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Commentary

ONE of the most impressive electronic status symbols is now being marketed in the United States of America and the possibilities which it offers for complete and utter relaxation in the not too distant future are most exciting.

Housed in a nine foot long walnut cabinet and known as a complete home entertainment system it contains everything in the way of sound and television reproduction that its owner can desire—an a.m., f.m. stereo tuner, record changer, stereo control panel and pre-amplifier, stereo amplifier and loudspeakers, a four-track tape recorder and reproducer, a colour television receiver and a video tape recorder capable of recording up to an hour and a half.

In addition there is a vidicon camera unit which can be used with the video recorder or with the colour television receiver itself, together with a timer to switch on the recorder for a given programme without further attention or to record one programme while another is being viewed, and finally twin microphones for stereo recording.

And the price ?—$30 000, but the price does include the presence of an engineer to supervise the installation ! As far as it is known, there is nothing on this side of the Atlantic to equal this in the way of home entertainment, although no doubt the various items of equipment are made in this country and could be assembled at short notice.

It should not be assumed, however, that we are lagging behind in the development of electronic aids for our modern affluent society. What we are striving to do is first to create enough leisure time to enable us to sit indefinitely in front of such a complete home entertainment system.

Already an electronic automation system has been installed in a hotel in the North of England which, with suitable modifications, could be applied to the home.

It consists in essence of a small computer which is programmed by the customer himself. On the menu there are some 100 items of food and drink, each item having a two digit code. Having made his choice the customer dials from his table the appropriate code for his needs in the order in which he wishes to receive them and the rest is automatic.

The machine prints out the number of his table, the items selected and the price, and the kitchen staff and waiters are instructed accordingly.

It is not difficult to imagine that such a system would be an immeasurable boon to the housewife. At the beginning of her day she could, with such a device, not only programme her choice of food for the day but, with suitable connexions to the refrigerator and cooker, the hour at which it was to be ready. Shortages of any particular item would be readily detected and to prevent her having to run out to purchase the missing item the shopkeeper could receive printed instructions together with the address to which the goods were to be delivered. Accounting would of course be included in the process.

This does not unfortunately completely relieve the housewife of all her chores, and without doubt the shortcomings of such a system are already being closely studied. According to Professor M. W. Thring and Mr. D. F. Netall who recently delivered a paper on this subject to the Society of Instrument Technology, it will be possible within the next ten years to develop a completely automatic robot—electronic of course—which will be capable of doing all the dull and uninteresting household routine.

In their paper they laid down six main tasks which such a robot should do, namely:

(1) Lay or clear a table.
(2) Make beds and change sheets.
(3) Dust, sweep and clear things away.
(4) Wash clothes with the help of a machine and iron them.
(5) Wash floors, baths, basins, sinks and cookers.
(6) Prepare food, but not cook it as this is considered to be of sufficient interest to be done personally.

The robot would be fitted with a memory unit and be taught to remember the correct places for things and furniture and to know where things were put away. When it had finished its daily round it would then put itself away in a cupboard under the stairs and connect itself to the mains to recharge its batteries. Shaped like an upright box it would have self propulsion mechanism and its arms which would have to handle things would be sensitive to weight and touch.

The most intriguing possibilities could arise if this robot could be 'married' to the computer which has just been described. All tasks would be completely eliminated and the family would then be able to relax before the home entertainment for twenty-four hours a day if so desired. The house would be kept spotless and so on, food prepared and delivered at the precise time, and the robot, under instructions from the computer, made to switch the home entertainment system from radio to television or to recording and at the end of the day even put the family to bed.

A New Approach to I.L.S. Modulation Depth Comparison

By G. G. Gouriet*, M.I.E.E.

The article describes a new method of measuring the difference in depth of modulation (d.d.m.) of the two i.l.s. radio beams that are used by aircraft for runway approach guidance. The measuring technique provides reliable measurement of values of d.d.m. less than 0·01 per cent which should be adequate to meet the new needs which are arising in the development of automatic landing systems. A brief description is given of an instrument which has been developed for the Royal Aircraft Establishment.

(Voir page 62 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 69)

SINCE its adoption in 1948 by the International Civil Aviation Organization the system known as i.l.s. (instrument landing system) has become the generally accepted method of runway approach guidance.

Up to the present time instrument landing has been somewhat of a misnomer in that the system has been insufficiently accurate for guidance to the point of touchdown and along the runway; it has, however, provided adequate guidance to a point about ½ mile from the runway at an altitude of some 200ft at which point visual landing is normally possible with the aid of the runway lighting system.

Automatic landing of civil aircraft has been studied extensively at the Royal Aircraft Establishment for many years and at the recent I.E.E. Conference on Electronic Research and Development for Civil Aviation, Wood[1] reviewed the problems and referred to the desirability of improving the i.l.s. performance to permit of landing and guidance along the runway. A paper by Norbury[2] dealt with improvements in i.l.s. ground equipment and referred to the need for precision test gear while a contribution by Gill, Smith and Asteraki[3] closed with the encouraging view that "... provided improved monitoring techniques are developed, current i.l.s. ground equipment can provide long term course line stability which is acceptable for a civil automatic landing system."

This article describes a new method of measuring and monitoring the all important parameter d.d.m. (difference in depth of modulation) on which the operation of the i.l.s. sytem is fundamentally based. The method will indicate reliably a d.d.m. as small as 0·01 per cent which, at the threshold of the runway, corresponds to a displacement in azimuth of 2·7in.

The I.L.S. System

The basic components of the i.l.s. system are two radio beams termed 'localizer' and 'glide path' which guide the aircraft in azimuth and elevation, respectively. The principle of operation is substantially the same for both beams and the brief description here will be confined to the localizer. The requirement is in fact more stringent for the localizer since this must define the centre line of the runway with high accuracy. The glide path determines the angle of elevation on approach, but the precise determination of height over the runway is provided by a radio altimeter.

The essential features of the localizer are shown in Fig. 1. A common carrier signal is fed to two separate modulators, one of which receives a modulating tone of 90c/s and the other, 150c/s. The two modulated carrier signals are fed to two separate aerials positioned with respect to a common reflector to produce two overlapping beams. By convention, the beam carrying the 90c/s modulator is off-set to the left of the runway centre line in the direction of approach and that carrying 150c/s is off-set by a similar amount to the right.

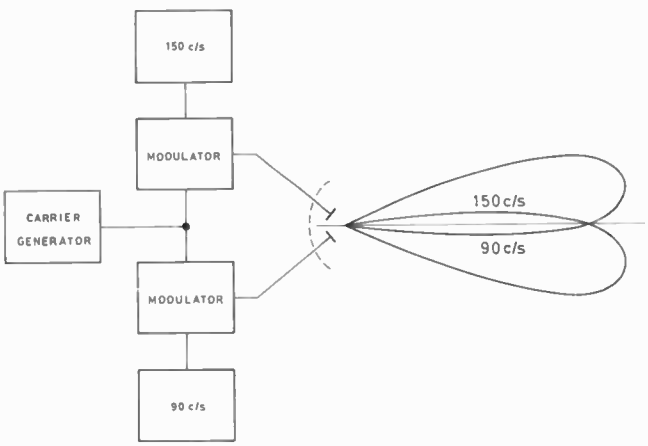


Fig. 1. Arrangement of i.l.s. localizer

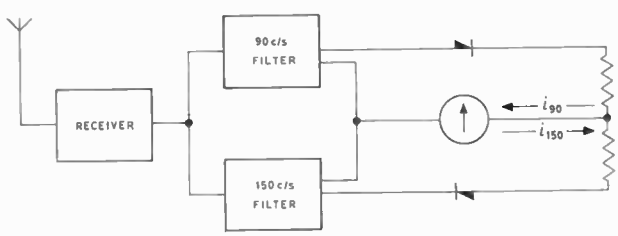


Fig. 2. Simplified diagram of i.l.s. receiver

It will be noted that the radiation pattern of the combined carrier is symmetrical about the centre line of the runway; the 90c/s and 150c/s sideband pairs will, however, retain their respective asymmetry since these signals are not common to the two beams.

The depth of modulation is identical for each beam and is nominally 40 per cent. On the centre line of the runway, however, the amplitude of the combined carrier will be double that of either beam while the amplitudes of the sidebands will be unaffected. With respect to the combined carrier the depth of modulation is thus 20 per cent for each of the two modulating tones.

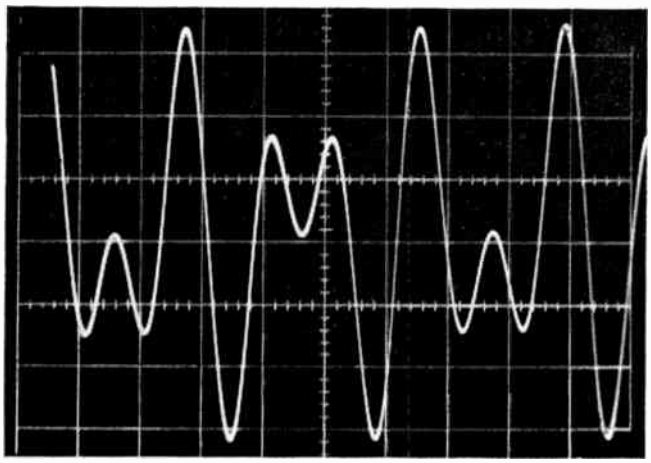
A simplified diagram of the aircraft receiver is shown in Fig. 2. After detection the two tones are separately

* *The Wayne Kerr Laboratories Ltd.*

filtered and rectified to produce two direct currents of opposite sign. The sum of these currents is indicated by a centre-zero meter movement and this will read zero when the two received tones are of identical amplitude, that is when the aircraft is on or over the centre line of the runway. If the aircraft is to the left of the centre line the amplitude of the received 90c/s tone will increase and that of the 150c/s tone will decrease causing the pointer to move to the right. Similarly, if the aircraft is to the right of the centre line, current will flow in the opposite direction causing the pointer to move to the left.

It should be emphasized that the receiver does not indicate the difference in field strength of the two beams. A high degree of a.g.c. is in fact used to prevent the receiver responding to changes in level of the combined carrier. It is the *depth of modulation* of the combined carrier by each of the two tones that the receiver is comparing and it is the difference in depth of modulation d.d.m., that is indicated by the meter movement. The sensitivity of the system is such that a d.d.m. of 1 per cent corresponds to a lateral displacement of 22·6ft at the runway threshold.

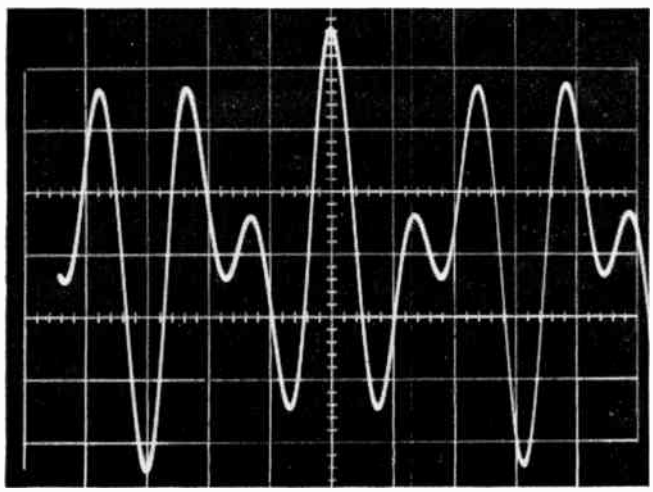
The glide path transmitter and receiver operate in a manner similar to the localizer except of course that a different carrier frequency is chosen. A single indicator using crossed pointers is in fact used in an ingenious manner to indicate simultaneously deviation in azimuth and elevation.



(a)

Fig. 3. Waveforms of combined tones for two extreme conditions of relative phase

(b)



The Measurement Problem

The need to set up ground equipment and align aircraft receivers to meet the stringent demands of automatic landing necessitates the introduction of test gear and monitoring equipment of extremely high accuracy. A basic requirement is for apparatus which will indicate reliably a d.d.m. of 0·01 per cent which is about an order better than the required system performance.

The problem of measuring small values of d.d.m. expressed as a percentage reduces to that of measuring the difference in amplitude of the 90c/s and 150c/s tones after detection and expressing this difference as a percentage of the carrier ampltiude. It is to be noted that a d.d.m. of 0·01 per cent will correspond to a difference in the amplitudes of the tones of 0·05 per cent since the depth of modulation of each tone is effectively 20 per cent.

The two tones are derived from a common signal generator and are therefore locked in frequency, but the frequency stability of the source may not be better than one or two per cent. Since the phase relationship of the two tones is substantially constant the composite waveform is repetitive with a period equal to five cycles of 90c/s or three cycles of 150c/s. The actual wave-shape, however, will depend on the particular phase relationship of the tones and two extreme conditions are shown in Figs. 3(a) and (b) respectively.

In reviewing possible methods of measurement two broad approaches were eliminated as being instrumentally impracticable. First, all methods which involved filtering the tones were rejected on the grounds that the insertion loss of the filters could not be maintained with sufficient accuracy particularly since the tone frequencies may vary by one or two per cent. Secondly, methods which involved examining special features of the composite signal such as maxima, minima or zero crossings were rejected since in general such features vary with relative phase.

Method of Measurement

The new method of measurement* can best be described with reference to the two vector diagrams in Figs. 4(a) and (b). Fig. 4(a) shows the 90c/s and 150c/s tones as two vectors, A and B respectively, differing in amplitude and of arbitrary phase. They are shown rotating in opposite directions with respect to the stationary reference axis II', the position of which corresponds to that of a vector of frequency equal to the mean frequency of the two tones, i.e. 120c/s and with a phase equal to the mean phase. Thus, the two vectors each rotate at 30c/s with respect to the reference axis, the 90c/s vector in a clockwise direction and the 150c/s vector, anti-clockwise.

Fig. 4(b) describes an identical situation but now shows two vectors of equal length each proportional to the mean amplitude of the two tones, $(A + B)/2$. In addition there are two small vectors each of length $(A - B)/2$ representing the mean difference in amplitude of the two tones. The small vectors also rotate in opposition, each at a frequency of 30c/s but in this case the axis of symmetry is QQ' which is normal to the axis II'. It will be seen that when the latter pair of vectors are added to the former the diagram is identical to that of Fig. 4(a).

Thus the general case of the composite signal comprising two tones of unequal amplitude may be regarded as being the sum of two suppressed-carrier systems of modulation. In each case the suppressed-carrier has a frequency of 120c/s and the modulating signal has a frequency of 30c/s, but in one case the amplitude of modulation equals

* *Patent Application No. 2025/63.*

the sum of the amplitudes of the two tones while in the other it equals the difference of amplitudes. Furthermore, the two systems have a quadrature relationship in respect of both the phase of the suppressed carriers and the phase of the modulating signals. (See Appendix.)

Now suppose the composite signal comprising the two tones is applied to the input of a phase sensitive detector and a reference signal of 120c/s is used. Such a reference can be generated from the composite signal as will be described later. With the phase of the reference signal adjusted to coincide with the axis QQ', the output of the detector will be a 30c/s signal with an amplitude proportional to the amplitude difference of the two tones. If the tones are then adjusted to be of equal amplitude the 30c/s signal will vanish. Using selective amplification to detect the presence of 30c/s it is possible by this means to indicate a difference in amplitude as small as 0·005 per

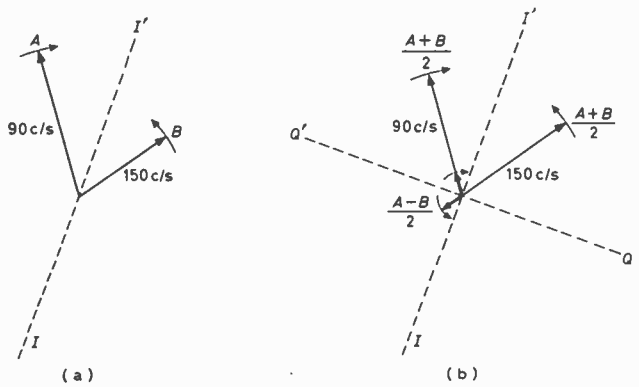


Fig. 4(a) (left). Tone vectors relative to 120c/s reference axis
(b) (right). Symmetrical sum and difference vectors equivalent to (a)

cent. The procedure is similar to that of balancing a bridge; the phase is adjusted to produce minimum output from the detector and the amplitude of the tones is then adjusted to produce a null.

If it is required to *measure* the amplitude difference of the two tones as opposed to making the difference zero, it is necessary to distinguish between the 30c/s component due to inequality of tone amplitudes and that due to misalignment of the 120c/s reference phase. Referring again to Fig. 4(b), it will be seen that the 120c/s reference vector has no component along the axis II' when its phase is correctly adjusted and any 30c/s component detected by it will be solely due to an amplitude variation along the axis QQ'. If, however, the phase of the 120c/s reference is in error it will also detect a 30c/s component along the axis II' but as mentioned earlier the two components will be in phase quadrature and may therefore be separated. The separation is effected by using a pair of phase sensitive detectors operating in quadrature so that one detects the 'quadrature' component relating to the axis QQ' and the other detects the 'in-phase' component relating to II'. The 30c/s reference signal required for these detectors is obtained from the 120c/s reference signal by frequency division.

The outputs are displayed separately on two centre zero meters, one of which indicates the amplitude difference of the two tones and is calibrated in terms of percentage d.d.m., while the other indicates the phase error of the 120c/s reference signal.

The 120c/s reference signal may be derived from the two tones in a number of ways. One way is to apply the composite signal to a square law circuit which in addition to harmonics will produce sum and difference frequencies. The sum term will be 240c/s and frequency division by a factor of two will produce 120c/s. The sum and difference frequencies may also be produced by filtering the two tones and applying them to the two inputs of a balanced modulator to obtain the product.

Before describing details of the instrument which has been developed it is worth while discussing briefly what happens when the phases of the 120c/s and 30c/s reference signals are incorrectly adjusted. It is shown in the Appendix that the two meters referred to above give indications proportional to the following quantities:

$$\text{d.d.m.} \propto A\cos(\phi - \theta) - B\cos(\phi + \theta) \quad \ldots\ldots \quad (1)$$

$$120\text{c/s phase} \propto A\sin(\phi + \theta) + B\sin(\phi - \theta) \quad \ldots\ldots \quad (2)$$

where ϕ is the phase error of the 120c/s reference signal

θ is the common phase error of the 30c/s reference signals

A and B are the respective amplitudes of the 90c/s and 150c/s tones.

If the 120c/s reference phase is correctly adjusted then $\phi = 0$ and equations (1) and (2) reduce to:

$$\text{d.d.m.} \propto (A - B)\cos\theta$$

$$120\text{c/s phase} \propto (A - B)\sin\theta$$

Thus if $A = B$, corresponding to a d.d.m. of zero, both meters read zero regardless of the value of θ. If $A \neq B$ and $\theta = 0$ the phase meter will read zero and the d.d.m. meter will give the required indication proportional to $A - B$. An error of a few degrees in the common phase of the 30c/s reference signals will have little effect on accuracy.

Consider now the case where the 30c/s reference signal is correctly adjusted so that $\theta = 0$. In this instance:

$$\text{d.d.m.} \propto (A - B)\cos\phi$$

$$120\text{c/s phase} \propto (A + B)\sin\phi$$

Again if $A = B$ the indication of d.d.m. will correctly be zero regardless of the value of ϕ, but if ϕ is not zero it will be clearly evident on the phase meter since $(A + B)\sin\phi$ will be relatively large even for small value of ϕ.

This simple analysis shows that there is an advantage to be gained by adjusting first the common phase of the 30c/s reference signals; even a small error in the phase of the 120c/s reference signal will then be immediately evident on the phase meter.

Accurate adjustment of the 30c/s reference phase can be accomplished if the phase of the 120c/s reference signal is displaced by 90° to coincide with the II' axis in Fig. 4(b). Thus if in equations (1) and (2), $\phi = \pi/2$ then the meter which normally indicates d.d.m. will now read a quantity proportional to $(A + B)\sin\theta$. This will be zero when θ is correctly adjusted and will give a sensitive indication of small errors since $A + B$ is a large quantity. For this condition the phase meter will read $(A + B)\cos\theta$ and with θ correctly adjusted will indicate $A + B$. This is proportional to the mean amplitude of the two tones and therefore affords the means of measuring the mean depth of modulation as opposed to difference in depth.

Instrumentation

The instrument, which has been developed for the Royal Aircraft Establishment, is fully transistorized and portable and will operate from batteries or a mains supply.

A block diagram is shown in Fig. 5. The output of the receiver is an a.f. signal comprising the 90c/s and 150c/s tones. This signal is fed to a phase sensitive detector (p.s.d.) and also to a reference signal generator, which

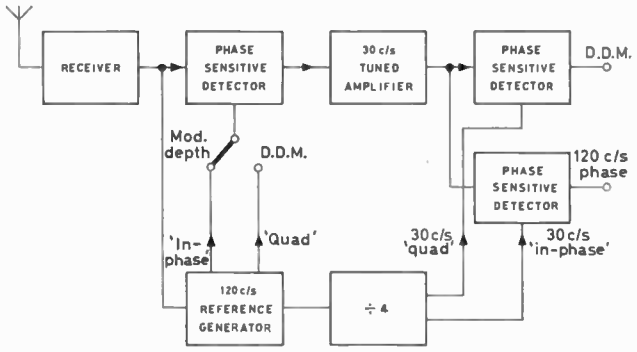


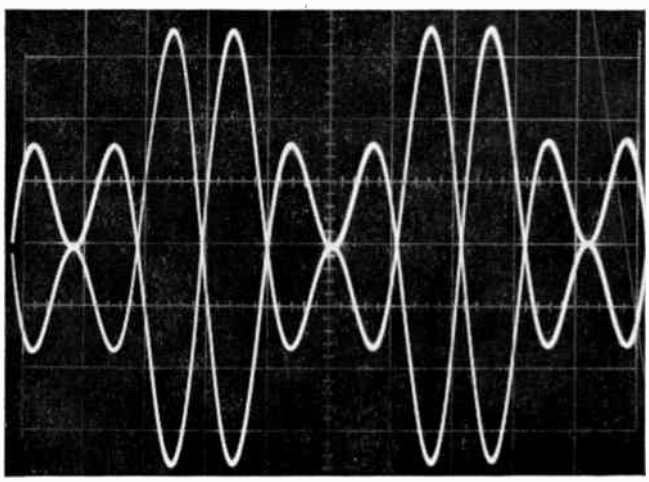
Fig. 5. Arrangement of measuring instrument

derives from the two tones the mean frequency of 120c/s. The 120c/s reference generator provides two outputs, one of which is termed the 'in-phase' reference and the other the 'quadrature' reference. Either of these outputs may be selected by a switch and fed to the p.s.d. If the 'in-phase' reference is used, the output of this p.s.d. will be a 30c/s signal of amplitude proportional to the sum of the amplitudes of the two tones, from which a measure of modulation depth may be derived. If the 'quadrature' reference is used the output will be proportional to the difference of amplitude which in turn is proportional to d.d.m.

