out by applying the electrical potentials from an unanaesthetized cat simultaneously to the telemeter unit and a conventional amplifier used for biological work. The results showed little difference for normal levels of input potentials but at higher levels it was possible to overload the telemeter amplifier.

A typical example of the changes of electrical activity produced by a change in behaviour is illustrated[3] in Fig. 5. Fig. 5(a) shows the pattern of a particular region of the brain, when the motions only for the presentation of food to the animal have been completed at the point marked by the arrow. In Fig. 5(b) the motions were repeated in the

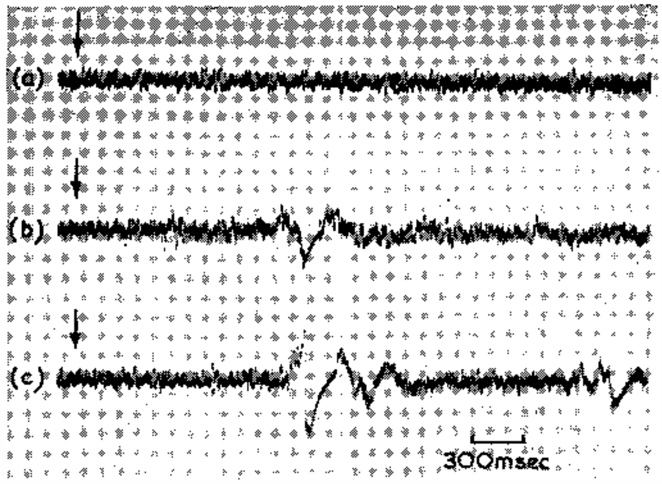

Fig. 5. (a) Motions of presentation of food but none taken
(b) As for (a) but food taken
(c) Stimuli of 4kc/s tone applied for 0·1sec.

same manner but this time were accompanied by food, which was swallowed, and a definite pattern of response obtained. Before Fig. 5(c) was obtained, the presentation of food was accompanied a number of times by a 4kc/s note lasting for 0·1sec and the record shows a similar response produced by the sound alone at a point marked by the arrow.

Conclusions

The results show that the technique of radio transmission of the electrical potentials picked up by micro-electrodes in the brain is practicable and can be used for demonstrating changes in activity of a normal unanaesthetized animal. It is possible to build a transmitter that is within the carrying capacity of a cat. The limiting factor in respect of the degree of freedom was the change in signal strength produced by animal movement. If behaviour involving more vigorous activity is to be investigated, other modulation systems may be preferred, but for small animals the maximum allowable size and weight will be a determining factor in any design.

Acknowledgments

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A Multiple Channel D.C. Recording System

By H. D. Scott*

An amplitude modulation multiple carrier system has been designed to permit the tape recording of electrical signals in the range d.c. to 10c/s inclusive. Up to 12 independent data signals, a voice channel, and timing signals may be accommodated on a conventional single track portable magnetic tape recorder. Special circuits have been devised to effectively cancel spurious amplitude fluctuations introduced by the recorder. The system is linear to an accuracy of ±1 per cent of maximum instantaneous signal amplitude.

(Voir page 377 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 382)

IN geophysical research, it is frequently desirable to simultaneously tape record a number of electrical signals, occurring in the frequency range d.c. to a few cycles per second. The conventional type of tape recorder is unsuitable for direct recording of data signals of this nature as it is unable to handle frequencies below about 30c/s. Although special f.m. magnetic tape recorders are available commercially for recording signals in the frequency range 0 to 100c/s, several considerations limit their general acceptability. The initial cost of the recorders, particularly the multiple track instruments, is prohibitively high for many applications and in addition, the performance of the recorders, although satisfactory for the frequency range 1c/s to 100c/s, is usually poor below 1c/s. Serious drifting of the d.c. level with consequent restriction in accuracy is frequently encountered.

An amplitude modulation system which overcomes the preceding objections has been designed, using a conventional single track low speed magnetic tape recorder. It is used in conjunction with special electronic circuits, to provide accommodation for a possible 12 independent data signals, together with speech and timing signals.

The signal processing is such that a data signal waveform in the range d.c. to 10c/s is preserved to an accuracy of ±1 per cent of maximum instantaneous amplitude.

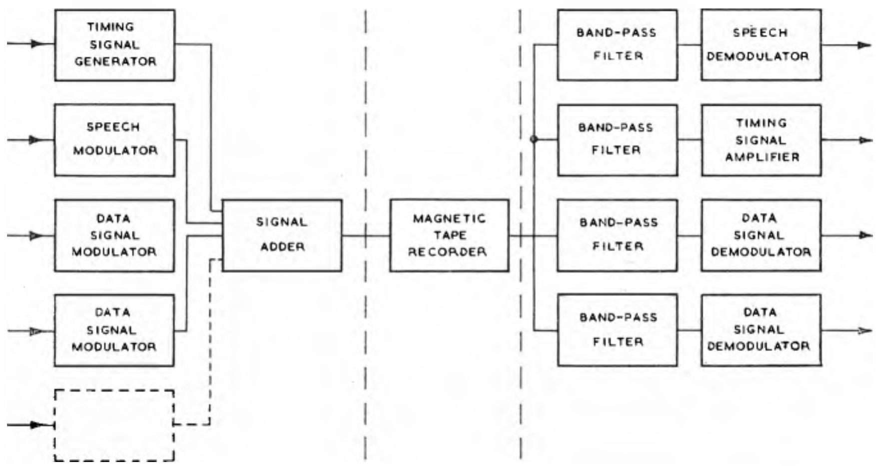


Fig. 1. Basic multiple channel d.c. recording system

General Description of Technique

The basic system is shown in Fig. 1 where data, voice, and timing signals amplitude modulate carriers, which are combined and recorded on a single track tape recorder. On playback, the signals are separated with filters, demodulated, and the original signals recovered.

Inherent in the tape recording process is the introduction of amplitude fluctuations or noise modulations on the envelope of each carrier, caused by imperfections in the tape and the variable contact of the tape with the recording and playback heads. Since the noise appears as a modulation on the signal, it is a constant percentage of the signal amplitude and ordinarily causes little difficulty when data is recorded directly, but it can cause serious degradation, when a carrier system is used. The difference in the situations is illustrated in Fig. 2 where the first example shows the degradation of a directly recorded signal, and the second example the greatly increased signal deterioration as a result of the amplitude modulation process.

In the tape recorder used, noise components are generated with frequencies ranging from a fraction of a cycle per second to several kilocycles per second. In the present system only those noise components which occur in the frequency range 0 to 10c/s are of concern, since all higher frequency components are removed by conventional filters. Over this low frequency range, the noise is of a continuous periodic nature and is of the order of 20dB below the carrier level, for carrier frequencies below 5kc/s.

For carriers of 5kc/s and below, it has been established that the noise modulations of carriers recorded a few hundred cycles apart are well correlated, and this fact has been used to construct a device to effectively cancel the noise.

The non-uniform degradation of a low frequency data signal as a result of the usual amplitude modulation, carrier recording process is illustrated in Fig. 3 where (a) shows the original signal, (b) the recovered signal, and (c) the noise component in (b).

The noise cancellation involves the production of another noise signal similar to (c) but opposite in phase, which when added to the recovered signal (b) will just cancel the noise, leaving a data signal essentially noise-free as shown at (d). A data signal modulated carrier and an unmodulated carrier of suitable frequency separation, are recorded simultaneously. A noise signal obtained by demodulation of the recorded unmodulated carrier (now noise modulated) is treated and added in reverse phase to the noise modulated signal obtained from the data signal carrier.

Fig. 4 shows a graphical representation of how the original noise is generated, and the cancellation noise

* *Defence Research Board, Canada.*

isolated, reversed, and injected. (a) shows a low frequency square wave to be recorded, (b) the signal modulated carrier, and (c) the same modulated carrier after recording and playback. (d) and (e) show the effect of the recording process on an unmodulated carrier which was recorded simultaneously with (b) and differs from it in frequency by a few hundred cycles. The noise components of the modulated carrier (c) and unmodulated carrier (e) are

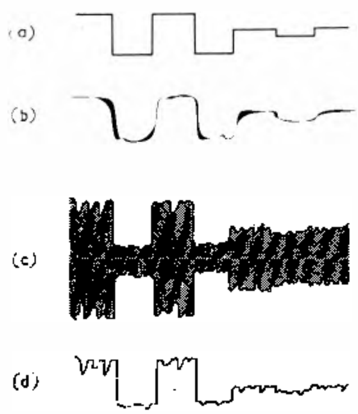


Fig. 2. Illustration of the comparative signal deterioration of directly recorded and carrier data signals

(a) Original data signal
(b) Noise modulation on directly recorded data signal
(c) Noise modulation on carrier recorded data signal
(d) Demodulated carrier recorded data signal

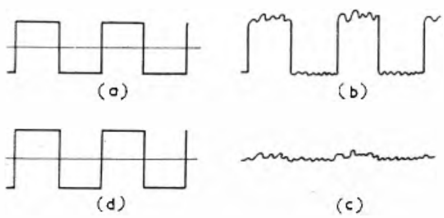


Fig. 3. Illustration of the non-uniform noise modulation of a carrier recorded data signal

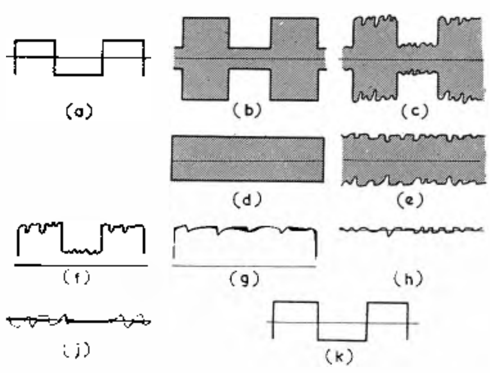


Fig. 4. Illustration showing the mechanisms of noise generation and noise cancellation

similar in character but differ in strength. The mean amplitude of the noise component of (e) is uniform, whereas that of (c) is varying in accordance with the carrier envelope.

After rectification and recovery of the modulation components from the two carriers, the resulting signals will be: from (c) the polarized signal shown at (f), the three components of which are the original data signal, a variable strength noise component, and a d.c. component, from (e) a steady polarized noise signal as shown at (g). The d.c. terms are introduced in the recovery process and their removal or modification is accomplished by further processing.

Injection of a bucking bias on the noise signal (g) will yield a non-polarized noise signal as shown at (h), and a slight adjustment of the magnitude of the constant term of (f) will produce a signal with an amplitude practically proportional to the modulated carrier (c). The latter signal is then used to vary the noise signal (h) by a multiplication process. This produces a modified noise signal (j) with a waveform almost identical to that of the noise on the recovered data signal (f). Addition of this treated noise in the proper phase and amplitude, to the data signal (f) will then cancel the noise, and injection of a constant to produce a zero d.c. term will leave a nearly perfect replica of the original data signal as shown at (k).

Ideally, the multiplication factor (f) should be exactly proportional to the modulated carrier (c) without the noise,

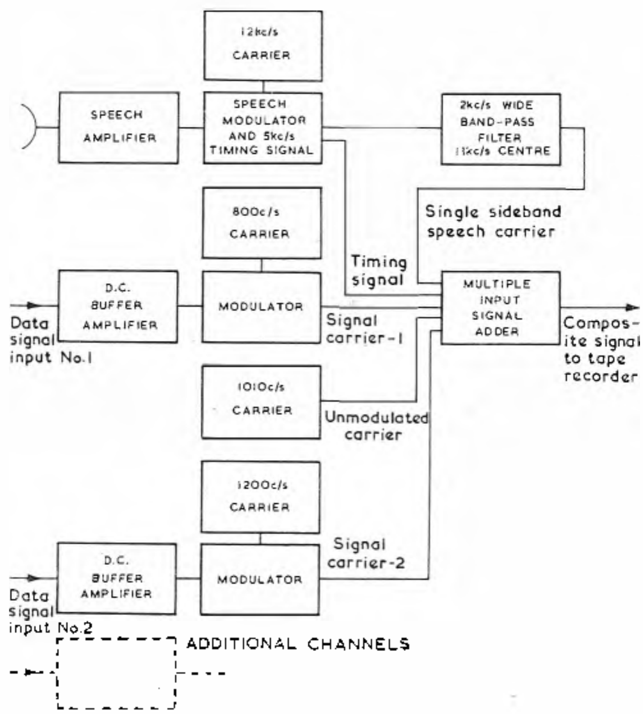


Fig. 5. Modulator and pre-recording input

however, since the noise component is relatively small, the approximation is satisfactory.

Although not of concern in the present requirement, it was observed that effective cancellation of higher frequency noise is also realized, and the technique appears particularly effective for the elimination of signal ‘drop-outs’.

Description of Prototype System

A practical version of the system employing the techniques described in the preceding section has been built, using an Ampex 400A portable tape recorder. At 15in/sec tape speed using ordinary 2 400ft length tape, one-half hour of continuous recording is available. The system is capable of handling two data signals, plus timing and speech signals. It employs carrier frequencies of 800, 1 010 and 1 200c/s for the data signals, 5kc/s for the timing signal, and 12kc/s for speech. The particular choice of data signal carrier frequencies was based partly on the necessity of insuring freedom from spurious signal generation, such as might occur through sum and difference frequency combinations.

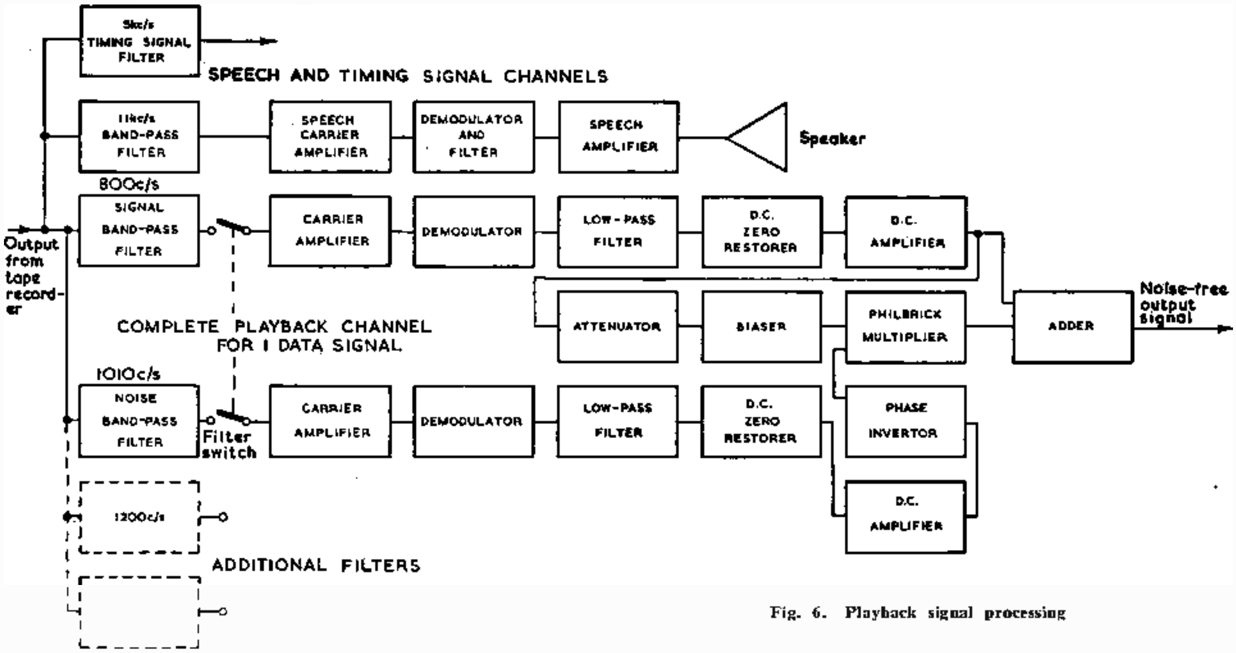


Fig. 6. Playback signal processing

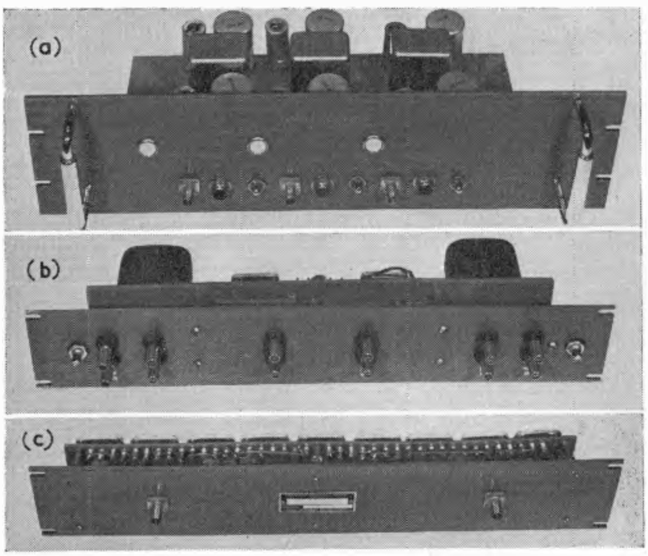


Fig. 7. Typical components of system showing unit construction

Aside from this precaution, it appears that little difficulty would be encountered in extending the system to accommodate another 10 data channels in the region below 5kc/s.

Fig. 5 shows a block diagram of the modulator and other pre-recording input apparatus, and Fig. 6 shows the playback equipment. The apparatus shown in the figures differs from the basic equipment of Fig. 1 because of the incorporation of the noise cancellation circuits as described in the preceding section. The changes include the addition of an unmodulated carrier generator to the pre-recording equipment and additional playback circuits required in processing the cancellation noise.

For multi-channel portable operation, it is only necessary to have the pre-recording equipment transportable, since playback is usually accomplished at a fixed station. Circuits were selected which enabled the construction of accurate and stable carrier modulation apparatus, particularly suitable for portable operation. Examples of the modular construction of typical components are shown in the photographs of Fig. 7 where (a) shows a triple carrier generator capable of producing simultaneous fixed frequencies of 800, 1 010, and 1 200c/s, (b) a dual channel modulator and (c) a typical bandpass passive filter used in the playback equipment. Schematic diagrams of the basic oscillator and modulator circuits employed are shown in Figs. 8 and 9 respectively. The playback equipment, with the exception of the band-pass filters, is assembled from commercially available apparatus.

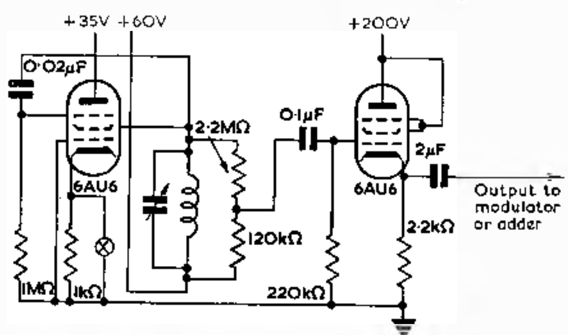
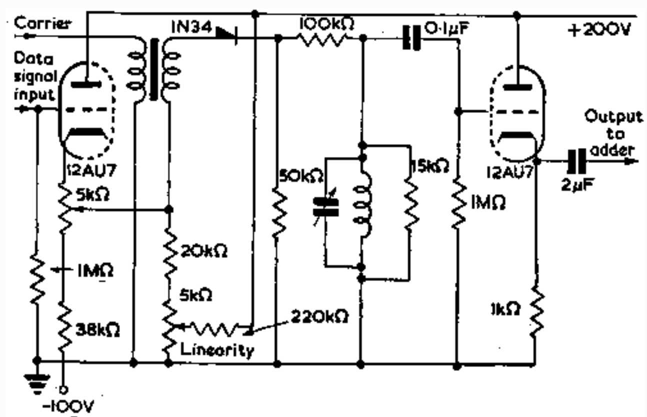


Fig. 8. Carrier generator employing transitron oscillator

Fig. 9. Schematic of modulator



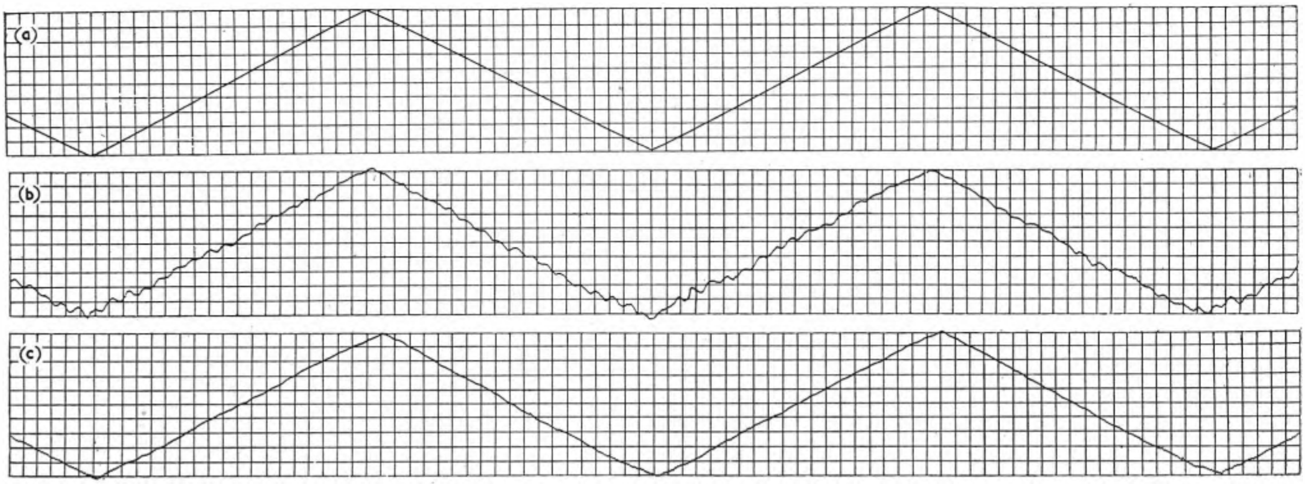


Fig. 10. System response to a triangular waveform
(a) 0·1c/s input signal
(b) Output signal without noise cancellation feature
(c) Output signal completely processed

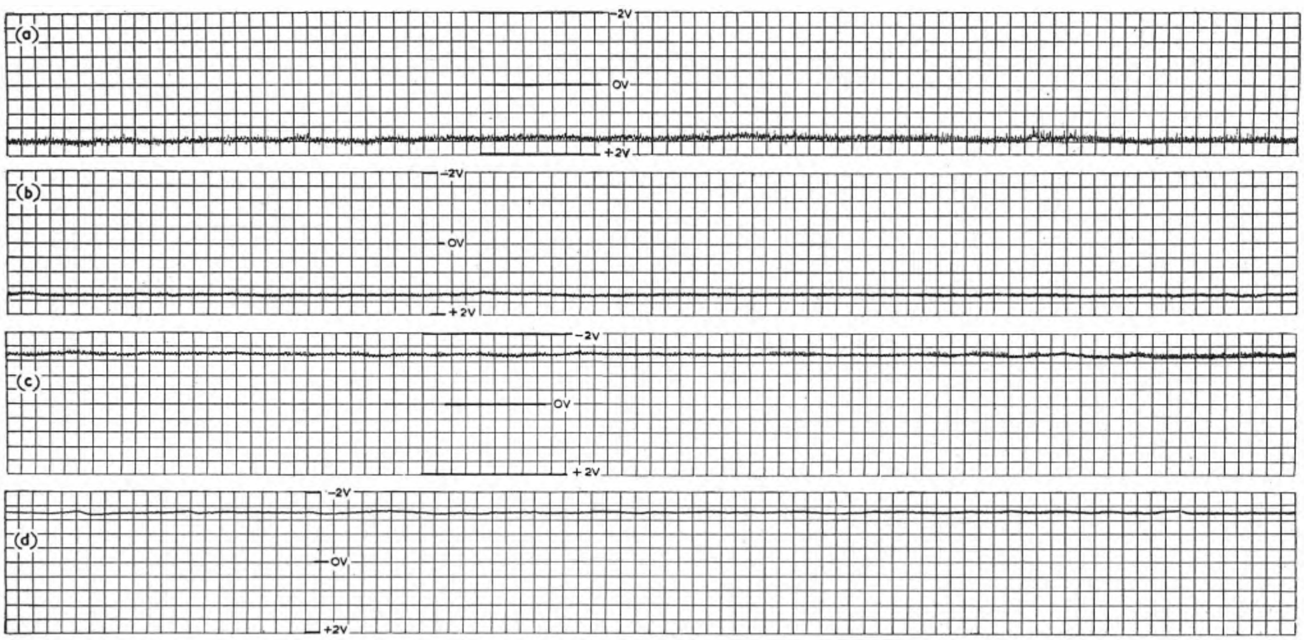


Fig. 11. System response to d.c. signals
(a) Response, without noise cancellation feature, to a steady positive d.c. voltage of 7min duration
(b) Response as (a) completely processed
(c) Response, without noise cancellation feature, to a steady negative d.c. voltage of 7min duration
(d) Response, as (c) completely processed

Extension of the system to allow the accommodation of more data channels would merely involve replications of the modulator equipment and additional filters in the playback equipment. If simultaneous playback of a number of data signals is desired, it would be necessary to provide a playback processing channel for each signal. However, most requirements would only necessitate the playback of one or two signals at a time, in which case, a single or double channel, comprising the demodulators and associated noise reduction circuits would be sufficient.

System Performance

The frequency response of the system is uniform within 1 per cent throughout the range 0 to 10c/s, and is principally determined by the constants of the band-pass filter in the playback equipment. Extensions to this range may be obtained by using filters with a wider pass-band. With the present filters the rejection is such that cross-over with neighbouring filters occurs at a point approximately 50dB below maximum response, and no interference is observed between channels. Increasing the pass-band would of course, reduce the number of available channels in a given portion of the spectrum.

Figs. 10 and 11 show the actual response of the system to typical input signals and the extent of noise cancellation obtainable. The ±5 per cent degradation of the triangular waveform as a result of the a.m. carrier recording process is quite apparent in the centre of Fig. 10, and the extent of the noise cancellation is exemplified in the third extract, where no portion of the waveform now departs by more than ±1 per cent of maximum from the original. The examples in Fig. 11 show the considerable improvement obtained for both positive and negative steady d.c. signals.

Conclusion

Employment of amplitude modulation together with noise cancellation has enabled the use of conventional magnetic tape recorders for signals in the frequency range 0 to 10c/s. Although the system described was designed to handle only two independent data signals, there is every indication that, with proper choice of carrier frequencies, little difficulty would be encountered in extending the system to accommodate many more signals.

Although more extensive tests would be required to determine definitely the long term performance of the equipment, it appears likely that unless radically interrupted by component failure, uniform operation would prevail. The usual precautions with respect to stable power supplies, proper ventilation of apparatus, and the use of care in adjustment will lessen the possibility of increased error.

Acknowledgment

The author wishes to extend his sincere appreciation to the professional and technical staff of the Naval Research Establishment whose assistance in the project was instrumental to its success. Especial thanks are due to Dr. R. P. Chapman for direction in the development and Mr. F. G. Millar for help in preparing the manuscript.

ERGONOMICS AMID ELECTRONICS

The application of anatomy, physiology and psychology to the study of man at work, and the combination of these with engineering to fit the job and the machine to the operator, has been named Ergonomics; Human Engineering is the term used in the U.S.A. The problems of fitting together men and machines have arisen from the speed of technological progress during and since the war. Ten years ago workers interested in these problems founded in England the Ergonomics Research Society, the first of its kind in the world.

However, the industrial application of Ergonomic knowledge has been pioneered in the U.S.A. Several of the chief American aircraft firms employ more human factors specialists than the whole of British industry. By contrast the lead in what Ergonomic work is being done in British companies appears to be taken not by aircraft but by electrical and electronic firms. At the tenth anniversary conference held recently in Oxford by the Ergonomics Research Society on "Ergonomics; its place in industry", more than a quarter of the persons present who came from industry were from electrical or electronic companies.

Three companies in particular appear to be actively engaged with Ergonomics as well as electronics. Metropolitan Vickers Ltd has had an Appearance Design group for a number of years. The General Electric Co. Ltd Atomic Energy Division has recently started an Ergonomics section and E.M.I. Electronics Ltd has had a research psychologist and laboratory at work on Ergonomic problems for nearly five years.

At the Oxford conference two papers were presented on electronic aspects. Mr. J. Arrowsmith (E.M.I.) discussed "Numerical Machine Tool Control and the Operator" and pointed out how this form of automation changed the skills required of the production team and eased the load on the operator. In conventional production methods, special tools usually have to be designed and made; for 'controlled machines' these are, in general, unnecessary, but there is the different task of programming the control data. With a 'numerical' machine a complicated shape can be cut in a single operation, whereas with conventional machines several cutting changes are necessary and perhaps several different machines may have to be used.

The comparison of methods shows that, although the numerically controlled machine is automatic, it must still have an operator in charge. His tasks have been eased, however, since he is no longer responsible for the accuracy and shape of the work. Thus the controlled machine achieves its aim of increasing production, not by eliminating the operator, but by easing his task and enabling more to be produced per man.

Mr. B. Shackel (E.M.I.) reviewed the past and offered some suggestions for the future from his experience of practising "Ergonomics amid Electronics". The Ergonomist can help the engineer in three particular parts of his work, on the detailed design of displays and controls, on the general layout of equipment panels and on the basic problems of system design for man-machine compatibility. Ergonomic research is also being directed by various workers towards problems of design for easier maintenance and the training of personnel in better fault-finding procedures.

As instances of the use of Ergonomic advice during the design stage, some oscilloscopes, the EMIAC analogue computer and some aspects of an airline seat-reservation system were illustrated. The latter provided an interesting example of how an Ergonomic method, analysing in minute detail how the operator would 'talk' to the computer and preparing an exact sequential man-machine flow diagram, was found to be very useful to the engineering design itself as well as helping to ensure adequate attention to operator requirements.

Finally, Mr. Shackel pointed out the need not so much for more specialists to do this work for the engineers as for more engineers to learn and apply the general results of ergonomics research. It might well prove desirable that ergonomics should be an ancillary subject during the training of engineers and at least an optional subject in the syllabus and examinations for membership of the Professional Institutions. In this way the engineering profession would show yet again its ability to absorb the results of academic research and put them to sound practical use.

THE MODULATOR AS A PHASE DETECTOR

A Note on the Error due to a Finite Switching Voltage applied to a Shunt Modulator

By W. Fraser*, B.Sc.(Eng.), A.M.I.E.E. and R. E. Schemel*, B.Sc.(Eng.)

Errors occur in the indication of a rectifier modulator when used as a phase detector if the switching voltage is not very much larger than the signal. The variation and magnitude of this descrepancy is considered in terms of the ratio of the input voltages for the case of a transformerless shunt modulator. It is shown that a ratio larger than 7 : 1 is required if the error is to be less than 1 per cent. Details of some experimental tests are given.

(Voir page 377 pour le résumé en français: Zusammenfassung in deutscher Sprache Seite 382)

A MODULATOR circuit with two inputs and one output connexion can in general be used as a phase detector, inasmuch as the output may be arranged to give an indication of the phase difference between the two inputs when these have the same frequency. Conventionally, rectifier modulator circuits employ transformers to permit the connexion of unbalanced inputs. These transformers are undesirable when the wanted modulation product is of zero frequency, and they also introduce phase shifts which are troublesome when the circuit has to operate over a wide range of frequency. It has been shown that the transformers

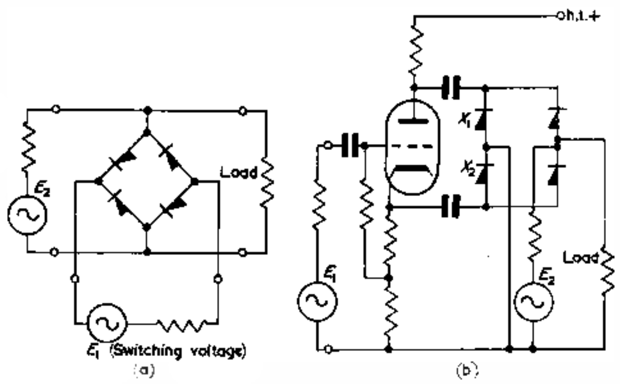


Fig. 1. (a) Shunt modulator
(b) Re-arrangement of (a) using a phase-splitter stage

may be dispensed with[1] if one of the inputs (corresponding to the carrier, or switching voltage) is connected via a valve phase-splitter stage; thus the shunt modulator of Fig. 1(a) may be arranged as shown in Fig. 1(b). As a modulator the rectifiers X_1 and X_2 may be replaced by resistors, but for use as a phase detector it is preferable to modify the circuit as shown in Fig. 4.

Phase Detection

If the two inputs to the modulator are represented respectively as $E_1 \sin \omega t$ and $E_2 \sin (\omega t + \phi)$ it is easily shown that the output has a direct component given by

$$E_0 = \frac{1}{\pi} E_2 \cos \phi$$

Hence if the input voltages are fixed in amplitude the d.c. output is proportional to the cosine of the phase difference between the inputs. This is only true, however, if three simplifying assumptions are made. Firstly, the rectifiers are assumed to possess constant forward and reverse impedances, which are resistive; switching of the rectifiers is assumed to be entirely due to the polarity of the carrier or switching voltage, and finally the rectifiers themselves are deemed to possess perfect switching characteristics, i.e. the change-over from forward to reverse resistance occurs at zero voltage. In practice, none of these assumptions is true. When used as a phase detector the greatest error is introduced by the second assumption which is clearly invalid when the switching voltage passes through zero.

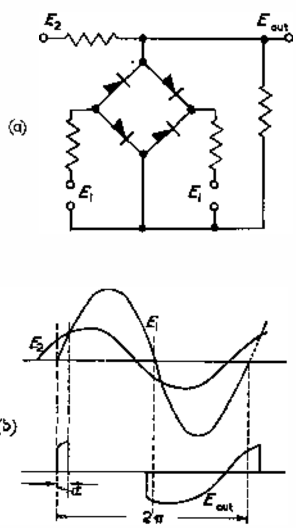


Fig. 2. Effective circuit arrangement and error due to finite switching voltage

Error Due to a Finite Switching Voltage

The effective circuit arrangement may be redrawn as in Fig. 2(a). In the idealized case the rectifier combination acts as either a zero or high impedance shunt on the output load, depending on the polarity of the switching voltage.