The output of the p.s.d. is amplified by a 30c/s selective amplifier and fed to two more p.s.d's. The two 30c/s reference signals for these detectors are derived from the 120c/s reference by frequency division and again the two signals bear a quadrature relationship. The 'quadrature' reference is appied to the p.s.d. associated with the measurement of d.d.m. and the d.c. output of this p.s.d. is indicated on a centre-zero meter calibrated to read $\pm 0{\cdot}2$ per cent d.d.m. f.s.d. The 'in-phase' reference is applied to the other p.s.d., the d.c. output of which is indicated on another centre-zero meter. As described earlier the purpose of this meter is simply to indicate that the phase of the 120c/s reference is correctly adjusted.

To measure depth of modulation it is necessary to measure the sum of the amplitudes of the two tones and this is achieved by choosing for the 120c/s reference the 'in-phase' signal. In this event a signal proportional to to the sum of the two amplitudes will appear at the output of the p.s.d. which operates on the 'in-phase' axis and which normally indicates the 120c/s reference phase

Fig. 6. Waveform of Fig. 3(a) with time-base frequency an odd-multiple of 60c/s



error. A small meter may be used for this latter purpose and since it is required only to indicate a null, a calibrated scale is unnecessary. When measuring depth of modulation this small meter is switched out of circuit and is replaced by the more accurate meter which measures d.d.m. The actual measurement is provided by comparing the amplitude of the tones with that of the carrier and this is accomplished with an accuracy of $\pm 0{\cdot}5$ per cent.

Calibration

The null indication which obtains when the d.d.m. is zero is an inherent feature of the method of measurement. It is an indication of equality and at least in theory it requires no calibration or standard of reference. It is, however, essential to have an alternative means of establishing the equality of amplitudes, under laboratory conditions, with similar or greater resolution; it is only by such means that a test signal can be provided to prove the proposed method of measurement.

With pure tones it is possible to compare the amplitudes by comparing separately the powers dissipated in a common thermistor by each of the two tones. Using a precision impedance bridge it is possible by this means to detect differences in amplitude as small as 0·001 per cent but such a measurement demands carefully controlled laboratory conditions and considerable patience.

Fortunately there is a relatively simple way of confirming the equality of amplitudes which requires only a high-grade oscilloscope and a stable i.l.s. tone generator. The tones should be pure and if necessary must be filtered to remove harmonics before they are combined. The method makes use of a particular feature of the waveform which is evident when it is displayed on an oscilloscope with a time-base frequency which is an odd multiple of 60c/s*. The repetitive trace obtained with the waveform of Fig. 3(a) is shown in Fig. 6 and it will be seen that there are two peaks, one a minimum and the other a maximum, which coincide at a point of zero amplitude. If the two tones are of equal amplitude the two peaks touch but do not overlap, provided that the relative phase of the tones is adjusted to produce exact mirror symmetry about the vertical axis which passes through the peaks referred to. The effect of a phase error of either sign is to cause the peaks to overlap and it is the minimum separation that corresponds to the correct phase.

Figs. 7(a), (b) and (c) show the centre of the trace with considerable expansion applied to both the x and y axes. Fig. 7(a) shows the condition of equal amplitudes while (b) and (c) show inequalities corresponding to plus and minus 0·1 per cent d.d.m. respectively. With a fine trace an inequality corresponding to less than $\pm 0{\cdot}01$ per cent d.d.m. can be observed by this means.

To measure d.d.m. at a value other than zero demands a standard of reference against which the instrument may be calibrated. The requirement is met by incorporating in the instrument a single time-constant comprising a standard resistor and capacitor. This serves to provide both a checking facility and a means of calibration. The principle will be explained with reference to Fig. 8 which shows the tones after r.f. detection as being produced by a zero-impedance generator and applied via a resistor R to the measuring terminal P. The tones are first adjusted to be of equal amplitude at the terminal P, by using the d.d.m. meter as a null indicator. For the purpose of calibration, the switch S is closed bringing the capacitor C into circuit. The resulting attenuation is slight but since

* *This feature was drawn to the author's attention by Mr. D. R. Reiffer of the Civil Aviation Flying Unit.*

the *RC* circuit is frequency selective the actual attenuation will be different for each tone and the time-constant is chosen to produce a known difference of amplitude.

If the required fractional difference in amplitude is denoted as x the time-constant T may be determined by writing:

$$(1 + \omega_1^2T^3)^{-\frac{1}{2}} - (1 + \omega_2^2T^2)^{-\frac{1}{2}} = x$$

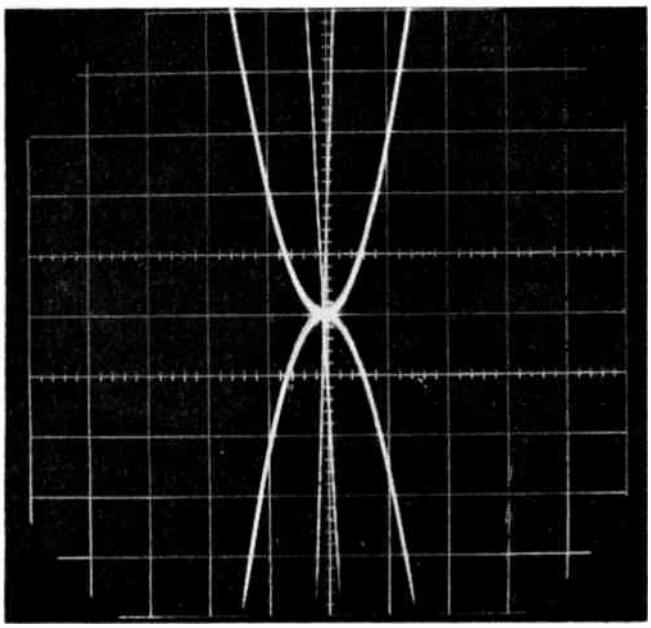
where ω_1 and ω_2 are the angular frequencies of the two tones with $\omega_2 > \omega_1$.

For very small values of x binominal expansion may be used to obtain the valid approximation:

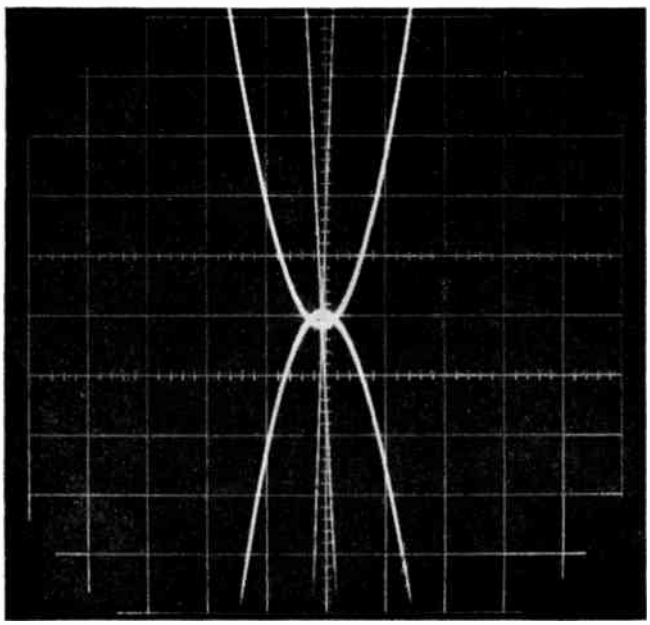
$$\frac{\omega_2^2T^2 - \omega_1^2T^2}{2} \simeq x$$

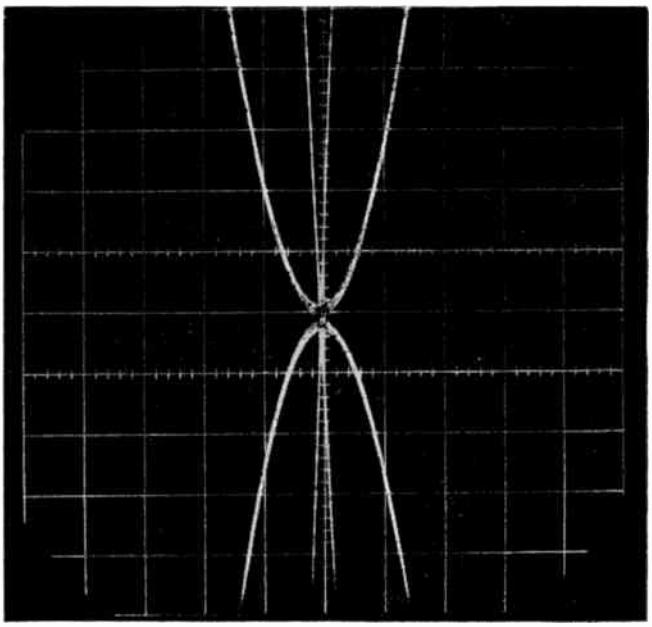
$$\text{or } T \simeq \left[\frac{2x}{\omega_2^2 - \omega_1^2}\right]^{\frac{1}{2}}$$

Fig. 7. Expanded waveform showing coincidence of peaks
(a) Zero d.d.m.



(b) (left) and (c) (right). ±0·1 per cent d.d.m. respectively





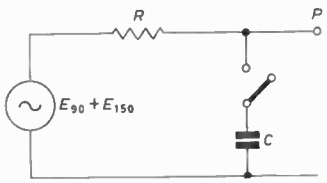


Fig. 8. Calibration of d.d.m. using *RC* time-constant

For the two tones in question this reduces to:

$$T \simeq (1/\sqrt{2\pi}) \cdot (x^{\frac{1}{2}}/120)$$

For an amplitude difference of 0·1 per cent, $x = 0{\cdot}001$ and the calculated value of T is 0·0593msec.

The fractional drop in amplitude of the 90c/s and 150c/s tones is, in this case, 0·0006 and 0·0016 respectively giving the difference of 0·1 per cent. The respective phase shifts are approximately 2° and 3·3°.

Conclusions

This article has described a new method of measuring d.d.m. as defined for the system of aircraft guidance known as i.l.s. The method affords the means of measuring accurately a difference in depth of modulation as small as 0·01 per cent which is required in order to test and align new systems which are being developed using i.l.s. signals for automatic landing. The method has in fact been shown capable of detecting differences as small as 0·001 per cent. A brief description has been given of an instrument which has been developed for the Royal Aircraft Establishment. The instrument has been designed to align i.l.s. signal generators which are used to test and calibrate aircraft receivers. It can also be used to monitor the beam on the centre-line of the runway or to measure d.d.m. as a function of lateral displacement. The method would be eminently suitable for permanent monitoring and could be readily adapted to provide a feedback signal to the transmitter so as to maintain automatically the condition of equality on the runway centre-line. The same principle if incorporated in the design of an aircraft receiver would offer a substantial improvement in both sensitivity and stability.

Acknowledgments

The author is indebted to Mr. D. M. O'Hanlon and Mr.

J. Symonds of the British European Airways Corporation for clearly defining the problem, to the Royal Aircraft Establishment and in particular Mr. J. Benjamin for helpful co-operation in the development and to the Ministry of Aviation who have sponsored the project and together with Wayne Kerr Laboratories Ltd have given permission for this article to be published.

Appendix

By taking the axis II' in Fig. 4(b) as the phase reference for the two tones the combined signal may be written as:

$$F(t) = A\cos(\omega_c - \omega_m)t + B\cos(\omega_c + \omega_m)t \quad \ldots\ (3)$$

where $\omega_c = \dfrac{\omega_{150} + \omega_{90}}{2}$ $(= 2\pi \times 120\ \text{rad/sec})$

and $\omega_m = \dfrac{\omega_{150} - \omega_{90}}{2}$ $(= 2\pi \times 30\ \text{rad/sec})$

Expanding the cosine terms and re-arranging:

$$F(t) = (A+B)(\cos\omega_c t \cos\omega_m t) + (A-B)(\sin\omega_c t \sin\omega_m t) \quad \ldots\ (4)$$

This may be regarded as the sum of two suppressed carrier modulation systems, one of which has a suppressed carrier $\cos\omega_c t$ and is modulated with:

$$(A + B)\cos\omega_m t$$

and the other, a suppressed carrier $\sin\omega_c t$ modulated with:

$$(A - B)\sin\omega_m t$$

Both the carriers and the modulation signals are thus in phase-quadrature.

A phase-sensitive detector using a reference signal $\sin\omega_c t$ with a phase error ϕ will produce an output proportional to:

$$(A+B)\cos\omega_m t \sin\phi + (A - B)\sin\omega_m t \cos\phi \quad \ldots\ (5)$$

as may easily be verified by multiplying equation (4) by $\sin(\omega_c t + \phi)$ and rejecting all components of twice the suppressed carrier frequency.

Equation (5) represents a 30c/s signal which will vanish if $\phi = 0$ and $A = B$.

A separate measure of the two components of equation (5) may be obtained using two more phase sensitive detectors, one with a reference signal $\sin\omega_m t$ and the other, $\cos\omega_m t$. The case will be examined where both reference signals are obtained from a common source with a phase error θ.

Multiplying equation (5) by $\sin(\omega_m t + \theta)$ and discarding terms involving $2\omega_m$ shows the output to be a d.c. signal proportional to:

$$(A + B)\sin\phi\sin\theta + (A - B)\cos\phi\cos\theta$$

This may be written:

$$A\cos(\phi - \theta) - B\cos(\phi + \theta) \quad \ldots\ (6)$$

This is the form of the d.c. signal applied to the d.d.m. meter.

In a similar manner it is found that using a reference signal $\cos(\omega_m t + \theta)$ the d.c. output signal is

$$(A + B)\sin\phi\cos\theta + (A - B)\cos\phi\sin\theta$$

which may be written

$$A\sin(\phi + \theta) + B\sin(\phi - \theta) \quad \ldots\ (7)$$

This is the signal which is applied to the 120c/s phase meter.

References

1. Wood, K. A. A Review of the Problems in the Application of Electronics to the Automatic Landing of Civil Aircraft.
2. Norbury, F. T. Recent Improvements in I.L.S. Ground Equipment.
3. Gill, F. R., Smith, M. E., Asteraki, J. D. An Experimental Assessment of the Stability of the Course Line of an I.L.S. Localiser Ground Equipment.

The above three papers were presented at the I.E.E. Conference on 'Electronics Research and Development for Civil Aviation', 2 to 4 October 1963, and are published in the Conference booklet.

Magnetic Researches

Solid-state researches, in particular studies of magnetic materials, often require simultaneous investigations of physical properties at very low temperatures and in high magnetic fields. Facilities for both these conditions are expensive and the maximum use of them can best be made in a laboratory specially designed and equipped for the work.

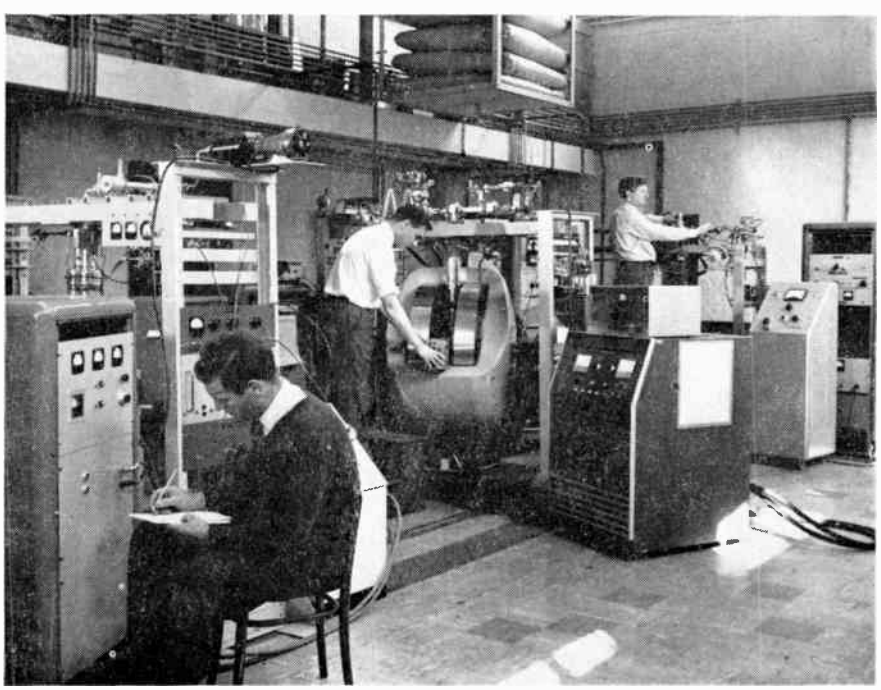
The illustration shows additional facilities installed in the Hirst Research Centre of The General Electric Co. Ltd, Wembley, Middlesex. The equipment is designed to work with a large 12in electromagnet providing magnetic fields of up to about 35 000 oersteds in a gap of 1¼in. It stands on a carriage which can be wheeled along rails into any of four experimental stations.

The Laboratory is equipped with liquid helium cryogenic facilities, connected to each of the experimental stations. Part of the storage balloon in the automatic helium gas recovery system can be seen above the magnet.

The photograph shows three stations where paramagnetic resonance studies are made of new magnetic materials. These have been grown at the Hirst Research Centre chiefly by the fluxed-melt technique and are in the form of highly perfect crystals.

Low temperature electron spin resonance measurements are of considerable help in understanding the nature and effects of trace impurities in solids. A recent problem to which this technique was applied concerned the physical nature of the damage occurring in alkali-corroded glasses.

Part of the new facilities for solid-state research



The Calculation and Measurement of the Gains of End-Fire V.H.F. and U.H.F. Aerials

By R. G. Manton*, Ph.D., B.Sc. (Eng.)

Graphical methods are described for calculating the gains of end-fire aerials from their radiation patterns. Two types of aerial are dealt with in detail, namely (a) a linear array of half-wave dipoles, and (b) an array which has a cylindrically-symmetrical radiation pattern.

It is shown how these methods may be applied to typical v.h.f. and u.h.f. receiving aerials such as single and multiple Yagis. Special forms of graph paper have been designed for this application. The technique of gain measurement by direct comparison with a half-wave dipole is also described.

(Voir page 62 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 69)

THE gain of an aerial is often one of its most difficult electrical properties to determine. There are many pitfalls in measuring the gain by comparing the power received by the aerial with that received by a standard aerial. This article shows how the gain may often be calculated quite accurately from measured radiation patterns and goes on to show how some of the pitfalls of direct measurement can be avoided.

Definition of Gain

From the principle of reciprocity it follows that the directional pattern of a receiving aerial is identical with its directional pattern as a transmitting aerial. For convenience, therefore, the aerials to be considered will in all cases be treated as transmitting aerials. Unless it is stated otherwise, the 'gain' of an aerial will refer to its intrinsic power gain in the direction of maximum radiation relative to that of a half-wave dipole, both aerials being in free space. By intrinsic gain is meant the gain neglecting mismatch or dissipation losses associated with the feeder. The gain may be defined as the ratio of the powers which must be fed to the two aerials in order to produce identical field strengths at a distant point. It is also equal to the square of the ratios of the field strengths which the aerials would produce at a distant point if they radiated equal powers. The gain is expressed either as a power ratio or in decibels.

Calculation of Aerial Gain from Radiation Patterns

Fig. 1 represents an aerial situated at the centre of a sphere of unit radius. If the field strength at any point on the surface of the sphere is E, the power radiated through an element δs of the surface is $kE^2\delta s$, k being a constant. The total power radiated is obtained by performing an integration over the surface of the sphere. Suppose that the maximum field at the surface of the sphere due to the aerial is unity, and that an isotropic source producing unit field at the surface of the sphere is used as a reference aerial. The power radiated by the latter is $4\pi k$ and the gain of the aerial relative to an isotropic source is therefore:

$$G_I = 4\pi / \int_s E^2 ds \quad \ldots\ldots\ldots\ldots \quad (1)$$

Its gain relative to a half-wave dipole is:

$$G_D = 4\pi / 1{\cdot}64 \int_s E^2 ds \quad \ldots\ldots\ldots\ldots \quad (2)$$

since the gain of a half-wave dipole relative to an isotropic source is 1·64.

The integration is greatly simplified if all elements (active or passive) are similar and form a linear array, or if the radiation pattern of the aerial has symmetry about an axis. Two cases of symmetry will be considered in the following sections.

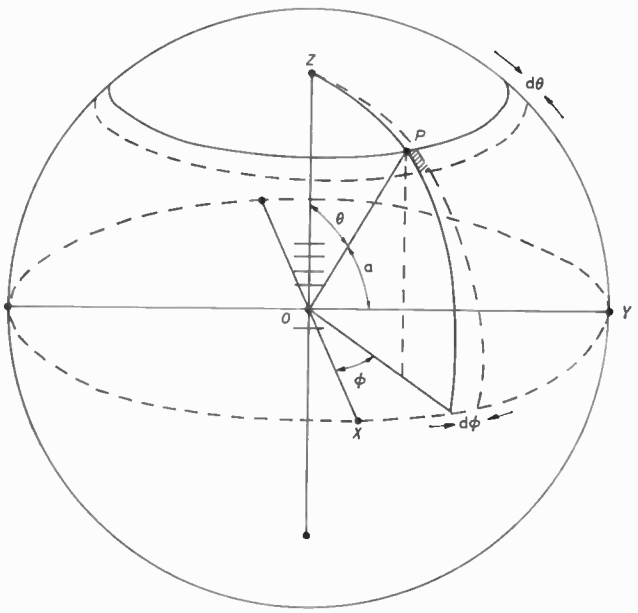


Fig. 1. System of co-ordinates

THE GAIN OF A LINEAR ARRAY OF HALF-WAVE DIPOLES (THE YAGI AERIAL)

Consider a linear array of half-wave dipoles in the y, z plane situated at the origin of Fig. 1 and radiating in the direction $0z$; the system of co-ordinates is defined in the figure. The radiation pattern of such an array is given by:

$$E = \frac{\cos\left((\pi/2)\cos\alpha\right)}{\sin\alpha} f(\theta) \quad \ldots\ldots\ldots \quad (3)$$

where $f(\theta)$ is the radiation pattern in the x, z plane normalized for a maximum value of unity. The multiplying factor is the radiation pattern of a half-wave dipole at angle α from the line of the dipole.

Since:

$$\cos\alpha = \sin\theta \sin\phi$$

* *The British Broadcasting Corporation.*

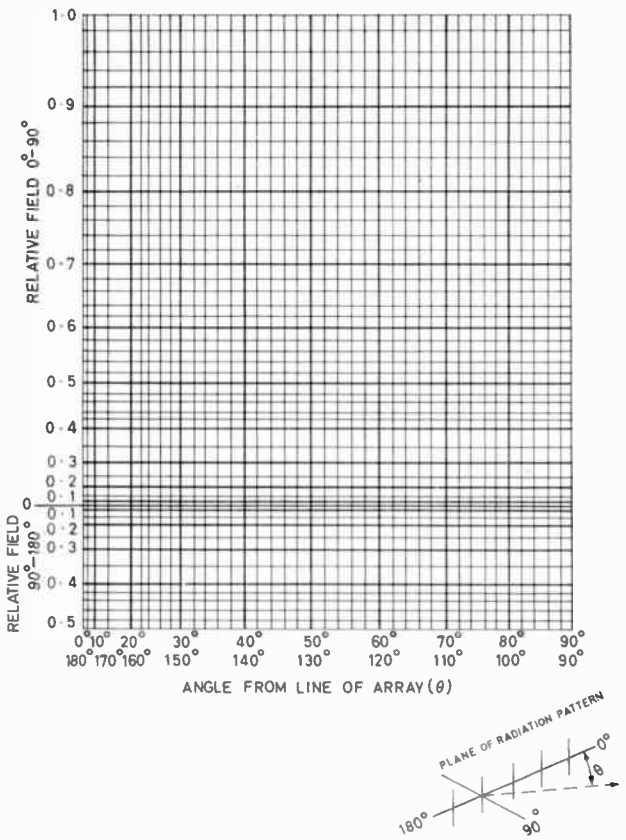


Fig. 2. Radiated power diagram for linear array of half-wave dipoles
The area of the grid above the line marked '0' represents the power radiated by a half-wave dipole between 0° and 90°

equation (3) may be written as:

$$E = \frac{\cos\left((\pi/2)\sin\theta\,\sin\phi\right)}{(1-\sin^2\theta\,\sin^2\phi)^{\frac{1}{2}}}\,f(\theta) \quad \ldots\ldots \quad (4)$$

From equation (2):

$$1/G_D = 1{\cdot}64/4\pi \int_s E^2 ds = 1{\cdot}64/4\pi \int_{\theta=0}^{\theta=\pi}\int_{\phi=0}^{\phi=2\pi} E^2 \sin\theta\, d\theta\, d\phi$$

$$= \int_0^{\pi} f^2(\theta)\, g(\theta)\, \sin\theta\, d\theta \quad \ldots\ldots\ldots \quad (5)$$

where:

$$g(\theta) = 1{\cdot}64/4\pi \int_0^{2\pi} \frac{\cos^2(\pi/2)\,\sin\theta\,\sin\phi)}{1-\sin^2\theta\,\sin^2\phi}\, d\phi \quad \ldots\ldots \quad (6)$$

The function $g(\theta)\sin\theta$ has been derived graphically and the results are given in Table 1.

For values of θ greater than 90° the tabulated values for $180° - \theta$ are used.

The total power radiated by the array may be derived by graphical integration of expression (5). A special form of graph paper, which is shown in Fig. 2, has been designed for this purpose.

The ordinate scale in Fig. 2 is proportional to $f^2(\theta)$ but is marked with values of $f(\theta)$, and the abscissa intervals are proportional to $g(\theta)\sin\theta$. The function $f(\theta)$, which is the H-plane radiation pattern of the array, can be plotted directly on to the graph paper.

TABLE 1

θ	$g(\theta)\sin\theta$	θ	$g(\theta)\sin\theta$	θ	$g(\theta)\sin\theta$	θ	$g(\theta)\sin\theta$
0	0	25	0·305	50	0·399	75	0·375
5	0·071	30	0·340	55	0·399	80	0·370
10	0·140	35	0·366	60	0·395	85	0·368
15	0·203	40	0·385	65	0·389	90	0·366
20	0·258	45	0·396	70	0·381		

Since the field radiated in the backwards direction between 90° and 180° is usually small compared with the forward field, the part of the graph paper which would correspond to large backward fields is not required. For convenience, therefore, the remaining part of the graph paper required for backward field is inverted and appears below the graph for the forward field. The total power radiated is thus proportional to the area between the curves for the forward and backward fields; a planimeter has been found both convenient and accurate for this measurement. The corresponding total power radiated by a half-wave dipole is proportional to twice the area of the grid above the line marked '0'. The ratio of the two areas gives the power gain of the aerial.

The gain calculated by this method is exact for a linear array of half-wave dipoles where all the dipoles lie in a single plane; the accuracy is also high for arrays with elements nearly a half-wavelength long, such as Yagi aerials. The method is not applicable to arrays comprising elements appreciably longer than a half-wavelength, to arrays where the mid-points of elements do not lie on the same axis (e.g., double-Yagis, or Yagis with multi-rod elements), or to arrays with curved screen reflectors or small planar rectangular screen reflectors. It may, however, be used for aerials with plane reflectors larger than 2λ square, because the dipole images can then be regarded as part of the array.

The Gain of an Aerial with Cylindrical Symmetry

Consider an aerial at the origin of Fig. 1 radiating symmetrically about the z axis. The radiation pattern of such an aerial may be written:

$$E = f(\theta) \quad \ldots\ldots\ldots\ldots\ldots \quad (7)$$

where $f(\theta)$ is assumed to be normalized to a maximum

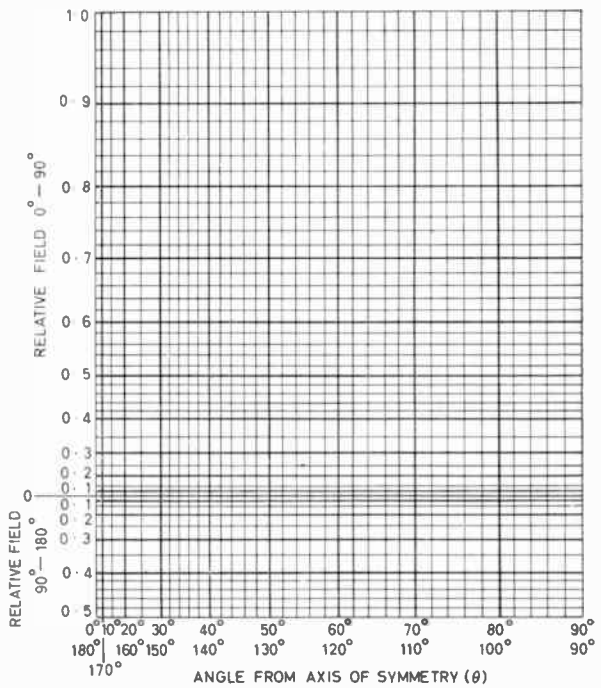


Fig. 3. Radiated power diagram for cylindrically symmetrical aerial
The area of the grid above the line marked '0' represents the power radiated by an isotropic source between 0° and 90°

value of unity. The integral in equation (1) then becomes:

$$\int_0^{\pi} f^2(\theta) \sin\theta \, d\theta \quad \ldots\ldots\ldots\ldots\ldots \quad (8)$$

for all values of ϕ.

This integration may be performed by plotting $f(\theta)$ on the graph paper shown in Fig. 3 and by measuring the area under the curve. The power radiated by an isotropic source may be found by putting $f(\theta) = 1$, in other words, by measuring twice the area of the grid above the line marked '0'. The ratio of the two areas gives the power gain of the aerial relative to an isotropic source; the gain relative to a half-wave dipole is then found by dividing by 1·64. The graph paper is similar to that described in the previous section, except that the abscissa intervals are proportional to $\sin\theta$. The part of the graph which corresponds to backward field is again inverted, and appears below the graph for the forward field.

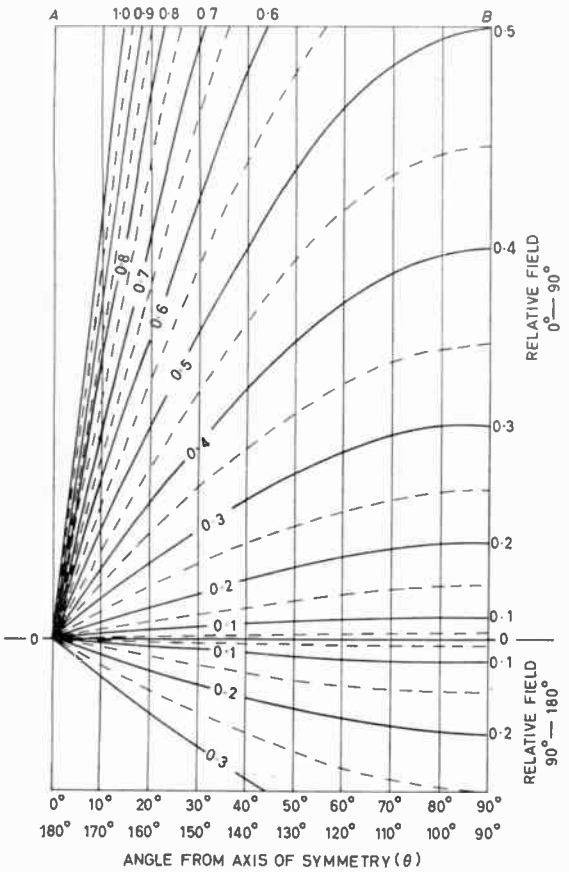


Fig. 4. Radiated power diagram for cylindrically symmetrical unidirectional aerial

The area of the grid above the line marked '0-0' (00AB) represents 0·322 of the total power radiated by a half-wave dipole

If the aerial under consideration has a narrow main lobe and a high gain, the area under the curve drawn on Fig. 3 may be difficult to measure accurately in relation to the area for an isotropic source. For this reason a different form of graph paper has been produced which takes advantage of the fact that most of the field is confined to a narrow range of angles about the angle $\theta = 0°$; this graph paper is shown in Fig. 4. It has a linear abscissa scale for θ and an ordinate scale which is effectively $f^2(\theta) \sin\theta$; however, lines in the form of sine curves, labelled for values of $f(\theta)$, facilitate direct plotting. The radiation pattern of the array is plotted by entering the relative field strength on the right-hand scale, and proceeding along the appropriate curve to the corresponding value of θ. The area under the resultant curve is then measured. The corresponding area for an isotopic source is represented by the area under the same type of curve for $f(\theta) = 1$. Only part of this curve is present, but there is a relationship stated on the diagram between the area of the grid and the corresponding area for a half-wave dipole. As before, the part of the graph which corresponds to the backward field is inverted and appears below the graph for the forward field.

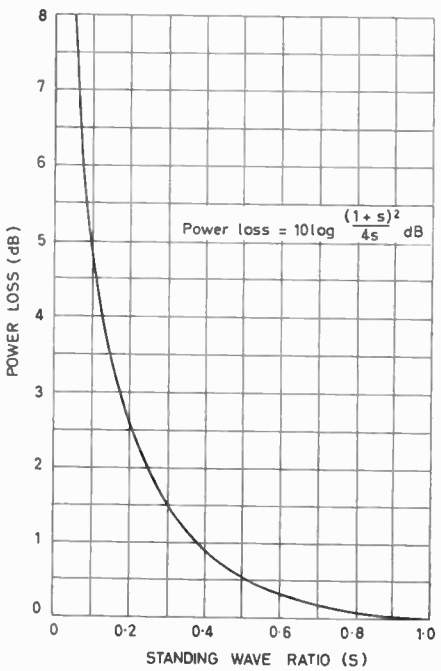


Fig. 5. Power loss due to mismatch

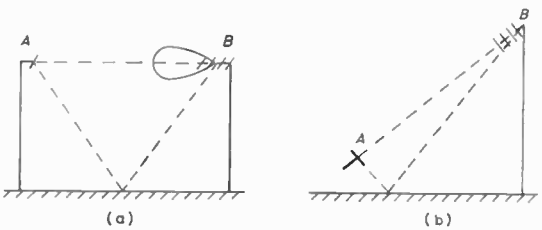


Fig. 6. Two methods of measuring aerial gain by comparison with a half-wave dipole

(a) represents the position of the dipole or the aerial under test
(b) represents the position of the fixed aerial

Applications

It has been shown how the gain of a single planar Yagi aerial may be obtained by plotting its H-plane radiation pattern on a suitable graph paper (Fig. 2). If the radiation pattern is correct the calculation of gain will be exact. It should be noted, however, that this paper cannot be used for multiple arrays of Yagi aerials. Although other types of special paper could be produced to deal with such arrays it is not convenient to do this, because a different paper would have to be used for each spacing between the Yagi aerials. Use may, however, be made of the alternative papers described in the previous section. Although these papers are strictly applicable only to aerials with perfect cylindrical symmetry, which are rarely met in practice, they may also be used for other aerials for which equivalent cylindrically-symmetrical radiation patterns can be found. This equivalent pattern, $f(\theta)$, is determined by calculating the root mean square of values

of $f(\theta)$ for radiation patterns measured in all planes containing the axis 0z. In practice, however, the number of patterns required to be measured depends upon the type of aerial, and in some cases it is sufficient to make measurements only in the E- and H-planes.

It should also be noted that the graph paper shown in Fig. 3 is also applicable to the calculation of the gain of an omni-directional transmitting aerial from its vertical radiation pattern.

In making H-plane radiation measurements with all types of aerials care has to be exercised to minimize re-radiation from the aerial down-lead. The presence of such radiation can be detected by comparing the front-to-back ratios of the E- and H-plane radiation patterns. The two ratios should, of course, be identical.

In any practical aerial system there may be loss due to a mismatch between the aerial and its feeder. This loss, which is shown plotted as a function of standing wave ratio in Fig. 5, should be subtracted from the aerial gain derived from the radiation patterns to give the effective gain of the aerial.

Measurement of Aerial Gain by Direct Comparison with a Half-Wave Dipole

The gain of an aerial relative to a half-wave dipole may be measured by observing the increase in signal strength which occurs when it replaces the dipole. Ideally this measurement should be carried out under free space conditions because ground reflections may give rise to errors. Recommendations for performing the measurement are given in a paper[1] published by the C.E.I. This gives in detail the precautions which are necessary for the minimization of errors due to site irregularities and instability of equipment. The methods given in this section do not include all the recommendations made by the C.E.I. but they include some of the essential practical aspects.

For the measurement a fixed aerial B, Fig. 6(a), is connected to a signal generator. A half-wave dipole is mounted at A and connected to a receiver; the dipole is then replaced by the aerial under test and the increase in received signal level noted. Corrections are then applied to allow for feeder attenuation and mismatch loss. In order that the mismatch losses may be predicted, the feeders to both aerials must have identical characteristic impedances and the receiver must be perfectly matched to the feeders*. Mismatch can then only occur between the feeders and the aerials themselves. The losses may be determined by measuring the standing wave ratios on the feeders and referring to Fig. 5. It should be noted that the gain measurement will tend to be more accurate if the aerials are reasonably well matched, since the mismatch losses are more difficult to assess accurately when the standing wave ratios are small.

The gain of the aerial under test is then found as follows:

Let the increase in signal level which occurs when the dipole is replaced by the aerial under test $= A$ dB
the attenuation loss in the feeder to the dipole $= B$ dB
the attenuation loss in the feeder to the aerial under test $= C$ dB
the loss due to mismatch of the dipole (see Fig. 5) $= D$ dB
the loss due to mismatch of the aerial under test (see Fig. 5) $= E$ dB

Then the intrinsic gain of the aerial under test, which should be equal to the gain calculated from radiation patterns is:

$$A - B + C - D + E \text{ dB}$$

The effective gain of the aerial is:

$$A - B + C - D \quad \text{dB}$$

It should be noted that the effective gain of the aerial depends on the characteristic impedance of the feeder to which it is connected. It is therefore preferable to perform the measurement using the type of feeder for which the aerial is intended; if this is not possible an appropriate correction must be made.

The effects of ground-reflected waves can be minimized in several ways. By making use of zeros in the radiation patterns of aerials A or B the reception of ground-reflected waves can be avoided altogether. Two ways of achieving this are shown in Fig. 6.

Fig. 6(a) shows how a high-gain fixed aerial B with negligible side lobes may be mounted at such a height that the ground-reflected wave corresponds with directions outside its main lobe, and is therefore small. This condition, however, may require the aerials to be mounted at an inconvenient height.

Fig. 6(b) shows an arrangement of aerials which can be used when the aerial under test A does not radiate in the E plane at right-angles to its direction of maximum radiation. Reception of the ground-reflected wave can then be avoided. With this arrangement the aerial under test and the dipole are usually at a more convenient height above the ground. Heights of the order of a wavelength or less should be avoided, however, because mutual impedance with its image in the ground may affect the impedance of an aerial significantly.

Alternatively, the aerials can be so mounted that the aerial under test receives equally from the directions of the direct and ground-reflected waves. The dipole will also receive equally from these directions for either plane of polarization provided that the aerials A and B are sufficiently far apart. If this procedure is adopted, the geometrical arrangement should ensure that the two waves are approximately in phase, i.e., by adjusting the relative heights to give maximum pick-up. For horizontally-polarized waves the reflection coefficient of moist ground is close to -1 in the v.h.f. and u.h.f. bands, and the direct and reflected paths should therefore differ by about a half-wavelength or an odd multiple thereof. A difficulty with the method is that the aerial under test may have a very narrow beamwidth so that the required conditions may be met only when the aerials are so far apart that reflections from site irregularities and obstacles cause measurement errors.

In all measurements the aerials A and B should be at least ten wavelengths apart, or ten times the largest dimension of the aerial under test, whichever is the greater. Care should be exercised to minimize re-radiation from masts and downleads.

Acknowledgments

The author wishes to thank the Director of Engineering of the British Broadcasting Corporation for permission to publish this article. He also wishes to acknowledge the contributions to the work made by his colleagues in the BBC Research Department. In particular, Mr. G. D. Monteath was responsible for the early work in producing the graph papers shown in Figs. 1 and 2.

* *This may conveniently be substantially accomplished by connecting a 10dB attenuator between the aerial feeder and the receiver. The characteristic impedance of this attenuator must be the same as that of the aerial feeder.*

REFERENCE

1. Methods of Measurement of Essential Electrical Properties of Receiving Aerials in the Frequency Range from 30Mc/s to 1000Mc/s. Commission Electrotechnique Internationale, Publication 138 (1962).

Application of a Repetitive Function Synthesizer
to generation of very low frequency signals and noise

By J. R. James*, A.M.Brit.I.R.E., M.I.E.E.E., and M. H. N. Potok*, M.A., B.Sc., Ph.D.

The flexibility of a repetitive function synthesizer which has previously been described makes it a very useful instrument for testing systems and components with very low frequency arbitrary signals and noise.

The assessment of the equipment from this standpoint, suggests the evolution of a most versatile and compact general test instrument for servomechanisms and analogue computers.

(Voir page 62 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 69)

THE purpose of the repetitive function synthesizer[1] (hereafter referred to as synthesizer) is to perform quickly a Fourier analysis on any arbitrary repetitive function. Since the method involves the synthesis of the function as a repetitive function of time, the synthesizer can be used as a waveform generator. There is no lower limit to the repetition frequency of the generated waveform and the present model has an upper limit of about 1·3kc/s due to the use of low frequency transistors.

The fact that sine, square and sawtooth waveforms can be accurately generated at any frequency lower than 1·3kc/s makes it a versatile function generator. In addition to this the freedom of waveshape extends its usefulness to analogue computing and noise testing of servomechanisms.

Before discussing these topics a résumé of the operation of the synthesizer will be given to clarify and emphasize the aspects which are relevant to the field of servomechanisms.

Résumé of the Operation of Synthesizer

A diagram of the synthesizer, Fig. 1, shows some of the fifty binary transistor stages which are connected in a ring and act as switches in series with the potentiometers. Only one switch is closed at any one instant and the application of a clock pulse causes the switch which is closed to open and the adjacent switch to close. By applying a train of clock pulses the ring acts as a rotary switch causing the slider voltage of each potentiometer in turn to be gated through the diodes to the load R_L. Thus by suitably adjusting the potentiometers any arbitrary waveform can be generated across R_L. The following features are important for servomechanism applications.

(a) The amplitude and d.c. level of any waveform is very stable over a period of several hours. This is to be expected since the waveform is not generated by oscillatory action (i.e. *RC* oscillators or analogue methods). The instrument has been designed to be fairly free from drift due to transistor leakage[1]. However the other transistor parameters can still vary with temperature. Temperature tests over a range of 0°C to 50°C show that there is slight drift at the high end of the range. This elevated temperature is considered unreasonably high for most laboratory applications but the stability could no doubt be improved by using silicon transistors.

(b) There is no lower frequency limit (e.g. periods of one cycle a day are feasible).

(c) From the principle of operation it is easily seen that the amplitude and d.c. level of a waveform do not vary with frequency. This is a considerable advantage when measuring a transfer function at various frequencies. (At frequencies in excess of 200c/s the clock pulse breakthrough on to the waveform may cause slight inaccuracies in this respect but this is out of the range of most servomechanism applications.)