In the practical case when the switching voltage is finite the circuit behaves as in the ideal case except for the interval of time in which the switching voltage is less than the other input (E_2). By a step by step consideration of the voltages applied to the rectifiers over a cycle of finite switching voltage it can be shown that the output is as drawn in the lower curve of Fig. 2(b). The d.c. output is no longer directly proportional to the cosine of the phase difference. For a phase difference ϕ, the critical points occur when

$$E_1 \sin \omega t = E_2 \sin (\omega t + \phi)$$

If now $k = E_1/E_2$ and $\alpha = \omega t$, then this condition gives

$$\tan \alpha = \frac{\sin \phi}{k - \cos \phi} \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

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The output from the circuit is at its full value from 0 to α, and from $(\pi - \alpha)$ to 2π; the mean output averaged over one cycle is thus

$$\frac{1}{2\pi}\int_0^{\alpha} E_2 \sin(\omega t + \phi)\, d(\omega t) + \frac{1}{2\pi}\int_{\pi-\alpha}^{2\pi} E_2 \sin(\omega t + \phi)\, d(\omega t)$$

and this reduces to

$$-(E_2/\pi)\cos\alpha\cos\phi$$

When $\alpha = 0$, a condition reached when k is infinite, the output becomes directly proportional to the cosine of ϕ. From equation (1)

$$\cos\alpha = \frac{k - \cos\phi}{\sqrt{[1 + k^2 - 2k\cos\phi]}} \quad \ldots\ldots\ldots \quad (2)$$

It will be seen that when $\phi = 0$ or $180°$, $\cos\alpha = 1$, and thus although k is finite there is no discrepancy in the d.c. output; when $\phi = 90°$ or $270°$, $\cos\phi = 0$ regardless of the

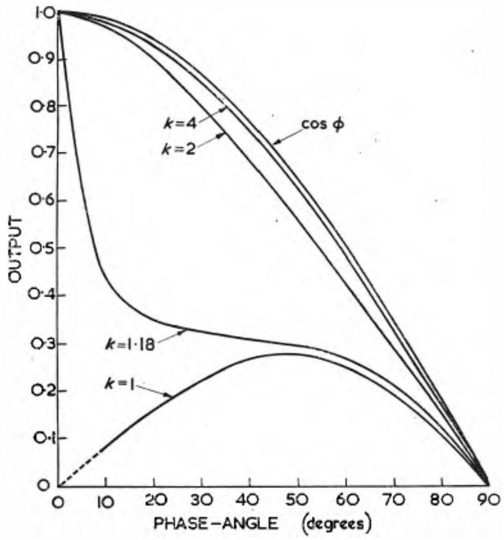

Fig. 3. Output against phase-angle for the range 0 to 90°

value of $\cos\alpha$ and so a finite value of k will again cause no error. Between these limits $\cos\alpha$ will not be equal to unity and an error will occur. It can be shown by differentiation of equation (2) with respect to ϕ that the maximum error occurs when

$$\cos\phi = 1/k \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

and so, for example, if $k = 2$ the maximum error will be at 60°. The actual value of the maximum error is obtained if the value for $\cos\phi$ in equation (3) is substituted in equation (2). This gives

$$\cos\alpha = \sqrt{(1 - 1/k^2)}$$

and if $k \gg 1$, $\cos\alpha \simeq 1 - 1/2k^2$.

Fig. 3 shows curves of output against phase-angle, for the range 0 to 90°, calculated for different values of k. When $k = 1$ and $\phi = 0°$, equation (2) is indeterminate; the rectifiers then have zero voltage applied across them. It will be seen that the curve changes shape between the values of $k = 1$ and $k = 2$. This change of shape does not occur if k is greater than a critical value which is $k = \sqrt{(2/\sqrt{3})}$, or $k = 1{\cdot}075$.

If $\cos\phi$ is to be measured with an accuracy of 1 per cent then k must be greater than 7·1; if, say, $k = 10$ the theoretical maximum value of the error due to this cause is $-0{\cdot}5$ per cent. These results correspond with the well-known criterion used in modulator practice that the switching voltage be large compared with the input signal.

If a measurement of the angle itself is required, then at the point of maximum error $\cos\phi = 1/k$, and if the measured angle is denoted by ϕ', then

$$\cos\phi' = \cos\alpha\cos\phi = \sqrt{(1 - 1/k^2)}/k$$

whereas $\cos\phi = 1/k$.

By a comparison of the series expansions for the two angles, the error is approximately $1/2k^3$ radians, and if this is to be less than say, 1°, then k must be greater than 3·1.

Experimental Tests

A series of measurements were made to test the validity of the theoretical predictions. Fig. 4 shows the circuit used.

As the modulator is a.c. coupled to the phase-splitter a d.c. path must be arranged to prevent the coupling capacitors from being charged by the rectified current; this is provided by an additional rectifier (X) as shown. R_1 was used to compensate for differences in the rectifiers, while R_2 and R_3 were inserted to increase, and equalize, the

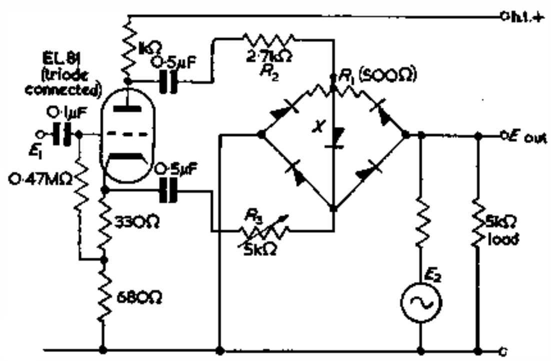

Fig. 4. The circuit used for experimental tests

source impedances of the switching voltage. Germanium rectifiers, with a forward resistance of approximately 150Ω, were used. They were selected by visual comparison of their forward characteristics on an oscillograph with the characteristics of a pair displayed simultaneously.

Tests were carried out at 1kc/s and 10kc/s. The ratio of voltages was varied from 4 to 30 and the corresponding outputs measured for phase differences between 0 and 90°. Close agreement was obtained with the theoretical prediction, with curves of the same form as shown in Fig. 3. The maximum discrepancy with the predicted value was 2 per cent in the case when a value of $k = 4$ was used. It should be noted that as a consequence of the curvature in the volt-ampere characteristic of practical rectifiers, their switching action is not instantaneous, and the effect is to increase the value of α. It was found that the error varied slightly with the value of the output impedance, and was a minimum when the load was matched to the impedance of the modulator. This was approximately 5kΩ.

Tests were also made with a square wave switching voltage. This reduces the time interval in which the switching voltage is less than the other applied voltage, and corresponds more closely to the ideal of an infinite switching voltage. Measurements at 10kc/s confirmed an improvement. For $k = 4$ the maximum deviation from a cosine curve was never greater than 1 per cent.

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The Design of Biased Diode Function Generators

By C. C. Ritchie*, M.A., and R. W. Young†

The design of biased diode function generators is considered and equations are derived relating the number of diode sections, the minimum error obtainable, and the spacing of the diode section to give this minimum error. The construction of a sine function generator, using these principles, is dealt with in some detail.

(Voir page 377 pour le résumé en français; Zusammenfassung in deutscher Sprache Seite 382)

To find solutions to problems in applied mathematics it is common practice to reduce the equations to a simplified linear form. This has been necessary because of the limitations of mathematical analysis, and when one resorts to numerical methods the time required may become prohibitive. For various reasons however, the engineer, chemist or physicist must now try to find solutions of the non-linear equations which in most cases express more correctly the behaviour of his system.

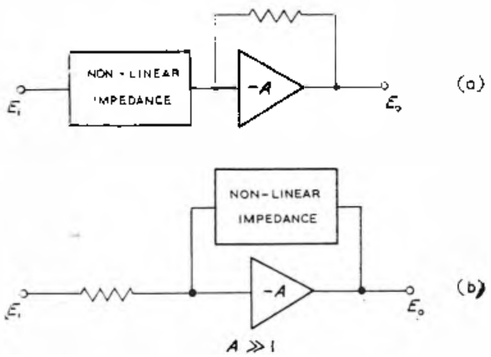


Fig. 1. Alternative positions of non-linear unit

If a digital machine is used for the computation the time required for the non-linear version may be many times that required for the linear. With an analogue computer on the other hand the time required is unchanged. This facility of the analogue computer of solving non-linear equations is one of the principal reasons for its widespread use.

A common method of introducing non-linear functions of a variable into an electronic analogue computer is by the use of an impedance which will pass a current proportional to the function when a voltage proportional to the variable is impressed across it.

If such a unit is used as the input impedance of a high-gain d.c. computing amplifier then (see Fig. 1(a)) the output voltage will be

$$E_o = -\text{const.}F(E_i) \quad \ldots\ldots\ldots\ldots\ldots (1)$$

If the unit is placed in the feedback position as in Fig. 1(b) then

$$E_o = -\text{const.}f(E_i) \quad \ldots\ldots\ldots\ldots (2)$$

where f is the inverse function of F. For example (a) if $F(E_i) = (E_i)^2$ then $f(E_i) = \sqrt{E_i}$, (b) if $F(E_i) = \sin E_i$ then $f(E_i) = \text{arc} \sin E_i$, and so on.

The non-linear impedance may be constructed from a number of biased diode switches. By this means an approximate representation of the function can be built consisting of a number of straight line segments, that is, the curve is replaced by a straight sided polygon. This type of unit is described in many papers and books.

A method is presented here of computing the values of the variable at which the diodes are switched, known as the 'break-points', and also the method of choosing the values of the approximate function at the break-points which will minimize the error.

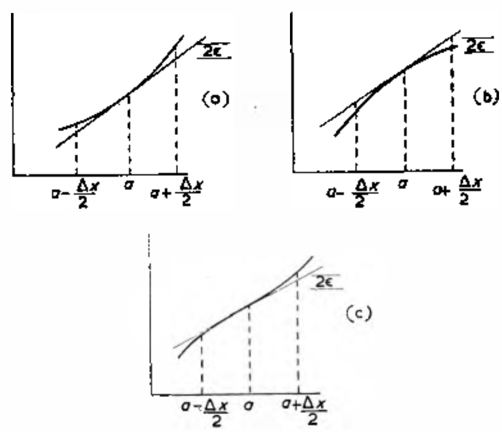


Fig. 2. Three possible relationships of curve to tangent

The design of a function generator using silicon diodes as switching elements is then considered.

Error in Using a Straight Line Approximation

The error ϵ of the approximation is defined as follows: If $f(x)$ is the value of the approximation to the required function $F(x)$ then ϵ is defined by the equation

$$\epsilon = |F(x) - f(x)| \quad \ldots\ldots\ldots\ldots\ldots (3)$$

Fig. 2 shows the three possible cases when a tangent is drawn to the given function at $x = a$.

In Fig. 2(a) the function is concave upwards, in Fig. 2(b) it is concave downwards, in Fig. 2(c) $x = a$ is a point of inflexion.

Taylor's expansion of the required function $F(x)$ at $x = a$ is:—

$$F(a + \tfrac{1}{2}\Delta x) = F(a) + (1/1!)\,(\Delta x/2)\,F'(a) + 1/2!\,(\Delta x)^2\,F''(a) + \ldots + (1/n!)\,(\Delta x/2)^n\,F^n(a) \quad \ldots\ldots\ldots\ldots (4)$$

The error (called 2ϵ for the moment) in using the tangent to the curve at $x = a$, at distance $\Delta x/2$ from a is

$$F(a + \Delta x/2) - F(a) - (\Delta x/2)\,F'(a) \quad \ldots\ldots (5)$$

* Brunel College of Technology.
† Brunel College of Technology, formerly Elliott Automation Ltd.

and this to a first approximation is equal to

$$1/2!\ (\Delta x/2)^2 F''(a) \quad \ldots\ldots\ldots\ldots\ (6)$$

In case (a) this is a positive quantity, in case (b) it is negative, in case (c) it is zero. For case (c), from equation (4)

$$\text{Error} = 1/3!\ (\Delta x/2)^3\ F'''(a) \quad \ldots\ldots\ldots\ldots\ (7)$$

At the point $x = 0$ the function $y = x^n$ has

$$y' = y'' = y''' = \ldots = y^{n-1} = 0,$$

so that the error at this point is approximately equal to:

$$1/n!\ (\Delta x/2)^n\ y^{(n)}(0) = (\Delta x/2)^n \quad \ldots\ldots\ (8)$$

If the tangent in Fig. 2(a) is moved vertically upwards a distance ϵ and that in Fig. 2(b) downwards through the same distance then the errors will be as follows:

	(a)	(b)
$a - (\Delta x/2)$	$+\epsilon$	$-\epsilon$
a	$-\epsilon$	$+\epsilon$
$a + (\Delta x/2)$	$+\epsilon$	$-\epsilon$

By this means the maximum error is halved. The artifice cannot be used in the case in Fig. 2(c) so ϵ must be equated to the expression (7) to make the system consistent.

The formulae giving the maximum interval for a given acceptable error are:

Cases (a) and (b) $\quad (\Delta x)^2 = \dfrac{16\epsilon}{|F''(a)|} \quad \ldots\ldots$ (Type 1)

Case (c) $\quad (\Delta x)^3 = \dfrac{48\epsilon}{|F'''(a)|} \quad \ldots\ldots$ (Type 2)

These formulae could be extended to cover the expression given in equation (8). In some cases it may be desirable to include a section which is tangential to the curve, e.g., at $x = \pi/2$ if it is desired to set up sin x. In this case one must equate equation (6) to ϵ

so that $\quad (\Delta x)^2 = \dfrac{8\epsilon}{|F''(a)|} \quad \ldots\ldots$ (Type 3)

To illustrate the accuracy of the above formulae consider the function $y = \sin x$ at the points $x = 0$, $x = 1{\cdot}000$, $x = \pi/2$.

At $x = 0$ there is a point of inflexion so that

$$\Delta x = \sqrt[3]{(48\epsilon/\cos 0)}$$

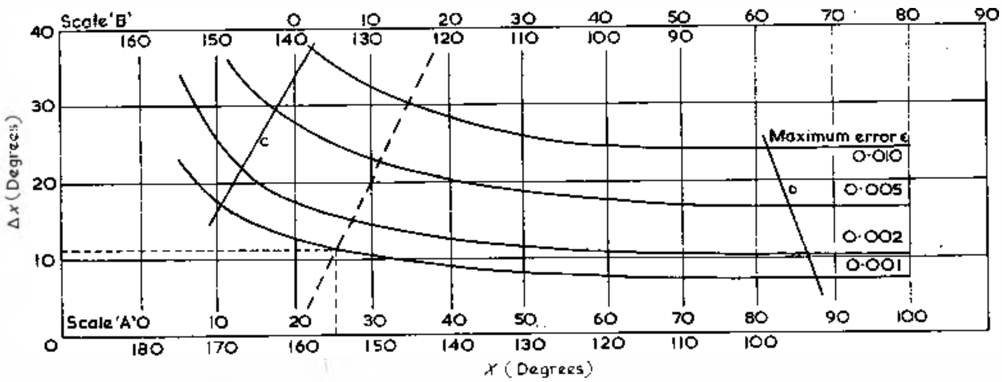
and for a value of $\epsilon = 0{\cdot}001$

$$\Delta x = 0{\cdot}3634$$

giving

$$(\Delta x/2) = 0{\cdot}1817$$

Fig. 3. Optimum interval as function of ϵ and x



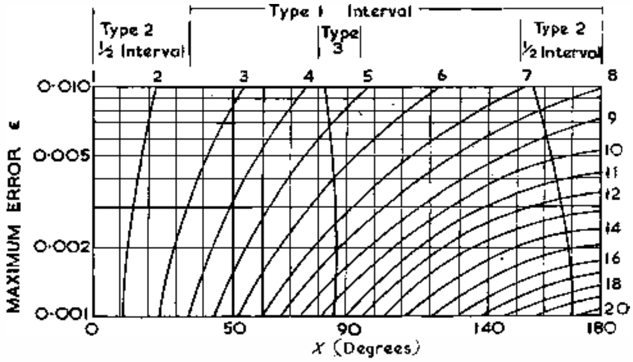


Fig. 4. Number and position of break points as functions of ϵ

sin $0{\cdot}1817 = 0{\cdot}1807$, so that the error is $0{\cdot}0010$ as required.

At $x = 1{\cdot}000$, for $\epsilon = 0{\cdot}001$ and using formula (Type 1)

$$\Delta x = \sqrt{\left(\frac{16 \times 0{\cdot}001}{\sin 1{\cdot}000}\right)} = 0{\cdot}1379$$

The end points are then 0·931 and 1·069

$$\tfrac{1}{2}\left\{\sin 0{\cdot}931 + \sin 1{\cdot}069\right\} = \tfrac{1}{2}\left\{0{\cdot}87672 + 0{\cdot}80222\right\} = 0{\cdot}83947$$

$$\sin 1{\cdot}000 = 0{\cdot}84147$$

The error is then 0·0020 that is 2ϵ as required.

At $x = (\pi/2)$ and using formula (Type 3) for $\epsilon = 0{\cdot}001$

$$\Delta x = \sqrt{(8 \times 0{\cdot}001)} = 0{\cdot}08944$$

$$(\Delta x/2) = 0{\cdot}04472$$

$\sin[(\pi/2 - 0{\cdot}04472] = 0{\cdot}99900$ giving the required value of the error.

Application to Function $y = \sin x$

$$y = \sin x$$

$$y'' = -\sin x$$

The type 1 intervals are given by

$$\Delta x = \sqrt{\left(\frac{16\epsilon}{\sin x}\right)}$$

This function of ϵ and x is given in Fig. 3 for the selected values $\epsilon = 0{\cdot}001$, 0·002, 0·005, 0·010 and for x from 0 to 180° (there is symmetry about x = 90°). From this graph the value of Δx can be read off, for example, to compute the interval starting at 20°, a value of x, say x_1, such that $x_1 - 20$ is equal to $\Delta x/2$ as given by the appropriate curve. This computation is facilitated by adding a further scale (B) so that on joining two points such as $x = 20°$ on them the point of intersection will be the mid-point of the interval whose length may be read off the Δx scale. For $\epsilon = 0{\cdot}001$, $\Delta x = 11{\cdot}2$ so that the next break point would be 31·2°.

On this graph the lines marked C and D are the boundaries of Type 2 and 3 intervals respectively.

It is a simple matter to construct from this a set of curves such as are shown in Fig. 4. This gives the position of the break points for values of ϵ from 0·001 to 0·010. From this it can be seen that one type 2 half-interval, four type 1 and one type 3 half-interval can cover $0° \leqslant x \leqslant 90°$ with a maximum error of about 0·38 per cent.

Table 1 gives the improvement in accuracy to be expected when the number of intervals is increased.

TABLE 1.

NUMBER OF INTERVALS			Maximum Error (per cent)
Type 1	Type 2	Type 3	
2	1	1	1·12
3	1	1	0·62
4	1	1	0·38
5	1	1	0·25
6	1	1	0·19
7	1	1	0·14
8	1	1	0·11

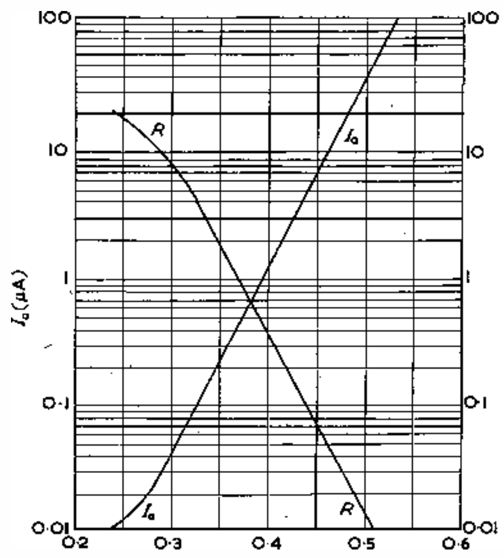


Fig. 5. Silicon diode characteristics

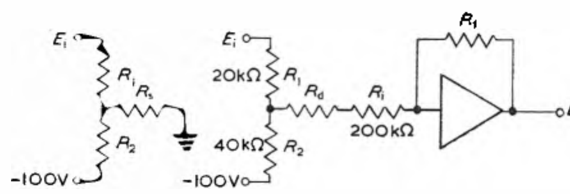


Fig. 6. Equivalent circuits of unit

Characteristics of Silicon Diodes

Fig. 5 shows typical I_a/V_a and R/V_a characteristics for a silicon junction diode. To examine the effect of this non-linear function the current through a typical unit must be computed as a function of the input voltage.

From Fig. 6(a)

$$i = \frac{(E_i/R_1) - (100/R_2)}{(1/R_1) + (1/R_2) + (1/R_s)} \cdot 1/R_s$$

$$= \frac{\alpha E_i - 100}{R_s(1 + \alpha) + R_2}$$

where $\alpha R_1 = R_2$.

If as in Fig. 6(b), R_s is the diode resistance R_d in series with the amplifier input resistor R_i, then

$$\alpha E_i - 100 = i\ (R_d(1 + \alpha) + R_i(1 + \alpha) + R_2)$$

Taking the values R_1, R_2 and R_i as shown in Fig. 6(b) then $\alpha = 2$ and Fig. 7 is the curve of i as a function of the input voltage E_i.

Basic Circuits

The function generator consists of a number of basic unit circuits of the types shown in Fig. 8. The diagrams on the right-hand side of this illustration show the output voltage of the amplifier as a function of the input voltage.

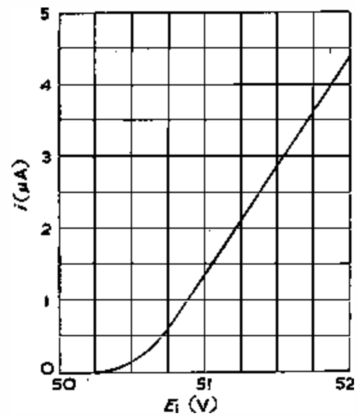


Fig. 7. Properties of single unit near break-point

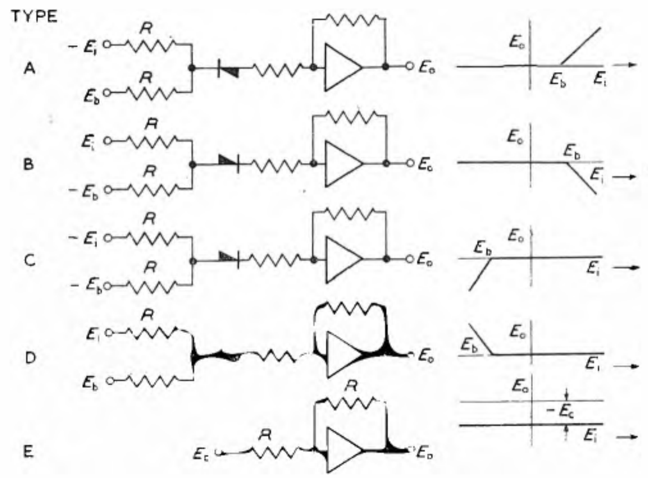


Fig. 8. Five basic circuits

Design of a Sine Function Unit

The portion of the curve to be simulated is

$$E_o = -100 \sin E_i$$

and with a scale of 1 volt per degree the limits of E_i and E_o are

$$0 \leqslant E_i \leqslant +90\text{V}$$
$$0 \geqslant E_o \geqslant -100\text{V}$$

This curve is shown in Fig. 9(a). It was decided to use eight diode units as this appeared to be a reasonable compromise when cost and accuracy were considered.

It will be noticed from Fig. 8 that a combination of one type B and a number of type A units would give a curve of the correct shape. This would, however, require the provision of both $+E_i$ and $-E_i$. It is possible using one of type E and a number of type D to avoid the necessity for this. Fig. 9(b) shows how these units are associated with the summing amplifier.

From this it will be seen that the computing and setting up of the various stages must be made from $E_i = 100$ to $E_i = 0$ as illustrated by Fig. 9(c).

The positions of the break-point is determined by the ratio R_1/R_2. Table 2 line 2 gives the break-point voltages E_B, as derived from Fig. 4.

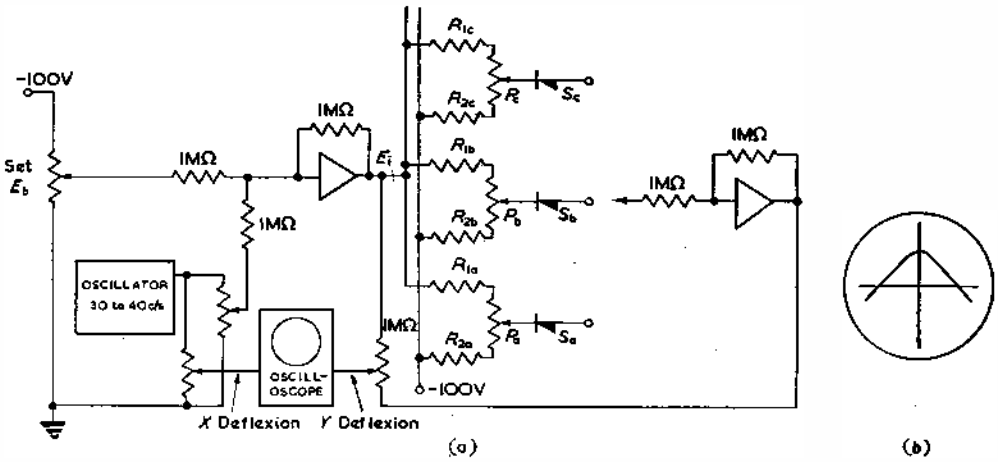


Fig. 10. (a) Circuit for setting break-points
(b) Typical oscilloscope display

TABLE 2.

BREAK POINT	1	2	3	4	5	6	7	8
E_B(V)	87	80	72	62	52	41	28	12·5
R_1 (kΩ)	100	90	82	82	68	62	47	22
R_2 (kΩ)	116	113	115	133	132	154	167	199

The values of R_1 and R_2 can be determined from the equations

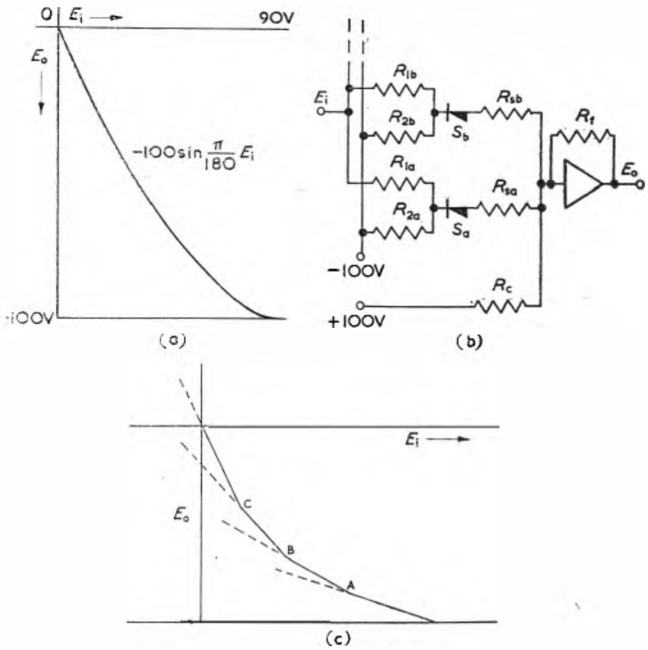
$$R_1 + R_2 = RN \qquad (9)$$

$$\frac{R_2}{R_1 + R_2} = \frac{|E_B|}{100 + |E_B|} \qquad (10)$$

Where R is the maximum acceptable load between the bias supply and the signal, and N is the number of diode sections.

For various reasons R was chosen to be about 25kΩ and as previously mentioned N had the value 8.

Fig. 9. (a) Function $-100\sin E_i$, 1V = 1 degree
(b) Method of associating the required types of unit
(c) Method of setting up function



Therefore

$$R_1 + R_2 \geqslant 200\text{k}\Omega \qquad (11)$$

$$\frac{R_2}{200} \leqslant \frac{|E_B|}{100 + |E_B|} \qquad (12)$$

The calculated values of R_o and R_f were kept as low as possible since for the type of resistors used (½W, high stability, 1 per cent) those of lower values have better long-term stability. By using a Wheatstone bridge 400kΩ resistors of this type were matched by selection to better than 0·1 per cent.

In order to locate the break-points accurately a potentiometer is placed between R_1 and R_2 the value being decided by the expected variation of this voltage caused by resistor tolerances. R_1 is usually a preferred value, and R_2 may in fact be up to three resistors in series in order that the potentiometer can have a small value of resistance, thus increasing its resolution.

Setting the Break-points

Fig. 10(a) shows the set-up which is used to locate break-points accurately. A sinusoidal voltage of about 10V peak-to-peak and about 30 to 40c/s is mixed with a d.c. signal from a potentiometer and fed into the unit. The 1MΩ resistor is connected to the diodes, stage by stage, the resulting output voltage being displayed on the Y-axis of an oscilloscope against the sinusoidal voltage on the X-axis. A 1MΩ potentiometer is used to mix the input and output voltages so that the change of slope caused by the diode 'breaking' is more apparent. When the 'break' is in the centre of the trace then the break-point potential is given by the d.c. component of E_i. Fig. 10(b) shows a typical break point as displayed by this method.

Setting the Slopes

The next step is to find the required values of R_s and this is best achieved by substituting a three-decade variable resistance box having a maximum value of 10MΩ. This need only have an accuracy of 1 per cent. By this means each slope may be set up in turn, the decade box being replaced by two fixed resistors and a variable resistor before proceeding to the next stage.

From the calculated maximum value of the error for eight diodes (0·14 per cent), it was decided to displace the curve at the break-points by $-0{\cdot}2$V. The adjusted values are shown in Table 3.

TABLE 3.

BREAK POINT	1	2	3	4	5	6	7	8
E_i	87	80	72	62	52	41	28	12·5
100 Sin E_i ..	99·87	98·48	95·10	88·29	78·80	65·60	46·95	21·64
E_o (V) ..	−100·0	−98·68	−95·30	−88·49	−79·00	65·80	−47.15	−21·84

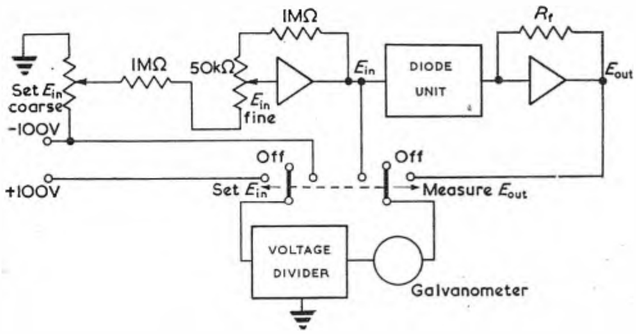


Fig. 11. Circuit for setting slopes

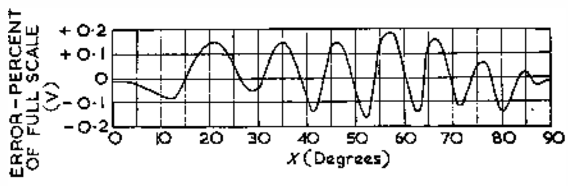


Fig. 12. Typical error curve

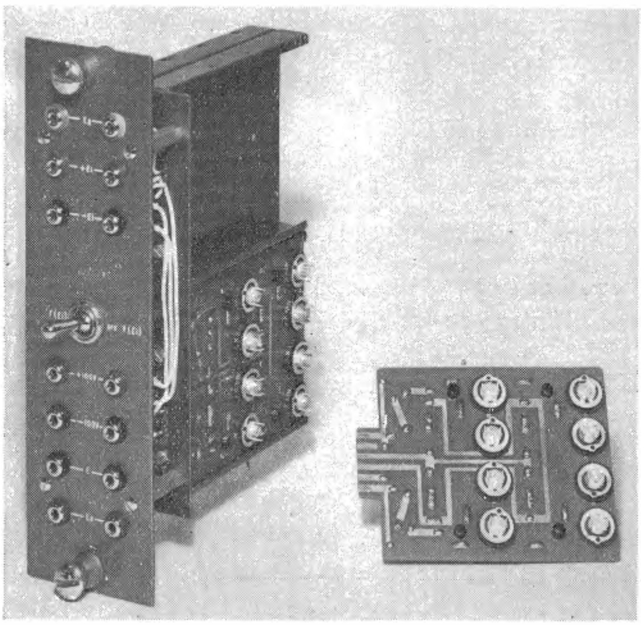


Fig. 13. A function unit

Fig. 11 shows the bridge circuit used for measuring E_i and E_o.

When the setting up was completed the errors for a large number of values of E_i were measured. Fig. 12 shows the error curve for the function discussed.

Arbitrary Functions

So far it has been assumed that the function has an analytical form. Frequently, however, it is necessary to deal with curves presented in graphical or tabular form. In this case one may (a) fit a polynomial statistically, (b) use second differences for determining break-point positions, (c) fit the slopes and break-points by eye. Using (c) an accuracy of ±2 per cent f.s.d. can usually be achieved.

Function Generator for G-PAC Computer

Fig. 13 illustrates a function unit. It consists of a framework which fits into the front of the Elliott G-PAC computer. Into this four printed circuit cards each containing four diode sections can be inserted. Cards are made up in sets for each function required.

Acknowledgment

The authors wish to thank the directors of Elliott Automation Ltd for permission to publish this article.

Semiconductor Factory Extensions

Work on the second stage of the central Mullard Semiconductor Plant at Southampton has now been completed. The new section adds approximately 50 000ft^2 of floor space to the plant's manufacturing capacity, and is already in production.

During the last two years (that is since the plant first began producing), the demand for transistors of all kinds has increased at a very high rate. Because of this, the building programme for the second stage of the Southampton plant was advanced some months ahead of schedule, and production of semiconductors elsewhere in the Company has also been stepped up.

Much of the space arising from the new section is given over to the large-scale production of silicon transistors and diodes. The demand for silicon devices, which can operate at much higher temperatures than their germanium counterparts, is growing rapidly for industrial and military purposes, and an increasing amount of the plant's resources is being devoted to manufacturing them. It is expected that by 1960 silicon devices will account for a significant proportion of the total output.

The problems of making silicon transistors in large numbers, at economic prices, and with the desirable characteristics required by equipment designers, have been engaging world-wide attention; and the successful production techniques evolved at Southampton have been arrived at only after intensive research programmes.

Since production began at Southampton, major advances in technology and manufacturing techniques developed in the plant have more than doubled its productivity.

The extra manufacturing capacity resulting from the completion of the new section, combined with the increases in productivity, means that the plant's output in 1959 will be more than twice that of 1958, representing, in monetary value, two-thirds of the Company's total semiconductor output. The remaining third is supplied by the Mitcham plant and other factories in the organization.

The range of types in the Mullard semiconductor production this year will be wide enough to satisfy most of the requirements of the radio and electronics industry both at home and overseas.

The next stage in the development of the Southampton plant is the construction of a 30 000ft^2 administration wing, scheduled for completion early in 1960. This will release for manufacturing purposes a further area of factory floor space now being used for offices.

Following this a further large section is to be added to the main factory building.

When completed, the Southampton plant will employ between 2 000 and 2 500 people. Its payroll at present numbers 1 000 of whom no fewer than 70 are graduate scientists and engineers working in the plant's research and development laboratories.

The total number employed on transistor production throughout the Mullard organization is at present 1 500.

A Large Screen X-Ray Image Amplifier

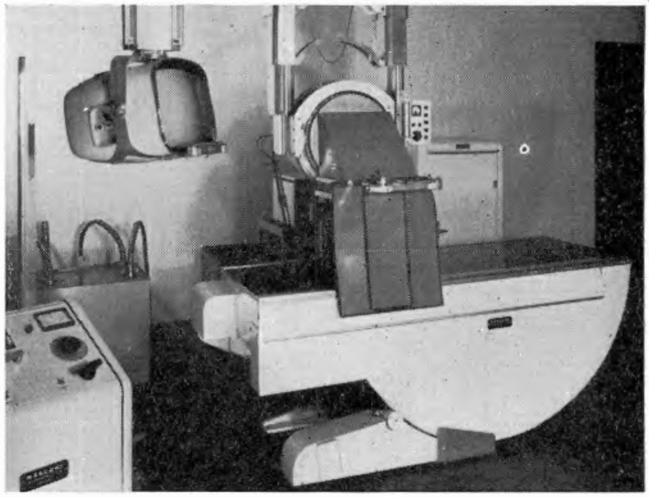
A 12in X-ray image amplifier of a design suitable for all types of clinical application has been produced and demonstrated by Marconi Instruments Ltd.

A valuable feature of this equipment is that it will lead to a lessening of the X-ray dosage to the patient. During tests on the equipment, the abnormally low dose-rate of 2mr/sec has been used to view a thorax while maintaining an image of sufficient clarity for accurate diagnosis.

The system relies on the reproduction of the fluoroscopic image on a television-style monitor screen, thus permitting the monitor to be placed in the best position for comfortable viewing by the radiologist. It is also possible to have several additional and quite independent monitors operating at points remote from the examination room. This facility is especially useful for consultations and for application in teaching hospitals. A further feature of this apparatus is the provision for remote cine radiography and serial radiography, which makes it possible to produce a continuous record of the large fluoroscopic image at doses tolerable to the patient.

Although presentation of the final image is somewhat different from the conventional method, the radiologist is not called upon to develop new techniques. The method of operation is not complicated in any way and the only additional controls with which he has been provided are five push-buttons and two switches.

The push-buttons, which are physically large and therefore easily operated when wearing lead-rubber gloves, control the sensitivity of the image amplifier and do not involve any alteration to X-ray output. They provide the operator with a means of selecting the best possible image available at any one X-ray technique and their preset positions can be chosen by the radiologist at the time the equipment is installed. The small remote control unit carrying these push-buttons is also equipped with a milliammeter, giving a direct reading of X-ray tube current, and a continuously variable current control.



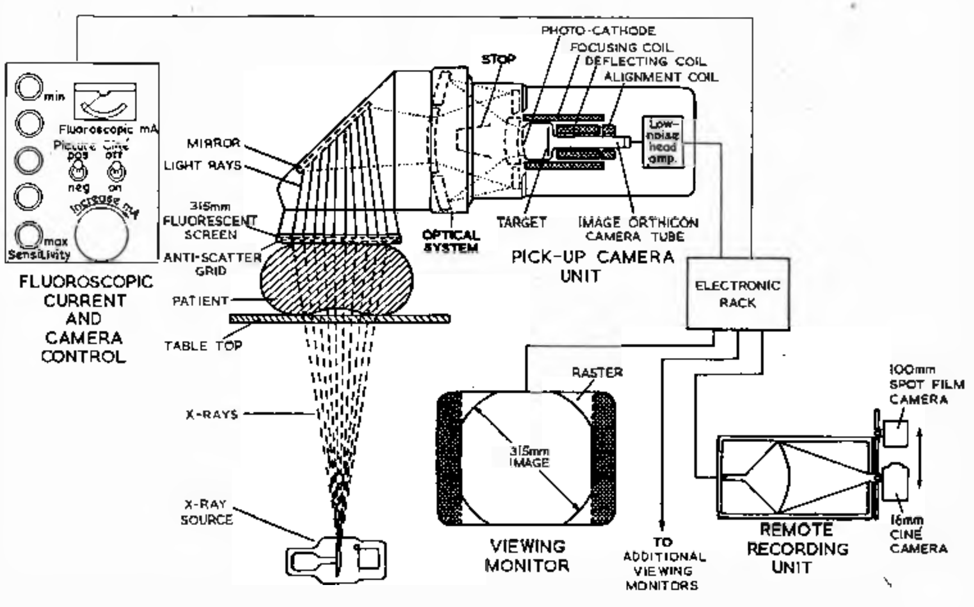
The complete equipment

One of the two switches fitted to the remote control unit operates a serial film or cine radiographic unit, thus permitting the radiologist to make a permanent record of any part of an examination. This procedure does not cause any interruption to the image appearing on the monitor screen and cine radiographic techniques can now be carried out at normal screening doses.

The second switch governs the polarity of the final image. This facility is unique to the system and enables the radiologist to reproduce the image in positive or negative form at will.

Although not yet fully developed, an 'add-on' unit which will produce a reduction in patient dose of up to 25 times, will be available in the near future. This unit will employ a 10in direct viewing storage cathode-ray tube and will provide an alternative system to the conventional fluoroscopic techniques in which the patient must be irradiated during the whole period required to assimilate the information contained in the image. By employing this unit it will only be necessary to irradiate the patient for the time actually needed to form the image; this is then held on the viewing monitor without further radiation to the patient until the next image is required. By causing a slow repetition rate, a stroboscopic view of moving body-parts is obtained.

Fig. 1. General arrangement of the image amplifier equipment



The camera unit is ceiling suspended and is clamped in position immediately above the table-top. By attaching the unit to the screen tower it is possible to ensure that the centre of the X-ray tube focus is in line with the centre of the fluorescent screen and that this condition is maintained at all times.

After passage through the patient, the X-ray beam impinges on a high-definition fluorescent screen contained on the base of the camera unit. The resultant image is reflected, via a mirror, into an efficient lens system and thence to the photo-cathode of a special type of 4½in image orthicon camera tube. Following electronic amplification the image is then reproduced on the screen of a television-style monitor.

In addition to the fluorescent screen, lens system and image orthicon camera tube, this unit also contains the low-noise head amplifier and the scanning unit.

The final image is displayed on a 17in rectangular cathode-ray tube, the actual image occupying the central area of the screen, being 11in square with rounded corners 12in in diameter. This size is identical with the size of the original fluorescent screen contained in the camera unit so that, although the image has been increased in brightness, the physical size remains unaltered. To give the radiologist some additional control over the quality of the final image the monitor is fitted with a brilliance and a contrast control, but once these controls have been adjusted, it is not normally necessary to interfere with them. A one-thousand-line triple-interlace system is employed and the general arrangement of the equipment is shown in Fig. 1.

The viewing monitor is suspended on a single telescopic arm attached to an overhead carriage mounted on rails which run parallel to the camera unit rails. When fully extended, the monitor is low enough to be viewed comfortably by the seated radiologist and when fully retracted it can be parked at one end of the rails in a similar way to the camera unit. In use, the monitor can be rotated through 85° about the vertical axis and 20° about the horizontal axis.

A Simple Maximum Selecting Circuit

By J. N. Shearme*, B.Sc.(Eng), A.M.I.E.E.

A description is given of a simple method of selecting the maximum of a set of voltages and expressing its position in the set in analogue form. The method has been applied to tracking the 'formants' or regions of maximum energy in a speech signal as part of a bandwidth reduction process.

(Voir page 377 pour le résumé en français: Zusammenfassung in deutscher Sprache Seite 382)

A CONSIDERABLE amount of work is being done towards reducing the bandwidth required for speech transmission by analysing the speech signal and transmitting only signals describing information bearing characteristics of it. At the receiver, speech is synthesized from these signals. Reduction of bandwidth by a factor of at least 20 to 1 is theoretically possible in this way.

A large class of sounds are characterized chiefly by the frequencies of the regions of maximum energy in their spectra. These regions are called 'formants' and an important part of the analysis process in some methods of bandwidth reduction consists of tracking their movements.

A promising method of tracking formant positions relies on examining the rectified outputs of a set of contiguous filters covering the frequency range occupied by a particular formant and expressing the frequency of the filter having maximum output as a voltage analogue[1]. It seems possible that this process of selecting the greatest of a set of signals and expressing its position in the set in analogue form might have other applications and a very simple circuit that has been developed to perform this function may therefore be of general interest. The method is only suitable for operating on sets of signals which vary fairly slowly, i.e. contain no components of frequency greater than a few hundred cycles per second at the most.

Principle of Operation

Consider the Wheatstone bridge shown in Fig. 1.

At balance the tap on r is at point $x = 0$. If the impedance of the detector is very large at the frequency of the bridge generator f the p.d. across it is directly proportional to the fraction x of the resistance r.

Suppose r and its tap are replaced by a series of equal resistors and the junctions between these resistors are connected through diodes to the set of d.c. sources whose e.m.f's are to be compared (see Fig. 2). In addition the detector is shunted by a path of resistance P but very high impedance at the frequency f. Suppose the instantaneous e.m.f's of the sources are e_1, e_2 - - - -.

With suitable circuit values the p.d. across the resistors $r/5$ can be so small compared with e_1, e_2, - - - - that the cathodes of all the diodes are at virtually the same potential and only the diode connected to the d.c. source of highest e.m.f. conducts. If, for example, $e_4 > e_1, e_2, e_3, e_5$, the bridge is effectively earthed at x and an alternating p.d. propor-

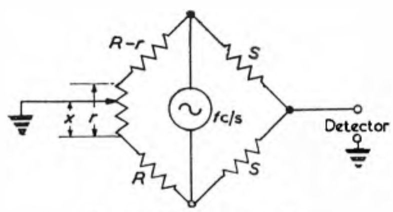


Fig. 1. Wheatstone bridge

tional to $4r/5$ (i.e. proportional to the 'number' of the generator of maximum e.m.f.) appears at the detector. High-pass filtration and rectification yields the direct voltage analogue.

There will, of course, also be a direct p.d. across the detector; although this is irrelevant to indicating which source has maximum e.m.f. it is of interest that this p.d. is proportional to the actual magnitude of the maximum e.m.f.

Interpolation

It may be, as in the case of formant tracking, that the set of voltages being examined are sample values of a continuous function of voltage and that what is required is not the greatest sample, but the maximum of the function, e.g. if the two greatest outputs are equal then the maximum of the function might reasonably be inferred to lie midway between them. The circuit described above can very simply be modified to provide a degree of interpolation of this sort.

Referring to the circuit of Fig. 2 again, suppose now that

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the value of e_3 increases towards e_4. The reverse voltage across the e_3 diode is reduced and its incremental resistance decreases. In the region where e_3 is within a few tenths of a volt of e_4 the incremental resistances of the two diodes are comparable and the effective earth point of the bridge moves smoothly across the $r/5$ resistor connected between them. In this condition the position of maximum voltage will be interpolated as lying between the sources of e_3 and e_4. However, interpolation only occurs over a very small range of source e.m.f. differences. Moreover, this range is approximately constant irrespective of the magnitude of source e.m.f., whereas it is generally desirable that interpolation should start when the outputs of two sources are in a given ratio. More useful interpolation can be obtained by connecting suitable resistors in series with the diodes.

Suppose these resistors all have the value P (equal to the d.c. resistance across the detector) and let P be much greater

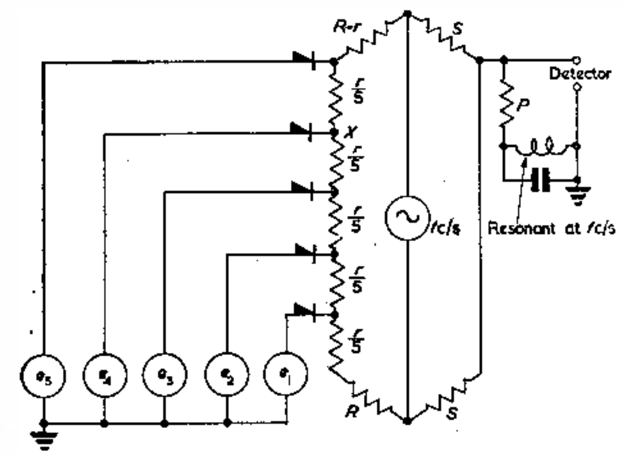

Fig. 2. Voltage sources to be measured

than the resistors in the bridge circuit. So long as there is one source e.m.f. which exceeds the remainder by more than 6dB, the remaining diodes will be reverse biased. The diode connected to the maximum e.m.f. will have very small incremental resistance compared with the other diodes and the bridge will be effectively earthed through this diode only. As soon as the e.m.f. of another source approaches within 6dB of the maximum e.m.f., the two diodes concerned will start to share the total forward current, their incremental resistances will become comparable and the effective earth point of the bridge will shift smoothly between them. When the two e.m.f's are equal the earth point will be midway between their diode connexions. (In this condition a third source e.m.f. has to rise to approximately $\frac{2}{3}$ of the maximum value before it starts to play a part in interpolation, a fourth to within $\frac{3}{4}$ and so on). Note that the point where interpolation starts depends on the ratio between the maximum e.m.f. and other e.m.f's and is independent of the actual e.m.f's over a wide range.

It is necessary to shunt the diode series resistance with a suitable capacitance so that the changes of incremental resistance of the diodes shall not be swamped. If this is not done there tends to be a large range of voltage difference between two sources where the incremental resistance of both diodes is much less than their series resistors and the maximum is therefore interpolated as lying halfway between the sources.

The time-constant of the series resistor and its associated capacitor places a restriction on the maximum rate of change of the source e.m.f's that can be handled.

Use of the Circuit as a Formant Tracker

Fig. 3 illustrates the main features of a formant tracker which operates by determining the frequency of maximum energy in the band 700 to 2 500c/s of a speech signal.

This frequency band is covered by 10 equally spaced filters the outputs of which after rectification and smoothing vary slowly in the range 0 to 20V (no appreciable components of frequency higher than 50c/s are present). These outputs are examined by the maximum selector. Interpolation takes place between the channel with maximum output and any other channel within 6dB of that output. The 5kc/s output of the maximum selector is filtered to remove the low frequency signals and after amplification and recti-

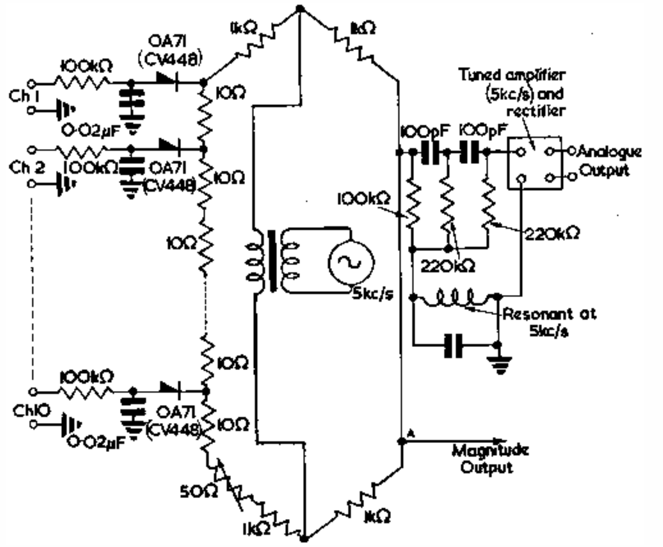

Fig. 3. Use of circuit as a formant tracker

fication indicates the frequency of maximum energy on the scale 1V = 25c/s. The d.c. potential at the point A of the bridge is proportional to the actual magnitude of the signal in the region of its maximum energy. Thus the tracker provides signals indicating both the position and magnitude of the region of maximum energy.

In this particular application there are frequent periods when the whole set of voltages being examined is zero. In this condition the incremental resistance of all the diodes is fairly low (about 40kΩ each) and the bridge is effectively earthed at the centre of the chain of 10Ω resistors. The analogue output corresponds to a maximum in the centre channel of the set. This could easily be altered if required by a small bias on any appropriate diode.

The circuit has been found in practice to track the frequency of maximum energy smoothly and accurately. The accuracy is better than 50c/s, but of course this is a function of the number of filters and their characteristics and bears only indirectly on the accuracy of the maximum selector. Nevertheless, since the channels are spaced at 180c/s intervals it is evident that useful interpolation is provided.

Acknowledgements

The author wishes to thank Mr. J. N. Holmes for several useful suggestions in the development of the circuit. The work has been carried out at the Joint Speech Research Unit of the Post Office, and official permission to publish this article is acknowledged.

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The Design of Balanced Amplifiers Using Components of Commercial Tolerance

By D. J. Dewhurst*, M.Sc., B.A.

Although many circuits intended to compensate for the use of commercial tolerance components in balanced amplifiers have been published, it is usually found that best results are obtained by the use of accurately matched pairs of components. In this article an analysis of the circuit using mismatched components is presented. This explains the observed behaviour, and permits the design of an amplifier in which component tolerances can be specified.

(Voir page 377 pour le résumé en français: Zusammenfassung in deutscher Sprache Seite 382)

THERE is a considerable literature on the behaviour and design of balanced amplifiers for the amplification of a desired out-of-phase signal in the presence of undesired in-phase signals. The most successful amplifier of this type is the well-known 'long-tailed pair'. The basic design appears to be due to Matthews[1]. Improvements in stability were introduced by Offner[2], who employed his design for electroencephalography. Reviews of practical developments are given by Parnum[3] and by Dickinson[4]. An analysis of the circuit is given in outline by Valley and Wallman[5], and in more detail by Seely[6] and by Millman and Taub[7].

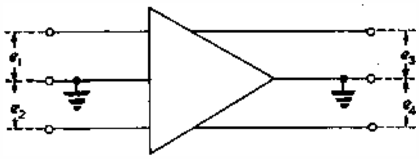

Fig. 1. Basic balanced amplifier

Definition of Terms

It is important to have a clear definition of the terms used. Consider the balanced amplifier shown in Fig. 1, in which all voltages are measured with respect to earth.

Consider the input voltages e_1 and e_2. The input signal at any instant may be expressed as the sum of a pure in-phase input signal e_{II} and a pure out-of-phase input signal e_{0I}. The in-phase component is that amount by which both input terminals move, which is the mean of e_1 and e_2, and is thus given by

$$e_{II} = \frac{e_1 + e_2}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The out-of-phase component is that amount by which each input terminal departs from the mean, one positively and the other negatively, and is thus given by

$$e_{0I} = \pm \frac{e_1 - e_2}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

It is usually quoted as a positive value.

For example, if at some instant $e_1 = +5\text{V}$ and $e_2 = -3\text{V}$, then $e_{II} = +1\text{V}$ and $e_{0I} = \pm 4\text{V}$. The two input terminals are considered as moving one volt positively together, and then departing from this mean value in opposite directions by four volts. The advantage of this concept is that if the system responses to a pure in-phase and to a pure out-of-phase signal are known, its behaviour for any other type of signal may be obtained. By the same argument, the in-phase output voltage e_{I0} and the out-of-phase output voltage e_{00} may be obtained:

$$e_{I0} = \frac{e_3 + e_4}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

and

$$e_{00} = \pm \frac{e_3 - e_4}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

These remarks apply even if an unbalanced signal is considered. If e_2 is held at earth while e_1 is varied, it is still possible from equations (1) and (2) to calculate two fictitious signals applied to e_2, which in this case will always be equal and opposite.

Four separate gains of such an amplifier may be defined.

(1) The ratio of out-of-phase output to out-of-phase input,

$$e_{00}/e_{0I} = \frac{e_3 - e_4}{e_1 - e_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

This represents the amplification which is actually desired from the amplifier.

(2) The ratio of out-of-phase output to in-phase input,

$$e_{00}/e_{II} = \frac{e_3 - e_4}{e_1 + e_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

This figure is required to be kept to a minimum, since it represents an output indistinguishable from the desired one, but caused by a spurious input. In a perfectly balanced amplifier it is zero.

(3) The ratio of in-phase output to in-phase input,

$$e_{I0}/e_{II} = \frac{e_3 + e_4}{e_1 + e_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

This is required to be kept to a minimum, since it governs the amount of spurious signal presented to a following amplifier or cathode-ray tube. In the usual amplifier stage it has a value of about unity.

(4) The ratio of in-phase output to out-of-phase input,

$$e_{I0}/e_{0I} = \frac{e_3 + e_4}{e_1 - e_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

This is also required to be kept to a minimum, since it represents an amount of spurious signal at the output generated by the desired input; this can readily overload a following amplifier. In a perfectly balanced amplifier it is zero.

The rejection ratio of an amplifier is defined as the ratio of out-of-phase output with an out-of-phase input to out-of-phase output with the same input applied in-phase: it may be expressed either directly as a voltage ratio, or in decibels. A desirable minimum value for biological work is 10 000, or 80dB. There is usually little point in exceeding this value for external measurements on human or animal subjects, since at this value tissue resistance is such that typical interference from alternating current mains presents an out-of-phase spurious signal which when amplified exceeds any out-of-phase output due to an in-phase spurious

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signal. However, for internal closely spaced electrodes in brain, nerve, or muscle where electrical stimulation is being used, a higher rejection may be of advantage. Commercial amplifiers having 90 to 100dB rejection ratio are available.

In taking a measurement of this type it is important to specify the actual amount of in-phase input used, since the rejection ratio defined above assumes a linear system and thus a small input. Quite moderate in-phase inputs produce a non-linear response from the usual amplifier.

Analysis of Cathode-Compensated Amplifier

The use of cathode feedback compensation has proved a very satisfactory practical method of correcting for some unbalance in pairs of components. A study of this circuit

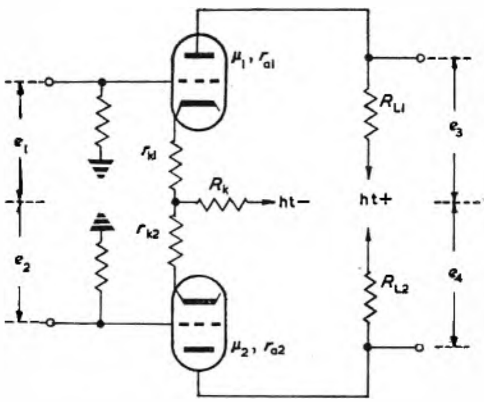

Fig. 2. Unbalanced cathode-compensated amplifier

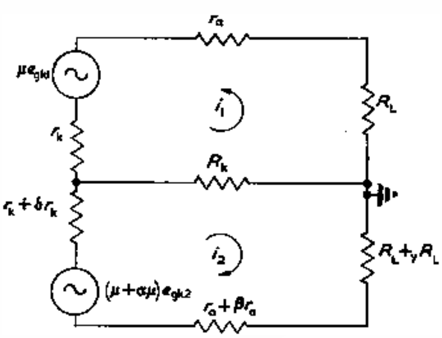

Fig. 3. Equivalent circuit of amplifier

(Fig. 2) was accordingly made to determine the scope and limitations of the method.

Let the fractional unbalances of supposedly matched parameters be as follows:

Let

$\mu_1 = \mu$ and $\mu_2 = \mu + \alpha\mu$

$r_{a1} = r_a$ and $r_{a2} = r_a + \beta r_a$

$R_{L1} = R_L$ and $R_{L2} = R_L + \gamma R_L$

$r_{k1} = r_k$ and $r_{k2} = r_k + \delta r_k$

Then the equivalent circuit is as shown in Fig. 3, taking the loop currents in opposite directions for symmetry.

The loop equations for this circuit are

$$i_1\big(r_a + R_L + r_k(\mu+1) + R_k(\mu+1)\big) + i_2 R_k(\mu+1) = \mu e_1 \quad \ldots\ (9)$$

$$i_1 R_k(\alpha\mu+\mu+1) + i_2\big[\big(r_a + R_L + r_k(\mu+1) + R_k(\mu+1)\big) + \beta r_a + \gamma R_L + \alpha\mu(r_k+\delta r_k) + \delta r_k(\mu+1) + \alpha\mu R_k\big] = (\alpha+1)\mu e_2 \quad \ldots\ (10)$$

Let circuit parameters A, B, C, D be defined as follows:

$A = (\mu + 1)R_k$

$B = r_a + R_L + (\mu+1)r_k + (\mu+1)R_k$

$C = \beta\,.\,r_a + \gamma\,.\,R_L + \alpha\,.\,\mu(r_k + R_k) + \delta\,.\,(\mu+1)r_k + \alpha\delta\,.\,\mu r_k$

$D = \alpha\,.\,\mu R_k$

Then equations (9) and (10) become

$$i_1 B + i_2 A = \mu e_1 \quad \ldots\ (11)$$

$$i_1(A+D) + i_2(B+C) = (\alpha+1)\mu e_2 \quad \ldots\ (12)$$

Thus

$$e_3 = R_L i_1 = \mu R_L\,.\,\frac{e_1(B+C) - e_2 A(\alpha+1)}{B(B+C) - A(A+D)} \quad \ldots\ (13)$$

and

$$e_4 = R_L(\gamma+1)i_2 = \mu R_L(\gamma+1)\,.\,\frac{e_2 B(\alpha+1) - e_1(A+D)}{B(B+C) - A(A+D)} \quad \ldots\ (14)$$

Out-of-phase Output Gains

$$2e_{00} = e_4 - e_3 = \mu R_L\,.\,\frac{e_2\big((\gamma+1)(\alpha+1)B + (\alpha+1)A\big) - e_1\big((\gamma+1)(A+D) + B + C\big)}{B(B+C) - A(A+D)} \quad \ldots\ (15)$$

For a pure in-phase input $e_1 = e_2$ and $2e_{II} = 2e_1$
so

$$e_{00}/e_{II} = \tfrac{1}{2}\mu R_L\,.\,\frac{B(\alpha+\gamma+\alpha\gamma) + A(\alpha-\gamma) - D(\gamma+1) - C}{B(B+C) - A(A+D)} \quad (16)$$

For a pure out-of-phase input $e_2 = -e_1$ and $2e_{0I} = 2e_1$
so

$$e_{00}/e_{0I} = \tfrac{1}{2}\mu R_L\,.\,\frac{B(2+\alpha+\gamma+\alpha\gamma) + A(2+\alpha+\gamma) + D(\gamma+1) + C}{B(B+C) - A(A+D)} \quad \ldots\ (17)$$

In-phase Output Gains

$$2e_{I0} = e_4 + e_3 = \mu R_L\,.\,\frac{e_2\big((\gamma+1)(\alpha+1)B - (\alpha+1)A\big) + e_1\big(B + C - (\gamma+1)(A+D)\big)}{B(B+C) - A(A+D)} \quad \ldots\ (18)$$

For a pure in-phase input,

$$e_{I0}/e_{II} = \tfrac{1}{2}\mu R_L\,.\,\frac{B(2+\alpha+\gamma+\alpha\gamma) - A(2+\alpha+\gamma) - D(\gamma+1) + C}{B(B+C) - A(A+D)} \quad \ldots\ (19)$$

For a pure out-of-phase input,

$$e_{I0}/e_{0I} = \tfrac{1}{2}\mu R_L\,.\,\frac{B(\alpha+\gamma+\alpha\gamma) - A(\alpha-\gamma) + D(\gamma+1) - C}{B(B+C) - A(A+D)} \quad \ldots\ (20)$$

Rejection Ratio

$$R = \frac{e_{00}\text{ for } e_2 = -e_1}{e_{00}\text{ for } e_2 = +e_1} = e_{00}/e_{0I}\,.\,e_{II}/e_{00}$$

$$= \frac{B(2+\alpha+\gamma+\alpha\gamma) + A(2+\alpha+\gamma) + D(\gamma+1) + C}{B(\alpha+\gamma+\alpha\gamma) + A(\alpha-\gamma) - D(\gamma+1) - C} \quad \ldots\ (21)$$

The rejection ratio will become infinite either in the perfectly balanced circuit, when $\alpha = \beta = \gamma = \delta = 0$, or for any other combination of parameters which makes the denominator of equation (21) zero.

Effect of Mismatch in Valve Parameters

Take as an example the typical case of a stage of balanced amplification using a low μ twin triode, such as the 6SN7GT

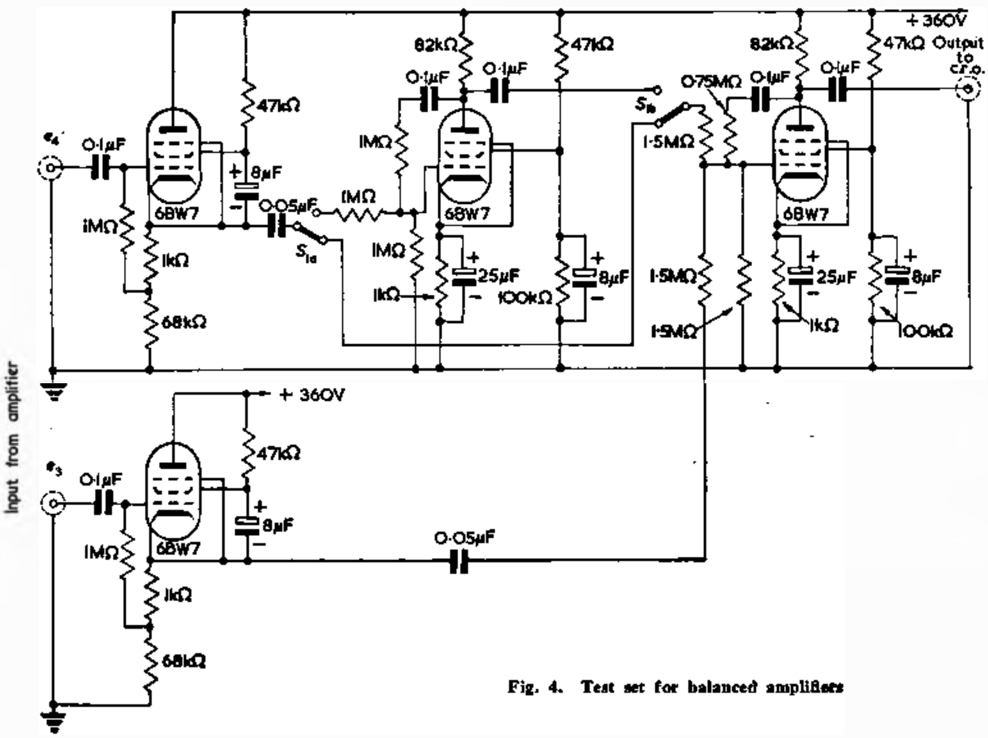

Fig. 4. Test set for balanced amplifiers

or 12AU7, in the circuit shown in Fig. 2. Let the parameters for this circuit be $\mu = 19$, $r_a = 7\text{k}\Omega$, $R_k = 50\text{k}\Omega$, $r_k = 1\text{k}\Omega$, $R_L = 100\text{k}\Omega$. (R_L will of course be the effective anode load resistance, including the following grid leaks). Then substitution of these values in equations (16) to (21) gives the results shown in Table 1, which shows the unbalance required in the cathode feedback resistors (δ) to compensate for typical degrees of unbalance in amplification factors (α), anode resistances (β), and load resistances (γ).

It will be seen from Table 1 that a considerable unbalance in anode resistances can readily be corrected by a slight adjustment of the cathode feedback resistors, without affecting the performance of the amplifier in other respects. The same degree of unbalance in the anode load resistances can be corrected by a rather greater adjustment, at the expense of a somewhat increased in-phase output from the amplifier. Lastly, the same degree of unbalance in amplification factors can be corrected only by a very large unbalance in cathode feedback resistors; this however does not materially worsen the performance of the amplifier. Evidently a suitable procedure is to employ a potentiometer in place of r_{k1} and r_{k2}, and to set up pairs of valves in the circuit, selecting those for which infinite rejection can be obtained within the range of adjustment of the potentiometer. It has been found that at least half of a batch of commercial valves can be paired in this fashion.

TABLE 1. Cathode feedback compensation for unbalance in other parameters.