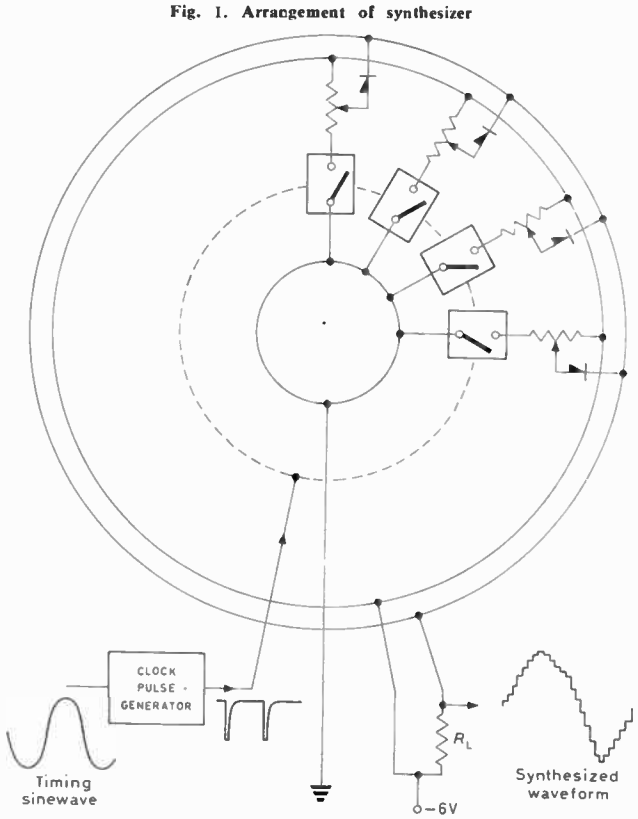
(d) The amplitude of the synthesized waveform produced by the ring of binary stages is of the order of 3V peak-to-peak. In the synthesizer it is amplified by a d.c. amplifier to about 100V fixed or 20V variable. It is the latter output which is used in the experiments of the next section.

Performance of Synthesizer as a Function Generator

Existing function generators are expensive and bulky because of their complexity and usually only cover a limited range. From the points already mentioned it seems that the synthesizer has every advantage.

The fact that for every waveform, fifty potentiometers have to be set up is not considered a disadvantage. This takes about five minutes which is short compared with the usual time for servo measurement. The setting up could be speeded up by using a digital voltmeter. As an

Fig. 1. Arrangement of synthesizer



* *Royal Military College of Science.*

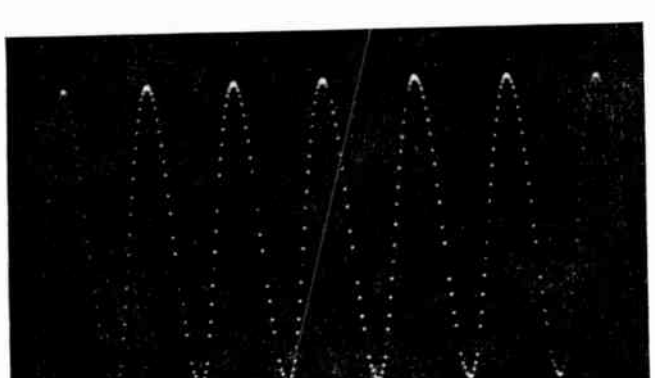


Fig. 2. Synthesized 100c/s sine wave

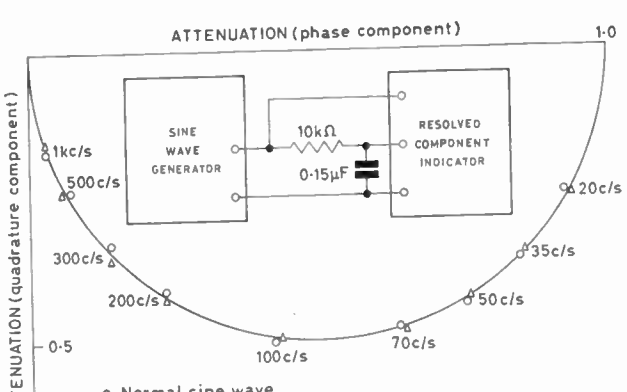


Fig. 3. Circle diagram plot usiog synthesized waveform

additional refinement a spare set of potentiometers could be incorporated within the instrument so that the operator could switch from one preset waveshape to another preset waveshape and back without having to readjust the potentiometers each time.

The accuracy of synthesis of a variety of waveshapes is described elsewhere[1]. A synthesized sine wave is shown in Fig. 2 and its spectrum in Table 1 at 100c/s. The sine wave compares favourably with one generated from a high quality signal generator except that the level of the higher order harmonics is greater. This is of course produced by the small steps on the waveform and it is desirable to find out if this will interfere with any measurements. This will be dealt with in the next experiments where this synthesized sine wave is used.

TABLE 1
Spectrum of 100c/s Synthesized Sine Wave

HARMONIC NUMBER	DECIBELS
1	0
2	60
3	50
4	53
5	58
6	50
7	53
8	51
9	55
10	56

Compatibility of Synthesized Sine Wave and Resolved Component Indicator

A 0·15μF capacitor and 10kΩ resistor were used to simulate a simple lag system and the circle diagram was measured from 20c/s to 1kc/s using a standard sine wave generator and the Solartron resolved component indicator type VP250. The sine wave generator was then replaced by the synthesizer and the experiment repeated. The results, Fig. 3, show that there is no perceptible difference and therefore the presence of the higher order harmonics does not upset the measurement.

Measurement of a Servomechanism

The response, Fig. 4(a), of a basic position control servomechanism with velocity feedback, Fig. 4(b), was measured from 0·4c/s to 10c/s using a Short control system analyser MkI. The system is seen to be second order. The response of the system to the synthesized sine wave was observed using a Lissajous figure. At frequencies over the previous range the Lissajous figure due to the synthesized sine wave was identical to that obtained using a normal smooth sine wave. At the higher frequencies the system distorted the output response but these effects were independent of type of sine wave (synthesized or normal) being used. It is therefore concluded that the higher frequency components of the synthesized sine wave do not interfere with the above measurement. It could be said that the synthesis produces a noise effect at discrete harmonically related frequencies (no particular component being in excess of −50dB which is indeed very small).

Application to Analogue Computing

Since any desired waveshape may be generated using the synthesizer it has obvious applications to analogue computing. A typical third order linear system was set up on a Solartron MiniSpace computer, Fig. 5(a), and a synthesized triangular waveform was used as a signal. The output response and signal was recorded using a pen recorder Fig. 5(b). It is seen that the small steps on the signal do not appear in the response and act as high frequency noise. The frequency of the signal was near to the resonant frequency of the system.

Use of Synthesizer for More General Tests

The above experiments show that the synthesizer does in fact perform all the functions of a conventional function generator. Some additional features of the synthesizer will now be discussed.

Application to Non-Linear Systems

The variety of waveshapes which are available may be an advantage when testing non-linear systems. The non-linearities usually distort the output response to such an extent that it is no longer a recognizable function of time and very often it is necessary to perform a Fourier analysis on this distorted response. It is in this respect that the synthesizer can be used to a definite advantage to perform this analysis in a rapid manner[1].

Superposition of Noise on Signals

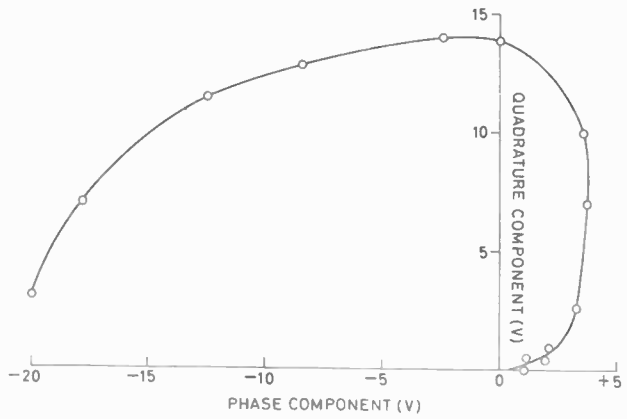
It is possible to simulate the effect of a signal in the presence of noise when setting up the synthesizer. This is demonstrated using a sine wave synthesis, Fig. 6(a). The presence of noise could also be limited to certain parts of the signal as in Fig. 6(b). The nature of this noise is of course somewhat limited.

Synthesizer as a Noise Generator

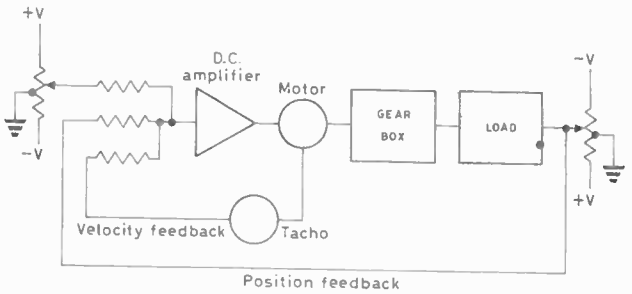
There appears to be considerable interest in the use of white noise for testing servomechanisms. Noise generators have been produced that cover the range 0 to 10c/s but there is some doubt as to the useful lower limit of this type of instrument.

It has been found possible to synthesize noise using the synthesizer and the advantage of this method would seem to be once again that there is no lower frequency limit.

An experiment was set up to demonstrate this principle and the block diagram is shown in Fig. 7. The pulse



(a)



(b)

Fig. 4(a). Frequency response of position control servo with velocity feedback
(b). The servo tested

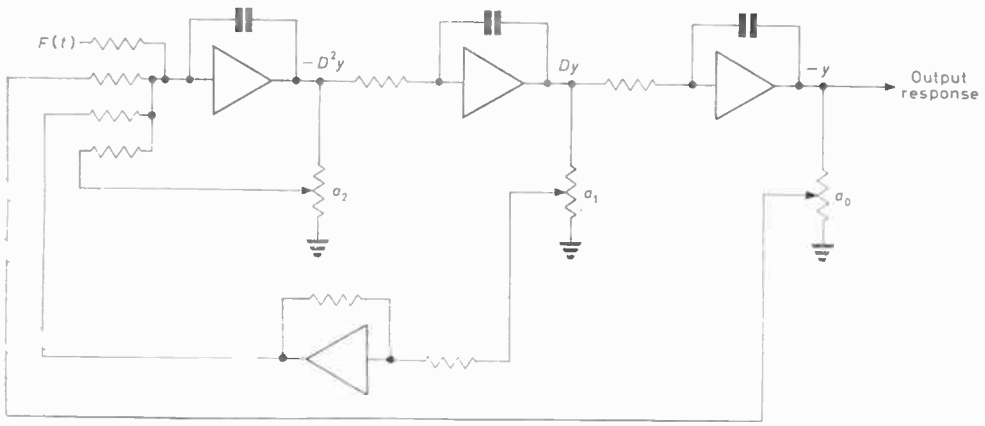
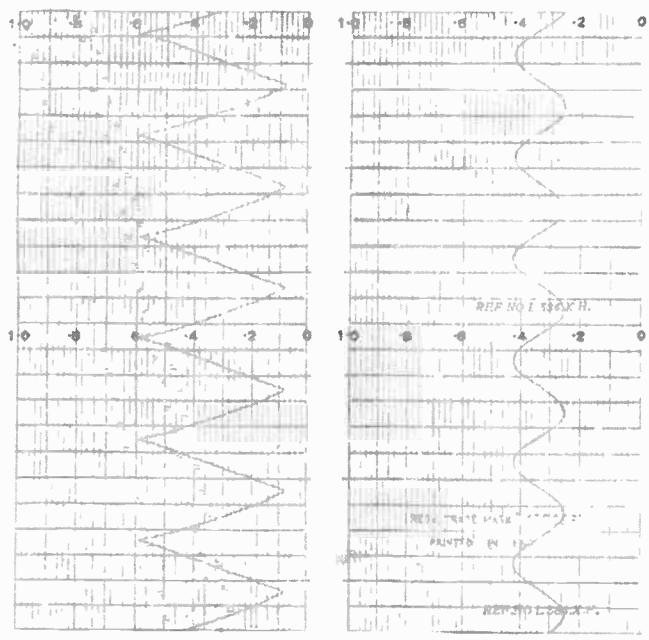


Fig. 5(a). Third order computer programme



(b). Response to a synthesized triangular wave

generators are triggered from two low frequency thyratron noise sources. The amplitude of noise fed to Generator 1 is such that the effective triggering pulses are incident at about 40kc/s on the average. By reducing the noise fed to Generator 2 it can be triggered at a very low rate (i.e. on the average a fraction of 1c/s or lower. For very low frequency triggering a more sophisticated random source would no doubt have to be used, such as two noise generators feeding a coincidence amplifier).

The two random pulse trains from the generators are fed to a gating circuit so that 1 is gated by 2. The resulting output is fed to the synthesizer and consists of random bursts of random pulses. If the burst of pulses is greatly in excess of 50 then the relative position of the last binary stage to be actuated, with respect to the other fifty, varies in a random manner with each burst. If the synthesizer has been set up to synthesize a sawtooth waveform whose amplitude is 5V say, then each step represents an increment of 0·1V. It follows that the application of this random pulse train to the synthesizer will produce an output which varies in a random manner with time and whose amplitude varies in discrete steps of 0·1V between two limits in a random fashion. The mean and r.m.s. value of this noise output is that of the original sawtooth. Thus by setting up on different single valued waveshapes such as the sawtooth, various r.m.s. values of noise can be obtained.

The results of the above experiment are shown in Figs. 8(a), (b), (c), and (d) where the noise output in (c) and (d) has been set up to have a lower r.m.s. value than in (a) and (b). The length of each trace is about 10sec being the slowest time-base of the oscilloscope. To make the photographs clearer some filtering was applied to the noise output in (b) and (d) to remove the high frequency sweeping effect of the bursts of pulses. The sloping tops of the pulses are caused by the oscilloscope. In (c) and (e) even greater filtering was used so that the leading edges could be seen. The noise output in (b) and (d) has been slowed down by reducing the level of triggering noise controlling generator 2.

Since the present synthesizer cannot be triggered above a rate of 50 × 1·3kc/s it follows that randomness of amplitude of the above process falls off at higher rates

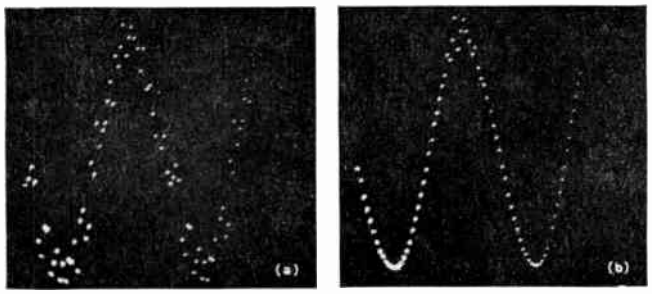


Fig. 6(a). Synthesized sine wave in presence of noise
(b). Synthesized sine wave with noise on crest

(> 5c/s) of burst incidence. (Since the burst width and hence the randomness is limited by the incidence of bursts.) However noise at these frequencies can be generated fairly easily and it is the very low frequencies which are of interest. As the burst rate is reduced the burst width can of course be increased and so it follows that the randomness of amplitude selection improves rapidly with decreasing burst rate.

At burst rates below 1c/s the process should be random enough to qualify as white noise. Power spectra measurements would be extremely involved at these frequencies and no attempt was made to check the above statement. However the following points tend to substantiate it. First there is no cross-correlation between the two noise sources and second there should be very little autocorrelation in amplitude selection, at burst rates of about 1c/s. (If the burst width is one-fifth of a second and the pulses in the burst incident at about 40kc/s then the sawtooth waveform will be swept about 160 times and the selection of the final step should be quite random. The randomness could be calculated using the measured probability function for incident pulses in a burst and summing this over the associated number of sweeps, but it is considered that the application does not justify it.)

The above experiment illustrates the possibility of producing white noise at very low frequencies. White noise below 1c/s would have limited application in servo tests and would be confined mainly to hydraulic systems. However such a noise generator is no doubt of interest if only as a specialized piece of equipment.

It is thought that the above method of producing white noise may also be of interest to other fields, such as testing of trigger circuits, generation of random numbers which are random with time, etc. The latter could easily be done by using a digital read-out.

Conclusions

The above discussion and tests confirm that the repetitive function synthesizer has definite applications as a test instrument in the field of servomechanisms.

In the present synthesizer the timing oscillator frequency is 50 times that of the generated waveform. Thus to achieve an output periodic at 0·001c/s the timing oscillator would be 0·05c/s. Since the timing waveform need not be sinusoidal this is easily achieved with a *CR* type oscillator. The method of synthesis applied to function generators, therefore simplifies the timing procedure.

Using the synthesis principle, a function generator could be developed which would be much more versatile than existing generators. The salient features would be:

(a) Complete freedom of waveshape.

(b) No lower frequency limit.

(c) Constant output with varying frequency.

(d) No expensive or bulky components. The equipment could be completely transistorized.

On the other hand these features could be embraced in a more involved instrument with the additional facilities.

(a) Digital read-out from binary stages for rapid setting up.

(b) Built in spectrum analyser for use on non-linear servomechanisms.

(c) Built-in gated pulse generator and noise sources to enable very low frequency white noise to be synthesized.

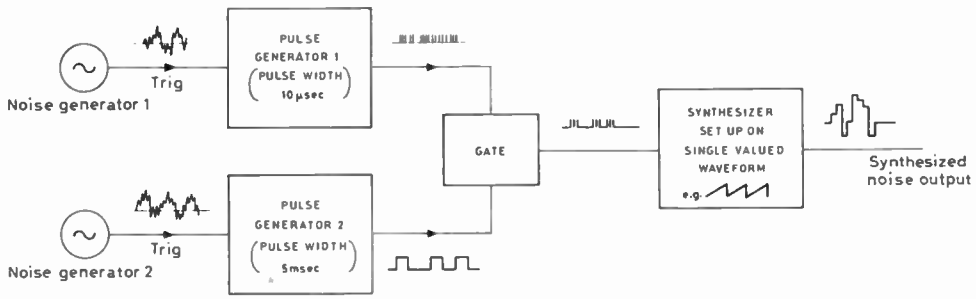
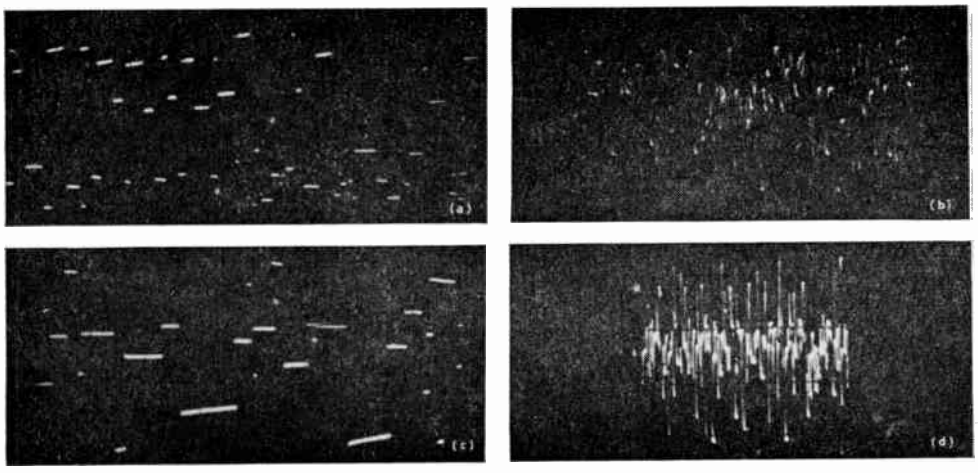


Fig. 7. Noise synthesizing circuit

Fig. 8. Synthesized very low frequency noise
The noise output in (c) and (d) has been set to have a lower r.m.s. value than in (a) and (b)



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Applications of a Gate Controlled Switch in D.C. Power Circuits

(Part 1)

By M. J. Wright*, B.Sc.

The Gate Controlled Switch is a silicon controlled rectifier which can be turned both 'on' and 'off' at the gate terminal. This facility makes the device particularly suitable for high power switching and control in d.c. energized circuits.

An equivalent circuit is presented which explains the features of importance in circuit design. The main applications considered are: (a) Triggered and free running pulse generators; (b) D.C. power amplifiers; (c) D.C. voltage regulators; (d) Speed control of d.c. electric motors (e) Voltage control of rotary generators.

Many of the high power circuits described are simpler than the corresponding transistor circuits at low power levels.

(Voir page 63 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 70)

ONE of the most recent solid state devices to become available to the engineer is a Gate Controlled Switch (abbreviation g.c.s.)—a silicon controlled rectifier which can be switched both 'on' and 'off' at the gate terminal. The 'gate turn-off' facility enables a single high voltage device to control high powers in d.c. circuits.

Characteristics of a Gate Controlled Switch

A pnp/npn combination of transistors is commonly used as an equivalent circuit to explain the characteristics of silicon controlled rectifiers. The addition of three components, two resistors and a Zener diode, as shown in Fig.

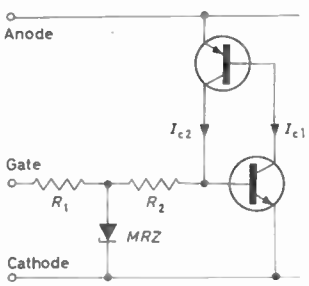


Fig. 1. S.C.R. equivalent circuit

1, conveys a clearer picture, particularly regarding gate-to-cathode characteristics. In terms of this equivalent circuit, properties of controlled rectifiers which are of importance in the design of d.c. circuits are as follows:

(1) The normal s.c.r. does not turn off on applying a short-circuit (or low resistance connexion) between gate and cathode terminals. The internal resistors R_1 and R_2 prevent the short-circuit from being established across the base-emitter junction of the npn transistor.

(2) Whether the rectifier is conducting or not, the gate-to-cathode resistance is low when the gate is forward biased (i.e. positive with respect to the cathode). Forward gate-to-cathode voltages of a few volts are not necessarily damaging since the resistors in series with the junction limit the current flow.

(3) When the rectifier is non-conducting, the input resistance is high if the gate is a few volts negative with respect to the cathode. If this voltage is increased, a low slope resistance is eventually obtained due to avalanche breakdown (Zener diode *MRZ*). Reverse gate to cathode voltages exceeding this avalanche voltage should not be applied except perhaps for very short times during turn-off.

If the s.c.r. is conducting, the reverse gate to cathode resistance is low (resistors R_1 and R_2 in series with the conducting base-emitter diode).

(4) To turn off a controlled rectifier at the gate terminal, sufficient reverse current must be supplied to reduce the base current of the npn transistor to the value which takes the pair out of the saturated condition. However, this reverse current is limited to the value I_{GM} where

$$I_{GM} = \frac{\text{Breakdown voltage of } MRZ}{\text{Value of resistor } R_2}$$

Thus, any controlled rectifier can be turned off at the gate, but low values of current I_{GM} combined with high transistor gains usually restrict to low values the anode current which can be turned off. To manufacture a device having a gate turn off ability at high anode currents one requires:

(a) Low values of series resistance R_2.

(b) A low loop gain for the two transistors at the operating current. The gain must, of course, equal or exceed unity for the device to hold on.