CONDITION OF UNBALANCE	1	2	3	4
μ unbalance	0	10%	0	0
r_a unbalance	0	0	10%	0
R_L unbalance	0	0	0	10%
α	0	+0·1	0	0
β	0	0	+0·1	0
γ	0	0	0	+0·1
Required for infinite rejection ratio $\left(\frac{e_{00}}{e_{11}} = 0\right)$ δ	0	+0·950	−0·035	+ 0·135
r_{k_2}	1000 Ω	1950 Ω	965 Ω	1135 Ω
$\frac{e_{00}}{e_{01}}$	15·0	14·1	15·0	15·0
$\frac{e_{10}}{e_{11}}$	0·89	0·89	0·89	0·94
$\frac{e_{10}}{e_{01}}$	0	−0·03	0	0·67

Test Set for Balanced Amplifiers

A difficulty which is frequently encountered in the testing of balanced amplifiers is the actual measurement of the out-of-phase and in-phase components of the amplifier output. If an oscilloscope or valve-voltmeter with an accurately balanced input is available, the out-of-phase component can be measured directly between the amplifier output terminals, but there is no corresponding direct means of measuring the in-phase output. By the use of the circuit shown in Fig. 4, it is possible to measure either component with reasonable accuracy on an unbalanced oscilloscope or valve voltmeter. Each of the two outputs from the amplifier being tested is fed to an identical pentode cathode-follower, to avoid the effects of loading and of differences in stray capacitances in the following circuits. The output of one cathode-follower may then either be taken directly or be inverted in a unity-gain anode-follower, and added to the other cathode-follower output in an anode-follower adder with a gain of 0·5 from either input. Thus the output from this anode follower represents either $(e_3 - e_4)/2$ or $(e_3 + e_4)/2$, depending on whether the invertor is or is not in circuit. The accuracy of this instrument depends on the precision with which the gains of the two anode-followers are adjusted, but there is no difficulty in obtaining a rejection ratio of the order of 60dB for the whole instrument. This is considerably in excess of that available from the average oscilloscope having a balanced input.

Acknowledgment

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Magnetic Core Matrices for Logical Functions

By A. L. Freedman*, M.Sc.

The general principle of a method for performing logical functions using matrices of magnetic cores having a square hysteresis loop is explained. Some applications of this method are discussed. The field of its usefulness is outlined and the inherent advantages and limitations pointed out.

(Voir page 377 pour le résumé en français; Zusammenfassung in deutscher Sprache Seite 382)

IN 1952, Rajchman[1] described a method of carrying out logical operations by means of square hysteresis-loop core matrices. The binary adder of Fig. 1 is an example of the method proposed. The square loop cores are denoted by the narrow rectangles 0 to 7, and the addend, augend and carry digits each energize one out of a pair of input windings, each winding embracing four cores. If any of the input digits is a 1, the left-hand winding of the corresponding pair is energized; when a digit has the value '0', the right-hand winding of the pair is energized. The current in any energized input winding is sufficient to cause magnetic saturation in the initial or N sense in the cores embraced by the winding. The input currents are combined and applied to the winding marked S, which on each core has one-third of the number of turns of any single input winding. For any combination of input digits current flows in three of the input windings, and the ampere-turns generated by the windings S are therefore equal to those generated by each input winding. They are, however, in the opposite direction, and consequently any core which is not embraced by at least one of the energized input windings will be switched to the P state. It can be seen from the arrangement of the input windings that there is just one such core for each of the eight possible combinations of input digits. The arrangement so far described constitutes a binary to one out-of-eight conversion matrix. It is turned into an adder by the provision of two pairs of output windings, one pair for the sum digit and the other for the new carry digit. The left-hand winding of each pair threads the cores which are switched when the sum (or new carry) digit is to be a 1, while the right-hand winding of each pair is a complementary output which provides an output pulse when the sum (or carry) is a '0'. The set of input windings marked R is used for resetting the cores. Table 1 illustrates the operation of the adder for each input combination.

TABLE 1.

AUGEND	ADDEND	CARRY	CORE SWITCHED	SUM	NEW CARRY
0	0	0	0	0	0
0	0	1	1	1	0
0	1	0	2	1	0
0	1	1	3	0	1
1	0	0	4	1	0
1	0	1	5	0	1
1	1	0	6	0	1
1	1	1	7	1	1

The principle of this type of logical circuit can be summarized as follows:—The number of cores required is equal to the number of combinations of input conditions. For each input combination one of the cores is selected by AND-gating and switched. The desired function is then obtained by OR-gating the appropriate cores; it should be borne in mind that given an array of cores any OR-gate can be set up simply by threading a wire through the cores concerned.

As pointed out by Rajchman in his patent specification there is a variety of ways of obtaining the AND-gating action on the inputs. Fractional switching currents can be chosen so that only the sum of several such currents suffices to switch the core. This is probably the least satisfactory method from the point of view of design tolerances and is in fact impractical in the case of more than two inputs. In another method, current is supplied to an inhibiting winding embracing all cores and the driving currents are so chosen that only the sum of a given number of them will overcome the effect of the inhibiting current and switch a core. This method affords bigger design margins. The biggest margins are obtained by methods of the type shown in Fig. 1. In a variant of this arrangement due to Renwick* the switching pulse is obtained from a separate source instead of by combining the input currents. No precise simultaneity of the inputs is then required, it is only necessary for the switching pulse to be applied while all the inputs are present.

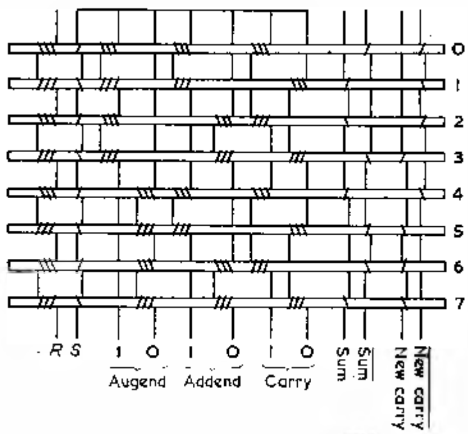

Fig. 1. Binary adder

The above method of realizing logical functions with core matrices differs radically from the techniques employed with relays or valve and diode gates. It may be considered as a direct realization of the function table without any concern for the nature of the logical function. It is therefore particularly applicable to functions which are defined solely by the function table. One may, for instance, have two sets of numbers with the numbers of one set corresponding to numbers in the other set in an arbitrary fashion. The operation of finding the number in the second set from the corresponding number in the first set is sometimes called translation, the numbers of the second group being referred to as the translations of those in the first. Translation of this kind takes place in some automatic telephone systems; for example, a subscriber's directory number may be translated into another number which indentifies his equipment in the exchange. Fig. 2 shows how

* *Formerly Ericsson Telephones Ltd.*

* *The use of matrices for performing logical functions has been independently proposed by Mr. W. Renwick at a colloquim at the University Mathematical Laboratory, Cambridge, in 1956.*

such a translator can be set up with magnetic cores. The inputs are numbers of up to three decimal digits. The rows of both matrices normally carry bias current so that all cores are biased into N saturation. The second and third digit inputs cause the bias currents of the appropriate rows to be removed while the first digit input applies a switching current to one of the columns of the 9×10 matrix. Every core in this matrix carries an output winding which threads one column of the 10×85 matrix. For each combination of input digits a single core in the 9×10 matrix will switch and generate a switching current in one of the columns of the bigger matrix, where again only one core

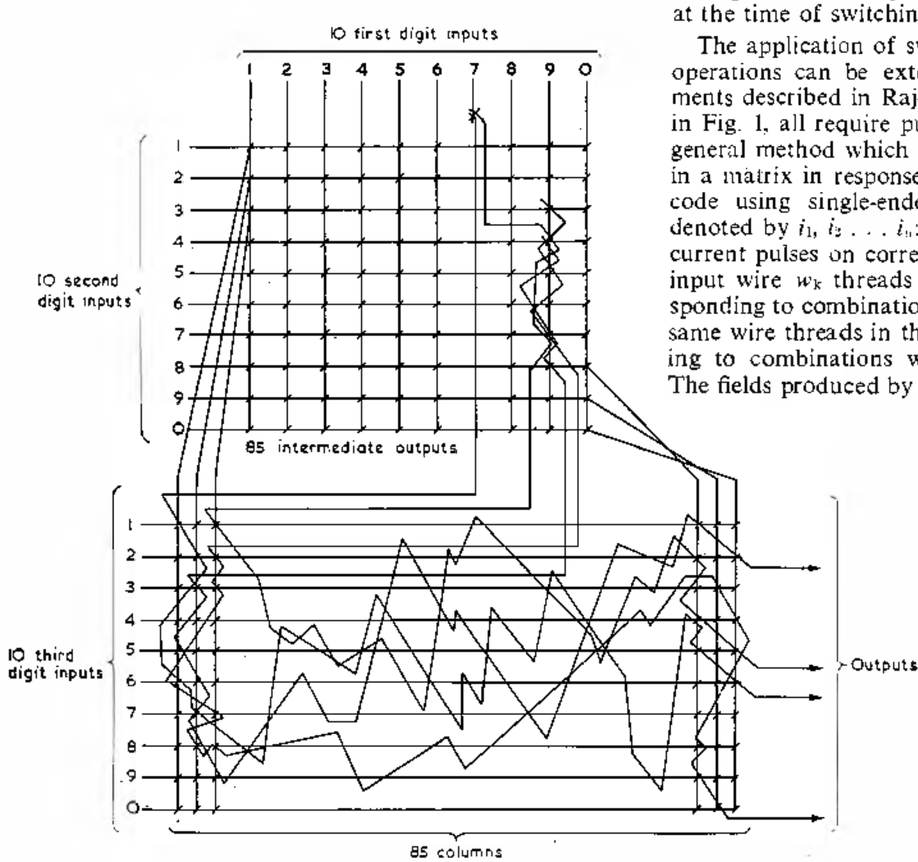

Fig. 2. Number translator

will switch. The output wires, four of which are shown in Fig. 2, are threaded according to the following rule: One output wire threads all the cores corresponding to numbers whose translations contain the same first digit. This is repeated for all the digits of the translations. The maximum number of output wires threading a single core is equal to the maximum number of digits in a translation. Any desired relationship between translation and inputs can be obtained by suitably threading the output wires. Where a translation exists for an input with less than 3 digits it is possible to effect an economy in cores by threading output wires through the cores of both matrices. In the case shown in Fig. 2 translations exist for one single-digit number and 5 two-digit numbers. The single core threaded by first digit input 'seven' has either to be provided with means for restoring to the N state or else it has to be of non square-loop material.

The method adopted for AND-gating the first and second digit inputs is to use one of them to remove a constant bias and to employ the other to produce a switching current. It was developed by Renwick for his 'direct access' magnetic core stores[2]. This technique is usually applicable when there is a sub-set of inputs such that one and only one input out of that sub-set is present at a time. The three input digits have been combined by a two-stage AND-gating arrangement rather than an array of three-input AND-gates for the following reason: If a three dimensional approximately $10 \times 10 \times 10$ array had been adopted each input wire would have threaded about 100 cores and when one core was switched the other 99 would have been disturbed. As an output wire might conceivably have threaded all 99 disturbed cores the accumulated effect might well have exceeded the output due to the switched core. With the arrangement actually adopted only 9 cores are disturbed at the time of switching.

The application of switching matrices to perform logical operations can be extended in many ways. The arrangements described in Rajchman's patents, like the one shown in Fig. 1, all require push-pull inputs. There is, however, a general method which makes it possible to switch one core in a matrix in response to a combination of inputs in any code using single-ended inputs only. Let the inputs be denoted by $i_1, i_2 \ldots i_n$: it is assumed that they cause input current pulses on corresponding wires $w_1, w_2 \ldots w_n$. An input wire w_k threads in the P direction, all cores corresponding to combinations which contain the input i_k, and the same wire threads in the N direction, all wires corresponding to combinations which do not contain the input i_k. The fields produced by the input windings are all equal and each is sufficient to switch a core. Inhibiting windings are provided which apply to each core a field $m - 1$ times the field produced by the input windings, where m is the number of input windings threading the core in the P direction. This ensures that no core will switch unless all the inputs of corresponding combination are present. On the other hand, a core will not switch if other inputs than those of the corresponding combination are present, because the additional inputs will apply additional N fields to the core. A binary decoder operating on this principle for the numbers 0 to 7 is shown in Fig. 3. The input and inhibiting wires thread the cores in the directions indicated by the letters N or P at the cross points; where no letter appears, the core is not threaded by the wire. The constant input is applied at the same time as the digit inputs and switches the '0' core when no other input is present. The means for resetting the cores and the output windings are omitted from this figure.

The single-ended input decoder suffers from two disadvantages, namely that all the inputs must be precisely simultaneous and that the method of AND-gating depends on the balancing of the fields in the P and N directions. If there are many inputs this entails precise control of current magnitude

The above limitations on single ended decoding matrices do not apply when the matrices are used for decoding information expressed as signals on k out of m leads. In one application of this kind transistors were used as current sources supplying the matrix, and the limited average dissipation of available transistors made it impossible to supply constant bias current. Other requirements were that neither exact simultaneity of inputs nor precise control of input current magnitudes should be necessary, and that the decoded information should remain stored on the cores until erased by a resetting pulse. The ten-core matrix shown in Fig. 4 meets these conditions and will decode signals appearing as pulses on 2 out of 5 leads. The letters at the intersections again indicate the directions in which the windings thread the cores. It will be seen that in this case also each input wire threads in the *N* direction all cores corresponding to combinations which no not contain that input. If current pulses are applied to any two of the inputs all cores except the one corresponding to the combination of these two inputs will be biased off (i.e. in the *N* direction). If during the period for which both inputs are present a pulse is applied to the switching wire, which threads all

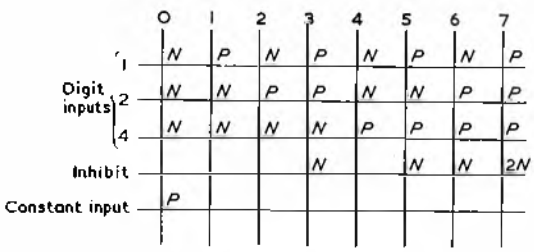

Fig. 3. Binary decoder with single-ended inputs

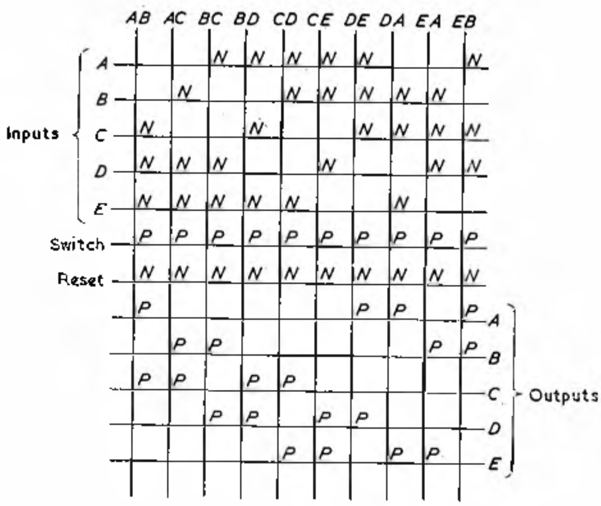

Fig. 4. 2 out of 5 decoder with single-ended inputs

the cores in the *P* direction, the one core which has not been biased off will switch. It will remain in the *P* state until a pulse is applied to the resetting winding which threads all cores in the *N* direction. Output pulses are obtained both when the core is switched and when it is reset. If a single output wire is threaded through each core, the original 2 out of 5 signals are decoded into 1 out of 10 form; alternatively output wires can be threaded through the cores for re-encoding into 2 out of 5. If the output wires are so threaded that the signals are re-encoded not into the input combination but into the next one in order, as shown in Fig. 4, the re-encoded signals can be used as new inputs to the matrix, which then generates each 2 out of 5 combination in succession. Such a matrix will effectively work as a counter in the 2 out of 5 code. It may be noted that in an application like this the cores are used both as logical elements and as storage elements.

The EDSAC II microprogramming matrix[3] is a core matrix pulse pattern generator. A transistorized version of such a generator is being developed by Mr. W. Loughhead*. The principle of operation is illustrated in Fig. 5. Taking the initial state to be that in which core *A* is set while all the other cores are reset, a resetting pulse applied to a winding threading all the cores (not shown in the figure) resets core A. At the same time the transistor switches marked *t* are made to conduct, while the transistor switches marked *s* remain non-conducting. In resetting, core A generates currents in windings 1 and 4 which set cores 1 and 4. These currents are in such a direction as to drive cores C and D to the '1' state. However, the resetting current threading all the cores in the matrix prevents these two cores from being set.

A setting pulse is now applied to a winding (not shown in Fig. 5) threading the set of co-ordinate cores, one for each row and one for each column, marked 1 to 4. At the same time the transistor switches *S* are made to conduct. Cores 1 and 4 are reset, generating currents in windings 11 and 14 which set core B only. This cycle is repeated for all the

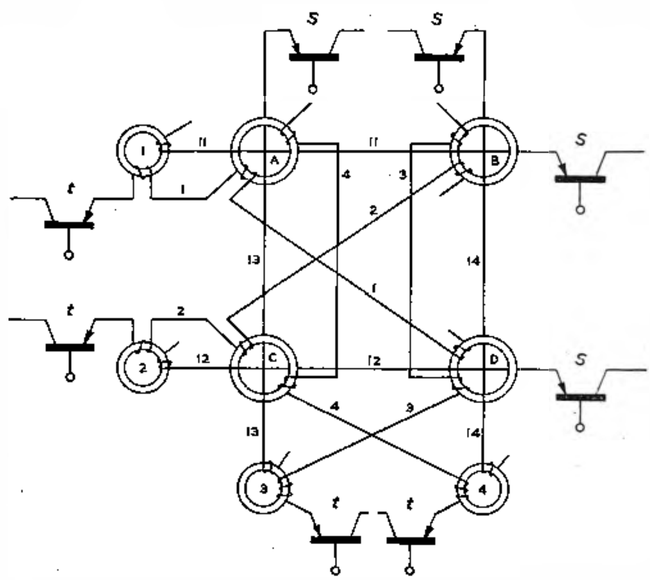

Fig. 5. Core-transistor pulse pattern generator

cores in the matrix. Outputs are taken from the cores through output windings not shown in the figure. The order in which the matrix cores are switched depends solely on the way in which windings 1 to 4 are threaded so that any desired switching order can be obtained. The operation of a pulse pattern generator of this type is inherently asynchronous and the cores act in turn as AND-gates, storage elements, OR-gates and amplifiers.

The straightforwardness and simplicity of core matrix logic is one of the main advantages of the technique. Because of this inherent simplicity the circuits can be designed with large margins of safety so that they function very reliably. The limitations of the method stem basically from the fact that the technique does not contain a general method for using the outputs from one matrix as inputs to the next one; all the inputs are presented simultaneously and the answer obtained directly. This, of course, makes for rapid working, but the number of cores required may in some cases become prohibitive—for example, a 40-bit parallel adder would require 2^{80} cores. However, if the logical processes to be performed can be arranged so that the number of signals which have to be transferred from one matrix to another is small, amplifiers can be provided for this purpose or one of the methods associated with

* *Ericsson Telephones Ltd, private communication.*

core shift register logic[4] can be employed. It is important to note that if amplifiers are used the output from a matrix is available at the same time as the inputs are applied. The total delay through a core matrix system with amplifiers is comparable to that obtained with diode and amplifier logic. When the logical function which has to be realized is defined solely by a function table the matrix method is certainly superior to any other method, even if a large number of cores is necessary.

Acknowledgments

The author thanks the directors of Ericsson Telephones Ltd for permission to publish this article, and acknowledges his indebtedness to his former colleagues in the Ericsson laboratories for co-operation and encouragement in the course of its preparation. Discussions with Mr. W. Renwick and Dr. D. J. Wheeler of the University Mathematical Laboratory, Cambridge, have also been most helpful.

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1. RAJCHMAN. Brit. Patent 737420.
2. RENWICK, W. A Core Matrix Store with Direct Selection Using a Magnetic Core Switch Matrix. *Proc. Instn Elect. Engrs. 104B*, 436 (1957).
3. WILKES, M. V., RENWICK, W., WHEELER, D. T. The Design of the Control Unit of an Electronic Digital Computer. *Proc. Instn Elect. Engrs. 105B*, 121 (1958).
4. LOEV, D., MIEHLE, W., PAIVINIEN, T., WYLEN, T. Magnetic Core Circuits for Digital Data Processing Systems. *Proc. Inst. Radio Engrs, 44*, 154 (1956).

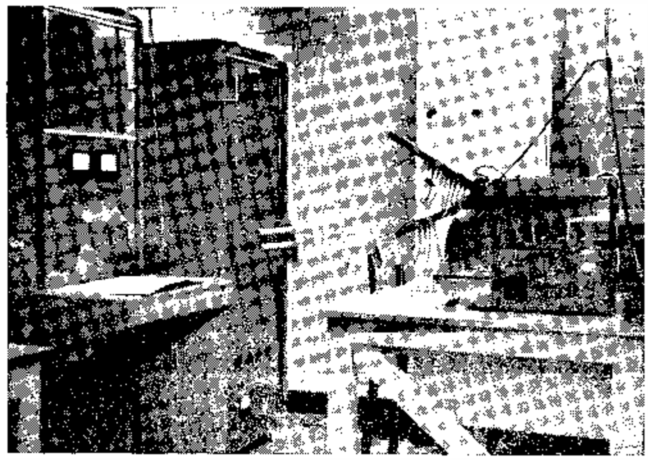
An Automatic Semiconductor Testing and Data Recording Machine

A machine which is largely digital in operation has been developed by the Sylvania-Thorn Colour Television Laboratories Ltd, London, for the purpose of minimizing the production-test costs of semiconductor diodes and transistors, while at the same time ensuring an extremely high standard of testing and grading.

The basic rate of testing is 10 000 tests per hour, i.e. 1 000 devices per hour with up to ten tests per device with a maximum resolution of ±2 per cent. Measured quantities are recorded simultaneously on punched tape and on printed pages for the purpose of Quality Control. The tests are applied sequentially and provision has been made to compare each measured quantity with upper and lower limits which can be prescribed for every test. Whether a measured quantity is inside or outside limits can be made to determine whether some or all of the remaining tests are applied or inhibited. In order to accommodate double testing procedures in which devices are loaded or stressed environmentally between original and final inspection, provision has been made to facilitate correlation of data generated and to identify more easily those devices whose characteristics are instable or changing.

This is achieved on the page printer by interlacing the later results with the original and by omitting the later result provided that it is the same as the original. In this way attention is drawn only to those units which have changed and the magnitude of these changes can be observed by direct subtraction.

Functionally the machine consists of a central control unit to which is added a number of plug in test units. These provide the a.c. and d.c. test conditions necessary to apply a particular specification. In this way flexibility is preserved and one control unit can be made to cover a range of diodes and transistors. The ranges of current and voltage envisaged at present are 1μA to 10A and 100mV to 1kV. The basic arrangement of the machine is shown in Fig. 1.



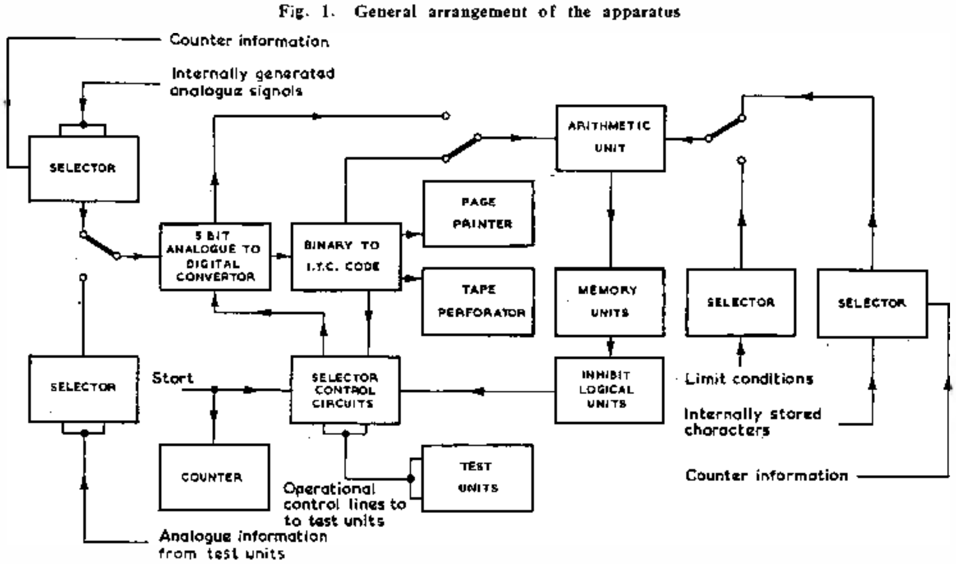
The semiconductor testing machine. The electronic units are on the left; on the right is an automatic diode testing jig and behind it is the page printer.

The equipment is fully transistorized and makes use of standard telegraph machinery for producing output data. All analogue quantities which are generated during the test procedure are digitized, firstly into a five bit straight binary code for processing by the machine and subsequently into the International Telegraph Code for output purposes. By converting immediately from analogue to digital form, all likely sources of error and drift are concentrated in one part of the machine and provision has been made for an automatic self-check to occur once per device tested. This reduces the incidence of undetected errors to a vanishing small level. In addition other self-checking programmes are available for periodic or daily checks.

More facilities have been incorporated in this machine than may be required in general and it is possible to operate, for example, without the test sequence being determined by the results of foregoing tests, or without the double inspection facility. If the full facilities will never be required a simplified machine can be supplied.

It is felt that a grading or classifying requirement exists and this can be satisfied by an additional logical unit, provided that the number of types which can stem from a given start is limited to, say, two or three in the case of transistors and rather more in the case of diodes.

Fig. 1. General arrangement of the apparatus



An Electronic Timer with Voltage Control of Setting

By R. Gladstone*

This timer (which is believed to be new in principle) is a development of the creeping cathode-follower, or Bootstrap circuit. The difference lies in providing a power drive to the grid, to give a constant but easily adjustable rate of change over the full operating grid control range of the valve. The direction of change may be positive or negative, and the rate of change may be varied over very wide limits by either of two independent variable linear circuit parameters, by a third parameter capable of step change, and over a limited range by a fourth.

(Voir page 377 pour le résumé en français: Zusammenfassung in deutscher Sprache Seite 382)

THERE are many applications where a time interval proportional to a voltage needs to be generated. A quick reset is often of value, and sometimes the timed interval must be independently varied by a second or even a third parameter.

A relatively simple method of doing this is described, and the accuracy, linearity and dependability are all of a high order, suitable for the majority of industrial control purposes.

The timer consists of a triode cathode-follower using a valve of a type having low grid current, the EF36/86 class being particularly suitable. The requirement is that with the grid floating on a capacitor of capacitance appropriate to the timing required, the cathode voltage drift is not significant. There is with many valves little difficulty in keeping timing errors due to this cause to less than 1 per cent. This error can readily be made negligible.

The timer output, taken from the cathode, will normally be used to trigger a control circuit, when it reaches a definite positive or negative going value. In a common application, a critical positive voltage would operate a flip-flop circuit energizing a relay, and this is shown in Fig. 1.

The timing drive is continuously maintained, and the cathode voltage will continue to rise until grid current sets in, and finally balances the timing power input. The trigger point must be set at a value substantially below this level so that there will be no loss of linearity at the end of the run, with fair allowance for drift in the valve characteristics.

Timing power is conveniently drawn from the mains transformer of the power pack. As a safety precaution, a series capacitor of about 0·01μF is inserted in the line, with a leak, say 1MΩ across it. This a.c. supply is then brought to a small variable capacitor, conveniently in the range 50pF to 1 000pF.

The other side of the variable capacitor is taken to anode and cathode of each of two gas filled diodes. The cathode of the first is taken to the grid, and the anode of the second to the cathode of the cathode-follower. This sense assumes that the breakdown voltage of the tubes is higher when the electrodes are reversed, and that the timing run of the cathode-follower will go positive. A negative going run is obtained by reversing the grid-cathode connexions to the cathode-follower.

It is further important that any difference in striking voltage between the two tubes is not greater than the difference between forward and reverse connexions of the individual tubes. Selected neon tubes of any kind may be used, but the employment of a pair of suitable reference tubes avoids the necessity for selection. The current loading is a small fraction of a microampere so that current handling capacity is of no importance, and life is indefinitely long. The type 85A2 is very suitable.

Consider, now, the action of the circuit as shown in Fig. 1. Let the a.c. drive have a peak voltage V_p. Let the capacitance of the variable capacitor be set at C_1, while

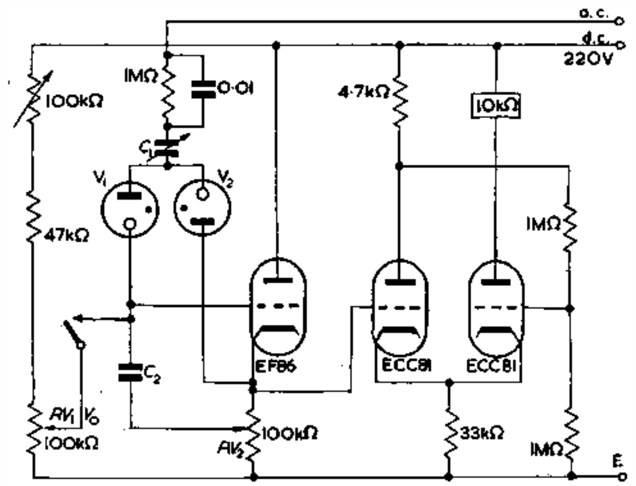


Fig. 1. The timer circuit

the main cathode-follower float capacitor has a capacitance C_2. Let the voltage V on C_2 be set at a value V_0 by momentarily connecting it to a source at this voltage. V_0 is assumed to be somewhere below the final triggering voltage at the output and of course well below the point of grid current. It should not be below the negative supply level. V_0 is of course the primary variable input parameter of the circuit, and may well be derived from a preceding circuit.

For convenience, the voltage on the tube side of C_1 relative to earth will be considered, and this will be referred to as 'the voltage on C_1'. V_1 and V_2 are the gas-filled tubes, with breakdown voltages V_T. It is found that at the low currents involved, tubes do not generally maintain at any voltage below the striking level, even on d.c.

V_1 feeds C_2 and V_2 goes to cathode. With grid voltage V, the cathode voltage will be $V + fV$, usually some 1 to 10V higher than V. fV can be kept low by using a high

* Wiggins Teape & Co. Ltd.

mutual conductance possibly at the cost of a reduced grid base.

Now on the first negative going cycle of the supply, the anode of V_1 and cathode of V_2 are carried negative. The anode of V_2 is fV volts more positive than the cathode of V_1. Moreover the critical voltage of V_2 in this direction is less than that of V_1. When this critical voltage is reached, V_2 will strike, and this will ensure that V_1 cannot strike with further increasing voltage to C_1.

C_1 will therefore reach an absolute value of $V + fV$, less V_T, the critical voltage of V_2, and when peak V_p is passed, and the supply voltage begins to rise, V_2 will extinguish. Consider the rise of supply voltage from its negative peak V_p.

When C_1 rises to a value $V + V_T$ tube V_2 will fire. Its critical voltage in this direction is lower than that of V_2, and the acting cathode of V_2 is in addition somewhat positive compared with that of V_1.

At negative peak, C_1 stands at a voltage $V + fV - V_T$.

It has been seen that V_1 will fire when C_1 reaches $V + V_T$. This will occur when the supply voltage has moved from the negative peak V_p by a voltage $2V_T + fV$. For the purpose of simplifying this examination, fV which will be small in comparison with $2V_T$ will be temporarily neglected.

V_1 will accordingly fire, and the supply voltage will continue to rise to a value $+ V_p$.

The voltage on C_1 will however be held very nearly to $V + V_T$ because C_2 will be many times larger than C_1. However, once V_1 has fired, current will flow from C_3 into C_1, thus raising the voltage on C_2 very slightly.

After V_1 has fired (when the supply voltage reaches $- V_p + 2V_T$) the supply voltage will continue rising to $+ V_p$. The rise after V_1 has fired will therefore be $2 V_p - 2V_T$.

This rise of voltage will effectively divide itself between C_1 and C_2 in the inverse ratio of their capacitances. C_2 will accordingly rise by $C_1/C_2 \times (2V_p - 2V_T)$. And this rise will take place at each cycle of the supply. A fair approximation for design purposes (using 50c/s) that will give the rate of rise (or fall) in volts/second, is given by

$$\frac{100\, C_1 \times (V_p - V_T)}{C_2}$$

The factor fV was neglected in this calculation, and in fact the voltage rise per step will be related to $2V_T + fV$ and not $2V_T$. With the creeping cathode-follower the rate of rise varies directly with fV, and over fairly wide ranges the rate may vary by a factor of 2 to 4. If V_T is made about 150, the variation in timing rate will be of the order of one per cent during the run. For most normal applications low voltage tubes are satisfactory, and have the advantage of minimizing the effect of changes in the driving supply.

Taking a typical case, with C_1 set at 100 pF, C_2 at 1μF, V_p at 350 and V_T at 105, the 50 c/s rate of rise would be 2·45V/sec. Assuming that the useful cathode-follower range is 100V, the maximum delay time will be about 41sec, and will vary linearly with the depression of the starting voltage applied to C_2. By adjustment of C_1 between 50pF and 500pF, the maximum delay can in practice be altered from 100sec to 8sec. By altering C_2, this timing can be multiplied or divided almost indefinitely. Timing less than 2sec involves increasing random error due to start and stop of the 50c/s steps. A final and sometimes useful means of varying the rise rate in a linear manner is to make the cathode-follower load a potentiometer, and to return C_2 to the slider (as shown in Fig. 1) instead of to the negative supply. The timing rate will increase linearly with the potentiometer setting towards the cathode.

The calculation appears to agree very well with practical trials using values of C_1 down to about 150pF, but with lower values the actual rate of change falls more greatly than the calculation indicates, and at 20pF the time of run was several times that calculated (Fig. 2 shows a comparison of calculated and actual times obtained). Since the value of C_1 will normally be pre-set to suit a practical requirement this divergence is of little importance, but it is probably wise to avoid designing for much less than 50pF. The 85A2 tubes failed to burn with C_1 set below a value of 15pF.

For very long timing runs, the a.c. drive voltage may be reduced, but voltage variation will have an increasing effect. The supply may be fed from a potentiometer, to provide yet another control input point, but this method will not be linear with potentiometer setting. Temperature effect was checked using a pair of 85A2 tubes, and at 60°C it was still too small to decide whether the time was increasing or decreasing.

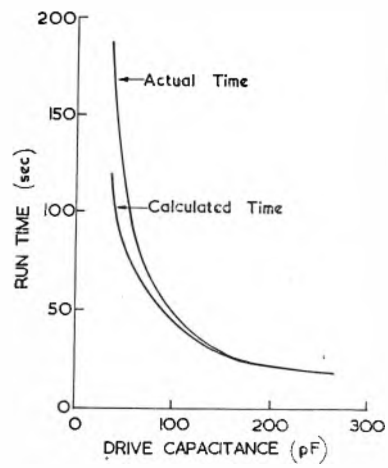


Fig. 2. Actual and calculated values of running time against drive capacitance

It will be observed that Fig. 1 includes a flip-flop circuit which is very suitable for triggering from this form of timer. There is an overlap of two or three volts at the input grid, and unless the applied timing voltage is sufficient to overcome this, the relay will not pull in. However, time ratios in excess of 20:1 are safely possible. To obtain linearity of timing against input voltage it is of course necessary to arrange that zero timing voltage at the timer input will just cause the flip-flop to fall back. In the figure, the setting is readily found by putting RV_1 at full positive, holding the charging contacts closed, and decreasing RV_3 slowly until the relay just drops out.

RV_2 represents the introduction of a second linear variable. Where this is not required, C_2 is taken direct to earth. Where very large timing ranges are required, the value of C_2 may be changed by switching. The necessity for good insulation in the floating grid circuit must not be overlooked, and it is advisable to use ceramic base switches and valveholders. Relay or other contacts involved should have Bakelite insulation strips replaced by Perspex. The greater the value of C_2 that is used, the less becomes the importance of leakage.

Acknowledgments

The author wishes to thank the Directors of Wiggins Teape and Co. Ltd for permission to publish this article.

LETTERS TO THE EDITOR

(We do not hold ourselves responsible for the opinions of our correspondents)

Sampling Generator

Dear Sir,—With reference to Mr. A. Fischmann-Arbel's article in your December 1958 issue, it seems that an encoder for delta modulation may be constructed with the described sampling comparator in a much simpler way than illustrated in the block diagram of Fig. 3, on page 685, with less components and no delay lines. This alternative way is in line with the block-diagrams in de Jager's original article[1].

This arrangement (Fig. A) uses only the positive going output of the differential amplifier, which, through a threshold, triggers a monostable multivibrator. As long as pulses appear at its output the voltage at the integrator output rises. When no pulses appear at the multivibrator the integrator output voltage is made to decrease at the same rate. If a d.c. voltage is applied at the signal input the multivibrator will fire and remain quiet on alternate clock-pulses, provided one pulse is sufficient to increase the integrator output voltage by more than required to pass the threshold at the multivibrator input, at the time of the next pulse.

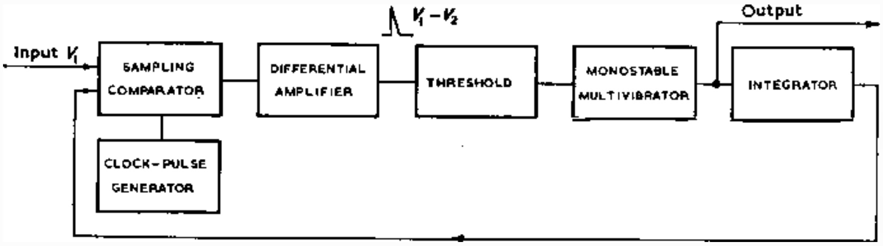


Fig. A. Simple arrangement for sampling comparator

Yours faithfully,
Jonathan Mass,
Ministry of Defence,
Hakirya,
Tel Aviv.

REFERENCE

1. de Jager, F. Delta Modulation. *Philips Res. Reps.* 7, 442 (1952).

The Author Replies:

Dear Sir,—The sampling comparator was originally developed for use in the binary quantizer, and in the incremental delta modulation[1] encoder described in the original article. The incremental code has certain advantages over the conventional delta code for signals whose power is concentrated in the lower half of the signal bandwidth, and requires the complete encoder.

Only later was the circuit adapted for use as an encoder for conventional delta modulation, to which Mr. Mass's suggestion applies.

May I use this opportunity to point out two errors in Fig. 4 of the original article: The value of the cathode bias resistor for V_2 is 4·7kΩ and not 47kΩ, and V_{6A} should be a 12AT7, instead of a 12AU7.

Yours faithfully,
A. Fischmann-Arbel,
Ministry of Defence,
Hakirya,
Tel Aviv.

REFERENCE

1. Mass, J. An incremental remote position control system. National Telemetring Conference, Chicago. 1955.

Sampling Oscilloscope with 'Frozen Feedback'

Dear Sir,—With reference to Mr. Reeves' informative articles on stroboscopy in March and April issues of Electronic Engineering, we have been using a feedback sampling oscilloscope which has a feedback system differing from that of Mr. Reeves' Class 2. This system largely avoids servo instability at low sampling rates and possesses one further advantage. Fig. 1 shows the logic of the voltage measuring servo system but omits all the remaining circuits for timing etc. which are required in the complete instrument.

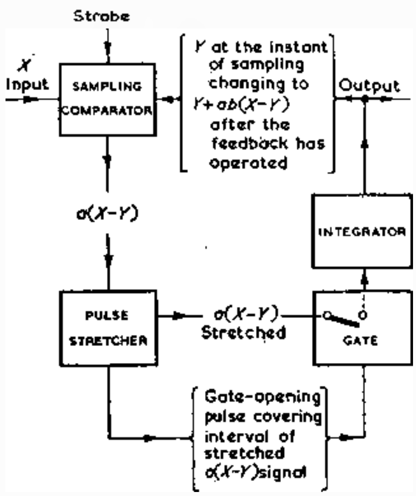


Fig. 1. Feedback system

X is the signal voltage being measured. Y is the servoed reference voltage which is also the output. The sequence of events is:

(1) On receipt of a strobe pulse the sampling comparator produces an error signal $a(X - Y)$ where a depends on the properties of the comparator.

(2) This $a(X - Y)$ signal is stretched for a convenient time (say 100μsec) which is less than the interval between samplings and the stretched signal is applied to the input of the integrator via the gate.

(3) As this signal arrives the output potential of the integrator changes from Y to $Y + ab(X - Y)$ where b depends upon the length of the stretched $a(X-Y)$ pulse and upon the constants of the integrator.

(4) This voltage $Y + ab(X - Y)$ is the reference voltage for the next sampling and remains 'frozen' until that sampling occurs.

Simple analysis shows that if ab lies between 0 and 2 the system is stable and, further, that if $ab = 1$, the system converges completely in one sampling. The Y voltage after adjustment by the feedback system is thus equal to the X voltage at the instant of sampling. The function of the integrator is to allow one to apply to the Y voltage an increment proportional to the $a(X - Y)$ voltage or error signal whatever the Y voltage may already be.

This description would suggest that the Y voltage can be made to follow the X voltage exactly. This is not quite true, for any real electronic integrator (known to me) is imperfect; that is, the resting potential of its input is slightly influenced by the potential of its output. Because this is so, the condition of balance will not be exactly $X - Y = 0$ for all values of X. This variation can be made very small by making the gain of the integrator, considered as a d.c. amplifier, very large.

If the integrator output voltage is to remain frozen between the receipt of stretched $a(X - Y)$ pulses the integrator must receive no input current during these intervals. Because the integrator input potential varies this can only be ensured by completely isolating its input between stretched $a(X - Y)$ pulses. This is done with a special sort of gate which is effectively an electronic switch in series with the input.

Because the feedback system (and with it the output voltage) is frozen between samplings, the behaviour of the machine is independent of the sampling rate. Servo instability can only occur if the sampling rate is so low that the integrator drifts between samplings.

A further advantage is conferred by the feature of convergence in one step. Even if the variation in input voltage between samplings is large the output of the machine will reproduce it, subject to the limitation that, as far as the height of the step is concerned, the system is 'unfedback' (i.e. Reeves' Class 1). For reproduction to be perfect the sampling comparator would have to be precisely linear. Since it will not be, this sets a practical limit on the height of step between samplings which will be honestly portrayed.

Normally one uses enough samples to avoid large steps, however if the pulses being examined are not quite identical (see Sugarman[1] for the use of an unfed-back sampling 'scope under these conditions') steps will occur whatever the sampling rate.

Yours faithfully,
C. W. McCutchen,
Cavendish Laboratory,
Cambridge.

REFERENCE

1. Sugarman, R. Sampling Oscilloscope for Statistically Varying Pulses. *Rev. Sci. Instrum.* 28, 933 (1957).

Proportional Control Using a Phase-Shift Thyratron Operated from a D.C. Signal

Dear Sir,—The phase-shift thyratron is an excellent device for proportional control. However, when it is operated from an a.c. signal, this signal has to be of the same frequency as the power supply. Moreover, the bridge must be near the equilibrium point before control is taken over by the instrument[1]. These difficulties are avoided by using a phase shifting circuit controlled from a d.c. signal. This d.c. signal may be the amplified output of an a.c. bridge, and rectified

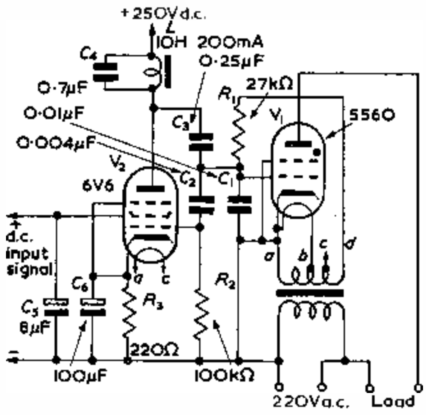


Fig. 1. Proportional control using a phase-shift thyratron operated from a d.c. signal

through a phase sensitive rectifier. The frequency of the bridge supply is, then, independent of the power supply.

The phase-shift is obtained by means of a reactance-valve-circuit. Its principle is a classic one and is widely used as a modulator in frequency-modulation. It has not been used, so far, at so low a frequency as that of power lines.

Referring to Fig. 1, V_1 is the thyratron Its grid voltage (with respect to the cathode) is the voltage across C_1. The values of R_1 and C_1 are such that the reactance of C_1 at 50c/s is very high compared to R_1. Hence, the voltage across C_1 is in phase with the supply voltage to R_1C_1, which is chosen to be out of phase with the thyratron's anode voltage.

The reactance of C_2 at 50c/s is very high compared to R_2 so that the voltage across R_2 leads by almost 90° the voltage across C_3R_2 (i.e., the thyratron's grid voltage). The anode current of V_2 is in phase with the voltage across R_2, i.e., it also leads by 90° the voltage across C_1.

The a.c. component of V_1 anode current flows in parallel with capacitor C_1 (the parallel connexion is through the coupling capacitor C_3); and as it leads the voltage across C_1, it has the same effect as would an added capacitor across C_1 and which would pass the same amount of current. The greater the mutual conductance of V_1, the greater the magnitude of its anode a.c. component and, hence, the greater the magnitude of the equivalent added capacitance. When, by varying the mutual conductance of V_1, the effective capacitance across C_1 can be varied and, hence, the phase of the grid voltage of the thyratron. The mutual conductance of V_2 is controlled through the d.c. potential applied to its screen grid. R_3 provides self grid bias while C_5 and C_6 are low impedance paths at 50c/s to avoid degeneration. C_4 and L form a 50c/s tuned circuit for maximum gain at 50c/s while eliminating stray r.f. signals.

Maximum phase shift obtainable is a ¼ of a cycle. A change of potential at the screen grid of V_1 from 50V d.c. to 150V d.c. proves sufficient (the effective capacitance across C_1 is increased about a hundredfold) and the thyratron's state shifts from no conduction at all to conduction 25 per cent of the time.

A change in the characteristics of V_2 due, for example, to ageing, does not affect the performance of the regulator. The valve can be replaced even by other types with the same pin connexions (such as 6K6 or 6L6) without notable change of performance. This is explained by the fact that the whole instrument is a servo-loop where the gain from the error signal to the compensating power is very high.

This circuit was used for temperature regulation of a liquid metal bath with a platinum resistance thermometer. Because we had to use equipment existing already, we employed a d.c. bridge, a sensitive galvanometer and a photocell whose d.c. signal was amplified through one valve only. Without much elaboration, the regulation was better than 0·1°C with power supply variations of 10 per cent. The bath was used five to six continuous hours per day for periods of several days each, at temperatures ranging from 250 to 350°C. The controller needed no adjustment from day to day.

Yours faithfully,
J. Leibovitz,
Israel Institute of Technology, Haifa.

REFERENCE

1. Sturtevant. *Rev. Sci. Instrum.* 9, 278 (1938).

Free Running Transistor Blocking Oscillators

Dear Sir,—In the design of free running transistor blocking oscillators, the main object is to provide a pulse of known width at a known and preferably variable repetition frequency. A resistance-capacitance network, RC, in the emitter circuit (Fig. 1) provides control of both pulse width and repetition frequency simultaneously, but in an almost unpredictable manner, the indeterminate

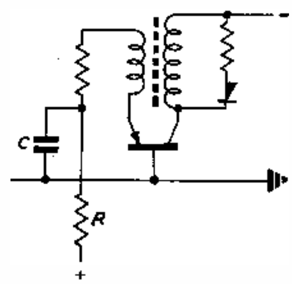


Fig. 1. Basic circuit

factor being the voltage developed across the capacitor during the charge and discharge cycles.

The use of a Miller capacitance C_1 in a second transistor X_2 (Fig. 2) enables an effective capacitance to be inserted in the circuit, but the change in voltage at the point of connexion is now very small. The blocking oscillator may therefore be designed to provide a pulse of known constant width, irrespective of the repetition frequency.

The circuit shown in Fig. 2 provided a pulse of 1µsec at a repetition frequency which was variable from 300kc/s (V =

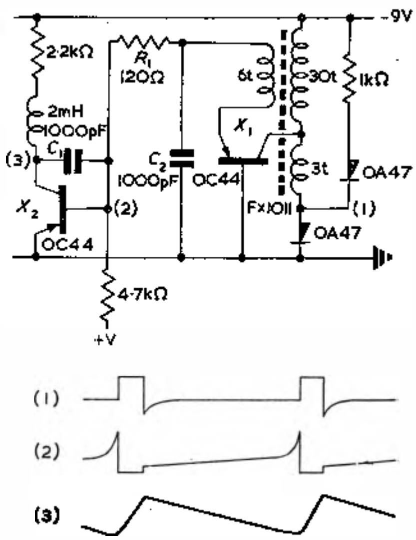


Fig. 2. Improved circuit and waveforms

12V) to 60kc/s (V = 2V). The circuit would oscillate at frequencies lower than this, but the low bias current applied was not sufficient to cause the point of regeneration to be stable, and some jitter was then apparent. The repetition frequency may also be affected by ambient temperature variations if the applied bias current is not large compared with the collector-base cut-off current (I_{co}) of X_2.

To avoid lengthening of the output pulse due to hole storage delay, the blocking oscillator transistor is clamped out of bottoming by means of a primary overwind and a diode.

The capacitor C_2 is included to permit fast regeneration, but its time-constant with R_1 is made short compared with the width of the pulse.

Yours faithfully,
W. L. Stephenson,
Mullard Research Laboratories.

BOOK REVIEWS

The Solid State for Engineers

By Maurice J. Sinnott. 522 pp. 80 figs. Medium 8vo. John Wiley Inc., New York. Chapman and Hall, Ltd., London. 1958. Price 100s.

THE aim of this book is to acquaint engineers and engineering students with the principles of solid state physics. In this the book succeeds very well indeed, by giving briefly, but very clearly a description of the basic principles which underlie the behaviour of solids. The text is everywhere precise and accurate without going into too great and too complicated details, and would form an admirable basis of a course on the solid state for engineers.

The text is mainly descriptive, avoiding complex mathematical treatment and there are a number of helpful illustrative problems. The working out of these problems is indicated and they add greatly to the clarity of the description. They serve as excellent examples for the solving of any simple solid state problems which may arise in the work of the engineer. As pointed out in the introduction, in many cases some simple, but careful thought on how to use the book will replace tedious searching of handbooks and extensive reading of specialized literature.

The organization of the subject matter is logical and helpful. The first three chapters are concerned with the structure of matter and methods of examination and study of structure.

It is very refreshing to see the two chapters which follow describing phase equilibria and rate processes in solids. These items are missing in many books on the solid state, but their importance in metallurgy and solid state chemistry can hardly be over emphasized. The part dealing with ternary systems is perhaps a little too short.

The following four chapters describe the different kinds of solids, metallic, ionic, covalent and molecular dealing with binding forces, structures and bonding theories.

The first half of the book concludes with chapters on deformation, dislocations and problems of strength, crystallization and grain boundaries in polycrystalline substances. These matters are, of course, of enormous importance to the engineer.

The second half of the book is devoted to the physical properties of solids, e.g. mechanical, electrical, magnetic, optical and some surface properties. Here again the current, sometimes complex theories, are presented in great clarity with emphasis on the physical processes, thus enabling the reader to obtain understanding rather than volume of knowledge. This understanding is again and again applied in the solution of illustrative problems.

Each chapter has a list of references of well chosen modern text books for further study.

The only unfortunate omission is any mention of the method of radiofrequency and microwave spectroscopy, which has become such an important subject both for the study of solids as well as in its application in ferromagnetic nonreciprocal devices and solid state molecular amplifiers. It is to be hoped that this omission will be rectified in the next edition.

The book is very clearly printed and the diagrams are well drawn and adequately explained.

K. Hoselitz

Principles and Practice of Radar

By H. E. Penrose and R. S. H. Boulding. 803 pp. 574 figs. Demy 8vo. 6th Edition. George Newnes Ltd. 1959. Price 50s.

IN this edition, details have been included of True Motion Radar Displays for marine installations, the cosecant squared aerial, and the use of circular polarization as a means of minimizing the effect of rain interference on airfield radar displays. The extensive section—of more than 280 pages—dealing with actual equipments manufactured by British Thomson-Houston, Cossor, Decca, Kelvin-Hughes, Marconi and Sperry, has been further extended to cover the latest surveillance radar equipment, etc. Development is rapid in the field of radar, and the exacting requirements which a modern installation is called upon to meet are reflected in the use of higher and higher frequencies. In order that this revised edition shall be as up to date as possible, microwaves and the particular problems met with at these wavelengths are fully considered. Some of the latest developments, such as lenses and slot aerials, have also been included.

Industrial Electronics Handbook

Edited by W. Schottky. 384 pp. 96 figs. Medium 8vo. Friedrich Vieweg & Sohn, Braunschweig. 1958. Price DM46.80

THE nine sections of this handbook cover basic engineering and mathematics, physical laws, control elements, power supplies, control circuits, circuit applications, mechanical design, ultimate utilization requirements, and technical information sources. It includes the work of experienced specialists from more than a dozen companies and research centres.

Each section is complete unto itself. Graphical and tabular presentations are freely used, and additional references on each topic are listed.

Among specific subjects covered are computers, instrumentation, regulators, relays, transducers, amplifiers, and military and industrial utilizations.

The Story of the Ionosphere

By J. A. Harrison 103 pp. 123 figs. Demy 8vo. Hulton Educational Pubs. Ltd. 1958. Price 10s. 6d.

THIS is a 'popular' book written, apparently, for schoolboys in the 12 to 16 age group, although nowhere in the text or on the dust-cover is this intention made clear and it would undoubtedly have been less misleading if the jacket bore a clear label 'A book for boys'. The book is of no value to the adult engineer.

The title of the book is misleading; it would have been more appropriately called 'A popular story of radio' since it starts with Clerk Maxwell who "predicted the nature of wireless waves", and passes via the stages of Hertz, Marconi, Fleming and early broadcasting to 'Radar in War and Peace' and to 'Radio Astronomy', all in exactly 100 pages. Matter relating to the upper atmosphere scarcely fills a dozen pages.

There may well be a need among schoolboys for books of this nature but for heaven's sake let them be accurate and there can be no excuse for the prolixity of errors and loose or misleading statements with which parts of this book abound. Maxwell did *NOT* "predict the nature of wireless waves", Hertz did *NOT* find that the frequency of his oscillators was "Largely determined by the dimensions of the metal plate connected to the spark-gap", the apparatus Hertz used bore *NO* resemblance to that depicted as a replica in Fig. 12, the first electric telegraph in America was *NOT* opened in 1854, the coherer was *NOT* discovered by Sir Oliver Lodge and the planet Plato (sic) is *NOT* a mere "30 light-minutes" from the Sun. These are but a few of the loosely phrased inaccuracies in the text of this book the author of which would do well on future occasions to have his manuscripts more critically vetted before it reaches the irrevocable stage of the printing press.

G. R. M. Garratt

The Theory and Design of Magnetic Amplifiers

By E. H. Frost-Smith. 487 pp. 80 figs. Demy 8vo. Chapman & Hall Ltd. 1958. Price 75s.

THERE are not so many books on this subject and this one is certainly among the best. It describes both theory and practice in thorough detail. There is, however, a greater wealth of detail about small output amplifiers than about large amplifiers.

The various types of magnetic amplifier are dealt with in much the same order as they originally appeared. The early transductor, with its complexity of intrinsic current feedback, is followed by the even more complicated self-excited transductor. The relatively simple auto-excited transductor, and the flux-reset type of high speed amplifier, are not considered until later. It is the usual sequence, but it seems that there might be a simpler approach.

The behaviour of magnetic amplifiers has many facets, some of which are not too easily understood. The author's thorough treatment of these matters should leave no doubts. The discussions show real appreciation of practical problems. However, the use of 'firing time', and likewise 'firing angle', to describe the instant of core saturation appears inappropriate. Surely 'saturation time' and 'saturation angle' would be more correct.

It is rather surprising to find a statement of 'power amplification' for the voltage controlled flux-reset type of high speed amplifier, in which power is dissipated in the control element. Nevertheless, upon examination the statement serves to show that the essential presence of a magnetic core imposes performance limitations on both high and low speed amplifiers alike, although noticed in different ways. In general, the treatment of high speed amplifiers is inclined to be brief but otherwise of much the same high standard as the rest of the book.

It is pleasing to find a little more than usual concerning low power level amplifiers. So often this important group of amplifiers receive scant attention in works of this nature.

The chapter on design fills only a small part of the book. However, it should not cause disappointment since design calculations are relatively simple compared with the complications of magnetic amplifier theory and behaviour. Let it be added that successful design requires a thorough understanding of such details.

The book will doubtless be welcomed, not only in its own right, but as the first of a series on subjects concerning Automation and Control Engineering.

R. D. Pettit

BBC Handbook 1959

282 pp. Demy 8vo. The British Broadcasting Corporation. 1959. Price 5s.

THIS handbook gives details of the sizes of the audiences that are served both by sound radio and television. Some 14½ million adults are estimated to watch BBC television each day, while an average of 22 million listen to BBC sound radio at least once a day. The overall cost per hour of the services ranges from £176 for overseas programmes to £589 for home radio programmes. Television costs six times as much as radio, averaging £3,468 per hour. The BBC's belief that television viewers are entitled to expect a range and choice of programmes comparable to that which has been developed in sound broadcasting is reiterated in the handbook. The BBC has long maintained that this could only be achieved by the provision of two centrally-planned services giving a choice of alternative programmes, and for this reason the Corporation has sought the allocation of the necessary frequencies and the other resources required to start a second BBC television service at the appropriate time.

The handbook lists many of the achievements of the Engineering Division of the BBC, and describes continuing experiments in colour television and experimental high power television transmissions in Band V, and in stereophonic sound.

Preparation of Single Crystals

By W. D. Lawson and S. Nielsen. 255 pp. 133 figs. Demy 8vo. Butterworths Scientific Publications. 1958. Price 45s.

THE book is essentially concerned with the practice of growing purer and more perfect single crystals of semiconducting compounds. The authors have themselves been actively engaged in this work for several years, and their aim has been to bring together in one book the available information on techniques for growing crystals and for the purification and preparation of materials, with an essentially non-mathematical appreciation of the mechanism of crystal growth and of the origin of imperfections in crystals.

FBI Register of British Manufacturers 1959

1450 pp. Medium 8vo. 31st Edition. Kelly's Directories Ltd and Iliffe & Sons Ltd for the Federation of British Industries. 1959. Price 42s.

THIS comprehensive guide to a substantial cross-section of British industry, contains lists of the products and services of over 7 500 member firms under more than 5 400 alphabetical headings. In addition to the Classified Buyers' Guide there are seven other sections in the Register, giving addresses of companies and firms, and valuable information about Trade Associations, proprietary names, trade marks, etc. A feature providing a useful reference for buyers not fully conversant with British product terms, is the French, German and Spanish glossaries. These give translations of every product term used in the main buyers' guide, each being numbered for easy reference between the English headings and their translations.

The Register contains an introduction by the President of the Federation of British Industries, Sir Hugh Beaver, K.B.E.

Halbleiterprobleme—Volume IV (Semiconductor Problems)

Edited by W. Schottky. 384 pp. 96 figs. Medium 8vo. Friedrich Vieweg & Sohn, Braunschweig. 1958. Price DM46.80.

A SYMPOSIUM on semiconductor problems was held for the fourth year running under the auspices of the semiconductor committee of the association of German physical societies. The contributions to the symposium held at Heidelberg in 1957 are published in the present volume, the fourth of a series. The editor gives in a foreword brief summaries of the contributions to which is added his own article on "The question of the rational denotation of lattice defects" (ES) and a paper by M. Schön on "The kinetics of photoconducting and phosphorescence in crystals" (ES). The other five contributions are by H. Haken on "The present state of exciton research in semiconductors" (ES), by P. Haasen and A. Seeger on "Plastic deformations of semiconductors and their effect on the electrical properties", by H. D. Koswig and O. Stasiw on "The spectral location of the absorption bands of lattice defect electrons in ionic lattices" (ES), by H. Lautz on "The technical utilization of the thermoelectric power of near-metals and semiconductors" (ES) and by J. Dosse on "The state of development and application of transistors" (ES). The contributions designated by (ES) have a brief English summary at their end.

A large number of references to literature is given in the footnotes to each contribution. An account on the discussions following all the contributions to the symposium is also given. A special feature of this volume is a systematic index of the grouping of the themes in the field of semiconductors with references to the papers which have appeared in the four volumes published till now. This index indicates which problems of the original programme have already been dealt with and which still await special treatment. But, of course, further research on the first named group is by no means excluded in a field which has made such rapid progress within the last decade.

It is regrettable that Professor Schottky indicates his intention of giving up his fruitful organizing and editorial activity in the semiconductor committee and it can only be hoped that his successor will prove to be as active and successful in the volumes to follow.

The present volume is well produced and should be of great value to all those interested in the science and practice of semiconductors.

R. Neumann

ELECTRONIC EQUIPMENT

A description, compiled from information supplied by the manufacturers, of new components, accessories and test instruments.

(Voir page 373 pour la traduction en français: Deutsche Übersetzung Seite 378)

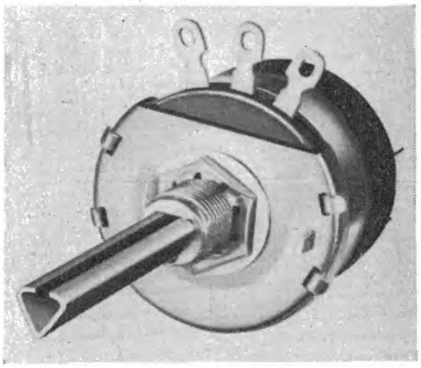
HOLLOW SPINDLE POTENTIOMETER

(Illustrated below)

The Plessey Co. Ltd, Ilford, Essex

A new design approach to spindle controlled variable components by The Plessey Company has resulted in the production of a triangular spindle potentiometer in which the spindle is formed from flat brass strip.

The design of the spindle is such that the need for machining special flats and knob fixings etc., has been obviated, all locations and fixings being achieved by bending or forming the hollow brass spindle to accommodate a polystyrene ring which, in turn, holds the brush gear. The limit stop and switch operating lug are also incorporated in the polystyrene ring.



Another advantage of the new method of construction relates to the control knob. This merely needs a triangular plain hole slightly smaller than the spindle size to give positive location in three alternative positions. Conventional methods can, of course, be used. Furthermore, inherent flexibility in the spindle prevents straining of the control.

The bush and back plate are a one-piece zinc-based die casting, which gives great rigidity and accuracy of location. Insulation resistance in the potentiometer is extremely good by virtue of the use of polystyrene.

EE 10 751 *for further details*

VERY LOW FREQUENCY GENERATOR

(Illustrated right)

Servo Consultants Ltd, 17 Woodfield Road, London, W.9.

This new generator has been designed to provide a precision test instrument for use in development and testing of control systems and automatic machines. It combines simplicity of construction and robustness with good stability of waveform and amplitude and frequency calibration. It is completely free from transients at frequency changes, starting and stopping.

The main part of the generator consists of a resolver rotating with carefully stabilized angular speed ω_m. Such a resolver can be considered as a variable ratio transformer, where the turns ratio is proportional to the sine of the angle between the stationary winding and the resolving rotor at any instant, i.e., to $\omega_m t$. The stator is supplied with a constant amplitude carrier signal of frequency: $\omega_c = 2\pi\ 2\,400$rad/sec, which can be represented as:

$A \sin \omega_c t$.

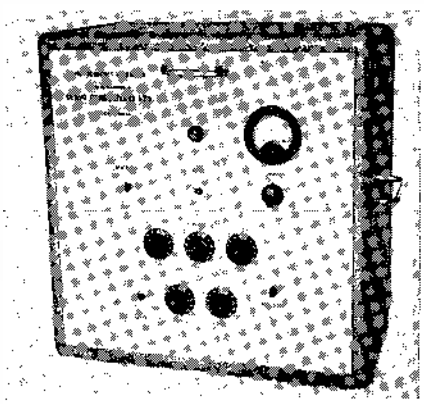
The output from the rotor will be proportional to the supply voltage multiplied by the turn ratio:

$A \sin \omega_c t . \sin \omega_m t$.

This signal is then rectified by means of a phase sensitive rectifier which removes the carrier component of the signal. The signal is then applied to an attenuator and a cathode-follower to produce an output signal with a low source impedance.

The resolver is driven through a two-speed gearbox by means of a servo motor-generator and a high gain servo amplifier. The output of the generator is applied as velocity feedback to the input of the amplifier, where it is compared with a velocity input signal derived from an electronically stabilized supply by means of a chain of high stability precision resistors. The high gain of the amplifier ensures that the motor runs substantially at the speed corresponding to the voltage selected. It may be noticed that the amplitude of the output signal does not depend in any way on the generated signal frequency as it is a function of only the input carrier voltage and the turns ratio of the transformer. The carrier is derived from a stabilized oscillator and is further monitored by means of a meter on the front panel of the instrument.

It is possible to stop the generator at any point within the output waveform cycle. The generator will start from any pre-set position without introducing any transient. The starting and stopping is almost instantaneous as the servo motor is capable of very fast acceleration and braking.



The mechanical output of the generator is available in the form of a rotation of a shaft revolving with a speed of 1rev/cycle. It can be used therefore as a precision variable speed drive for experimental laboratory use.

Two models are available; the type 110 which has a frequency range of ·001c/s to 100c/s and type 111 which has a frequency range of ·0001c/s to 10c/s.

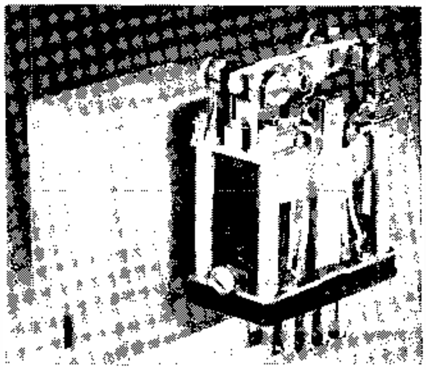
EE 10 752 *for further details*

MINIATURE A.C. CHOPPER RELAY

(Illustrated below)

Ericsson Telephones Ltd, Beeston, Nottingham

This miniature chopper utilizes the principle and design of the E.T.L. polarized relay. It combines exceptionally high performance with a high degree of stability in relation to adjustment.



The general principle is such that susceptibility to electromagnetic pick-up between contacts and the driving magnetic flux is low, and it also enables a geometrically and mass balanced armature system to be used. This system is mounted balanced on a torsional suspension and is therefore immune from pivoting trouble.

Two changeover contacts can be provided, each of which is isolated from the other electrically and the contact output can be arranged to give make-before-break or break-before-make action on both contact units. Precise operation of contact pairs is made possible by the specially designed spring buffering system which regulates the spring compliance throughout the armature stroke, so that symmetrical contact output is obtained with no contact bounce.

This chopper is available with several adjustments and various contact efficiencies. The common features are: (1) size and fixing centres, (2) single or two changeover contacts, (3) special 12-pin 'plug-in' or 'solder tag' base, (4) dust-proof cover, (5) demountable gasket.

In general, these choppers can be used with any system involving the conversion of low-power voltage signals. They are particularly useful in applications requiring error voltage measurements or null detections and in applications requiring the conversion of minute d.c./d.c. or d.c./a.c. signals for purposes of amplification in computers, electronic and electrical apparatus, servomechanisms, etc.

The standard working frequency is 50c/s, but choppers for other frequencies can be made available on order.