(c) A gate to cathode avalanche breakdown voltage which allows the required turn off current to flow.

(5) A positive gate current will decrease the 'holding current' of the rectifier, while a negative gate current will increase the ho'ding current.

(6) The gate current required to fire a particular rectifier is a function of the anode to cathode voltage and of temperature. It is relatively independent of the load resistance.

The gate current and gate voltage required to turn off a g.c.s. increase as the anode current increases. Typical values are 250mA at 6V to turn off 5A anode current. The gate current and gate voltage required will also increase slightly with junction temperature and anode voltage.

(7) The leakage current between anode and cathode can be decreased by connecting a resistor, 100 to 1 000Ω in value, between gate and cathode. This prevents the collector leakage current of the pnp

* *Joseph Lucas Ltd.*

transistor from being amplified by the npn transistor. The external resistor can also increase the forward anode to cathode breakover voltage.

(8) An increasingly positive gate voltage applied to a g.c.s. which is non-conducting will produce a progressive increase in 'leakage current' until, at some leakage current value below the holding current, the rectifier triggers on.

An increasingly negative gate voltage applied to a heavily conducting g.c.s. has no effect initially. As the gate current approaches the value required for turn off, the anode current falls slightly and the rectifier is taken out of the fully saturated condition. A further increase in gate voltage turns off the g.c.s. and the gate impedance switches to a high value. A low impedance turn off voltage would thus cause a high gate current to flow only until such time that the g.c.s. turned off.

The existence of these 'transistor action' regions at gating currents below the firing levels should be noted, for they can lead to very high dissipations in circuits using relatively slowly varying gate conditions. Sharp gating pulses, particularly for switch off, will ensure that the transistor action regions are passed through quickly as well as producing fast rise and fall times with minimum delay times. Rise and fall times of the order 1 to 2μsec are obtainable at anode currents of a few amperes.

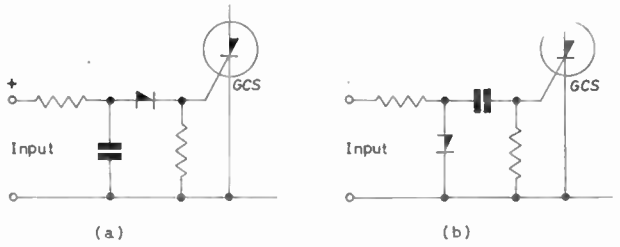


Fig. 2. Four-layer diode firing circuits

Firing Circuits

In applying the g.c.s. to electronic feedback control systems (e.g. constant voltage d.c. power supplies, voltage control of electrical generating machines, speed control of d.c. motors) it will be required to switch the g.c.s. on and off in response to the changes in a low power error signal. The four-layer diode relaxation oscillator, see Fig. 2, is a convenient method of transforming a low current error signal to a suitable power level for firing purposes.

Advantages are:

(1) Fast rise time, high current pulses can be produced from a d.c. input ensuring that the rectifier is switched rapidly between its two stable states.

(2) A continuous gate current of value just below that necessary for firing can never flow.

(3) The oscillator can be arranged to operate from either positive or negative inputs producing output pulses of either polarity.

(4) The arrangement is extremely economical in components. For the pulse generation, the capacitor is the power source and the four-layer diode a high speed switch. However, the capacitor may also serve as a delay element, the four-layer diode determining the voltage at which the capacitor is discharged.

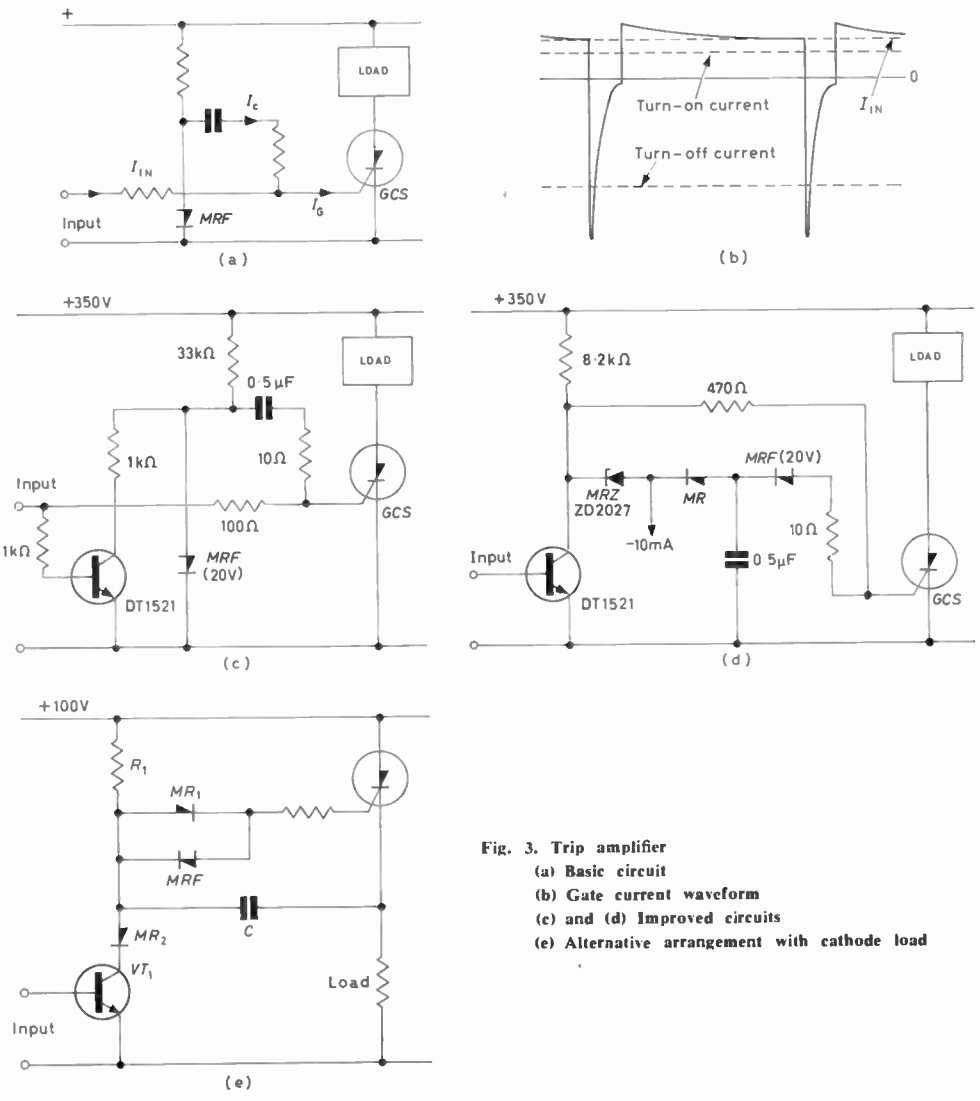


Fig. 3. Trip amplifier
(a) Basic circuit
(b) Gate current waveform
(c) and (d) Improved circuits
(e) Alternative arrangement with cathode load

The four-layer diode circuits shown in Fig. 2 utilize positive input signals to gate the rectifier 'on' (Fig. 2 (a)) or 'off' (Fig. 2(b)). Negative inputs may be utilized by reversing the diodes MRF_1 and MRF_2 in which case Fig. 2(a) would fire the rectifier off and Fig. 2(b) would fire the rectifier on.

The relaxation oscillator of Fig. 2(b) is incorporated

in the high sensitivity trip amplifier firing circuit of Fig. 3(a). High current, negative pulses are continuously applied to the g.c.s. gate to render it non-conducting for short time intervals. When the turn off pulse terminates, the applied positive input signal I_{IN} determines whether the g.c.s. becomes re-conducting, or remains off. If I_{IN} exceeds the forward firing current, the load is energized between turn off pulses, while for values of I_{IN} below the forward gate firing current, the load is completely de-energized. Fig. 3(b) shows the variation of gate current against time for the condition where the applied input current is sufficient to turn on the g.c.s. at the termination of each turn off pulse. For low frequency applications, e.g. where a relay or contactor is the load, the pulse generator could operate at 100c/s switching off the g.c.s. for 100μsec. The g.c.s. would then be conducting for 99 per cent of the time in the circuit energized condition. For inductive loads, a parallel diode would maintain a continuous load current and protect the g.c.s. from induced e.m.f.'s during turn off.

Figs. 3(c) and 3(d) show ways of preventing the turn off pulse generator from operating when a sufficiently positive input signal is applied. Referring to Fig. 3(c), the transistor is non-conducting with zero input signal. The pulse generator is operated and the rectifier is off. A positive input signal of sufficient magnitude energizes the load as before, but, at the same time, causes conduction of the transistor. This prevents the voltage across the four-layer diode from excxeeding approximately 1V and no turn-off pulses are produced. The load is therefore 100 per cent energized.

If a negative supply rail is available, a more sensitive arrangement is possible since the transistor can also amplify the input signal as in Fig. 3(d). For an input signal which saturates the transistor, no forward current is supplied to the g.c.s. gate via the 470Ω resistor. Current from the negative rail operates the relaxation oscillator and the load is de-energized. With no forward base drive applied to the transistor, a positive current of 40mA flows into the g.c.s. gate maintaining it conducting. The potential at the transistor collector terminal is about +20V (40mA flowing through 470Ω). The 27V Zener diode conducts the negative current (10mA) supplied to the circuit and prevents the capacitor from charging. Thus, no turn-off pulses are produced and the load is fully energized. To avoid holding the g.c.s. near its turn on point, the 1mA base current for the transistor can be supplied from a previous earthed emitter transistor stage to which it is directly coupled, base to collector. Direct coupled positive feedback from the collector of the second stage to the base of the first would complete a bistable arrangement. This connexion is used in Fig. 11.

An alternative arrangement is shown in Fig. 3(e). With the transistor non-conducting, application of the h.t. voltage produces a flow of current through resistor R_1 and diode MR_1 to gate the g.c.s. into conduction. Forward gate current then ceases since both cathode and gate of the g.c.s. are now within a volt or so of the potential of the positive rail. Switch off is accomplished by conduction of the transistor which charges the capacitor (left-hand side negative going) until the four layer diode *MRF* switches on to discharge the capacitor via the gate terminal. Diode MR_2 protects the transistor from reverse collector voltages during the discharge of the capacitor. The load remains de-energized providing VT_1 base current is sufficient to maintain such a low voltage across the transistor that negligible current flows to the gate.

Since the circuits of Fig. 3 do not provide sharp firing on pulses to the g.c.s. gate, they are more suited for use with g.c.s.'s of low holding currents and/or when relatively low h.t. voltages are employed.

Two four-layer diodes in parallel can use a common capacitor C to provide sharp gating pulses of either polarity. A positive input signal to the circuit in Fig. 4(a) will charge capacitor C positively until the switching voltage of MRF_1 is reached. The capacitor then discharges via the rectifier gate. For input currents below the holding current of the four-layer diode, pulses are continuously produced. Similarly, a negative input current charges the capacitor until the switching voltage of MRF_2 is reached when a negative pulse is produced at the rectifier gate. Diode MR_1 prevents the reverse voltage rating of diode MRF_1 from being exceeded.

Gating pulses of either polarity are obtained from the same relaxation oscillator by means of the bridge network shown in Fig. 4(b). Components MRF, C and R_1 form the relaxation pulse generator, and R_2, R_3, R_4 and R_5 form the bridge. Charging current for capacitor C flows via resistor R_1 and diode MR_1 until the diode *MRF* switches to its low impedance condition. During the charging time, no current flows in the bridge resistors and the rectifier gate is connected to its cathode via the low resistance bridge. When diode *MRF* conducts, the charged capacitor is connected across one diagonal of the bridge such that the junction of R_2 and R_4 is negative with respect to earth and the junction of R_3 and R_5 is positive with respect to

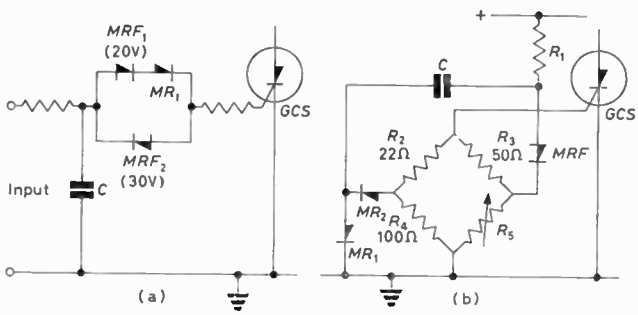


Fig. 4. Positive and negative gating pulse generators

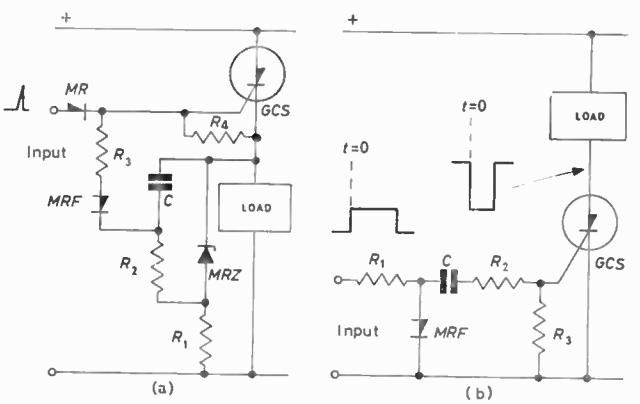
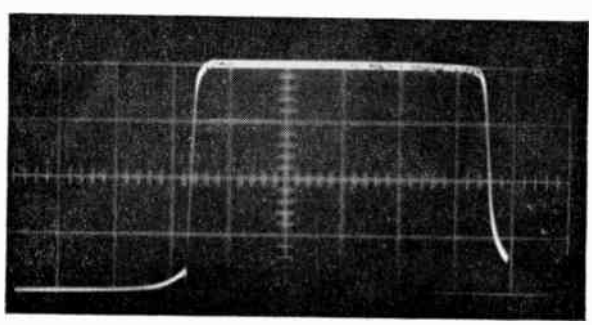


Fig. 5. Triggered pulse generators and (below) the waveforms produced by (b)



earth, and the capacitor discharges. The output of the bridge drives the rectifier gate positive if R_5 is high in value and negative if R_5 is low in value. If the resistor R_5 is the collector-emitter path of an earthed emitter npn transistor, the controlled rectifier is gated on when the transistor is biased off and will be gated off when the transistor is driven into heavy conduction.

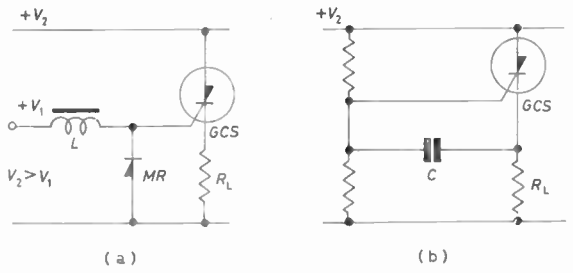


Fig. 6. Simple free running pulse generators

Triggered Pulse Generators

Figs. 5(a) and 5(b) show triggered pulse generators which are switched on by the positive leading edge of the trigger pulse and are switched off by a capacitor discharge into the gate terminal. Referring to Fig. 5(a), the positive input pulse is fed to the g.c.s. gate via diode *MR*. The trigger pulse must deliver a current I_{ON} at a voltage V where:

I_{ON} = Gate current required to turn on the g.c.s.

$V = R_L . I_H + V_F + V_1$

R_L is the load resistance

I_H is the rectifier holding current

V_F is the gate to cathode voltage when gate current I_{ON} flows.

V_1 is the forward voltage drop of diode *MR*.

With the g.c.s. conducting, the h.t. voltage across the load takes the Zener diode *MRZ* into conduction. The stabilized voltage across the Zener diode charges capacitor *C* via resistor R_2. When the voltage across the capacitor reaches the switching voltage of the forward biased diode *MRF*, the capacitor *C* discharges via the rectifier gate terminal switching off the g.c.s. and terminating the output pulse. The circuit resets in the time taken for the capacitor discharge current to fall below the holding current of the four-layer diode. A resistor R_4 between the rectifier gate and cathode ensures:

(1) No false firing of the rectifier at high temperatures due to its own leakage currents.

(2) The capacitor discharges fully even though the gate-cathode impedance is high once the rectifier has turned off.

If the power supply is stabilized or if an accurate pulse width is not necessary, components *MRZ* and R_1 may be omitted, the lower end of R_2 being earthed. Compared with transistor or s.c.r. high power monostable arrangements the circuit is exceedingly simple. Other features are:

(1) Fast rise and fall times are obtained.

(2) Trigger sensitivity is high compared with the output power which may be switched.

(3) Power efficiency is high both in the 'circuit triggered' and quiescent conditions.

(4) A wide range of delay times is obtainable. In particular, delay times of several seconds are easily achieved.

(5) The reset time is short.

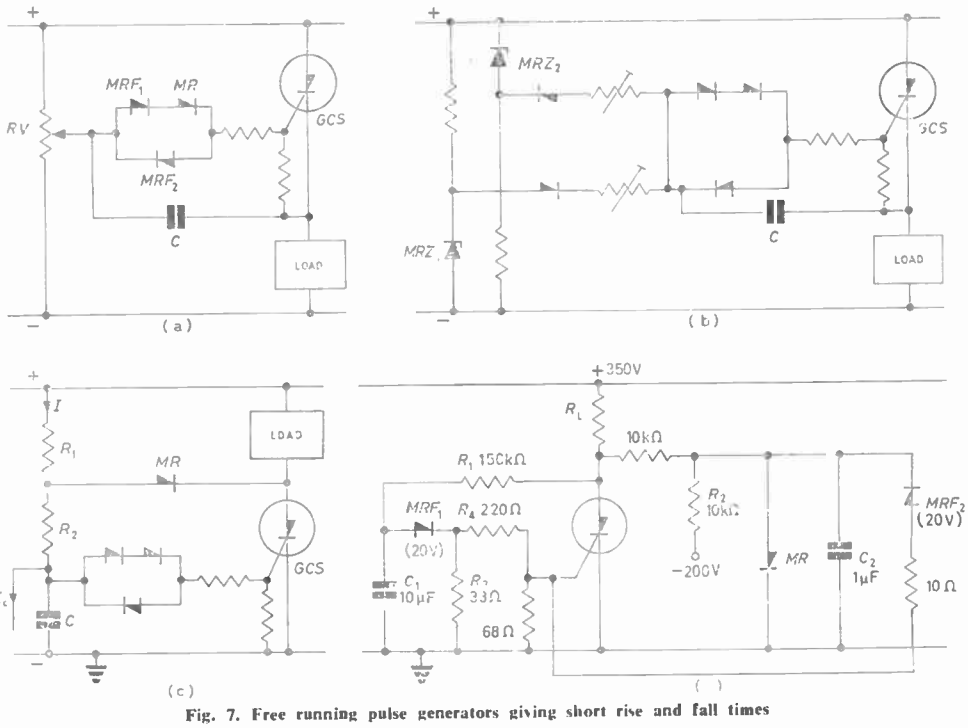


Fig. 7. Free running pulse generators giving short rise and fall times

Triggering this circuit from a separate free-running relaxation oscillator produces a free-running rectangular pulse generator of easily varied frequency and pulse width.

In the circuit of Fig. 5(a), and in a number that follow, the charging current for the capacitor need not necessarily be below the four-layer diode holding current. The turn off pulse de-energizes the load so removing the source of holding current for the diode. It is nevertheless a good design policy to keep the charging current below the diode holding current. This ensures that a temporary circuit fault or overload does not leave the circuit permanently energized: the turn-off pulse generator continues to apply pulses until the g.c.s. does turn off and control its regained.

The circuit of Fig. 5(b) is particularly suitable for direct coupling to a transistor multivibrator. The rectifier is gated on during one change of state of the multivibrator and is gated off before the next change of state by capacitor discharge. The positive input voltage step causes a current flow via R_1, *C*, R_2 and the gate of the g.c.s. This current must exceed the firing current and switches the g.c.s. on. The continued flow of input current charges capacitor *C* until the voltage across diode *MRF* renders the latter conducting. The capacitor discharge current flows via the gate terminal of the g.c.s. and switches it off. Diode *MRF* is selected to have a holding current below the input current so that it remains conducting for the duration of the input pulse. When the positive input pulse terminates,

MRF reverts to its high impedance condition and the circuit is reset.

Fig. 5(c) shows the waveform of a 2A, 100V, 50μsec duration pulse produced across a resistive load by the circuit of Fig. 5(b).

Free-Running Pulse Generators

Two simple free-running pulse generators are shown in Figs. 6(a) and 6(b). In both cases, application of power to the circuits causes an increasing positive gate current to flow until the g.c.s. is switched on. A sharp change in cathode potential then occurs as the voltage V_2 is developed across the load. The reactive components prevent any rapid change in gate-cathode current or potential difference so that the gate potential approximates to the voltage V_2. Gate current now decreases, passes through zero and increases negatively until switch off occurs.

Note the effect of the load in the cathode arrangement which gives the properties:

(1) The output voltage (across R_L) is fed back to the gate circuit. This feedback reverses the polarity of the forcing voltage each time the g.c.s. changes state resulting in continuous oscillations.

(2) The negative supply rail can be utilized directly to drive the gate negative with respect to the cathode to achieve switch off. This is not possible when the cathode connects directly to the h.t. negative rail.

A marked improvement in operation results from inserting the firing circuit of Fig. 4(a) into the circuit of Fig. 6(b) to give Fig. 7(a). Capacitor C can now be charged from a high impedance source since it is isolated from the low impedance gate by the non-conducting diodes MRF_1 and MRF_2. When the voltage across the forward biased diode reaches its switching voltage, a sharp gating pulse is applied to the g.c.s. resulting in a fast switching action. By varying the potentiometer setting, the pulse ratio across the load may be varied continuously from one extreme (load fully de-energized) to the other (load fully energized).

Fig. 7(b) shows two modifications:

(1) Separate potentiometers allow independent setting of the pulse duration and its repetition frequency.

(2) Zener diodes stabilize the timing circuits against variations in power supply voltage.

If a negative supply rail is available the circuit arrangement of Fig. 7(c) may be used. The advantage gained is that the load, when de-energized, no longer carries the charging current for capacitor C. With the load de-energized, capacitor C charges positively if the current through resistors R_1 and R_2 in series exceeds the fixed current I_c, these currents being in opposition. Diode MR prevents any flow through the load. When the rectifier fires 'on' diode MR conducts and the junction of R_1 and R_2 is taken within a volt or so of earth potential. Current I_c now exceeds the current through R_2 and the capacitor charges negatively until it is discharged to switch off the rectifier.