EE 10 753 *for further details*

ANALOGUE COMPUTER

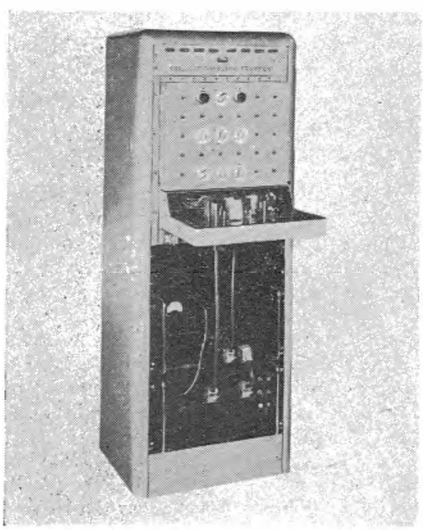
(Illustrated below)

Airmec Ltd, High Wycombe, Buckinghamshire

This equipment consists essentially of two power supply units which provide all the stabilized voltage supplies necessary for the operation of a complete computer installation, which may consist of as many as ten each of computer amplifiers and drift correction amplifiers.

Associated with the amplifiers is a computer unit which is one of the salient features of this equipment. It provides a basis to which the user can fit potentiometers, relays and feedback components, the accuracy, tolerance and cost of which can be related to the resolution accuracy required as an answer to the problem. The inputs and outputs from the amplifiers, the relay supplies and machine unit voltages, are all connected to this unit by two leads terminated in Unitor plugs (one machine unit being the maximum output from the amplifier, which is equal to −100V).

Two panels are associated with the computer unit, one of which is fitted with sockets to provide for connexion of plug-in feedback components across the amplifier, and the other provides for interconnexions between the amplifiers and potentiometers. It also provides suitable initial condition voltages for integrators and machine unit voltages, together with a control switch for the operation of 'set amplifier zeroes', 'set initial conditions' and 'run'. A 'hold' switch is also incorporated to enable the computation to be stopped at any desired instant.



This whole unit is designed to fix on to the front of the amplifier panel from which it is readily detachable, and allows any problem to be set-up completely before fixing into the frame for operation.

A unit construction design has been adopted in the development of this equipment to permit the incorporation of any one of the units into existing systems or, by the addition of a cabinet rack and amplifier frame, to provide a complete computer installation which can be expanded to meet the most exacting analogue computing requirements with cost always related to the solution accuracy needed.

EE 10 754 *for further details*

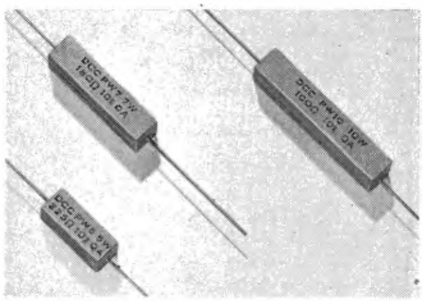
WIRE-WOUND RESISTORS

(Illustrated below)

Dubilier Condenser Co. (1925) Ltd, Ducon Works, Victoria Road, North Acton, London, W.3

Designated as types PW-5, PW-7 and PW-10 these high temperature wire-wound resistors are the latest addition to the Dubilier range of power resistors.

Each resistor comprises a tightly and uniformly spaced wire, wound on a glass fibre core which is silicone processed. Solder coated wire terminations are secured to this element by auto-assembly



equipment. The element is housed in a ceramic case of rectangular section and secured therein with a special cement seal which mechanically bonds to the ceramic case, resistance element and terminations.

These resistors are available in a range between 0·5Ω and 10kΩ the normal tolerance on resistance value being ±10 per cent. The resistance changes less than 5 per cent after 100 hours at 40°C ambient and 95 per cent relative humidity and less than 2 per cent after three times normal load for 5sec. The maximum temperature coefficient between −55°C and +275°C is of the order of 0·03 per cent/°C.

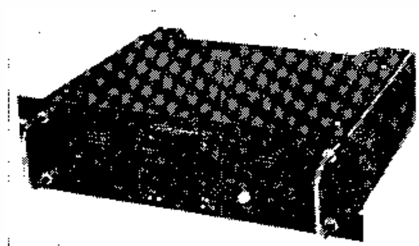
EE 10 755 *for further details*

INTERVAL TIMER

(Illustrated above right)

General Radiological Ltd, 18, New Cavendish Street, London, W.1.

This timer was originally developed for the control of slow scalers, type NE.075, but can be used to control any process which can be initiated by either a short exponential impulse or the operation of



a changeover contact, and terminated by a second impulse or the return of the changeover contact to the original position.

Pulses from a hermetically sealed electromechanical timing unit are fed at 4 per second to a 'scale of four' to provide output impulses at 1 per second.

The timing unit starts automatically when the unit is switched on and is compensated over the temperature range −10°C to +50°C.

The impulses operate an electromechanical counter which subtracts one digit per impulse from the preset time indicator. When the predetermined time interval has elapsed the changeover contacts and the unit remains in the 'ready' state.

If the external connexion between start terminals is still made counting will recommence as soon as the reset signal has been applied. If the external connexion is not made it will be necessary to provide a reset signal and a start signal.

An 'adding' counter can be fitted in addition to the 'subtracting' counter to provide an indication of elapsed time.

The unit may be operated manually from switches on the front panel, or by remote control.

EE 10 756 *for further details*

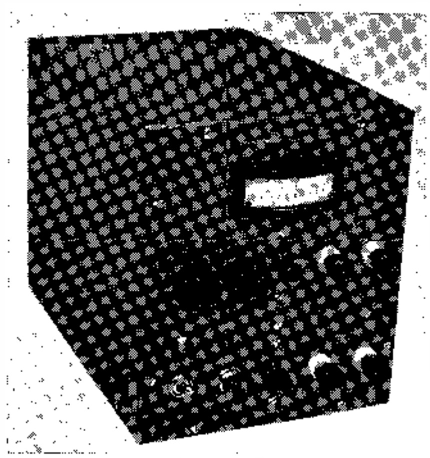
BRIDGE DETECTOR

(Illustrated below)

Rivlin Instruments Ltd, Doman Road, Yorktown Industrial Estate, Camberley, Surrey

The RIL bridge detector has been designed as a modern substitute for the classical galvanometer.

High sensitivity is combined with fast response time and complete meter protection making it a suitable instrument for use by both skilled and unskilled personnel. The instrument is entirely self contained and includes internal batteries



for energizing the bridge circuit. Both battery and detector input circuits are carefully insulated to avoid measurement errors due to leakage paths to earth.

In use the detector is connected directly to the bridge and the battery is controlled via a manual switch.

Basically the instrument consists of a chopper type d.c. amplifier working into a phase sensitive detector. Overload protection is inherent in the circuit so that damage to the meter cannot occur. A 50c/s filter is incorporated to minimize a.c. pick-up from the bridge, and any residual pick-up can be cancelled by means of a balance control.

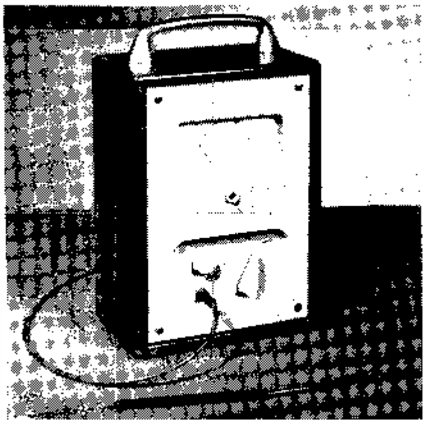
EE 10 757 *for further details*

ELECTRONIC THERMOMETER

(Illustrated below)

Wayne Kerr Laboratories Ltd, Chessington, Surrey

This thermometer was developed originally for measuring the exothermic temperature rise of resin castings, it is particularly suitable for measuring component temperatures; overheating of instruments and thermal losses in solid and liquid systems.



A feature of the thermometer is its ability to measure temperature at the end of a long cable. A prototype instrument, now being used for geological survey, allows for the probe to be used 1 000ft below the earth's surface. The probe embodying a temperature-sensitive metallic oxide bead, is connected by a moisture-sealed lead to a sensitive d.c. bridge measuring circuit. The probe has a very small heat capacity and the temperature reading, therefore is practically instantaneous.

Because only a small amount of energy is required to power the probe, errors due to self-heating of the bead during operation of the thermometer are negligible.

There are two types of probe. (1) Immersion probe: this is fitted with a glass-sealed head suitable for immersion in liquids or gases. The probe body is a chemical-resistant epoxide moulding composition which is sealed to a nylon-covered lead. (2) Contact probe: this has the oxide element sealed into the epoxide probe body, and a thin metallic cover acts as a thermal contact.

The small mass of the metal and the efficient thermal insulating properties of the epoxide body ensure rapid stabilization of the contact. The thermal energy is still further conserved by the use of platinum-alloy leads, with a low Wiedemann-Franz ratio, for making electrical contact to the head.

The meter has two ranges 0 to 50°C and 50 to 100°C.

EE 10 758 *for further details*

STABILIZED POWER SUPPLY UNIT

Applied Electronics, 3a, Chestnut Grove, New Malden, Surrey

The 'Varicell' stabilized power supply manufactured by Applied Electronics is a continuously variable stabilized voltage unit with a low hum and ripple content having an output of 0 to 45V at 0·25A.

The circuit comprises a bridge rectifier followed by a series regulator and shunt control valve. Dry batteries are used as the voltage reference. This arrangement has the advantage of low cost, mechanical and electrical robustness, and the ability to withstand accidental overload. These features make the unit emminently suitable for use in laboratories, schools etc.

Coarse and fine controls are incorporated and the output is monitored on a high-grade voltmeter. The output is floating with provision for earthing either pole.

EE 10 759 *for further details*

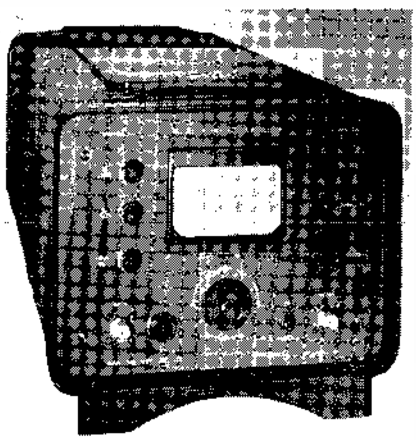
TRAVELLING-WAVE-TUBE AMPLIFIERS

(Illustrated below)

Marconi Instruments Ltd, Hertfordshire

Two new travelling-wave-tube amplifiers are now available. The type TF1278 is for use from 1 200 to 1 400Mc/s and type TF1278/1 has a range of 2 700 to 3 500Mc/s. They possess the low noise figures of 8dB and 7dB respectively—a feature which makes them particularly suitable for such applications as linear pre-amplifiers for microwave communication and radar receivers. Both have a gain variable up to at least 20dB with a maximum power output of nominally 1mW.

High-speed external pulse and phase modulation can be applied, allowing the instruments to be used as modulator



stages in microwave systems, or for obtaining a jitter-free modulated signal from a klystron source.

To allow gain adjustment and maximum flexibility in setting up, the helix and individual grid voltages are controllable from the front panel. Any of these voltages can be displayed on the multi-range panel meter, which can also be switched to monitor the helix and collector currents. If required, external gain control and monitoring may be employed. Type C coaxial connectors are used for the r.f. input and output.

The travelling-wave-tube, complete with all associated power supply circuits, is mounted in a light-alloy instrument case fitted with carrying handles. Weight is kept low by the use of an aluminium foil focusing solenoid, which is also designed to simplify tube replacement.

EE 10 760 *for further details*

SILVERED MICA CAPACITORS

Johnson, Matthey & Co. Ltd, 73-83 Hatton Garden, London, E.C.1

Recently added to the Johnson, Matthey range of silvered mica capacitors are JMC phenolic-dip protected capacitors.

The new capacitors, suitable for use over the temperature range −60° to +100°C, are protected by a dip coating of a special non-brittle phenolic material that is mechanically robust. The material is blue in colour and the markings are printed on the surface of the capacitors clearly and durably in white.

Combining the excellent electrical properties of the other capacitors in the Johnson, Matthey range, each JMC phenolic-dip protected capacitor is individually adjusted so that any value within the range of each type can be supplied. Two main series are available, eyeleted and fired.

The eyeleted capacitors are assembled from pierced silvered mica plates by means of composite silver plated eyelets, the design being such that no interplate connecting foils are used. The fired capacitors have higher long-term stability than the eyeleted, the plates used being fired into a solid block, a construction that does not necessitate mechanical joints or connecting foils.

EE 10 761 *for further details*

HIGH SPEED COUNTING TUBE

(Illustrated above right)

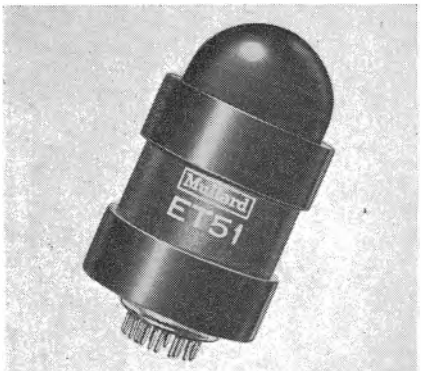
Mullard Ltd, Mullard House, Torrington Place, London, W.C.1.

Mullard Ltd have announced the introduction of a trochotron high-speed decimal stepping tube, for use as a counter or selector at speeds up to 1Mc/s.

The tube, called type ET51, is switched by a negative signal, and provides a constant-current output of 5·5mA—sufficient to drive a cold-cathode decimal indicator (such as the Mullard Z50 3M) and compatible with the input requirements of direct read-out digital indicators.

The trochotron is a vacuum device which makes use of crossed electric and magnetic fields to form a beam of electrons between a thermionic cathode and any of ten groups of three electrodes mounted radially about the cathode. The electric field is provided by the inter-electrode potentials within the tube and the magnetic field by a cylindrical permanent magnet fitted externally around the glass envelope.

Each group of electrodes consists of a spade, which forms and locks the beam in position; a target, which makes the beam available as a constant current output; and a grid, for switching the beam from one spade to the next. When power is first applied, all spades will be equally positive with respect to cathode and, due to the action of the magnetic field in preventing electrons reaching the electrode-groups, the tube will be in a 'cut-off' condition, with no beam formed. However, if the potential of any spade is reduced, by means of a high-speed pulse



or a d.c. voltage, the beam will form on the electrode group associated with that spade, and an output will appear on the corresponding target.

Once formed, the beam is held in this position by a combination of the spade series resistance and spade current until it is stepped to the next position by lowering the voltage on the associated switching grid.

Since only the grid in its immediate vicinity will affect the beam, the grids are connected internally in two groups: the odd-numbered grids in one, the even-numbered in the other. This makes it possible to use a d.c. input for switching and still obtain single position stepping, thus avoiding the necessity for a pulse of critical width.

The output characteristic of the trochotron is similar to that of a pentode valve, and in the ET51 over 80 per cent of the beam current appears in the output, the remainder being used to form and lock the beam.

EE 10 762 *for further details*

FULLY AUTOMATIC COIL WINDING MACHINE

Distributed by: R. H. Cole (Overseas) Ltd, 2, Caxton Street, Westminster, London, S.W.1

A new coil winding machine which operates fully automatically and does not require the services of an operator is now being manufactured by W. Aumann K.G. of Germany.

The machine consists of a revolving face plate to which the wire guide is fitted and of an indexing table which carries the coil jigs. Accurate layer winding is achieved by controlled movement of the face plate and can be maintained throughout the whole coil without the need for paper interleaving. Formers can be fed automatically to the jigs and ejected on completion of winding. Alternatively unsupported coils, i.e., field coils, can be wound on jigs and bonded on the machine after winding, all operations being completely automatic. It is also possible to bring out wire loops for tappings, to wind two or three interconnected coils, which can have different numbers of turns, on the same station or to wind several coils on the same former, i.e. r.f. coils for television sets. Primaries and secondaries of low voltage transformers can be wound using two winding heads with the same indexing table. The machine is fully adjustable to suit different types of coils, wire gauges, etc., and although most economical for large batch production, can be adapted for many tasks.

Maximum winding speed is 3 000rev/min. Wire gauges are from 18 to 45 s.w.g. and maximum coil dimensions up to 1·2in in length and 8in diameter. The machine is usually fitted with six working stations but up to twelve can be fitted on request.

A semi-automatic model is also available. In this case the operator controls the indexing of the table and removes the finished coils from the jigs, while the sequential arrangement permits work being carried out on the coils during the actual winding times.

EE 10 763 *for further details*

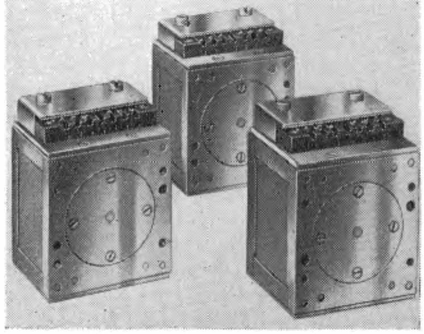
TORQUE MOTORS

(Illustrated below)

Woden Transformer Co. Ltd, Moxley Road, Bilston, Staffordshire

These units are correctly described as electromagnetic transducers and consist of a permanent magnet system incorporating an armature which is moved by the passage of current through control windings. The action may be differential or otherwise, depending upon the coil connexions. In a single ended system the transducers can be operated against a rate spring. Any degree of magnetic or electrical stiffness may be obtained to suit the particular application.

Feedback windings or potentiometers can be incorporated. The transducers can be operated completely immersed in oil



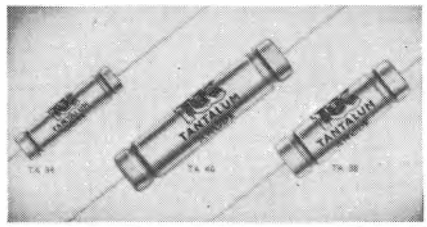
or provision can be made for fitting oil seals to prevent ingress of synthetic fluids which may have a deleterious effect upon the performance.

Where conversion of electrical signals into mechanical energy is necessary the sensitivity of the units is such that a few milliamperes of differential current can control large amounts of torque output from other devices.

The special design enables linear performance and fast rate of response to be obtained in conventional servo loops. Transducers are available for transistors, electronic and magnetic amplifier systems and can be supplied complete with hydraulic or pneumatic valves.

These units are available in a range of sizes, the angular movement in all cases being approximately 7° either side of natural centre.

EE 10 764 *for further details*



TANTALUM ANODE CAPACITORS

(Illustrated above)

The Telegraph Condenser Co. Ltd, North Acton, London, W.3.

This new range of tantalum anode capacitors has a working temperature range from −55°C to +125°C. Capacitors using tantalum foil anodes have a number of advantages over the more conventional types including a high capacitance value for small physical size.

Because tantalum is inherently inert and is not liable to corrosion, the reliability and shelf life of the capacitor are far superior to that of the usual aluminium anode capacitor and preliminary re-ageing is unnecessary after long dormant periods.

The leakage current is very low and stable; therefore these components may be used in certain timing circuits with confidence.

The wound tantalum foil element is contained in a metal tube, the ends of which are sealed with an epoxy-resin which has the property of affording a complete affinity to the metal tube and in turn to the axial wire termination. Polarization is indicated where applicable by appropriate crosses around the positive end of the tube. All non-polarized capacitors are fitted with a protective sleeving, whereas in the case of the polarized range sleeving is optional.

Terminations are 22 s.w.g. tinned nickel wires.

These capacitors are available in a range of working voltages from 6V to 150V and capacitance values from 0·25μF at the higher voltages to 200μF at the lower voltages.

EE 10 765 *for further details*

Short News Items

Cable and Wireless Ltd, have announced that the first of two orders for a total of 2 152 miles of submarine cable at a cost of £3 000 000 was issued by the Company to Submarine Cables Ltd of London. The cable will be made at the Telcon Works, Greenwich, and will be laid across the Atlantic between Scotland and Newfoundland in the summer of 1961. It will be the first ocean link in the 30 000 mile Commonwealth round-the-world telephone cable, estimated to cost £88 000 000. This order is for 552 miles of armoured cable for the shallow water sections and shore ends at a cost of £745 115. It is expected to be followed shortly by an order for 1 600 miles of lightweight cable at a cost of £2 254 400 for the deep-sea section. The lightweight cable is of a new type, specially developed for use with rigid, two-way submerged repeaters of British design. About 92 repeaters will be required for the trans-Atlantic section. This section, estimated to cost £9 000 000 is being jointly financed by the Company and the Canadian Overseas Telecommunication Corporation. The single cable will provide capacity for 60 simultaneous telephone conversations, or some 48 telegrams in place of any one of them.

The Department of Scientific and Industrial Research this year made the first of ten annual awards, under the terms of a will, to the research worker considered to have made an outstanding contribution to the research work of the department during the previous twelve months. This Wolfe Award in the form of a cheque for £500 was presented by The Lord President of the Council (Lord Hailsham) to L. Essen, O.B.E., D.Sc., Ph.D., A.M.I.E.E., at the Privy Council Office. Dr. L. Essen, a Senior Principal Scientific Officer at the National Physical Laboratory, was selected for the award on account of his work on the establishment of an atomic frequency standard as a basis for the future standard of time.

The British Exhibition which will open in the Coliseum Building, New York, on June 10, 1960, is now being organized and Sir Norman Kipping, Director General of the Federation of British Industries and Mr. W. P. N. Edwards, a Director of F.B.I., have gone to the United States to make preliminary arrangements. Britain plans to put on a demonstration of advances in British science, technology and engineering which will be combined with a display of Britain's most famous top quality consumer goods. The exhibition, which will last for two weeks, is expected to be the largest ever staged by one country within the confines of another.

Chimel S.A. have announced that they have further reduced the size of their solid electrolyte tantalum capacitors and that their present production includes capacitors of up to 6V 330μF; 10V 220μF; 15V 150μF; 20V 120μF and 35V 60μF; with temperature variations from $-80°$C to $+85°$C.

The Fifteenth Annual National Electronics Conference will be held this year on 12-14 October at the Hotel Sherman in Chicago. British representatives are invited to participate as exhibitors of electronic products or general participants of the Conference. Specific information on the Conference programme registration procedures and fees etc. will be forwarded on application to Mr. H. K. Bourne, United Kingdom Scientific Mission, 1907 K Street N.W., Washington 6, D.C., U.S.A.

Marconi Instruments Ltd, through their agents in Canada, the Canadian Marconi Company, have received an order from the Canadian Department of Defence Production for 200 000 dollars worth of telecommunication measurement equipment. Nearly two hundred instruments are to be provided, including signal generators, portable frequency meters, oscilloscopes, wave analysers, and transmission test sets. Of particular interest is the bulk order for the White Noise Test Set, Type OA 1249A; this equipment permits realistic measurement of intermodulation products and noise in multi-channel link equipments. Also on order is a quantity of the Derivative Test Set, Type OA 1259, which is used in testing and aligning radio link modulators and demodulators.

Plessey International Limited have announced the formation of a German company at Neuss, near Dusseldorf, which will further Plessey interests in the European market. Registered as Plessey Maschinen Elemente Gesellschaft m.b.H., with a nominal capital of DM.200 000, the new company will be responsible for the manufacture of many products in the light engineering field, particularly those relating to hydraulic equipment.

The University of Birmingham is to start a graduate course in the theory of electrical machinery this coming autumn and the possibility of awarding the degree of M.Sc. by examination on this course is under consideration. Details can be obtained on application to Mr. D. A. Bell, The Electrical Engineering Department, The University of Birmingham, Edgbaston, Birmingham, 15.

The Radio Industry Council announces that the 26th National Radio and Television Exhibition will be held at Earls Court, London, from Wednesday, 26 August, to Saturday, 5 September, with a preview on Tuesday, 25 August.

The Council of the British Institution of Radio Engineers has announced that it is to establish four additional Premiums for the authors of outstanding papers published in the Brit. I.R.E. Journal. It is intended that two of these Premiums shall take account more especially of the extensions in the field of electronics and its applications which have taken place during the last decade. The third Premium is for an outstanding paper on production techniques in the electronics industry, and the fourth has been endowed by a Past Chairman of the North Eastern Section to encourage the presentation of papers before that Section. In addition, the Council has decided to increase the value of the Clerk Maxwell Premium to 25 guineas. This is the senior premium and is awarded to the author of the outstanding contribution, irrespective of the subject, published in the Journal during the year. Details of the new Premiums are as follows:

Charles Babbage Premium: This Premium is for an outstanding paper on the design or use of electronic computers, and its title recognizes the pioneer work of Babbage in first formulating the requirements for a calculating machine. The value is 15 guineas.

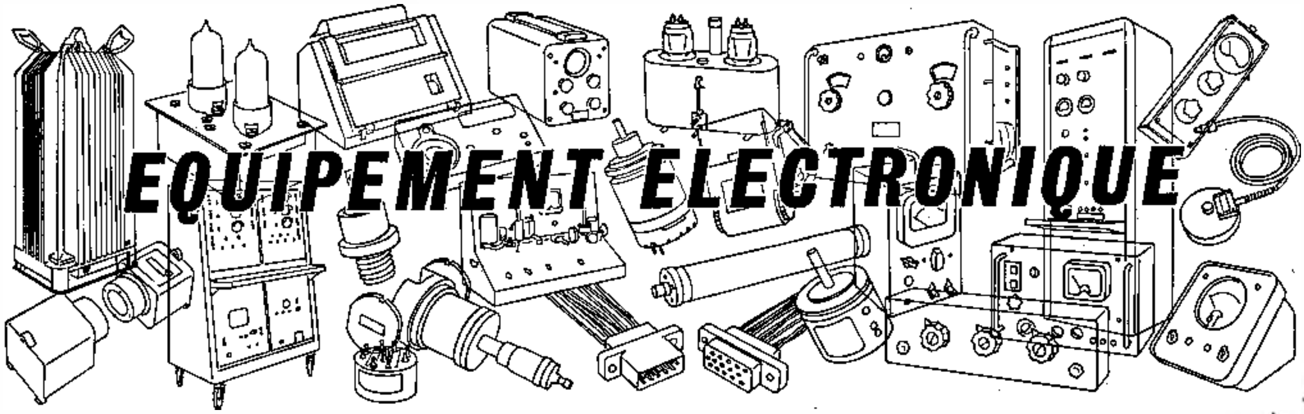
Lord Rutherford Premium: Electronics plays an ever-increasing part in control and instrumentation associated with atomic physics and nuclear engineering. The Premium commemorates the fundamental work carried out by Lord Rutherford at the Cavendish Laboratory, Cambridge. The value is 15 guineas.

Arthur Gay Premium: The importance of efficient methods of production in the electronics industry led to the establishment of this Premium for an outstanding paper on production techniques. The late Arthur Gay was a production engineer associated with H. J. Leak (Member) who has endowed the Premium. The value is 10 guineas.

Hugh Brennan Premium: This Premium is to be awarded annually to the author of the most outstanding paper read before the North-Eastern Section of the Institution, and subsequently published in the Journal. The value is 15 guineas.

Papers falling under the terms of reference of these four Premiums, and published in the Journal during 1959, will be automatically considered for the awards.

(Pages 373 to 382 French and German section)



EQUIPEMENT ELECTRONIQUE

Une description basée sur des renseignements fournis par les fabricants de nouveaux organes, accessoires et instruments d'essai

Traduction des pages 368 à 371

POTENTIOMÈTRE À BROCHE CREUSE

(*Illustration à la page 368*)

The Plessey Co. Ltd, Ilford, Essex

Une nouvelle conception de composantes variables à broche de commande a donné lieu à la réalisation par la Société Plessey d'un potentiomètre à broche triangulaire formée de bandes plates de cuivre.

La broche a été étudiée de façon à rendre inutile l'usinage de méplats spéciaux et le montage de boutons, tous les montages étant effectués par la flexion ou le façonnage de la broche creuse de cuivre pour pouvoir y loger un anneau de polystyrène portant le dispositif à balais. L'arrêt de limite et l'embout de commutation font également corps avec l'anneau de polystyrène.

Le bouton de commande constitue un avantage supplémentaire de cette nouvelle méthode de construction. Ce bouton ne nécessite qu'un simple trou triangulaire, de dimensions légèrement plus réduites que la broche afin d'assurer une localisation positive en trois positions différentes. On peut, évidemment, employer aussi les méthodes conventionnelles. Enfin, la flexibilité propre de la broche empêche l'effort de commande.

Le manchon et la table cylindrique sont un moulage en coquille à base de zinc, d'une seule pièce, ce qui assure une grande rigidité et une localisation précise. La résistance d'isolement du potentiomètre est extrêmement bonne, grâce à l'emploi du polystyrène.

EE 10 751 *pour plus amples renseignements*

GÉNÉRATEUR FRÉQUENCE TRÈS BASSE

(*Illustration à la page 368*)

Servo Consultants Ltd, 17 Woodfield Road, London W.9

Ce nouveau générateur constitue un vérificateur de précision, conçu pour l'essai de systèmes de contrôle et de machines automatiques. Il allie la simplicité de construction à la robustesse, tout en assurant des formes d'ondes, une amplitude et un étalonnage de fréquence des plus stables. Il est complètement exempt de perturbations transitoires à la mise en marche, à l'arrêt et aux changements de fréquence.

La partie principale du générateur consiste en un dispositif de résolution, tournant à une vitesse angulaire ω_m rigoureusement stabilisée. Ce dispositif peut être considéré comme un transformateur à rapport variable, dans lequel le rapport des tours est proportionnel au sinus de l'angle entre l'enroulement stationnaire et le rotor de résolution à n'importe quel moment, c'est à dire à $\omega_m t$. Le stator est alimenté par un signal porteur d'amplitude constante ayant une fréquence de $\omega_c = 2\pi\ 2\,400$ rad/sec. qu'on peut représenter comme: Sin $A\ \omega_c t$.

La sortie du rotor est proportionnelle à la tension d'alimentation multipliée par le rapport de tours soit: Sin $A\ \omega_c t$. sin $\omega_m t$.

Le signal est ensuite redressé au moyen d'un redresseur à sensibilité de phases qui supprime la composante porteuse du signal. Le signal est ensuite appliqué à un atténuateur et à une charge cathodique afin de produire un signal de sortie à basse impédance de source.

Le dispositif de résolution est actionné par une boîte à deux vitesses, mue par un servo-moteur générateur et un servo-amplificatur à grand gain. La sortie du générateur est appliquée comme réaction de vitesse à l'entrée de l'amplificateur, où elle est comparée à un signal d'entrée de vitesse provenant d'une alimentation électroniquement stabilisée au moyen d'une chaîne de résistance de précision de grande stabilité. Le grand gain de l'amplificateur assure la marche du moteur à une vitesse correspondant sensiblement à la tension choisie. On observera que l'amplitude du signal de sortie ne dépend nullement de la fréquence du signal produit car elle n'est que fonction de la tension porteuse d'entrée et du rapport des tours du transformateur. La tension porteuse provient d'un oscillateur stabilisé et elle est, en outre, contrôlée par un compteur sur le panneau avant de l'instrument.

On peut arrêter le générateur à n'importe quel point du cycle de formes d'ondes de sortie. Il pourra être mis en marche à n'importe quelle position préréglée sans causer de pertubations transitoires. La mise en marche et l'arrêt sont presque instantanés car le servomoteur est capable d'une accélération et d'un freinage très rapides.

La sortie mécanique du générateur s'effectue par la rotation d'un arbre à la vitese de 1 tour par cycle. Elle peut donc être utilisée comme vitesse d'entraînement variable de précision à l'usage des laboratoires expérimentaux.

Deux modèles sont livrables: le type 110, qui a une gamme de fréquences de 0.001 Hz à 100 Hz, et le type 111, dont la gamme va de 0,0001 Hz à 10 Hz.

EE 10 752 *pour plus amples renseignements*

RELAIS ÉCRÊTEUR MINIATURE C.A.

(*Illustration à la page 368*)

Ericsson Telephones Ltd, Beeston, Nottingham

Cet écrêteur miniature applique le principe et la conception du relais polarisé ETL. Il allie un rendement exceptionnellement élevé à un haut degré de stabilité en ce qui a trait au réglage.

Le principe général de l'appareil est tel que sa sensibilité à l'attraction électromagnétique entre contacts et flux magnétique d'entraînement est fort réduite. Il permet également d'utiliser un système d'induits équilibrés quant à la masse ainsi que géométriquement.

Ce système équilibré est monté sur suspension de torsion et ne donne donc pas lieu à des ennuis de pivotation.

Deux contacts inverseurs, isolés électriquement l'un de l'autre, peuvent être fournis. La sortie de contact peut être disposée de manière à pouvoir mettre et retirer le courant sur les deux éléments de contact. Le fonctionnement précis des paires de contacts est assuré par un système spécial de tampons que règle le jeu des ressorts pendant toute la course de l'induit, permettant ainsi d'obtenir une sortie de contact symétrique et sans rebondissement des contacts.

Cet écrêteur se fait avec divers réglages et différents rendements de contacts. Les caractéristiques communes de ces modèles sont:

—les dimensions et les centres de fixation,

—un contact unique ou deux contacts inverseurs,

—la base spéciale à 12 broches, inter-

changeable ou avec cosse à souder,
—le couvercle anti-poussière,
—la garniture démontable.

D'une manière générale, ces écrêteurs peuvent être employés avec n'importe quel système comportant la conversion de signaux de tension basse. Ils sont particulièrement utiles pour les applications nécessitant des mesures d'erreurs de tension ou l'indication de zéro, ainsi que pour les applications exigeant la conversion de signaux minuscules de c.c./c.c. ou c.c./c.a., pour l'amplification dans les calculateurs électroniques, dans les appareils électriques ou électroniques, dans les servomécanismes, etc. etc.

La fréquence de service standard est de 50 Hz mais des écrêteurs pour d'autres fréquences sont livrables sur commande.