The circuit of Fig. 7(d) has separate capacitors and charging resistors for the positive and negative gating pulse generators. This arrangement is more suitable when pulses of very uneven mark-to-space ratio are required. When the g.c.s. is non-conducting, capacitor C_1 charges positively with respect to earth via R_1 and the load. On reaching the breakover voltage of four-layer diode MRF_1, capacitor C_1 discharges to gate the g.c.s. into conduction. During the charging time of capacitor C_1, the voltage across C_2 is clamped to a small positive value by forward conduction of diode MR. When the g.c.s. conducts, capacitor C_2 is charged from the negative supply via resistor R_2 until four-layer diode MRF_2 conducts to switch off the g.c.s. While capacitor C_2 is charging, the low-potential of the g.c.s. anode prevents capacitor C_1 from re-charging. The purpose of the low valued resistor R_3 is:

(1) To allow rapid discharge of capacitor C_1 without exceeding the peak gate current rating of the g.c.s.

(2) To prevent the negative gate-to-cathode voltage during turn-off from being applied to diode MRF_1 and firing it into conduction. Resistors R_3 and R_4 form an attenuator.

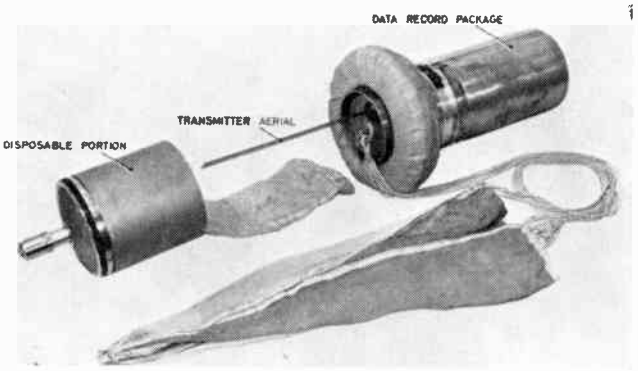
Pulses of 1msec duration at a p.r.f. of 1 per second are produced with the circuit values as shown in Fig. 7(d).

(To be continued)

An Aircraft Accident Data Recorder

A new aircraft accident data recorder—developed to stringent Aviation Ministry specifications and to be used initially on military supersonic high performance aircraft including the TSR2—will shortly be in service.

The recorder—developed by the Flight Simulator Division of Redifon Limited—monitors 280 items every second, as well as pilot's speech, and when the data record package is ejected by excess g forces or contact with water or fire, it contains a complete monitored 'account' of the last 15min of flight.



The accident data recorder

The ejected package contains its own radio transmitter audible for 48 hours up to 50 miles away to search aircraft flying at 10 000ft.

The Redifon Accident Data Recorder consists basically of a power unit, recording unit and signal multiplexing unit mounted in three standardized 'black boxes', plus an ejectable data record package. The recorder, having automatically monitored the 280 items of information (instrument readings, control surface positions, etc.) every second, as well as pilot's speech, ejects itself by means of a mechanism developed in association with M.L. Aviation Limited when activated by excess g forces or contact with water or fire.

The ejected package, which is virtually indestructible, contains, in addition to the radio transmitter, a fluorescent marker dye activated by sea water.

The package contains a complete monitored record of the last 15min of flight. This can be immediately 'translated' by its complementary ground replay equipment to assist the accurate and prompt identification of faults, diagnosis of errors or chronicling of events.

The recorder will operate with satisfactory ejection performance at altitudes up to 70 000ft down to sea level with speed up to 1 000 miles/h. The equipment operates over the pressure changes from extreme height to sea level and over a temperature range of $-40°C$ to $+90°C$ to meet arctic to desert conditions, and will work for periods of 1 000 hours between overhauls. The ejected package will withstand impacts up to 1 000g, fire temperature up to 750°C for 20min before and after ejection, and will eject under 30ft of sea water and surface from depths of 100ft with natural flotation.

It will withstand fuel, foam and other possible chemical hazards.

The recorder normally draws its power input from the aircraft emergency electrical system, but in the rare event of this supply failing there is automatic switchover to its own stand-by battery, so maintaining recording facilities for a further 15min.

A Simple Electronic Milliammeter

By G. F. Weston*, M.Sc., A.Inst.P. and P. Schagen, Ph.D.

An experimental glow discharge indicator is described in which the length of the glowing column is a linear function of the current. The length can be read with an accuracy of 5 per cent, and thus the tube can be used in applications where an indicating current meter is at present employed. The parameters affecting the full scale range are given. The tube is processed with the aid of standard sputtering techniques ensuring good initial and life characteristics.

(Voir page 63 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 70)

THE length of a glowing column from a low pressure gas discharge has been used as an indication of current both in scientific and commercial equipment. Usually the light from the cathode glow region of a discharge around a long wire cathode is employed, while the gas contains a percentage of neon. Existing devices are non-linear in their relationship between current and length of the glowing column, with fairly wide tolerances on their characteristics. This article describes an indicator of improved design which is processed with the aid of standard sputtering techniques, normally applied to stabilizers and high quality trigger tubes, and in which the length of the glowing column is a substantially linear function of the current. The processing schedule ensures stable initial operation and good life characteristics. The length of the glow can be read with an accuracy of about 5 per cent, and thus the tube can be used in any application where an indicating current meter or a 'magic eye' is at present employed.

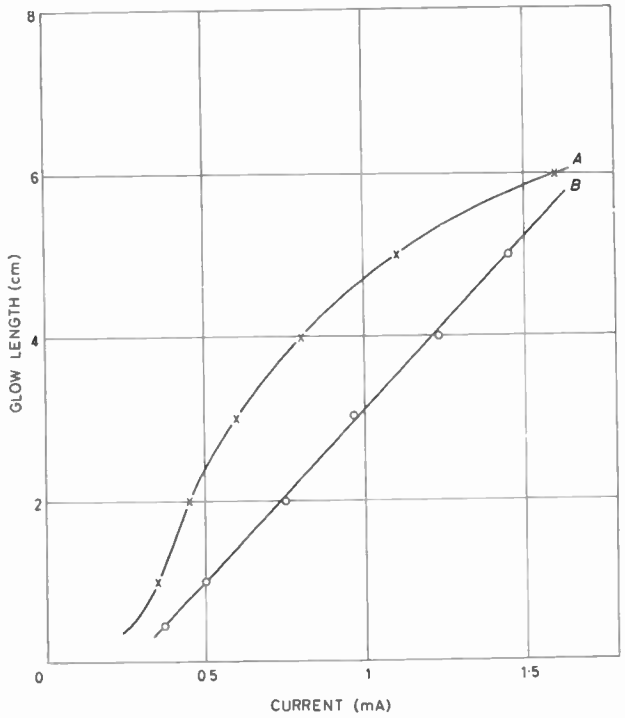


Fig. 1. Glow length/current characteristics
(a) of the Philips 4662 indicator tube
(b) of experimental indicator filled with 99 per cent Ne 1 per cent A

Design of the Tube

The design of the tube is based on the observed linear dependence of the length of the glow along a rod cathode on the current, when an anode of equal length is mounted parallel to the cathode and at a sufficiently short distance to avoid an anode glow. This has been compared in Fig. 1 with the non-linear characteristic of a 4662 indicator, where the anode is much shorter than the cathode. If the anode takes the form of a long wire, it has the additional advantage of shielding a portion of the glass envelope from material sputtered from the cathode. Thus the cathode can be cleaned by extensive sputtering and yet leave a window along the length of the tube. This window is wider than the optical shadow of the anode wire, and since the glow is of much larger diameter than the cathode it is clearly visible. A plan view of the position of the electrodes in the envelope showing the window in the sputtered layer is given in Fig. 2(a).

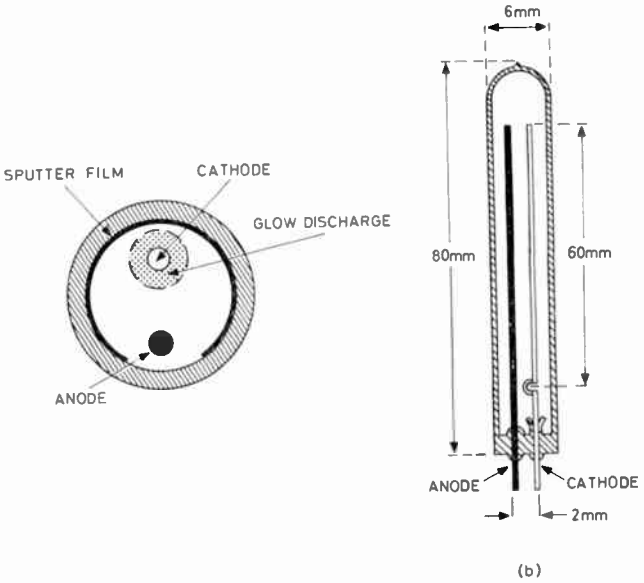


Fig. 2. Arrangement of indicator tube
(a) plan view showing the window in the sputter film
(b) side view showing the 'hollow cathode' bend at base of the cathode wire

If the tube is to be used as a linear current indicator, it is essential that the glow should commence at the base of the cathode, and that only the edge of the glow away from the base should move as the current is varied. This has been achieved by bending the cathode rod to form a hollow cathode near the base, as illustrated in Fig. 2(b). The principle of the hollow cathode is well known. If two portions of a cathode are close enough for the negative glow regions to overlap, enhanced ionization takes place with a lowering of the maintaining potential. The glow prefers to reside in the lower potential region, and thus the lower edge of the glow is effectively anchored.

* *Mullard Research Laboratories.*

The reduced spacing between the anode and the cathode at the bend, also lowers the breakdown potential ensuring that the glow starts at the base when the tube is initially switched on. An alternative method of lowering the breakdown and maintaining potentials near the base of the tube is to raise the Townsend coefficient, γ, of the cathode at the required point. With molybdenum electrodes this can be achieved by welding a small piece of zirconium to the cathode rod.

The dimensions of the tube can be chosen to suit the application. The current range depends on these dimensions and also on the gas composition and pressure. Most of the measurements reported in this article however, have been carried out on tubes containing molybdenum electrodes with a length of 6cm, a cathode diameter of 0·25mm and an anode diameter of 0·5mm. The overall dimensions of the tube were a length of 8cm and a diameter of 6mm.

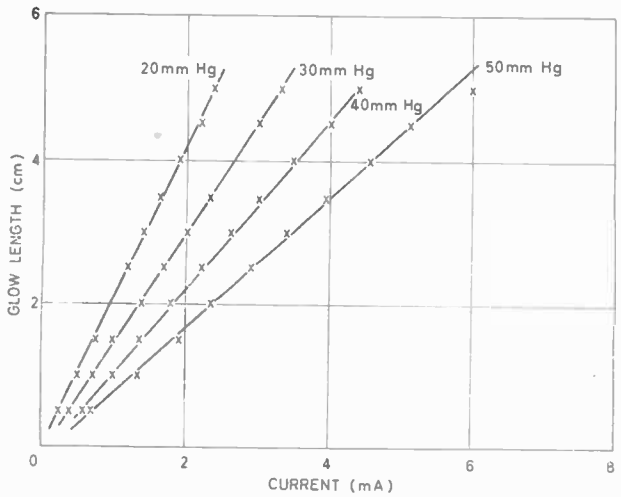


Fig. 3. Glow-length/current characteristics for indicator tubes filled to various pressures of neon

Glow-Length Versus Current Characteristics

The indicator tube operates in the normal glow region, behaving in a similar manner to a glow discharge under uniform field conditions. This means that the cathode area which is covered by the glow increases with increasing current while the current density remains constant. The current density in the normal glow determines the glow-length versus current characteristic. The variation of current density with gas composition and pressure enables the range of a particular tube to be selected within certain practical limits.

Increasing the pressure increases the current density in the normal glow, and thus the glow-length per unit current will decrease. This is demonstrated in Fig. 3 where glow-length is plotted against current for a tube filled to various pressures of neon. If the current density, j, is deduced from the slope of these characteristics then it is found that j varies as the square of the pressure, as illustrated in Fig. 4. This is in accordance with the generally accepted observation that j/p^2 is a function of the value of the normal cathode fall[1], which is substantially constant over the pressure range considered.

Also shown in Fig. 4 are the results obtained with two neon-argon mixtures. Small amounts of argon added to neon give rise to the well-known Penning effect[2,3], lowering the breakdown and maintaining potentials as a result of ionization of the argon by neon metastable atoms. The probability of this reaction is quite high, and the effect is most marked for very small admixtures of argon, with a maximum effect at about 0·5 per cent argon. The values of these parameters for three different gas mixtures used in the indicator tube are given in Table 1.

TABLE 1

Average Values of Maintaining Potential V_m, and Breakdown Potential, V_s, for the Indicator Tube

GAS	PRESSURE (mm Hg)	V_S (Volts)	V_M (Volts)
Ne	20	205	132
99% Ne 1% A	30	110	89
90% Ne 10% A	27	187	118

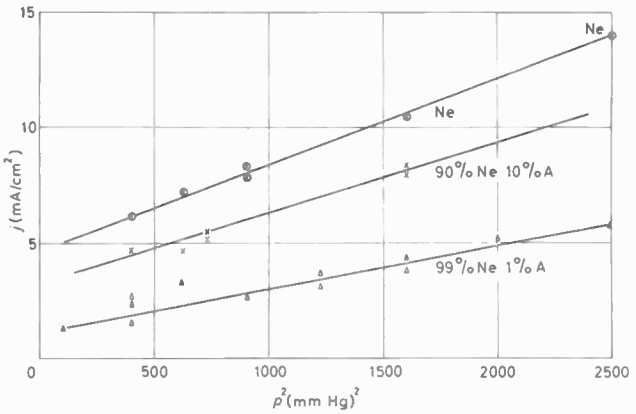


Fig. 4. Plot of current density against pressure for tubes having 0·25mm diameter cathodes

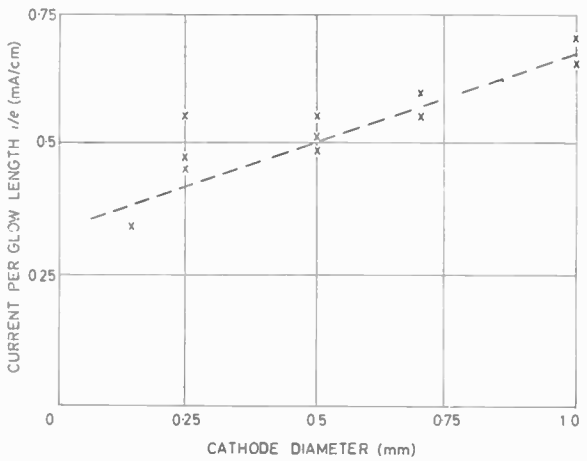


Fig. 5. Dependence of the current/glow-length characteristic on the cathode diameter. Tubes filled with neon at 20mm Hg

Since there is no anode fall, the maintaining potential is equal to the normal cathode fall. The current density is affected by the argon percentage in a similar way as the maintaining potential, and, therefore, the effect of the gas composition shown in Fig. 4 is also in accordance with the general theory. Thus the glow-length per unit current is greatest in the tube filled with 99 per cent neon +1 per cent argon and smallest when filled with pure neon to the same pressure. The pressures given in Table 1 were chosen from brightness and glow diameter considerations and do not give the same current densities.

Since the cathode surface area on which the glow is invested is given by πld, where d is the diameter of the wire and l the length of the glow, it might be expected that doubling the wire diameter would halve the glow-length for a given current. In practice, however, for small diameter wires the glow-length/current characteristic is less dependent on diameter; the wire had to be increased

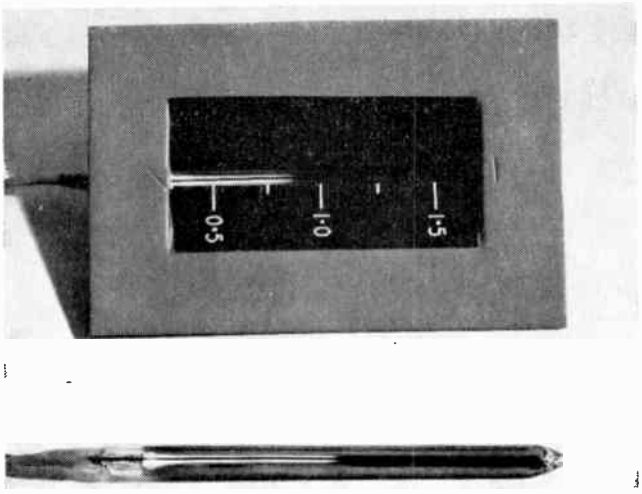


Fig. 6. Linear indicator tube with a simple panel mounting

from 0·15mm to 1mm in order to halve the glow-length for a given current. In Fig. 5 the current per unit glow length, i/l has been plotted against the diameter of the wire for tubes filled to 20mm Hg of neon. The spread between tubes makes it difficult to draw a curve through the points, but it is clear that as the diameter decreases the current density increases. If a linear relationship is assumed then i/l is proportional to $d + c$ where c is a constant of approximately 1·5mm. This is of the right order for the current density to be dependent on the diameter at the edge of the cathode fall, rather than the cathode diameter, but more accurate and wider ranging experiments would be required to confirm this.

Light Output and Life Measurements

The visibility of the glow depends on the intrinsic brightness or luminance of the cathode glow and its visible width. The former is particularly difficult to measure accurately due to the variation in brightness across the glow and the relatively small area concerned. As a rough guide measurements with a spot photometer gave values between 20 and 40 nit depending on the gas filling and pressure; the highest values were for pure neon. In general the glow is easily visible in a normally lit room, but is difficult to see in direct sunlight. The width of the window varies with the anode and envelope diameters; for an anode diameter of 0·5mm in a bulb of 6mm diameter, the width was about 2·5mm. A photograph of a tube with these dimensions is shown in Fig. 6, and above it the tube clipped in a simple mounting with a scale.

Since the tube will be operating in the normal glow region, the rate of sputtering during life is very small. Blackening of the window or cathode erosion is unlikely to occur for many thousands of hours. The main problem will be associated with change in the glow-length/current characteristics due to contamination, particularly when the glow is invested on only part of the cathode. A number of tubes are being life tested under these conditions. So far these tubes have been running for 3 000 hours. The maximum change of current required for a given glow-length is less than 10 per cent which is almost within the accuracy of reading the glow-length. There is some evidence that the variation is greater for the cathode area on which there is no glow during life than for the glow region, although no jump in characteristic was observed.

Conclusions

The experimental indicator tube described gives a linear relation between glow-length and current through the tube. Owing to the ill defined edge of the glow and the possibility of parallax it is doubtful if the length of the glow can be read with an accuracy which is higher than 5 per cent. The glow is clearly visible in a normal lit room but difficult to see in direct sunlight. Within these limitations it can be used as a current meter, provided that the supply voltage is available which is needed to strike and maintain the glow. The current range depends on gas composition and pressure, and to a lesser extent on the cathode diameter. For an 8cm long tube filled with 99 per cent neon 1 per cent argon at 30mm Hg, the current range was 1·5mA, the breakdown potential being 110V and the maintaining potential 90V. The difference of 20V between breakdown and maintaining potential means that the tube can be connected across the h.t. supply in series with a transistor, such as the OC71, as the control element. The fact that the tube can be processed by normal sputtering techniques gives confidence that the tube will have a reliable life of several thousand hours. This is supported by preliminary life tests.

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A Laser for the Atomic Weapons Research Establishment

The Atomic Weapons Research Establishment at Aldermaston has placed with Hughes International (U.K.) Ltd, an order for a Hughes laser type 202.

This model is one of a recent series of lasers developed by Hughes Aircraft Company, the parent organization of Hughes International (U.K.) Ltd.

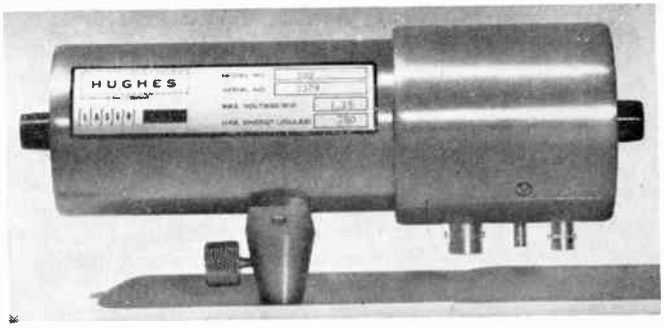
The Hughes laser model 202 is designed for experimental use in the laboratory or in industry. It is a cylindrical unit containing a flash-lamp, trigger transformer, and provision for mounting solid state laser materials. Both ends of the laser are open, permitting the laser beam to be directed from either or both ends of the laser material.

An important new feature in the design of the 202 is that, used as a normal laser, it has the advantage that optical sighting or alignment may take place along the axis of the system, through the laser material. It may also be used with external reflecting plates for internal-cavity modulation or Q-spoiling experiments, evaluation of laser materials, or reduction of beamwidth.

Without highly reflective coatings, the device may be used as a single pass optical amplifier. It may be operated in any position and without special cooling provisions for intermittent use.

Applications for the 202 are in welding, micromachining, photography, optical ranging, spectroscopy, metallography, chemistry, biological sciences, and semiconductor studies.

The model 202 laser



High Voltage Deuterium Filled Grid Controlled Rectifiers

By B. O. Baker*, B.Sc.(Eng.), A.C.G.I., A.M.I.E.E. and R. J. Wheldon*, B.Sc.

The hot cathode deuterium filled grid controlled rectifier is compared with other hot cathode discharge devices, and at voltages of 25kV and over certain advantages are claimed. The factors governing the design of such rectifiers which are discussed include: electrostatic fields, nature and pressure of gas filling, effect of activated surfaces, and efficiency of the thermionic cathode. Considerable advantage can be obtained by the use of deuterium instead of hydrogen, both in the ease of grid firing and in the ability to hold off high voltages.

These design principles have been applied in the development of two rectifiers, designated E2746 and E2816 for ratings of 25kV, 350mA mean current, and 40kV, 3·5A mean current respectively.

These valves have made possible the design of very compact high voltage power supplies which are robust and economic. The principles can be extended to higher voltages by the use of 'multiple box' structures, and to higher currents by suitable electrode cooling.

(Voir page 63 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 70)

RECENT advances in low pressure hot cathode thyratron design have led to the development of high voltage deuterium filled grid controlled rectifiers. These rectifiers have made possible the design of compact high voltage power supplies for high power radar sets. It is likely that there will be other applications for rectifiers of this type, for example in the fields of radio communications and radio-frequency heating.

The most commonly used grid controlled rectifiers contain mercury. These are ideal in many ways, because they are capable of very long lives, since they contain a virtually inexhaustible supply of mercury, and the low ionization potential of mercury leads to low arc drops and consequently good efficiency. However, one of the biggest disadvantages of hot cathode mercury filled grid controlled rectifiers is their very narrow ambient temperature range (+15 to +40°C). Their relatively long warm-up time is also a difficulty in some applications; and many mercury valves have poor lives under storage conditions because of attack of the cathode by the mercury vapour.

Xenon is an alternative gas filling, with a comparable ionization potential but much wider ambient temperature range (−55 to +70°C). The use of the boxed-in anode design[1] has enabled xenon diode rectifiers to be made with good lives from the point of view of gas clean up, and with xenon there are no storage problems. It has not been found possible, however, to make a xenon filled grid controlled rectifier for voltages in excess of 5kV. This is due to one of the properties of grid controlled rectifier circuits occurring during retarded commutation[2]. The output from the circuit can be controlled by delaying the grid firing so that the valve only conducts for a part of the cycle. Under this condition of retarded commutation in a circuit with normal smoothing, inverse voltage is applied to the rectifier anode much more rapidly than for natural commutation; this is called commutation snap. Since there is still ionized plasma in the grid-anode region during the first part of the negative cycle of voltage, the rectifier may not only arc back but also suffer very rapid gas clean up and its life will be too short unless the operating voltage is restricted.

In order to achieve voltage ratings in excess of 20kV therefore, it was decided to use hydrogen or deuterium for the gas filling. The term hydrogen in this article is used to cover the isotopes as well, with the exception of the section which directly compares the properties of hydrogen and deuterium. Owing to the higher mobility of the hydrogen ion compared with mercury or xenon, commutation snap is less of a problem because the deionization time is much shorter. Experience in pulse thyratrons has shown that by using a gas reservoir system, gas clean up is no longer a life limitation in hydrogen filled devices. It is also possible to make these devices operate satisfactorily over a wide ambient temperature range. This is a great advantage where widely varying climatic conditions have to be met, and the ability to work at high ambient temperature is also advantageous where space is at a premium.

The penalty to be paid for these advantages in a hydrogen filled device is the fact that the ionization potential of hydrogen is higher than that of mercury or xenon, and moreover due to the high mobility of the hydrogen ion, more ions reach the electrode surfaces where recombination occurs. In order to support an arc discharge therefore, further ionization must take place. The result is that the arc drop may be from 50V to more than 100V depending upon the electrode structure. Hydrogen filled grid controlled rectifiers are therefore only of interest where the operating voltage is so high that an arc drop of 50V is unimportant.

General Design Considerations

There are three classes of hot cathode grid controlled valves.

(1) Negative control.
(2) Zero control.
(3) Positive control.

Most mercury filled grid controlled rectifiers are included in the first class, which requires a negative bias to enable the rectifier to hold off high positive anode voltages. It is characteristic of this class of valve that the electrode structure is fairly open, and the electrostatic field from the anode penetrates to the region of the cathode. Most hydrogen filled pulse modulators, on the other hand, are very tightly baffled, so that the anode field does not penetrate to the cathode region, and these modulators are included in the third class. If the grid of the modulator valve is held at cathode potential, conduction will not occur, while with the first class it will. It might be noted here that negative bias is often applied

* *The General Electric Co. Ltd, Hirst Research Centre, Wembley.*

to the grid of pulse modulators, but for a different reason, namely that negative bias reduces the recovery time that must elapse before the anode can hold off a reapplied voltage. It is characteristic of positive control valves that a high power high voltage grid pulse is required to cause them to conduct.

Between these two classes of valve is the case where the structure is not so tightly baffled, so that although with the grid at cathode potential the device will not conduct, there is some anode field penetration in the region of the cathode, and this greatly assists in grid firing. One of the requirements for the grid controlled rectifiers under discussion is to keep the grid firing power low, in order to minimize the size and cost of trigger components. It is logical therefore to select the zero control class for this purpose. Negative control is excluded on the grounds that it is difficult to avoid grid emission problems in hydrogen filled valves operating with large values of bias and having relatively open structures.

Because the grid firing power is designed to be as small as possible, in three or six phase circuits spurious firing can be caused by transient surges produced when the valves in another phase are fired. These surges, feeding back from the anode circuit through the capacitance between anode and grid, produce a pulse on the grid causing the rectifier to conduct. One method of overcoming this problem is to design the rectifier with low grid-anode capacitance, and to trigger the grid in the normal manner. Another method due to N. S. Nicholls of R.R.E. is to apply a negative trigger pulse to the cathode with the grid earthed and to design the valve to minimize the cathode-anode capacitance. In this case a diode must be inserted between cathode and earth, to allow the passage of current through the cathode lead while preventing short-circuiting of the trigger pulse.

In a grid controlled rectifier the valve must hold off the maximum positive and negative anode voltage unless conduction is caused during the positive cycle by firing the grid. The instant in the anode voltage cycle when conduction takes place can be controlled by varying the angle of phase displacement between the anode voltage and the trigger pulse. This angle is called the ignition angle, and a fast rising grid pulse is used in order to control it accurately.

Electrode Design

Grid

The grid of any rectifier has two functions. One is to provide sufficient control of the anode field penetration into the cathode region to prevent breakdown before the triggering pulse is applied. The second is to attract a sufficient number of electrons into the region of the grid when a triggering pulse is applied, for complete breakdown to occur when a positive voltage is applied to the anode.

The second function is assisted by using a baffle between grid and cathode as a further trigger electrode. In practice it has been found best to connect the baffle to the grid with a high resistance, of the order of 100kΩ, and to feed the trigger pulse either to the grid or cathode. Under these conditions the baffle potential starts to rise to a positive value relative to the cathode, starting the ionization process at a low strike voltage. As soon as any appreciable current flows in the high resistance, however, the baffle potential falls while the grid is still positive relative to the cathode, and so the grid takes over. Finally, due to the presence of the anode field the breakdown occurs to the anode, and the valve is rendered conducting.

In order to study the electrostatic fields in grid controlled rectifiers, and to arrive at a suitable grid design for optimum operating conditions, a model was set up in an electrolytic tank[3]. Field plots were made of various configurations, and one of these is shown in Fig. 1. The anode field penetration can be reduced either by increasing the grid disk diameter relative to that of the hole, or by moving the disk nearer to the hole. It will be seen later, however, that these two methods affect other valve parameters differently.

The Anode-Grid Region

A study of the electrostatic field plot in Fig. 1 assists in determining the valve parameters which govern positive and negative breakdown voltages. This plot alone will not give the necessary information, because breakdown voltage is a function of gas pressure (the effect of which is not

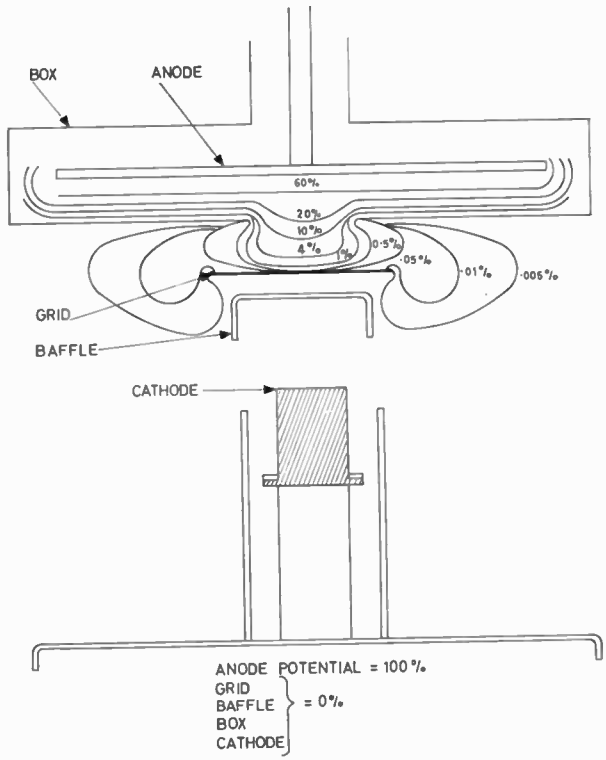


Fig. 1. Electrostatic field plot for E2746

stimulated by the electrolytic tank analogue) and distance. These points will now be considered in relation to two operating conditions:

(a) *Inverse Voltage Hold-off*

When the anode is negative, electrons originating from the anode are accelerated by the electrostatic field, which is relatively uniform near the anode. The electrons which go through the box aperture have reached a high velocity before they meet any transverse component of field to deviate their course from a straight line. For this reason they are not much deflected, and impinge on the top of the grid disk. It is reasonable to expect, therefore, that if breakdown occurs when the anode is negative, it will do so between anode and grid. Therefore it is the anode-grid clearance which determines the Paschen breakdown voltage for a given gas pressure (see Fig. 2). Residual ionization can be neglected as deionization is so rapid in hydrogen.

(b) *Forward Voltage Hold-off*

Electrons emitted from the cathode start at relatively low velocity, and do not gain sufficient energy to produce

ionization until they reach the vicinity of the grid. In this case therefore the shape of the field in the region of the grid is the governing factor, rather than the anode-cathode distance.

Measurements on grid controlled rectifiers have shown that a typical grid strike voltage is 30V at normal gas pressure. It is reasonable to assume, therefore, that if the anode voltage of the valve is increased until the field penetration causes the potential in the vicinity of the grid to rise to 30V, breakdown will occur between cathode and anode. This therefore enables the positive anode breakdown voltage to be predicted for any given electrode geometry for which the field has been plotted.

The implication of these operating conditions can now be considered. The low limit of spacing between the anode and its nearest electrode is set by field emission. Condition (a) sets the upper limit on the spacing between anode and grid disk from Paschen breakdown consideration. For

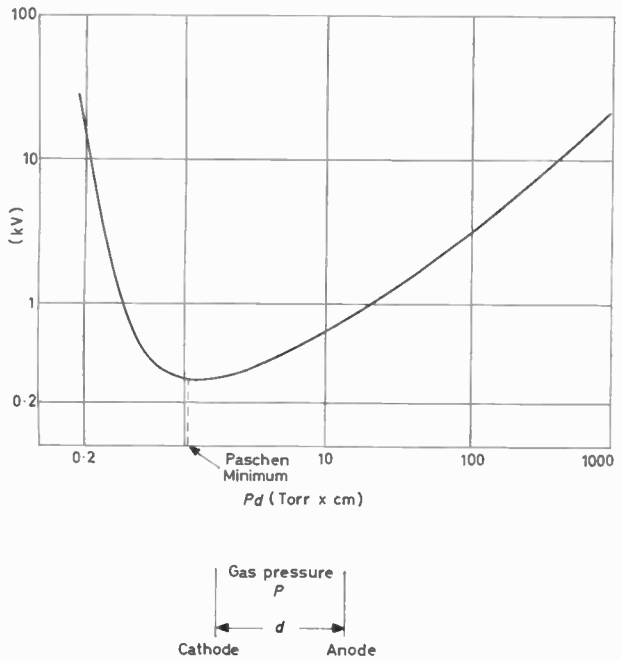


Fig. 2. Paschen breakdown curve for hydrogen (kV v *Pd*)

condition (b) the degree of penetration of the anode field through the grid must be controlled to give the best compromise between holding off high positive voltages on the anode, and having minimum triggering current. Adjustment can be made either by altering the overlap between the grid disk and the hole in the bottom of the box round the anode, or by altering the spacing between the grid disk and the box.

The Anode Seal

Electrical connexion to the anode is made through the anode seal, and a number of important design considerations must be taken into account in order that the anode seal shall hold off the high voltages.

(1) The gap between anode and box must be maintained constant right up to the glass seal, the magnitude of this gap being chosen to satisfy Paschen breakdown and field emission breakdown conditions.

(2) An insulator between two metal electrodes must be thick enough to prevent electrical conduction. (The resistivity of glass and ceramic is very dependent upon temperature.)

(3) Glass in a high field region must not be hot enough to emit electrons.

(4) There must be adequate spacing between metal and glass to prevent field emission from the glass.

(5) Sufficient length must be left outside the seal to prevent

(a) breakdown through the air

(b) breakdown along the surface.

(6) Metal sputtered by the discharge must be kept away from the main insulator.

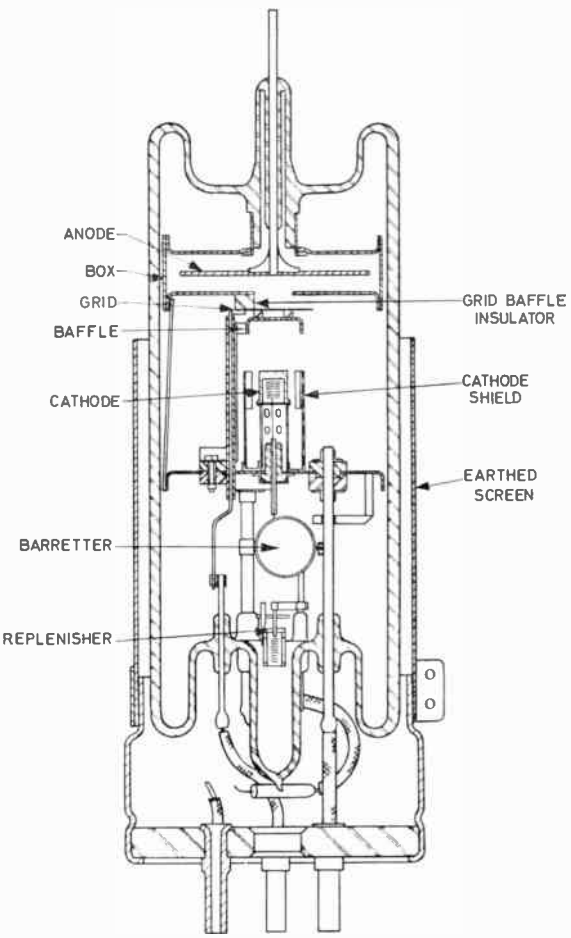


Fig. 3. E2746 (sectional drawing)

Examples of suitable anode seal designs for glass valves and ceramic valves are given in Fig. 3 and 4.

The Effects of Activated Surfaces

Having designed a valve which fulfils the requirements of voltage hold-off initially, this property of the valve may deteriorate due to the development of undesirable activated surfaces during its operational life. Emissive material originating from the cathode is evaporated on to hot electrode surfaces, such as the grid, baffle or cathode canister, where the anode field is sufficiently strong to cause breakdown. The problem is more pronounced in valves with open structures containing hydrogen, than in similar valves containing heavier gases.

The effects of activated surfaces on voltage performance may be minimized in several ways, for example:

(a) Coating the offending electrode surface with an emission inhibitor, such as gold[4] or titanium[5]. This method

has its limitations, for example gold evaporates above 500°C and is fairly easily sputtered, causing poisoning of the cathode emission, and in high field regions titanium has given problems of adhesion. Gold plating has however been used successfully; on a valve type with a life limited to a few hundred hours by the formation of activated surfaces, plating the cathode canister increased the life to over 5 000 hours.

(b) Removing the offending electrode surface where possible. This has been done in the E2746 to be described later, where it was found necessary to remove the cathode canister, which was a hot emitting surface, and which also formed a re-evaporating surface causing barium to reach the grid. Better results were obtained when the barium condensed on the cooler glass bulb. It was found necessary in this case to screen the bulb from the external anode field, which caused bulb charges and spurious triggering. An earthed screen external to the valve was used for this purpose.

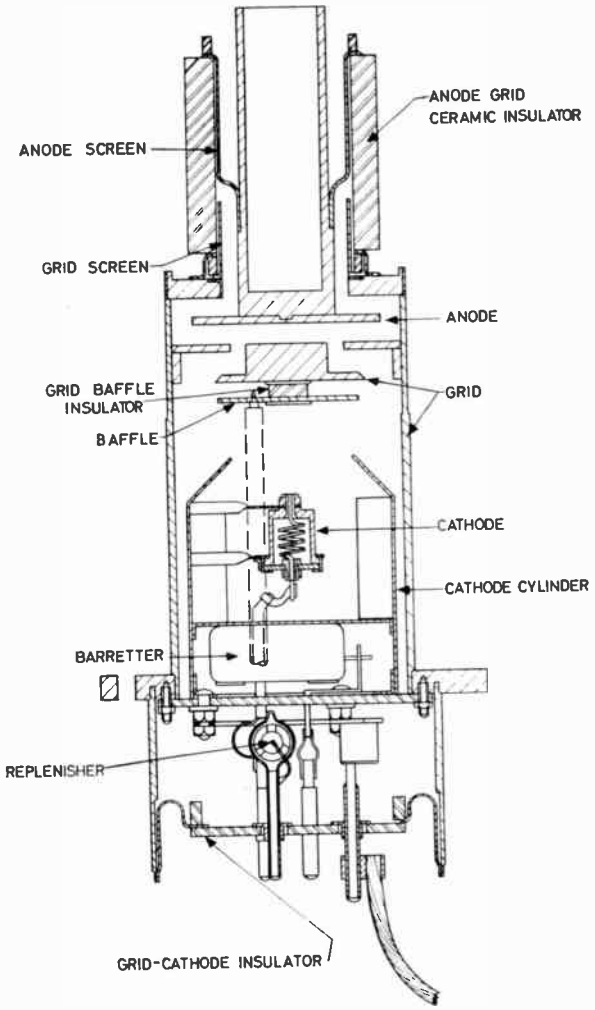


Fig. 4. E2816 (sectional drawing)

(c) Cooling the electrodes is the most satisfactory method of reducing unwanted emission. This is particularly suitable for the grid, for which the other approaches are not satisfactory. In low power devices, for example the E2746, good conduction cooling through the supporting members of the grid to a cooler part of the valve was satisfactory. For higher power valves such as the E2816 to be described later, a metal envelope with the grid in good thermal contact is the best approach, and for very high powers, water cooling of the grid is used[6] as in the E2986.

Cathode Design

The cathode emission requirement of rectifier valves differs from that of pulse modulators as the repetitive peak to mean ratio of cathode current is low, up to 6:1. In addition the cathode must withstand a current surge of relatively high value for a few cycles, if the load is momentarily short-circuited, without undue rise in arc drop. Although the oxide coated cathode has generally been used in hydrogen filled valves, the impregnated tungsten cathode has several advantages.

(a) High mean and repetitive peak currents can be drawn from a compact cathode, and hence the source of evaporation of emissive materials can be more effectively shielded.

(b) The emissive material is held in the pore of the base metal, and therefore offers little impedance to the passage of current compared with the oxide coated cathode. For the same reason also the impregnated cathode is more resistant to back bombardment by positive ions.

(c) Since the rate of evaporation of barium from the cathode is controlled by diffusion through the pores of the tungsten, the emission life of this cathode is in excess of 5 000 hours.

It has been found that a considerable current can be drawn from shields surrounding the cathode when they have become coated with emissive material. By suitable design of cathode and shield, a large proportion of the valve current can be supplied by the shield. It is economical on heater power to design the main cathode to supply the repetitive peak current, and the shield to supply the additional current required under the surge condition. Because of its controlled rate of evaporation of emissive materials, the impregnated tungsten cathode is an excellent primary cathode for use in combination with an emitting shield.

The Choice of Deuterium

The advantages of deuterium over hydrogen in pulse modulators have been described[7]. Hydrogen filled grid controlled rectifiers are also designed to operate on the left-hand side of the Paschen curve (Fig. 2) at pressures of a few tenths of a torr of gas. The breakdown characteristics of a gas is a function of the nature of the gas, its pressure and temperature, the distance between electrodes and the material and conditions of the electrode surfaces. Fig. 5 gives the breakdown curves between anode and grid of a typical grid controlled rectifier for hydrogen and deuterium, with the cathode hot. The upper pressure limit for a particular voltage rating is determined by the breakdown curve, and the lower pressure limit by the grid current to fire curve (Fig. 6).

Fig. 5 shows that the pressure for a given breakdown voltage is higher in deuterium, thus raising the upper pressure limit. The fundamental processes which control Paschen breakdown in this type of device are ionization of the gas by electrons, followed by secondary electron emission by positive ion bombardment of the negative electrode[8]. A difference in this secondary electron emission between the two gases may account for their breakdown characteristics[9].

From the point of view of hold-off voltage a valve designed for 25kV in hydrogen can be modified to

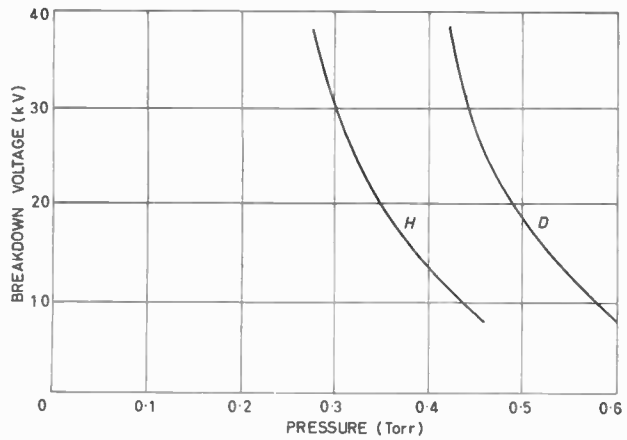


Fig. 5. Typical breakdown curves for hydrogen and deuterium (kV v *P*)

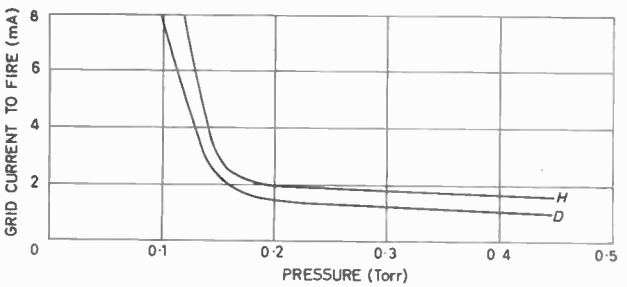


Fig. 6. Typical grid current to fire characteristics for hydrogen and deuterium (I_g v *P*)

operate at 40kV in deuterium, since for a given pressure the spacing between anode and grid can be increased for the heavier gas, hence the field emission limitation is raised to a higher voltage without incurring Paschen breakdown.