EE 10 753 *pour plus amples renseignements*

CALCULATEUR ANALOGIQUE

(*Illustration à la page 369*)

Airmec Ltd, High Wycombe, Buckinghamshire

Cet équipement se compose essentiellement de deux blocs d'alimentation fournissant toute la tension stabilisée nécessaire au fonctionnement d'une calculatrice électronique complète, qui peut comprendre jusqu'à dix amplificateurs de calculateur et autant d'amplificateurs de correction de dérive.

Le bloc calculateur, relié aux amplificateurs, constitue l'un des principaux éléments de l'équipement. Il est pourvu d'une base à laquelle l'utilisateur peut fixer des potentiomètres, des relais et des composantes de réaction, dont la précision, la tolérance et le coût peuvent être rapportés à la précision de résolution requise pour répondre au problème. Les entrées et les sorties des amplificateurs, les alimentations des relais et les tensions des éléments de la machine sont toutes reliées au bloc calculateur par deux conducteurs se terminant en fiches UNITOR (un élément de machine étant la sortie maximum de l'amplicateur, égalant ± 100 Volts).

Le bloc calculateur est rattaché à deux panneaux, dont l'un est muni de prises pour brancher les composantes réactives interchangeables à travers l'amplificateur, et l'autre d'interconnexions entre les amplificateurs et les potentiomètres. Il fournit des tensions appropriées de début aux intégrateurs et des tensions d'éléments de machine, et il également doté d'un commutateur de contrôle pour la commande des "zéros d'amplificateur réglés", des "conditions initiales réglées" et de la "marche". Un commutateur de "fixation" est également incorporé afin de pouvoir interrompre le calcul à n'importe quel moment.

Le bloc entier a été étudié pour pouvoir être monté sur l'avant du panneau d'amplificateurs dont il peut facilement être détaché et il permet de "composer" entièrement un problème donné avant de le fixer dans le cadre pour les opérations.

Cette calculatrice a été construite selon la formule "à éléments" afin de permettre d'incorporer n'importe lequel des éléments dans un équipement en service par l'adjonction d'un support à coffret et d'un cadre d'amplificateurs afin de former une installation de calcul complète, pouvant être développée pour répondre aux conditions de calcul analogique les plus astreignantes, le coût étant toujours en rapport avec la précision des solutions requises.

EE 10 754 *pour plus amples renseignements*

RÉSISTANCES BOBINÉES

(*Illustration à la page 369*)

Dubilier Condenser Co. (1925) Ltd, Ducon Works, Victoria Road, North Acton, London, W.3

Ces résistances bobinées, Types PW-5, PW-7 et PW-10, constituent la plus récente réalisation de la gamme de résistances de puissance Dubilier.

Chaque résistance comprend un fil métallique uniformément et étroitement enroulé sur un noyau en fibre de verre traité au silicone. Les terminaisons en fil métallique enrobé de soudure sont fixées à cet élément par auto-assemblage. L'élément est logé dans une enveloppe en céramique de section rectangulaire et il est maintenu en place par un joint de ciment spécial. Ce dernier agglomère mécaniquement à l'enveloppe en céramique tant l'élément de résistance que les terminaisons.

Ces résistances sont livrables en une gamme allant de 0,5 ohms à 10 kohms, la tolérance normale sur la valeur de résistance étant de ±10%. La résistance subit un changement de moins de 5% après 100 heures dans une température ambiante de 40° C et dans une humidité relative de 95%, et de moins de 2% après trois fois la charge normale pendant 5 secondes. Le coefficient de température maximum entre −55° C et +275° C est de l'ordre de 0,03% par degré centigrade.

EE 10 755 *pour plus amples renseignements*

SYSTÈME CHRONOMÉTRIQUE

(*Illustration à la page 369*)

General Radiological Co. Ltd, 18 New Cavendish Street, London W.1

Ce système chronométrique, conçu à l'origine pour les échelles à ralentissement du Type NE 075, peut, cependant, contrôler tout processus déclenché par une courte impulsion exponentielle ou par le fonctionnement d'un contact inverseur, et s'achevant par une seconde impulsion ou par le retour du contact inverseur à la position première.

Les impulsions partant d'une minuterie électro-mécaniquement scellée, alimentent, à raison de 4 impulsions par seconde, une "échelle de quatre" afin de produire des impulsions de sortie au taux de 1 impulsion par seconde.

La minuterie se met en marche automatiquement lorsque l'appareil est branché et elle est compensée sur une gamme de température de −10° C à +50°C.

Les impulsions actionnent un compteur électromécanique, qui soustrait un numéro par impulsion de l'indicateur de temps préréglé. Lorsque l'intervalle de temps prédéterminé s'est écoulé, les contacts inverseurs sont mis en action et l'appareil reste à l'état "prêt".

Si la liaison extérieure entre les bornes d'amorçage est toujours établie, le comptage recommencera aussitôt le signal de réenclanchement appliqué. Si, par contre, la liaison extérieure n'est pas établie, il faudra alors effectuer un signal d'amorçage.

On peut fixer un compteur "additionneur" en plus du compteur "soustrayeur," afin de pouvoir indiquer le temps écoulé.

Enfin, l'appareil peut être soit commandé à la main par les boutons du panneau de commande soit à distance.

EE 10 756 *plus pour amples renseignements*

DÉTECTEUR EN PONT

(*Illustration à la page 369*)

Rivlin Instruments Ltd, Doman Road, Yorktown Industrial Estate, Camberley, Surrey

Le Détecteur en pont RIL a été étudié afin de pouvoir remplacer le galvanomètre classique par une version plus moderne.

Sa haute sensibilité, alliée à une très courte durée de réponse et à une protection totale du compteur, en font un instrument pouvant être employé par un personnel spécialisé ou non-spécialisé.

Il est entièrement complet par lui-même et comprend des piles internes pour exciter le circuit de pont. Tant les circuits de batterie que ceux d'entrée du détecteur sont rigoureusement isolés afin d'empêcher des erreurs de mesure dues aux parcours de dispersion vers la masse.

En cours d'usage, le détecteur est directement relié au pont et la batterie est commandée par un commutateur manuel.

L'instrument se compose essentiellement d'un amplificateur de courant continu du type écrêteur relié à un détecteur sensible aux phases. Le circuit est pourvu d'un disjoncteur à maxima empêchant l'endommagement de l'appareil de mesure. Enfin, l'instrument comporte un filtre de 50 Hz qui atténue l'attraction de courant alternatif du pont, toute tension résiduelle pouvant être annulée au moyen d'une commande d'équilibre.

EE 10 757 *pour plus amples renseignements*

THERMOMÈTRE ÉLECTRONIQUE

(*Illustration à la page 370*)

Wayne Kerr Laboratories Ltd, Chessington, Surrey

Ce thermomètre a été conçu pour mesurer la hausse de température exothermique de moulages de résine. Il est particulièrement indiqué pour mesurer les températures de composantes, la surchauffe d'instruments et les pertes thermique dans des systèmes solides et liquides.

L'instrument se caractérise par le fait qu'il peut mesurer la température à l'extrémité d'un long câble. Un prototype, actuellement affecté aux relevés géologiques, permet d'utiliser la sonde à 305 mètres sous la surface de la terre. Cette sonde, qui comporte une perle d'oxyde métallique, sensible à la température, est reliée par un conducteur étanche à un circuit de mesure à pont c.c. sensible. La sonde a une très faible capacité de chaleur et la température peut donc être lue presque instantanément.

Etant donné qu'une quantité réduite d'énergie est nécessaire à l'entraînement de la sonde, les erreurs dues à l'auto-échauffement de la perle durant l'emploi du thermomètre sont insignifiantes.

Deux types de sondes sont livrables, soit: 1) la sonde à immersion, munie d'une tête scellée au verre et se prêtant à l'immersion dans des liquides ou des gaz, le corps de la sonde étant formé d'un moulage à époxyde chimiquement résistant, scellé à un plomb couvert de nylon; 2) la sonde de contact, dont l'élément oxyde est scellé au corps de sonde d'époxyde, tandis qu'une mince enveloppe métallique fait fonction de contact thermique.

La masse réduite du métal et les hautes propriétés d'isolement thermique du corps d'époxyde assurent la stabilisation rapide du contact. L'énergie thermique peut être conservée plus longuement par l'utilisation de conducteurs en alliage de platine, avec un faible rapport Wiedemann-Franz, pour réaliser le contact électrique avec la tête.

Le thermomètre comprend deux gammes soit: 0 à 50° C et 50 à 100° C.

EE 10 758 *pour plus amples renseignements*

BLOC D'ALIMENTATION STABILISÉE

Applied Electronics, 3a Chestnut Grove, New Malden, Surrey

Le bloc d'alimentation stabilisée "VARICELL", produit par la Société Applied Electronics, est un élément de tension stabilisée à variation continue ayant un faible niveau de bourdonnement et d'ondulation. Sa puissance de sortie est de 0 à 45 volts, à 0,25 ampères.

Le circuit comporte un redresseur de pont, suivi d'un régulateur série et d'un tube de commande de shunt. Des piles sèches sont utilisées comme repères de tension. L'avantage de ce dispositif est son faible coût, sa robustesse mécanique et électrique et sa résistance à une surcharge accidentelle. L'ensemble de ces caractéristiques rend l'appareil éminemment approprié pour l'emploi dans les laboratoires, écoles, etc.

L'appareil est pourvu de réglages précis et approximatifs, et la sortie est contrôlée par un voltmètre de haute qualité. La sortie est flottante et prévoit la mise à la masse de l'un ou l'autre des pôles.

EE 10 759 *pour plus amples renseignements*

AMPLIFICATEURS AVEC TUBES À ONDES PROGRESSIVES

(Illustration à la page 370)

Marconi Instruments Ltd, Herefordshire

Deux nouveaux modèles d'amplificateurs avec tubes à ondes progressives sont livrables dès maintenant, soit le type TF 1278, prévu pour une gamme de 1200 à 1400 MHz, et le type TF 1278/1, pour 2700 à 3500 Mhz. Leurs niveaux de bruit sont fort bas: 8 dB et 7 dB respectivement, ce qui les rend particulièrement indiqués pour servir, par exemple, de préamplificateurs linéaires pour récepteurs de radar et transmissions hyperfréquences. Les deux types ont un gain variable allant jusqu'à 20 décibels au moins, avec une sortie de puissance nominale de 1 mW au maximum.

En appliquant des impulsions externes à action rapide et la modulation de phases, on peut employer ces instruments comme étages modulateurs dans des systèmes hyperfréquences, ou encore pour obtenir un signal modulé sans vacillement à partir d'une source de klystron.

La spirale et les tensions de grille individuelles peuvent être commandées à partir du panneau avant, de manière à permettre le réglage du gain et le maximum de flexibilité durant le montage. N'importe laquelle de ces tensions peut être représentée sur le compteur à panneau toutes ondes, qu'on peut également brancher pour le contrôle de la spirale et des courants collecteurs. On peut utiliser, au besoin, le contrôle du gain externe. Des connecteurs coaxiaux Type C sont prévus pour l'entrée et la sortie haute fréquence.

Le tube à ondes progressives, complet avec tous les circuits d'alimentation correspondants, est monté dans un boîtier en alliage léger, muni de poignées de support. Le poids a été réduit au minimum par l'utilisation d'une solénoïde de focalisation en feuilles d'aluminium, qui présente également l'avantage de simplifier le remplacement du tube.

EE 10 760 *pour plus amples renseignements*

CONDENSATEURS AU MICA ARGENTÉ

Johnson, Matthey & Co. Ltd, 73-78 Hatton Garden, London, E.C.1

Les condensateurs JMC, protégés par trempe phénolique, viennent d'être ajoutés à la gamme des condensateurs au mica argenté de la Société Johnson, Matthey & Co. Ltd.

Ces nouveaux condensateurs qui conviennent à l'emploi dans les températures allant de −60°C à +100°C sont protégés par un enduit d'immersion de matière spéciale phénolique non friable et mécaniquement robuste. Cette matière est de couleur bleue et les repères sont imprimés en blanc, des façon distincte et durable, sur la surface de condensateurs.

En plus des propriétés électriques excellentes, à l'instar des autres condensateurs de l'assortiment Johnson Matthey, chaque condensateur JMC à protection phénolique est réglé individuellement de sorte que n'importe quelle valeur, dans la gamme de chaque type, peut être fournie. Il existe deux séries principales, soit celle à oeillets et celle "chauffée".

Les condensateurs à oeillets sont assemblés à partir de plaques percées de mica argenté, au moyen d'oeillets argentés composites, leur construction étant telle qu'aucune feuille de métal intermédiaire de jonction n'est employée. Les condensateurs "chauffés" ont une stabilité à long terme plus élevée que ceux à oeillets, les plaques employées étant jointes au feu en un bloc solide. Ce genre de construction ne nécessite, au demeurant, ni joints mécaniques ni feuilles de métal de jonction.

EE 10 761 *pour plus amples renseignements*

TUBE RÉPARTITEUR À ACTION RAPIDE

(Illustration à la page 371)

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

La Société Mullard Ltd vient d'annoncer la réalisation d'un tube répartiteur décimal à 'trochotron'. Ce tube à action rapide, Type ET 51, peut être employé comme compteur ou sélecteur à des vitesses allant jusqu'à 1 MHz.

Il est commuté par un signal négatif et il fournit une sortie de courant constant de 5,5 mA, permettant de commander un indicateur décimal à cathode froide (tel que le 'Mullard Z503M') et répondant aux conditions d'entrée d'indicateurs arithmétiques à lecture directe.

Le 'trochotron' est un dispositif à vide, utilisant des champs électriques et magnétiques croisés, afin de former un faisceau d'électrons entre une cathode thermionique et l'un des dix groupes de trois électrodes montées en étoile autour de la cathode. Le champ électrique est assuré par les potentiels entre électrodes à l'intérieur du tube, le champ magnétique étant fourni par un aimant permanent cylindrique monté extérieurement autour de l'enveloppe de verre.

Chaque groupe d'électrodes comprend une cosse qui forme et fixe à la fois le faisceau en place, une anticathode qui le rend utilisable comme sortie de courant constant et une grille pour le commuter d'une cosse à la suivante. Lorsqu'on applique la tension au début, toutes les cosses sont également positives par rapport à la cathode et, en raison de l'action du champ magnétique qui empêche les électrons de parvenir aux groupes d'électrodes, le tube sera à l'état 'déconnecté' sans qu'il y ait formation de faisceau. Si l'on réduit, cependant, le potentiel de n'importe laquelle des cosses, au moyen d'une impulsion à action rapide ou d'une tension en continu, le faisceau se formera sur le groupe d'électrodes se rattachant à cette cosse et une sortie apparaîtra sur l'anticathode correspondante.

Une fois formé, le faisceau est maintenu dans cette position en alliant la résistance de série des cosses au courant de ces dernières, jusqu'à ce qu'il soit avancé à la position suivante en réduisant la tension sur la grille de commutation correspondante.

Etant donné que seule la grille la plus rapprochée affecte le faisceau, les grilles sont reliées intérieurement en deux groupes, soit les grilles paires en un groupe et les grilles impaires en un autre. Ceci permet d'utiliser une entrée de courant continu pour la commutation, tout en obtenant une avance point par point, en évitant ainsi le recours à une impulsion de largeur critique.

La caractéristique de sortie du 'trochotron' est similaire à celle d'une lampe de penthode et dans le cas du tube Type ET 51, plus du 80% du courant de faisceau se trouve dans la sortie, le reste étant utilisé pour former et fixer le faisceau.

EE 10 762 *pour plus amples renseignements*

MACHINE À BOBINER ENTIÈREMENT AUTOMATIQUE

Distribuée par: R. H. Cole (Overseas) Ltd, 2 Caxton Street, London S.W.1

Une nouvelle machine à bobiner, à fonctionnement entièrement automatique et ne nécessitant pas les services d'un opérateur, vient d'être mise sur le marché par la Société W. Aumann A.G., Allemagne.

Cette bobineuse se compose d'un plateau tournant auquel est fixé le guide de fil métallique et d'une table à diviser portant les gabarits de bobines. Le bobinage précis en couches s'effectue en contrôlant le mouvement du plateau, qui peut être maintenu pendant l'enroulement de la bobine entière sans qu'il y ait besoin d'interfoliage de papier. Les filières peuvent être transmises automatiquement aux gabarits et rejetées après bobinage. Par contre, les bobines non soutenues, telles que les bobines de champ, peuvent être bobinées sur gabarit et maintenues sur la machine après enroulement, toutes les manoeuvres étant entièrement automatiques. Il est également possible de réaliser des boucles de fils pour branchements, de bobiner sur le même poste deux ou trois bobines reliées entre elles et pouvant avoir différents nombres de tours, ou d'enrouler plusieurs bobines sur le même gabarit, comme ce serait le cas pour des bobines haute fréquence de téléviseurs. On peut bobiner les primaires et secondaires de transformateurs basse tension en employant deux têtes de bobinage ayant la même table de division. La machine est pleinement ajustable aux divers types de bobines, calibres de fils, etc. et, tout en étant des plus économiques pour la production en masse, elle peut être adaptée à de multiples usages.

La vitesse de bobinage maximum est de 300 tours-minute. Les calibres de fils vont de la jauge normale 18 à 45, et les dimensions maxima des bobines sont de 30 mm de long et 203 mm de diamètre. La bobineuse est habituellement dotée de six postes de fonctionnement mais on peut porter ce nombre à douze, sur demande.

Il existe également un modèle semi-automatique. Dans ce cas, l'opérateur contrôle les divisions de la table et enlève les bobines terminées des gabarits d'enroulement, cependant qu'un dispositif séquentiel permet de travailler sur les bobines au cours du bobinage.

EE 10 763 *pour plus amples renseignements*

MOTEURS DE TORSION

(Illustration à la page 371)

(Illustration à la page 371)

Woden Transformer Co. Ltd, Moxley Road, Bilston, Staffordshire

Ces éléments, dont la désignation exacte serait celle de transducteurs électromagnétiques, consistent en un système à aimants permanents, incorporant un induit qui est actionné par le passage du courant à travers les enroulements de commande. L'effet peut être différentiel ou non, selon les connexions des bobines. Dans un système à extrémité unique, les transducteurs peuvent être actionnés en fonction d'un ressort de régime. On peut obtenir le degré voulu de rigidité magnétique ou électrique, nécessaire à n'importe quelle application.

Des enroulements à réaction ou des potentiomètres peuvent être incorporés à ces transducteurs. Ces derniers peuvent être utilisés entièrement plongés dans l'huile ou munis de joints d'étanchéité afin d'empêcher l'entrée de fluides synthétiques pouvant avoir un effet nuisible sur le fonctionnement.

Lorsqu'on convertit des signaux électriques en énergie mécanique, la sensibilité de ces éléments est telle que quelques milliampères de courant différentiel suffisent à commander de grandes quantités de sortie de torsion d'autres appareils.

La construction particulière de ces transducteurs permet d'obtenir un fonctionnement linéaire et un taux rapide de réponse dans des servo-boucles de type courant. Ils conviennent aux transistors, ainsi qu'aux systèmes électroniques et à amplification magnétique et ils peuvent être fournis complets avec tubes hydrauliques ou pneumatiques. Enfin, ils sont livrables en diverses grandeurs, le mouvement angulaire étant toujours à environ 7° de chaque côté du centre naturel.

EE 10 764 *pour plus amples renseignements*

CONDENSATEURS À ANODES DE TANTALE

(Illustration à la page 371)

The Telegraph Condenser Co. Ltd, North Acton, London W.3

Cette nouvelle série de condensateurs à anodes de tantale a une gamme de températures de service allant de $-55°C$ à $+125°C$. Les condensateurs utilisant les anodes à feuilles de tantale ont de multiples avantages par rapport aux modèles classiques, dont, en particulier, une haute valeur capacitive pour leurs dimensions réduites.

En raison de l'inertie propre du tantale et de son inoxydabilité, la sécurité du fonctionnement et le vieillissement au repos de ces condensateurs sont nettement supérieurs à ceux des condensateurs courants à anodes d'aluminium, de sorte qu'un traitement préalable de stabilisation n'est pas nécessaire après de longues périodes de repos.

Le courant de fuite est stable et très bas. On peut donc employer ces composantes avec confiance dans certains circuits de minutage.

L'élément à feuilles de tantale enroulées est renfermé dans un tube métallique dont les extrémités sont scellées à la résine d'époxie qui a d'étroites affinités avec le tube métallique ainsi qu'avec la terminaison de fil axial. La polarisation est indiquée où il y a lieu par des croix appropriées autour de l'extrémité positive du tube. Tous les condensateurs non-polarisés sont dotés d'un manchon de protection, tandis que pour les condensateurs polarisés les manchons sont facultatifs.

Les terminaisons sont en fil de nickel étamé de jauge normale 22.

Ces condensateurs sont livrables pour une série de tensions de service allant de 6 à 150 volts et des valeurs capacitives allant de 0,25 μF aux tensions élevées à 200 μF aux tensions basses.

EE 10 765 *pour plus amples renseignements*

Résumés des Principaux Articles

Un générateur d'ondes sinusoïdales à périodes horaires par G. Klein et J. M. den Hertog

Résumé de l'article aux pages 320 à 325

On peut obtenir une tension triangulaire déterminée à partir d'une tension sinusoïdale, au moyen d'un générateur à fonction inverse. En appliquant une réaction négative, on peut également renverser ce processus. Cette possibilité a été mise en pratique dans un générateur d'ondes sinusoïdales à très basse fréquence pour des périodes maxima de 3,5 heures. La distorsion est alors d'une petitesse insignifiante. Si, par contre, une légère distorsion est admissible, ces périodes peuvent être considérablement étendues. Une des principales particularités de ce générateur réside dans le fait qu'il ne s'y produit pas de phénomènes transitoires. On peut aussi utiliser ce générateur à fonction inverse pour divers autres usages, dont celui de voltmètre à variations logarithmiques, ayant une gamme d'environ 10 mV à quelques dizaines de volts.

Traçage automatique pour machines d'oxy-coupage par J. S. Cheverton

Résumé de l'article aux pages 326 à 329

L'appareil décrit dans cet article a été réalisé afin d'éviter de devoir guider les machines d'oxy-coupage à la main ou d'avoir recours à de coûteux gabarits métalliques. Il consiste essentiellement en une tête de sondage optique faisant partie d'un servo-système à circuit fermé, grâce auquel les découpages les plus compliqués peuvent être effectués en suivant un dessin de lignes simples. L'appareil peut être fixé à des machines d'oxy-coupage déjà en service.

Un traceur de courbes caractéristiques de transistors par J. F. Young

Résumé de l'article aux pages 330 à 336

Un Dékatron est utilisé pour produire une tension point par point qui contrôle le courant de base du transistor en cours d'essai. A chaque point, une tension demi-sinusoïdale est appliquée au transistor et le courant collecteur qui en résulte est tracé en courbe en fonction de la tension sur un oscilloscope extérieur. Une résistance série fournit le signal du courant et limite la dissipation du transistor. Cet appareil peut être employé également pour tracer les courbes caractéristiques de diodes courantes ou de diodes Zéner.

Un système de télémesure électroencéphalographique miniature par D. C. Gold et W. J. Perkins

Résumé de l'article aux pages 337 à 339

Les auteurs décrivent un système permettant l'enregistrement de l'activité électrique du cerveau d'un chat normal et libre de ses mouvements. La tension captée par une électrode fixée dans le crâne est amplifiée suffisamment pour pouvoir moduler un émetteur que le chat porte sur son dos. Les émissions reçues sont transmises à un appareil à écran cathodique ou à un enregistreur à bande magnétique.

Un système enregistreur multivoies C.C. par H. D. Scott.

Résumé de l'article aux pages 340 à 344

Un système multivoies à modulation d'amplitude a été conçu afin de permettre l'enregistrement sur bande magnétique de signaux électriques dans la gamme C.C. à 10 *Hz, inclusivement. Un magnétophone portatif ordinaire, à piste unique, peut recevoir jusqu'à douze signaux de données indépendants, une voie vocale et des signaux de minutage. Ce système comporte des circuits spéciaux pouvant éliminer efficacement les fluctuations parasites d'amplitude provoquées par l'appareil enregistreur. Il est, en outre, linéaire jusqu'à un degré de précision de* $\pm 1\%$ *d'amplitude de signal instantané maximum.*

Le modulateur en tant que détecteur de phases par W. Fraser

Résumé de l'article aux pages 345 à 346

Des erreurs peuvent se produire dans les indications d'un modulateur de redresseur lorsqu'il est utilisé comme détecteur de phases, si la tension de commutation n'est pas beaucoup plus élevée que le signal. L'auteur examine les variations et l'importance de ces différences en fonction du rapport des tensions d'entrée dans le cas d'un modulateur shunt sans transformateur. Il montre qu'un rapport de plus de 7 : 1 est nécessaire si l'on veut réduire l'erreur à moins de 1%. Pour terminer, il donne des détails de quelques essais expérimentaux.

L'étude de générateurs de fonctions de diodes polarisées par C. C. Ritchie et R. W. Young

Résumé de l'article aux pages 347 à 351

Les auteurs examinent l'étude de générateurs de fonctions de diodes polarisées en s'étayant sur des équations se rapportant au nombre de sections de diodes, au minimum d'erreur pouvant se produire ainsi qu'à l'espacement des sections de diodes exigé pour assurer ce minimum d'erreur. Ils décrivent en détail la construction d'un générateur de fonctions sinusoïdales appliquant ces principes.

Un simple circuit sélecteur de maxima par J. N. Shearme

Résumé de l'article aux pages 353 à 354

L'auteur décrit une méthode simple pour sélectionner la tension maximum d'une série de tensions et indiquer, sous forme analogique, sa position dans cette série. Cette méthode a été appliquée au repérage des "formants" ou zones d'énergie maximum d'un signal de parole, au cours d'un procédé de réduction de largeur de bande.

La construction d'amplificateurs équilibrés employant des composantes à tolérances commerciales par D. J. Dewhurst

Résumé de l'article aux pages 355 à 357

Quoiqu'on ait fait la réclame de nombreux circuits qui sont censés obvier à l'utilisation des composantes à tolérances commerciales dans les amplificateurs équilibrés, on constate, en général, que les meilleurs résultats sont obtenus par l'emploi de composantes en paires s'accordant avec précision. Cet article analyse un circuit employant des composantes ne s'accordant pas. Cette analyse explique le comportement observé et permet l'étude d'un amplificateur pour lequel les tolérances des composantes peuvent être spécifiées.

Matériaux de noyaux magnétiques pour fonctions logiques. par A. L. Freedman.

Résumé de l'article aux pages 358 à 361

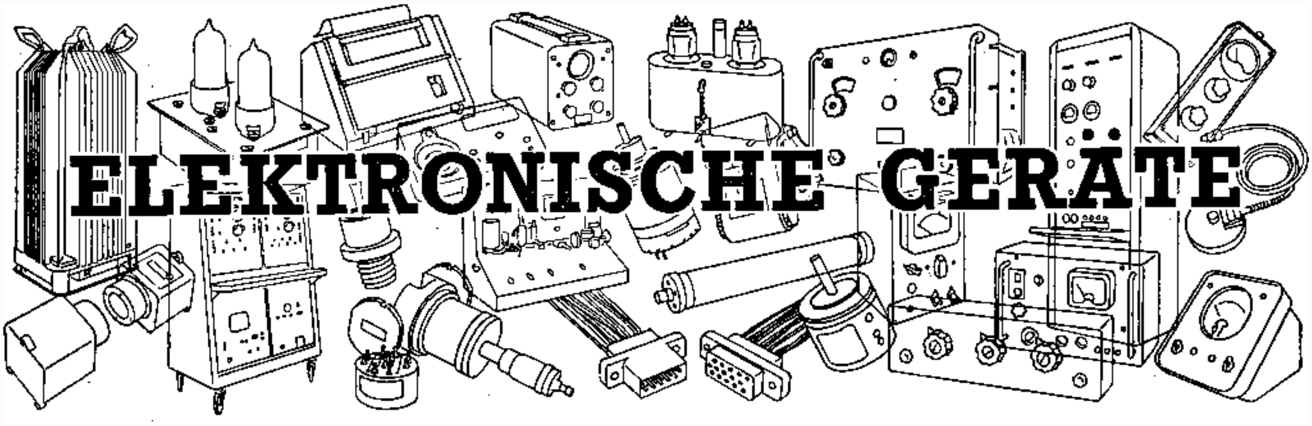
L'auteur explique le principe général d'un méthode pour l'exécution de fonctions logiques par l'emploi de matrices de noyaux magnétiques ayant une boucle d'hystérésis carrée. Il décrit, ensuite, quelques applications de cette méthode et poursuit par un aperçu de son champ d'utilisations, dont il souligne les avantages et les limites.

Un compte-temps électronique à réglage par contrôle de tension par R. Gladstone

Résumé de l'article aux pages 362 à 363

Cet appareil, dont le principe serait nouveau, s'inspire dans sa réalisation du circuit à charge cathodique de fluage ou circuit d'amplification à contre réaction. Il se différencie, cependant, par le fait qu'il fournit une commande de puissance à la grille, afin d'assurer un taux de changement constant, mais facilement réglable, sur toute la gamme de contrôle de la grille de fonctionnement du tube. La direction du changement peut être positive ou négative et on peut en modifier le taux de changement, dans une mesure très étendue, soit au moyen de n'importe lequel des deux paramètres de circuits linéaires variables indépendants, soit par un troisième paramètre, pouvant effectuer un changement de plots, soit, enfin, dans une moindre mesure, par un quatrième paramètre.

ELEKTRONISCHE GERÄTE



Beschreibungen neuer Bauelemente, Zubehörteile und Prüfgeräte auf Grund der von Herstellern gemachten Angaben. *(Übersetzung der Seiten 368 bis 371)*

POTENTIOMETER MIT HOHLSPINDEL

(Abbildung Seite 368)

The Plessey Co. Ltd, Ilford, Essex

Als Resultat neuer Konstruktionsüberlegungen hat die Plessey Company die Fertigung einer dreieckigen Potentiometerspindel begonnen, die aus Messingband hergestellt ist.

Die Spindelkonstruktion macht die Bearbeitung für besondere Flächen oder Knopfbefestigung unnötig. Alle Lage- und Befestigungsanordnungen werden durch Biegen und Verformen der Messinghohlspindel erzielt, die auch einen Polystyrolring aufnimmt, der seinerseits den Schleifarm trägt. Im Polystyrolring sind auch Anschläge und der Ansatz für die Schalterbetätigung vorgesehen.

Ein weiterer Vorteil der neuen Ausführung liegt in der Befestigung des Bedienungsknopfes. Im Knopf wird ein einfaches, dreieckiges Loch vorgesehen, das etwas kleiner als die Spindel ist und einen festen Sitz in drei wahlweisen Stellungen ermöglicht. Die herkömmlichen Befestigungsarten können natürlich auch Anwendung finden. Die der Spindel innewohnende Fedrigkeit verhindert Überdrehungsbelastung.

Die Rückplatte und Buchse sind aus Zinklegierung in einem Stück gespritzt. Das macht sie steifer, und sie halten ihre vorgeschriebene Lage besser ein. Durch die Verwendung von Polystyrol ist der Isolierwiderstand des Potentiometers ausserordentlich hoch.

EE 10 751 *für weitere Einzelheiten*

ULTRA-NF-GEBER

(Abbildung Seite 368)

Servo Consultants Ltd, 17, Woodfield Road, London W.9

Der neue Geber wurde als Präzisions-Laborgerät für Entwicklung und Prüfung von Reglerstrecken und automatischen Maschinen konstruiert. Einfache und widerstandsfähige Bauart zusammen mit Stabilität der Wellenform, Amplitude und Frequenzeichung kennzeichnen die Konstruktion, die auch vollständig frei von Einschwingvorgängen bei Frequenzänderung, Anlaufen und Halten ist.

Der Hauptteil des Gebers ist das Kraftstellglied, das mit einer sorgfältig stabilisierten Winkelgeschwindigkeit ω_m läuft. Solch ein Stellglied kann als regelbarer Umspanner betrachtet werden, in dem das Wicklungsverhältnis für jeden Zeitpunkt proportional zum Sinus des Winkels zwischen der feststehenden Wicklung und dem einstellenden Rotor ist, d.h. zu $\omega_m t$. Dem Stator wird ein Trägersignal gleichbleibender Amplitude zugeführt, dessen Frequenz $\omega_c = 2\pi 2400$ rad/sec ist, die als

$$A \sin \omega_c t$$

dargestellt werden kann.

Die Rotorabgabe ist dann proportional zur Netzspannung multipliziert mit dem Wicklungsverhältnis:

$$A \sin \omega_c t \,.\, \sin \omega_m t$$

Dieses Signal wird dann mittels eines phasenempfindlichen Detektors gleichgerichtet und dadurch der Trägeranteil des Signals entfernt. Das Signal wird dann über ein Dämpfungsglied einem Katodenverstärker zugeführt, der ein Ausgangssignal geringer Ursprungsimpedanz liefert. Das Stellglied wird über ein Getriebe mit zwei wahlweisen Geschwindigkeiten mittels eines Servo-Motors und Servo-Amplifiers mit hoher Verstärkung angetrieben. Die Geberabgabe wird als Geschwindigkeits-Rückkopplung dem Verstärkereingang zugeleitet, wo sie mit einem Geschwindigkeits-Eingangssignal verglichen wird, das von einem elektronisch stabilisierten Netzgerät mittels einer Reihe hochstabiler Präzisionswiderstände erzeugt wird. Durch den hohen Verstärkungsgrad läuft der Motor weitgehend mit einer der gewählten Spannung entsprechenden Geschwindigkeit. Die Amplitude des Ausgangssignales hängt in keiner Weise von der erzeugten Signalfrequenz ab, sondern nur von der Eingangs-Trägerfrequenz und dem Wicklungsverhältnis des Umspanners. Der Träger wird von einem stabilisierten Oszillator geliefert und wird auch durch ein Messgerät auf der Vorderseite des Gerätes angezeigt.

Der Generator kann an jedem Punkt der Ausgangs-Wellenform angehalten werden. Er wird von jeder vorgewählten Stellung aus anlaufen, ohne dass Einschaltvorgänge auftreten. Das Anlaufen und Halten ist fast momentan, da der Servo-Motor eine sehr grosse Beschleunigung hat und schnell bremsen kann.

Der Geber kann eine mechanische Leistung über einen Drehschaft abgeben, dessen Geschwindigkeit 1 Umdrehung/Periode ist. Er kann daher als Präzisionsantrieb mit variabler Geschwindigkeit für Labor-Versuche Verwendung finden.

Das Gerät ist in zwei Modellen lieferbar: als Modell 110 mit einem Frequenzbereich von 0,001 Hz bis zu 100 Hz und als Modell 111 mit einem Frequenzbereich von 0,0001 Hz bis zu 10 Hz.

EE 10 752 *für weitere Einzelheiten*

MINIATUR-WECHSELSTROM-ZERHACKER-RELAIS

(Abbildung Seite 368)

Ericsson Telephone Ltd, Beeston, Nottingham

Dieses Miniatur-Zerhacker-Relais ist nach denselben Konstruktionsgrundsätzen wie das polarisierte ETL-Relais gebaut. Es vereint ungewöhnlich hohe Leistung mit hoher Stabilität der Justierung.

Durch die Gesamtanordnung ist die Neigung zur elektromagnetischen Kopplung zwischen den Kontakten und dem magnetischen Steuerfluss gering, und es ist auch möglich, geometrisch und gewichtsmässig ausbalanzierte Ankeranordnungen zu verwenden. Diese Anordnungen arbeiten mit Drehfedern und vermeiden deshalb die mit Drehachsen verbundenen Schwierigkeiten.

Zwei Umschaltkontakte sind vorgesehen, die elektrisch von einander isoliert sind. Die Kontaktausgaben für beide Federsätze können entweder für „Schliessen vor Öffnen" oder „Öffnen vor Schliessen" geliefert werden. Besonders entwickelte Federdämpfungen, die den Federungswiderstand über den ganzen Ankerhub regulieren, ermöglichen genaues Arbeiten der Kontaktpaare und symmetrische Kontaktabgaben ohne Prallen.

Der Zerhacker ist mit mehreren Einstellungen und verschiedenen Kontaktgüten lieferbar. Die gemeinsamen Merkmale sind: 1. Grösse und Befestigungsmittellinien, 2. ein oder zwei Umschaltkontakte, 3. besondere 12-Stift-Einsteck-sockel oder Lötfahnenbasis, 4. staubdichte Schutzhaube und 5. abnehmbare Dichtung.

Diese Zerhacker können im allgemeinen in allen Anordnungen eingesetzt werden, in denen Spannungssignale kleinster Leistung umgewandelt werden. Die Relais sind besonders für Anordnungen mit Fehlerspannungsmessungen und Nullpunktanzeige geeignet, sowie für Verstärker in Rechnern, elektronischen oder elektrischen Geräten, Servosystemen usw., bei denen es sich um Umwandlung kleinster Gleichstromsignale in Gleichstrom- oder Wechselstromsignale handelt.

Die Arbeitsfrequenz ist 50 Hz, aber Zerhacker für andere Frequenzen können als Sonderausführungen bestellt werden.

EE 10 753 *für weitere Einzelheiten*

ANALOGRECHNER

(Abbildung Seite 369)

Airmec Ltd, High Wycombe, Buckinghamshire

Die Anlage besteht im wesentlichen aus zwei Netzgeräten, die alle erforderlichen Spannungen für die gesamte Rechneranlage liefern, die bis zu je zehn Rechnerverstärker und Driftkorrekturverstärker umfassen kann.

Eine ins Auge springende Charakteristik der Anlage ist ein Rechnerteil, der mit den Verstärkern zusammenarbeitet. Es ist ein Grundgerät, zu dem der Benutzer Potentiometer, Relais und Gegenkopplungselemente hinzufügt, deren Genauigkeit, Toleranzen und Kosten von der Lösungsgenauigkeit abhängen, die für die jeweilige Aufgabe erforderlich ist. Die Eingangs- und Ausgangsspannungen der Verstärker, die Relaisspeisung und die Maschinen - Einheitsspannungen werden alle mit diesem Rechnerteil durch zwei Kabel über Mehrfachstecker verbunden (eine Maschinen-Einheit ist die maximale Ausgangsspannung eines Verstärkers und gleich ± 100 V).

Mit dem Rechnerteil sind zwei Schalttafeln verbunden. Eine der Tafeln hat Einsteckbuchsen für die Gegenkopplungselemente, die mit den Verstärkern verbunden sind. Die andere Schalttafel stellt Verbindungen zwischen Verstärkern und Potentiometern her und liefert auch die Spannungen für die Einstellung der Anfangsbedingungen für die Integratoren und die Maschinen-Einheitsspannungen. Auf dieser Tafel befindet sich ein Bedienungsschalter für „Verstärkerlöschung", „Einstellung der Anfangsbedingungen" und „Rechnen". Ein „Stillstand"-Schalter ermöglicht es, die Rechnungsvorgänge zu jedem gewünschten Zeitpunkt anzuhalten.

Der ganze Teil ist so konstruiert, dass er von vorn an die Verstärkertafel anmontiert werden kann und leicht abnehmbar ist. Dadurch kann eine Aufgabe vollständig eingerichtet werden, bevor der Teil für den Rechenvorgang in das Gestell eingebaut wird.

Eine Bausteinkonstruktion wurde für die Entwicklung dieser Anlage gewählt, um die Eingliederung einzelner Geräte in die bestehenden Einrichtungen zu erleichtern, oder durch Zusatz eines Gehäuse- und Verstärkergestelles eine vollständige Rechneranlage herzustellen. Diese Anlage kann erweitert werden, um den anspruchsvollsten Rechnerbedürfnissen zu entsprechen, wodurch die Kosten immer im Verhältnis zur gewünschten Lösungsgenauigkeit gehalten werden können.

EE 10 754 *für weitere Einzelheiten*

DRAHTWIDERSTÄNDE

(Abbildung Seite 369)

Dubilier Condenser Co. (1925) Ltd, Ducon Works, Victoria Road, North Acton, London W.3

Mit der Einführung der neuen PW-5, PW-7 und PW-10 Hochtemperatur-Drahtwiderstände hat Dubilier die Auswahl der Hochleistungswiderstände erweitert.

Jeder Widerstand besteht aus einem Draht, der fest und mit gleichmässigem Abstand auf einem mit Silicon behandelten Glasfaserkörper gewickelt ist. Das Widerstandselement wird in automatischen Einrichtungen mit verzinnten Anschlüssen versehen und dann in einen keramischen Behälter mit rechteckigem Querschnitt mittels besonderer Bindemittel eingesiegelt, die an dem keramischen Behälter, dem Widerstandselement und den Anschlüssen mechanisch haften.

Die Widerstände sind in Werten von 0,5 Ohm bis zu 10 kOhm mit einer Nenntoleranz von $\pm 10\%$ lieferbar. Nach 100 Stunden in einer Umgebungstemperatur von 40° C und 95% relativer Feuchtigkeit beträgt die Widerstandsänderung weniger als 5% und für dreifache Nennbelastung für 5 Sekunden weniger als 2%. Der höchste Temperaturkoeffizient im Bereich von $-55°$ C bis $+275°$ C ist in der Grössenordnung von 0,03%/° C.

EE 10 755 *für weitere Einzelheiten*

ZEITINTERVALLMESSER

(Abbildung Seite 369)

General Radiological Ltd, 18, New Cavendish Street, London W.1

Dieser Zeitmesser wurde ursprünglich für die Steuerung des langsamen Untersetzers Modell NE 075 entwickelt, kann aber auch zur Steuerung jedes Vorganges eingesetzt werden, der entweder durch einen kurzen Exponentialpuls oder Betätigung eines Umschaltkontaktes eingeleitet und durch einen zweiten Impuls oder Rückführung des Umschaltkontaktes beendigt werden kann.

Ein hermetisch abgeschlossener elektromechanischer Taktgeber leitet vier Impulse per Sekunde einem vierfachen Untersetzer zu, der einen Impuls per Sekunde abgibt.

Der Taktgeber läuft mit dem Einschalten des Gerätes automatisch an und ist für Temperaturen von $-10°$ C bis $+50°$ C kompensiert.

Die Impulse betätigen einen elektromechanischen Zähler, der für jeden Impuls eine Ziffer von der eingestellten Zeitangabe abzieht. Nach Ablauf des Sollzeitintervalles werden die Umschaltkontakte betätigt, und das Gerät bleibt im betriebsfertigen Zustand.

Das Zählen beginnt wieder, wenn die Aussenverbindungen zwischen den Einschaltklemmen noch bestehen und ein Rückstellsignal zugeleitet wird. Falls die Aussenverbindungen nicht mehr bestehen, muss ein Rückstellsignal und ein Einschaltsignal gegeben werden.

Ausser dem „Abziehzähler" kann ein zusätzlicher „Addierzähler" eingebaut werden, um die verstrichene Zeit anzuzeigen.

Das Gerät kann von der Vorderseite durch Handschalter bedient oder auch ferngesteuert werden.

EE 10 756 *für weitere Einzelheiten*

BRÜCKEN-ANZEIGEGERÄT

(Abbildung Seite 369)

Rivlin Instruments Ltd, Doman Road, Yorktown Industrial Estate, Camberley, Surrey

Das RIL-Brücken-Anzeigegerät wurde als moderner Ersatz für das klassische Galvanometer entwickelt.

Hohe Empfindlichkeit, hurze Ansprechzeit und vollständiger Messgerätschutz ergeben ein Gerät, das für gelernte und ungelernte Arbeitskräfte geeignet ist.

Mit seinen eingebauten Batterien für die Erregung der Brückenschaltung ist das Gerät unabhängz. Die Batterien und die Eingangskreise des Anzeigers sind sorgfältig isoliert, um durch Nebenschluss zur Erde bedingte Messfehler zu vermeiden.

In Betrieb ist der Anzeiger direkt an die Brücke angeschlossen, und die Batterie wird durch einen Handschalter kontrolliert.

Das Gerät besteht grundsätzlich aus einem Zerhacker-Gleichstromverstärker, dessen Ausgang in einen phasenempfindlichen Anzeiger gegeben wird. Der Messer kann nicht beschädigt werden, da Überlastungsschutz dieser Schaltung eigentümlich ist. Um die Wechselstrom-Streuaufnahme von der Brücke zu vermindern, ist ein 50 Hz-Filter eingebaut. Irgendwelche restliche Grössen können im Nullverfahren annuliert werden.

EE 10 757 *für weitere Einzelheiten*

ELEKTRONISCHES THERMOMETER

(Abbildung Seite 370)

Wayne Kerr Laboratories Ltd, Chessington, Surrey

Das Thermometer wurde ursprünglich für die Messung exothermischer Temperaturanstiege in gegossenen Harzen entwickelt und ist besonders für Messungen der Temperatur von Bauelementen, von überhitzten Geräten und von Wärmeverlusten in Körpern oder Flüssigkeiten geeignet.

Mit dem Thermometer können Temperaturmessungen am Ende langer Kabel vorgenommen werden. Ein Prototypgerät, das nunmehr für geologische Messungen verwandt wird, ermöglicht den Einsatz des Temperaturfühlers 305 m unter der Erdoberfläche. Der Fühler enthält eine temperaturempfindliche Metalloxydkugel und wird über eine hermetisch abgedichtete Zuleitung an eine empfindliche Gleichstrom-Brückenschaltung angeschlossen. Der Fühler hat eine kleine Wärmekapazität und dadurch eine praktisch momentane Temperaturanzeige.

Die für die Fühler erforderliche Energie ist so gering, dass der Fehler, der durch die Selbsterwärmung der Kugel während der Messung hervorgerufen wird, vernachlässigt werden kann.

Der Fühler ist in zwei Typen lieferbar: 1. als Tauchfühler für Flüssigkeiten und Gase, mit einem mit Glas versiegelten Kopf und einem Fühlerkörper aus Epoxydharz, der Chemikalien widersteht und abgedichtet in eine nylonüberzogene Zuleitung übergeht, und 2. als Kontaktfühler, in dem die Oxydkugel in den Epoxyd-Fühlerkörper eingelassen ist und über ein dünnes Metalldeckblatt Wärmekontakt macht.

Die kleine Metallmasse und die ausgezeichneten wärmeisolierenden Eigenschaften des Epoxyd-Körpers stellen eine schnelle Stabilisierung des Kontaktes sicher. Die Verwendung platinlegierter Zuleitungen für die elektrischen Kontakte der Kugel, die ein kleines Wiedemann-Franz Verhältnis haben, trägt weiter zur Erhaltung der Wärmeenergie bei.

EE 10 758 *für weitere Einzelheiten*

STABILISIERTES NETZGERÄT

Applied Electronics, 3a, Chestnut Grove, New Malden, Surrey

Das von Applied Electronics hergestellte stabilisierte Netzgerät „Varicell" ist eine stufenlos regelbare Spannungsquelle mit geringer Brummspannung, die 0-45 V bei 0,25 A abgibt.

In der Schaltung folgt einem Brückengleichrichter ein Serienregler und eine parallelgeschaltete Reglerröhre. Trockenbatterien werden für Bezugsspannungen verwandt. Geringe Kosten, mechanische und elektrische Unempfindlichkeit und die Fähigkeit, zufälligen Überlastungen zu widerstehen, sind die Vorteile dieser Anordnung. Mit diesen Eigenschaften ist das Gerät für den Gebrauch in Labors, Schulen usw besonders geeignet.

Grob- und Feinabstimmung der Einstellung ist eingebaut, und die Ausgangsspannung wird mit einem hochwertigen Spannungsmesser überwacht. Die Ausgabe ist nicht geerdet, kann aber durch jeden der Pole geerdet werden.

EE 10 759 *für weitere Einzelheiten*

WANDERFELDRÖHREN-VERSTÄRKER

(*Abbildung Seite 370*)

Marconi Instruments Ltd, Hertfordshire

Zwei neue Wanderfeldröhren-Verstärker sind jetzt lieferbar. Die Type TF 1278 findet Anwendung von 1 200 bis 1 400 MHz und Type TF 1278/1 für den Bereich von 2 700 bis 3 500 MHz. Die niedrigen Rauschzahlen, 8 dB bzw. 7 dB, sind Eigenschaften, die sie für Verwendung als geradlinige Vorverstärker in Mikrowellen-Nachrichten- und Radarempfängern besonders geeignet machen. Beide Typen haben eine regelbare Verstärkung bis mindestens 20 dB bei einer maximalen Nennleistung von 1 mW.

Von aussen zugeleitete schnelle Impuls- und Phasenmodulation kann angewandt werden und ermöglicht den Einsatz der Geräte als Modulatorstufe in Mikrowellenanlagen oder für Erzielung unverzerrter modulierter Signale von Klystrons.

Die Wendelspannung und die einzelnen Gitterspannungen sind im Gerät von vorn einstellbar, um die Verstärkerreglung zu erleichtern und die Einstellung anpassungsfähiger zu machen. Jede der Spannungen kann auf dem Schalttafel-Vielfachmesser angezeigt werden, der auch für die Überprüfung der Wendel- und Kollektorströme umgeschaltet werden kann. Aussengeräte können für die Verstärkungsreglung und als Monitor auf Wunsch eingesetzt werden. Koaxiale Kupplungen finden für die HF Ein- und Ausgänge Verwendung.

Die Wanderfeldröhre ist komplett mit Netzanschluss in ein Leichtmetallgehäuse mit Traggriffen eingebaut. Die Verwendung von Aluminiumfolie für das Fokussiersolenoid hält das Gewicht niedrig und erleichtert das Auswechseln der Röhre.

EE 10 760 *für weitere Einzelheiten*

VERSILBERTE GLIMMERKONDENSATOREN

Johnson, Matthey & Co. Ltd, 73-83 Hatton Garden, London, E.C.1

Johnson Matthey haben vor kurzem die Auswahl ihrer versilberten Glimmerkondensatoren durch Einführung der durch Phenoltauchen geschützten JMC Kondensatoren erweitert.

Die neuen Kondensatoren können in einem Temperaturbereich von $-60°$ bis $+100°$ verwandt werden. Der schützende Tauchüberzug besteht aus einem besonderen Phenolmaterial, das nicht spröde und trotzdem mechanisch widerstandsfähig ist. Das Harz ist blau, und die Kondensatoroberfläche ist klar und haltbar in weiss beschriftet. Die hervorragenden elektrischen Eigenschaften der Johnson Matthey Kondensatoren sind auch hier vorhanden. Jeder der durch Phenoltauchen geschützten Kondensatoren ist einzeln justiert, so dass jeder gewünschte Wert in der Reihe jeder Type lieferbar ist. Zwei Hauptserien können geliefert werden: vernietet und zusammengeschmolzen.

Die genieteten Kondensatoren werden aus durchlöcherten Glimmerblättern mit zusammengesetzten Hohlnieten hergestellt, deren Konstruktion die Verwendung von Verbindungsfolien zwischen Blättern unnötig macht. Die zusammengeschmolzenen Kondensatoren haben eine höhere langfristige Stabilität als die genieteten, da die Blätter in einen festen Block zusammengeschmolzen werden, der keine mechanischen Verbindungen oder Verbindungsfolien aufweist.

EE 10 761 *für weitere Einzelheiten*

SCHNELLZÄHLRÖHRE

(*Abbildung Seite 371*)

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

Mullard Ltd hat die Einführung einer Trochotron-Dekaden-Zählröhre bekannt gegeben, die in Zählern und Suchern mit Geschwindigkeiten bis zu 1 MHz Verwendung findet.

Die als ET 51 bezeichnete Röhrentype wird mittels eines negativen Signales geschaltet und gibt einen gleichbleibenden Ausgangsstrom von 5,5 mA ab, der hoch genug ist, um einen Kaltkatoden-Dezimalanzeiger wie z.B. Mullard Z 50 M zu steuern und auch die Eingabebedingungen eines direkt ablesbaren Ziffernanzeigers erfüllt.

Das Trochotron ist ein Vakuuminstrument, das mittels kreuzender elektrischer und magnetischer Felder einen Elektronenstrahl zwischen einer glühelektrischen Katode und einer der speichenförmig um die Katode angeordneten zehn Gruppen von je drei Elektroden hervorruft. Das elektrische Feld wird durch die Spannung zwischen den Elektroden in der Röhre erzeugt und das magnetische Feld durch einen zylindrischen Dauermagneten, der von aussen den Glaskörper umfasst.

Jede Elektrodengruppe besteht aus einem „Spaten", der den Elektronenstrahl hervorruft und in der Stellung festhält, sowie einer Auffangelektrode, die den Strahl als gleichbleibenden Ausgangsstrom abgibt, und einem Gitter, um den Strahl von einem Spaten zum nächsten zu schalten. Wenn die Röhre angeschlossen wird, sind alle Spaten in Bezug auf die Katode gleichmässig positiv, und da das magnetische Feld die Elektronen verhindern wird, die Elektrodengruppe zu erreichen, ist die Röhre gesperrt und kein Elektrodenstrahl entsteht. Wenn jedoch die Spannung an einem der Spaten durch einen schnellen Puls oder eine Gleichstromspannung herabgesetzt wird, entsteht in der zugehörigen Elektrodengruppe dieses Spatens ein Elektronenstrahl und ein Ausgangsstrom wird von der entsprechenden Auffangelektrode abgegeben.

Sobald der Strahl hervorgerufen worden ist, wird er durch eine Kombination des Spaten-Serienwiderstandes und des Spatenstromes festgehalten, bis er durch Herabsetzung der Spannung am zugehörigen Gitter zur nächsten Stellung geschaltet wird.

Da nur das naheliegendste Gitter den Elektronenstrahl beeinflussen wird, sind die Gitter innerhalb der Röhre in zwei Gruppen verdrahtet: Gitter mit ungeraden Nummern in eine Gruppe und mit geraden Nummern in die andere. Dadurch ist es möglich, mit einer Gleichstromeingabe zu schalten und trotzdem einschrittige Stellungswechsel zu erreichen, so dass Pulse mit kritischer Breite vermieden werden können.

Die Ausgangskennlinien des Trochotrons sind denen einer Pentode ähnlich, und in der ET 51 werden über 80% des Elektronenstrahlstromes durch den Ausgang abgegeben. Der Rest wird für die Erzeugung und das Festhalten des Elektronenstrahles benötigt.

EE 10 762 *für weitere Einzelheiten*

VOLLAUTOMATISCHE SPULENWICKELMASCHINE

Vertrieb: R. H. Cole (Overseas) Ltd, 2, Caxton Street, Westminster, London S.W.1

Die deutsche Firma W. Aumann KG stellt jetzt eine neue vollautomatische Spulenwickelmaschine her, die keine Bedienung erfordert.

Die Maschine besteht aus einer Planscheibe mit der Drahtführung und einem Schalttisch mit den Spulenvorrichtungen. Die gesteuerte Bewegung der Planscheibe erzielt genaues Lagewickeln, das so gut während des ganzen Wickelvorganges aufrecht erhalten werden kann, dass die Spule keine Papiereinlage benötigt. Spulenkörper werden den Vorrichtungen automatisch zugeführt und nach Beendigung des Wickelvorganges automatisch ausgestossen. Andererseits können freitragende Spulen, wie z.B. Feldspulen, auf Vorrichtungen gewickelt und nachher auf der Maschine abgebunden werden, wobei alle Arbeitsgänge vollständig automatisch ablaufen. Drahtschleifen für Anzapfungen können herausgeführt werden, und es ist auch möglich, auf einem Ladeplatz zwei oder drei zusammenhängende Spulen zu wickeln, die verschiedene Windungszahlen haben. Die Maschine wickelt auch mehrere Spulen auf einem Spulenkörper, wie z.B. für HF Spulen für Fernsehgeräte. Der Einsatz von zwei Drahtverlegevorrichtungen für denselben Schalttisch ermöglicht das Wickeln von Primär- und Sekundärwicklungen für niederspannige Umformer. Die Maschine kann für die verschiedensten Spulentypen, Drahtstärken usw. eingestellt werden. Sie läuft am wirtschaftlichsten mit Massenproduktion, kann aber trotzdem für viele andere Aufgaben eingesetzt werden.

Die höchste Drehzahl ist 3 000 U/min. Die Maschine wickelt Spulen bis zu 203 mm Durchmesser und 30 mm Länge mit Drahtdurchmessern zwischen 0,07 mm und 1.22 mm. Sechs Ladeplätze sind in der Normalausführung vorgesehen, bis zu zwölf Ladeplätze können aber auf Bestellung als Sonderausführung geliefert werden.

EE 10 763 *für weitere Einzelheiten*

STELLMOTOREN

(*Abbildung Seite 371*)

Woden Transformers Co. Ltd, Moxley Road, Bilston, Staffordshire

Die Geräte werden richtig als elektromagnetische Umwandler bezeichnet und bestehen aus einer Dauermagnetanordnung mit einem Anker, der durch stromdurchflossene Steuerspulen bewegt wird. Es hängt von den Spulenverbindungen ab, ob die Wirkung differential oder anders erfolgt. In einer einseitigen Anordnung kann der Umwandler gegen eine konstante Feder wirken. Jeder gewünschte magnetische oder elektrische Steifheitsgrad kann für besondere Verwendungszwecke erreicht werden.

Rückkopplungsspulen oder Potentiometer können eingebaut werden. Der Umwandler kann vollständig in Öl eingetaucht arbeiten, oder Öldichtungen können geliefert werden, die das Eindringen synthetischer Flüssigkeiten verhindern, die auf die Wirkungsweise schädlich einwirken könnten.

Wo die Umwandlung elektrischer Signale in mechanische Energie erforderlich ist, können durch die Apparatempfindlichkeit wenige Milliampere Differentialstrom grosse Drehleistungsabgaben von anderen Geräten steuern.

Die Spezialkonstruktion ermöglicht eine geradlinige Wirkungsweise und schnelles Ansprechen in üblichen Reglerkreisen. Umwandler sind für Transistoren, elektronische und magnetische Verstärkeranordnungen lieferbar. Sie können mit angebauten hydraulischen oder pneumatischen Reglerorganen geliefert werden.

Diese Apparate werden in verschiedenen Grössen hergestellt, aber in allen Fällen ist die Winkelbewegung nach jeder Seite ungefähr 7° von der Mittelstellung.

EE 10 764 *für weitere Einzelheiten*

KONDENSATOREN MIT TANTAL-ANODE

(*Abbildung Seite 371*)

The Telegraph Condenser Co. Ltd, North Acton, London W.3

Die neuen Kondensatoren mit Tantal-Anoden haben einen Betriebstemperaturbereich von −55° C bis +125° C. Kondensatoren mit Tantal-Anoden haben eine Reihe von Vorteilen gegenüber den üblichen Typen, zu denen auch hohe Kapazitäten für kleine Körpergrössen gehören.

Da Tantal inert ist und eine natürliche Widerstandsfähigkeit gegen Korrosion hat, sind Betriebssicherheit und Lagerfähigkeit viel grösser, als für die üblichen Kondensatoren mit Aluminium-Anode, und die vorbereitende Neuformierung nach langer Zeit ohne Benutzung ist unnötig.

Der Reststrom ist sehr niedrig und beständig, so dass die Bauelemente in gewissen Zeitschaltungen ohne Bedenken Verwendung finden können.

Das gewickelte Tantal-Folieelement liegt in einer Metallhülse, deren Enden mit Epoxyharz ausgegossen sind, das eine grosse Bindekraft zur Metallhülse und auch zu den axialen Anschlussdrähten aufweist. Polarisation ist in angebrachten Fällen durch Kreuze um das positive Ende der Hülse herum angezeigt. Alle nichtpolarisierten Kondensatoren werden mit einer Schutzhülle geliefert, die für polarisierte Typen wahlweise zur Verfügung steht.

Die Anschlüsse bestehen aus verzinntem Nickeldraht mit einem Durchmesser von 0,56 mm.

Diese Kondensatoren können für Arbeitsspannungen von 6-150 V geliefert werden, und der Kapazitätsbereich geht von 0,25 μF für die höheren Spannungen bis zu 200 μF für die niedrigeren Spannungen.

EE 10 765 *für weitere Einzelheiten*

Zusammenfassung der wichtigsten Beiträge

Ein Sinuswellengeber für stundenlange Perioden von G. Klein und J. M. den Hertog

Zusammenfassung des Beitrages auf Seite 320-325

Mit Hilfe eines Umkehrfunktionsgebers ist es möglich, von einer sinusförmigen Spannung eine dreieckige abzuleiten. Durch Gegenkopplung kann das Umgekehrte erreicht werden. Ein Sinuswellengeber für ultraniedrige Frequenzen mit einer maximalen Periode von 3½ Stunden wurde unter Ausnutzung dieser Möglichkeiten entwickelt. Verzerrungen sind so niedrig, dass sie vernachlässigt werden können. Wo geringe Verzerrungen zulässig sind, kann die Periodendauer wesentlich erhöht werden. Die Abwesenheit kurzlebiger Vorgänge ist ein wichtiges Kennzeichen dieses Gerätes. Der Umkehrfunktionsgeber kann auch für verschiedene andere Zwecke eingesetzt werden. Eine dieser Anwendungsmöglichkeiten ist ein logarithmisches Voltmeter für Spannungen von ungefähr 10 mV bis über 10 V.

Automatische Führung für Brennschneidemaschinen von J. S. Cheverton

Zusammenfassung des Beitrages auf Seite 326-329

Das in diesem Beitrag beschriebene Gerät wurde konstruiert, um die manuelle Führung der Brennschneidemaschine oder teuere Metallschablonen überflüssig zu machen. Im Wesentlichen desteht das Gerät aus einem optischen Fühlerelement, das in der geschlossenen Schleife einer Servo-Anordnung liegt und genügend Führung von einer einfachen Strichzeichnung erhält, um komplizierte Formen zu schneiden. Das Gerät kann an vorhandene Brennschneidemaschinen angebaut werden.

Transistor-Kennlinienschreiber von J. F. Young

Zusammenfassung des Beitrages auf Seite 330-336

Eine mit Hilfe eines Dekatrons erzeugte stufenförmige Spannung steuert den Basisstrom des zu messenden Transistors. Für jede Stufe wird eine halbsinusförmige Spannung angelegt, und der dadurch entstehende Kollektorstrom wird mit Hilfe eines Aussen-Oszillografen über der Spannung sichtbar gemacht. Ein Serienwiderstand liefert das Stromsignal und begrenzt die Transistor-Verlustleistung. Die Kennlinien für gewöhnliche und Zener Dioden können auch mit dem Gerät aufgezeichnet werden.

Miniatur Elektroencephalograf-Fernmesseinrichtung von D. C. Gold und W. J. Perkins

Zusammenfassung des Beitrages auf Seite 337-339

Eine Fernmesseinrichtung für die Aufzeichnung der elektrischen Gehirntätigkeit einer frei und ungehindert sich bewegenden Katze wird beschrieben. Spannungen werden von einer im Schädel befestigten Elektrode abgenommen und ausreichend verstärkt, um einen auf dem Rücken der Katze getragenen Sender zu steuern. Die Sendungen werden empfangen und entweder einem Elektronenstrahl-Sichtanzeigegerät oder einem Tonbandgerät zugeleitet.

Mehrkanal-Gleichstrom-Aufzeichnungsanordnung von H. D. Scott

Zusammenfassung des Beitrages auf Seite 340-344

Die Entwicklung einer amplitudenmodulierten Trägerfrequenzanordnung ermöglicht die Magnetbandaufzeichnung elektrischer Signale über den Bereich von Gleichstrom bis einschliesslich 10 Hz. Bis zu 12 unabhängige Informationssignale, ein Sprachkanal und Zeitzeichen können mit einem normalen, tragbaren, einspurigen Tonbandgerät aufgezeichnet werden. Besondere Schaltungen wurden entwickelt, um die durch das Tonbandgerät hervorgerufenen Amplitudenschwankungen auszugleichen. Die Anlage ist innerhalb ± 1% der momentanen Höchstsignalamplitude geradlinig.

Der Modulator als Phasendetektor von W. Frazer

Zusammenfassung des Beitrages auf Seite 345-346

Bei Verwendung eines Gleichrichter-Modulators als Phasenanzeiger treten Fehler auf, falls die Schaltspannung nicht viel grösser ist als das Signal. Für diese Verhältnisse wird die Anderung und Grösse dieser Unstimmigkeit für den Fall eines transformerlosen Parallelmodulators betrachtet. Es wird gezeigt, dass das Verhältnis grösser als 7 : 1 sein muss, um den Fehler unter 1% zu halten. Einzelheiten einiger Versuchsprüfungen werden beschrieben.

Die Entwicklung von Dioden-Funktionsgebern mit Vorspannung von C. C. Ritchie und R. W. Young

Zusammenfassung des Beitrages auf Seite 347-351

Die Entwicklung von Dioden-Funktionsgebern mit Vorspannung wird behandelt und Gleichungen werden abgeleitet, die sich auf die Anzahl der Diodenabschnitte, den erzielbaren geringsten Fehler und die Verteilung der Diodenabschnitte zur Erzielung dieses Minimumfehlers beziehen. Die Konstruktion eines nach diesen Gesichtspunkten entwickelten Sinus-Funktionsgebers ist ausführlich behandelt.

Eine einfache Höchstwert-Suchschaltung von J. N. Shearme

Zusammenfassung des Beitrages auf Seite 353-334

Eine einfache Methode für die Bestimmung des Höchstwertes in einer Spannungswertgruppe wird beschrieben, dessen Lage in der Gruppe in analoger Form ausgedrückt ist. Die Methode wurde angewandt, um, als Teil einer Untersuchung zur Verringerung der benötigten Bandbreite, die Formanten oder Gebiete grösster Energie in einem Sprachsignal zu verfolgen.

Die Entwicklung ausgeglichener Verstärker unter Benutzung von Bauelementen mit handelsüblichen Toleranzen von D. J. Dewhurst

Zusammenfassung des Beitrages auf Seite 355-357

Trotz der Veröffentlichung vieler Schaltungen für ausgeglichene Verstärker, die handelsübliche Toleranzen verwandter Bauelemente kompensieren sollen, muss festgestellt werden, dass die besten Resultate im allgemeinen bei Verwendung angepasster Bauelementpaare erreicht werden. In diesem Beitrag wird eine Analyse der Schaltung mit falschangepassten Bauelementen betrachtet. Dadurch wird das beobachtete Verhalten erklärt und die Berechnung von Verstärken ermöglicht, für die zulässige Bauelement-Toleranzen angegeben werden können.

Magnetische Kernmaterialien für logische Funktionen von A. L. Freedman

Zusammenfassung des Beitrages auf Seite 358-361

Die allgemeinen Grundsätze einer Methode werden erläutert, die mittels Matrizen magnetischer Kerne mit rechteckiger Hystereseschleife logische Funktionen ausführen kann. Die Anwendungsmöglichkeiten werden umrissen und die innewohnenden Vorteile und Beschränkungen aufgezeigt.

Ein elektronischer Zeitintervallmesser mit spannungsgesteuerter Einstellung von R. Gladstone

Zusammenfassung des Beitrages auf Seite 362-363

Der elektronische Zeitintervallmesser ist eine Entwicklung der Kathodenverstärkerschaltung mit mitlaufender Ladespannung und es wird angenommen, dass er auf neuen Prinzipien beruht. Der Unterschied liegt in der Anwendung einer Gitter-Leistungssteuerung, die einen konstanten, aber leicht einstellbaren Anderungsmassstan über den ganzen Arbeitssteuerbereich des Röhrengitters ergibt. Die Anderungsrichtung kann positiv oder negativ sein, und der Anderungsmassstab kann in sehr weiten Grenzen durch jeden der beiden unabhängig variablen, geradlinigen Kreisparameter, durch einen dritten Parameter für Stufenänderungen oder durch einen vierten Parameter innerhalb eines begrenzten Bereiches beeinflusst werden.