Fig. 6 shows that the failing pressure, at which the grid current to fire becomes excessive, is lower in deuterium. In the process of grid firing the electron current to the grid produces a plasma of electrons and positive ions in the region of the grid. The anode will take over when the electron density in the plasma reaches a certain level. The plasma tends to decay, due to the process of ambipolar diffusion. Since the rate of diffusion of a positive ion is inversely proportional to the square root of its mass[10], the plasma density and hence the electron density will be greater in deuterium for a given current to the grid. Conversely the current required to produce a given plasma density will be less with the heavier ion.

Another advantage of deuterium arising from its slower rate of diffusion is lower anode-to-cathode voltage drop, a reduction of 15 per cent being typical. All these factors have led to the choice of deuterium for high voltage grid controlled rectifiers, in spite of its slightly higher cost. Deuterium is produced by electrolysis of D_2O, the resulting gas being admitted into the valve through a palladium tube. Mass spectrometer analysis has shown that deuterium produced in this way has typically 1 to 5 per cent of hydrogen impurity which has been found acceptable. Reservoirs designed to operate with hydrogen operate satisfactorily with deuterium.

Two Typical Rectifiers

The design principles already discussed have been incorporated in two high voltage deuterium filled grid controlled rectifiers.

Type E2746

This is a glass envelope valve (Fig. 3) for operation up to 25kV hold-off voltage and 0·35A mean anode current. The grid, in which 50 per cent of the valve dissipation may occur, is cooled by conduction through brazed insulating supports made of Sintox ceramic, whose thermal conductivity is comparable with that of mild steel. The box around the anode is at cathode potential, and since the grid-cathode region is not screened internally it is necessary to have an external electrostatic screen. Without this screen electrostatic charges on the glass bulb interfere with normal operation. The valve has been designed for grid triggering; it contains a titanium deuteride reservoir controlled by a barretter mounted within the valve envelope.

Table 1 includes ratings and data for this valve.

Type E2816

This is a developmental convection cooled metal-ceramic rectifier with a target rating of 40kV hold-off voltage and 3½A mean anode current. The metal envelope has been employed so that the grid can readily be cooled to prevent grid emission. It is desirable to use ceramic seals in a metal envelope valve for two reasons, firstly, the metal components cannot be outgassed by normal eddy current heating techniques and therefore it is necessary to bake up to 700°C during manufacture and secondly, ceramic seals are more rugged. The metal envelope valve has been chosen in preference to the ceramic enevlope valve since better grid cooling is possible and also the grid-anode insulator is situated behind the anode and cannot become coated with sputtered material. This design is intended for cathode triggering

TABLE 1
Ratings and Data for Typical Deuterium Filled Grid Controlled Rectifiers

PARAMETER	UNITS	E2746	E2816
Heater voltage	V.r.m.s.	6·3	6·3
Heater current	A	8	14
Reservoir voltage	V.r.m.s.	—[1]	6·3
Reservoir current	A	—	2
Warm up time	Sec	300	300
Max. forward hold-off voltage	kV	25	40
Max. peak inverse voltage	kV	25	40
Max. mean current	A	0·35	3·5
Max. peak current	A	2	25
Max. surge current	A	50[2]	300[2]
Min. trigger pulse peak voltage	V	100	100
Grid d.c. bias	V	−5	0
Max. trigger generator impedance	kΩ	20	2
Min. trigger pulse duration	μsec	10	10
Anode-cathode volt drop	V	60	65
Anode-grid capacity	pF	0·1	—
Anode-cathode capacity	pF	—	0·05
Ambient temperature	°C	+90 −45	+90 −45
Envelope	—	Glass	Metal and ceramic
Overall length	in	9½	11
Envelope diameter	in	2½	2½
Maximum diameter	in	3	4
Base	—	B5D pin dimensions & disposition	Flying leads
Weight	lb	1½	4

(1) Internally connected across cathode heater

(2) Maximum of two successive half cycles of current at supply frequency 50c/s

where the grid, which is connected to the envelope, is earthed.

Fig. 4 shows a sectional drawing of the E2816 and Table 1 lists target ratings and data. The titanium deuteride replenisher is controlled by a barretter mounted within the envelope, thus any back heating from the discharge produces a drop in barretter current which compensates for the effect of back heating on the replenisher.

Conclusion

This article has described the main considerations in the design of hot cathode high voltage grid controlled rectifiers. These rectifiers enable the circuit engineer to design rectifier sets that are compact, light, robust and economic. The introduction of the metal envelope class of valve and a better knowledge of the heat dissipation in the various electrodes has considerably extended the power range without a significant increase in valve size. Grid control also makes possible the use of surge suppression fault-protection, since the grids can be extinguished in the event of a fault. Deuterium filled grid controlled rectifiers permit reliable operation at high ambient temperatures, which is a great asset to the circuit designer for whom space is at a premium.

It is difficult to predict the future of high voltage grid controlled rectifiers. Already the development of semiconductor devices is providing alternative methods of control for some applications. It seems likely, however, that in the field of very high voltage and medium current, the deuterium filled grid controlled rectifier will hold its own for many years to come. Double box structures are under investigation and these are expected to achieve voltage ratings in the region of 75kV. Mean current ratings of the order of 100A should be feasible with present techniques in a device with water cooled grid and anode, as used in the E2986 pulse thyratron.

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A Ship's Inertial Navigation System

A contract for the manufacture of a ship's inertial navigation system designed by the Admiralty Compass Observatory has been placed with the Sperry Gyroscope Co. Ltd.

This follows the successful development of Admiralty equipment which is now installed in H.M. Submarine Dreadnought, and the new equipment is to be installed in aircraft carriers, the new County class destroyers and the hunter-killer nuclear submarines of which the first is to be H.M. Submarine Valiant.

The original idea of ship's inertial navigation is attributable to Dr. Charles Draper of Massachusetts Institute of Technology who designed the first S.I.N.S. to undergo sea trials. This early equipment showed inertial navigation to be a practical proposition and formed the basis of today's U.S. Navy Submarine Navigation Systems.

The system, known as S.I.N.S., continuously defines a ship's position and heading on the earth's surface, and as a by-product provides speed and highly accurate vertical datum.

It is an entirely self-contained and passive instrument and permits navigation under water or ice without the necessity of coming to the surface at frequent intervals to make star fixes. It cannot be jammed or interfered with.

The heart of the equipment is a stable platform and an electronic computer. The platform carries a sensitive two-axis accelerometer and three high-precision single-axis integrating gyroscopes mounted with their sensitive axes mutually at right-angles. The accelerometer, which is in effect a very sensitive pendulum mounted on the platform in such a way that it can be rotated relative to the ship, provides electrical signals proportional to accelerations in two directions at right-angles.

In many inertial navigation systems, the requirement is for the platform to be stabilized with respect to space. In the S.I.N.S. application it is desired to know the position of the ship on the surface of the earth and therefore the equipment is corrected to compensate for the rotation of the earth as well as the motions of the ship in yaw, pitch and roll.

To achieve the above requirement it is necessary to establish a true vertical from which all reference is made. The accelerometer and gyroscopes are interconnected through suitable electronic servo circuits so that equilibrium will only be established when the axes of the platform are parallel to the axes of the earth and the pendulum is pointing to the centre of the earth, thus giving a true vertical. Measurement of the angle between the true vertical and the axis parallel to the earth's axis gives the latitude of the equipment.

Having established 'steady state' conditions, any movement of the ship over the earth's surface will disturb the accelerometer and by measuring the output in the North-South plane and integrating, the velocity can be determined, this in turn can be used to rotate the pendulum support to restore the original position, thus continuously measuring the latitude angle. Similarly, a movement in the East-West plane will mean that the East-West velocity can be measured by integrating the East-West accelerometer output, and knowing latitude this can be converted to rate of change of longitude.

The combined North-South and East-West velocities give speed over the ground and the total distance run is obtained as a by-product.

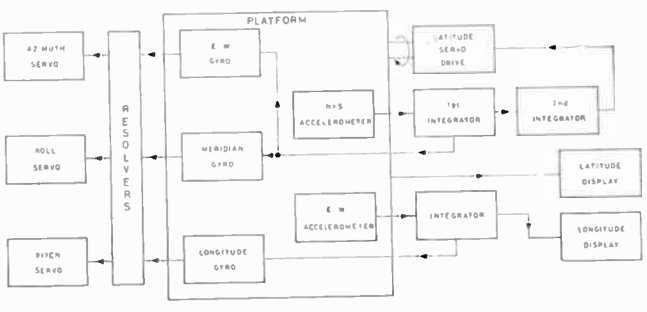
The most important components are gyros and accelerometers which must be made to a degree of precision unknown in other fields. The accelerometer, of very ingenious design, was developed at the Admiralty Compass Observatory by scientists of the Royal Naval Scientific Service, and proved to be an outstanding success, combining extreme simplicity with very high accuracy.

The gyroscope is the most difficult component to make and requires specially designed clean rooms and a very precise test equipment. The dimensions must remain stable to within a few millionths of an inch, otherwise the gyro will not maintain its position in space with sufficient accuracy.

Scientists at Admiralty Compass Observatory and engineers at British Aircraft Corporation deve'oped self-acting gas bearings for the gyro wheel and re-designed the gyro.

It is a practical proposition when maintaining a more or less steady course and speed, as in merchant ship operations, to plot the ship's track with considerable accuracy, even though fixes and observed positions may be far apart. For practical reasons, Her Majesty's Ships seldom stay long on a particular course, and an example of this is the gyrations of an aircraft carrier as she turns in and out of wind to operate her aircraft. In these latter circumstances use of the compass and log is not a great help, and the wander of one and the slip of the other, in rapid manoeuvres, is not conducive to accurate finding.

Arrangement of the navigation system



A 'Patients Monitor' for Hospital Out-Patients Departments

By J. A. Reynolds*

The instrument automatically counts the number of persons entering and leaving the room. It records the number in the room at any instant and displays this numerically on a bank of 'Digitron' indicators. A voltage proportional to the count is available for a standard chart recorder to give a continuous record. Analysis of these records allows a minimum waiting time appointments schedule to be planned.

(Voir page 63 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 70)

A PROBLEM in the out-patients departments of hospitals is the reduction of the time spent waiting by patients prior to being interviewed by the physician.

Various methods have been employed to evaluate this waiting time in order to design a suitable appointments system and prevent large groups of patients accumulating, with the accompanying annoyance of a long delay between appointment time and consultation.

Usually the method of estimating the average waiting time has meant some person supervising the flow of patients and recording this data. For example, cards may be used in which the patients entry and exit times are noted and future appointments based on these results utilized to minimize the waiting time.

In all these methods constant supervision is necessary to obtain reliable figures on which to base future appointments.

An instrument that would automatically provide this data without any co-operation at all from patients is an ideal solution, but would involve an extremely complex system and in all probability is an impossible task to be one hundred per cent efficient. A pilot approach to this problem utilizing automatic monitoring has resulted in the design of a simple recording instrument and within certain limitations, enables a reasonable appointments system to be devised.

Two desirable features required of the instrument were (a) the instantaneous count be shown numerically in convenient locations and (b) a continuous record of the patients flow over the clinic period. Standard chart recorders being available it was decided to use these to obtain permanent records.

A difficulty encountered quite early in the preliminary specification for an automatic monitor was that patients usually are accompanied by a visitor or two, and a count of the persons actually present in the waiting room of a clinic is not a direct indication of the number of patients actually awaiting consultation.

A survey on a number of clinics showed that the week to week ratio of patients to visitors remained fairly constant and it was decided to use this overall count as the basis of an automatic system, the results from which future appointments could be planned.

General Principles

The basic instrument was designed for a single entrance/exit waiting room. See Fig. 1.

Pedestals on either side of the entrance are arranged to focus twin beams on to two photocell receptors. Depending upon which direction the beams are interrupted a unit count is either added or subtracted from the total count already recorded and initiates a two-way uniselector to provide a numerical display on 'Digitrons' and provide an output voltage proportional to the count for operating the chart recorder.

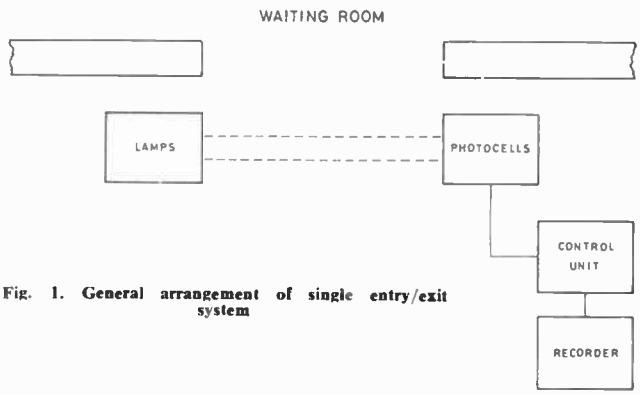


Fig. 1. General arrangement of single entry/exit system

The total count at any instant is displayed by 'Digitrons' on the front panel of the control unit and a stepwise deflexion is recorded on the paper chart. Provision has been made to extend the Digitron reading to a remote position such as a sister's office or physician's consulting room to provide an indication of the number of persons waiting at the particular clinic.

Inhibiting circuits in the control unit ensure that a count is only recorded for a complete entry or exit from the waiting room, thus even if both beams are occluded a count is not recorded until the interfering body has completely passed them. This safeguard is essential as it was found during the trial runs that false counts were recorded owing to persons half entering the room and leaving again.

Description of Instrument

The control unit is housed in a cabinet 15in by 9in by 11in. Standard type 3000 relays are used throughout: the coil working voltage being 50V. The uniselector coils were chosen to operate at this voltage and thus the complete unit is operated from a single 50V supply. Half-wave rectified a.c. mains is used to operate the Digitrons.

Fig. 2 shows the complete circuit and may be subdivided into three parts as follows.

(a) Lamps and photocells.

(b) Count display and recorder output.

(c) Relay control unit.

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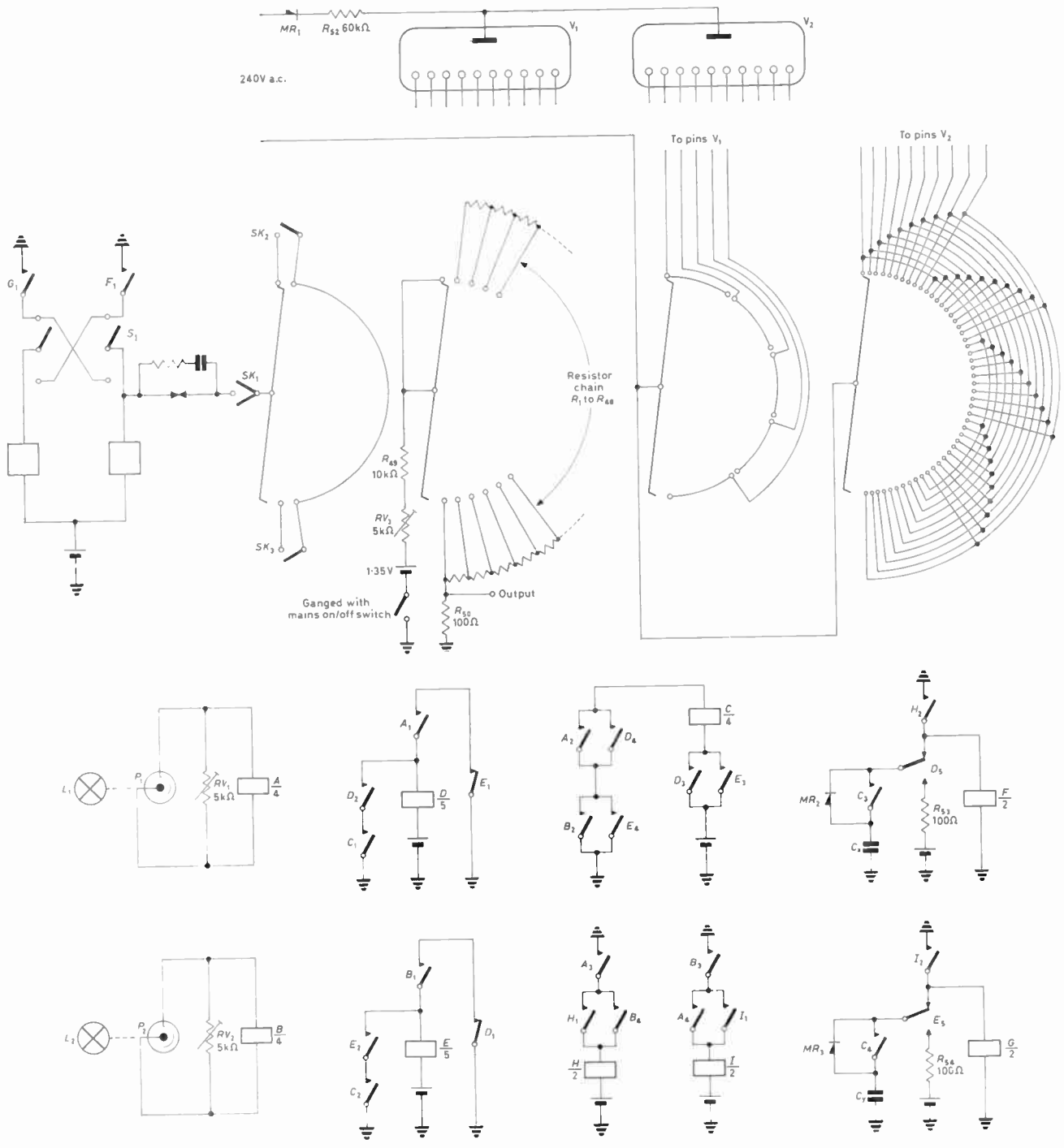


Fig. 2. Complete circuit

(a) LAMPS AND PHOTOCELLS

The lamps and photocells were mounted in pedestals which can be placed in any convenient position. They are identical in appearance, and consist of heavy cast pillars with broad bases which have suitable levelling screws for initial adjustment of the light beams. Two 12V car bulbs L_1 and L_2 are used to produce the parallel beams with suitable optical focusing. The supply for the lamps is taken from a step-down transformer mounted in the pedestal base.

To keep the circuits as simple as possible Mullard ORP11 photo-conductive cells were chosen. This enabled a relay to be placed in series with each photocell directly and retain the use of one power supply. Controls RV_1 and RV_2 allow the sensitivity of the photocells to be adjusted so that the relays A and B are energized when the light beams are incident upon their cathodes but de-energized when the beams are occluded. A simple hood shielding the photocell optics in conjuction with RV_1 and RV_2 allows operation in normal daylight conditions.

(b) COUNT DISPLAY AND RECORDER OUTPUT

The recording of counts, their numerical display and the chart recorder output is simultaneously carried out by a two-way uniselector. The two-way uniselector basically is similar to the familiar unidirectional type except

that it has twin driving coils and a modified ratchet drive enabling it to be driven in either direction by energizing the appropriate coil.

An eight level 25 way single-ended wiper type uniselector wired as a four pole fifty outlet switch allows a maximum count capacity of forty-nine to be displayed.

When the beams are broken in the correct sequence the relay control unit actuates relay F or G which in turn actuates the appropriate coil of the selector. A positive or negative count is recorded depending upon whether F_1 or G_1 is closed. The switch S_1 allows a choice of which direction is taken as positive or negative depending on the location of the pedestals. Interchange of these units to suit the locale only requires S_1 to be set in the correct mode for counting.

SK_1, SK_2 and SK_3 is a ganged standard telephone keyswitch mounted on the front panel of the control unit. Using one bank of the selector as a homing arc self-drive conditions may be achieved by closing SK_1 and either SK_2 or SK_3. Closing SK_1 and SK_3 will cause the selector to drive to its 'zero' position and similarly by closing SK_1 and SK_2 the selector will drive to its full scale condition.

When driven to full scale the chart recorder may be set to read the desired excursion by adjusting RV_3. Any intermediate count may be set into the instrument by use of the switch and reading the Digitron indicator.

The chart recorder input voltage is derived from a series chain of resistors R_1 to R_{48} in the form of a stepped variable resistor. R_{49} is connected from R_{48} to ground and the potential across this resistor provides the voltage analogue of the count. As the selector arm rotates in a clockwise direction it successively shorts out the individual resistors producing a rising staircase pattern on the chart recorder. Reversal of the selector arm likewise produces a decreasing staircase pattern. Analysis of the chart readings is facilitated by a simple cursor calibrated in counts along its length. By sliding the cursor along the chart and reading off the ordinate counts statistical studies can be achieved from this easily obtained data.

Specially graded resistors were not required for the chain network, 5 per cent high stability types selected to the nearest calculated value produced equal interval steps such that discrepencies in their heights were negligible and barely discernable on the recorder.

The values required to operate any particular chart recorder will depend upon its voltage range. Calculation of the chain is a simple matter.

The remaining banks of the selector are used to operate the Digitrons V_1 and V_2 and are wired in decades as shown in Fig. 2. Mains voltage is used to operate these via a silicon rectifier MR_1 and limiting resistor R_{52}.

(c) Relay Control Circuit

Relay contacts of the control circuits are shown in Fig. 2 in the normal quiescent condition when the light beams are incident on the photocells and relays A and B are energized.

The function of the relay control unit is basically that of a simple bi-directional counter. The action of counting an entry or exit is identical and it is proposed to describe the passage of a movement in one direction only.

For the purpose of illustrating the action of the control circuit it will be assumed that the light beams are interrupted in the order L_1 before L_2.

Interruption of the beam L_1 incident on P_1 decreases the current through relay A and de-energizes it. Contact A_1 completes the circuit of relay D through the closed contacts E_1 to ground energizing relay D. A_2, A_3, and A_4 'make' and prepare a circuit for relays C, H, and I.

When relay D operates, contact D_1 disconnects relay E from the circuit and prevents it from being energized when contact B_1 is closed. A hold circuit is prepared for relay D by contact D_2 and will keep this relay closed independent of A_1 once contact C_1 has closed. D_3 connects the 50V supply to relay C. A changeover contact D_5 connects C_x to the supply voltage via a 100Ω resistor and silicon diode MR_2. This capacitor is prevented from charging owing to the high back resistance of the diode.

When the beam from L_2 is interrupted relay B is de-energized. B_1 is closed but a complete circuit is prevented from being made by D_1 being open and relay E is immobilized. B_2 completes the circuit for relay C. The

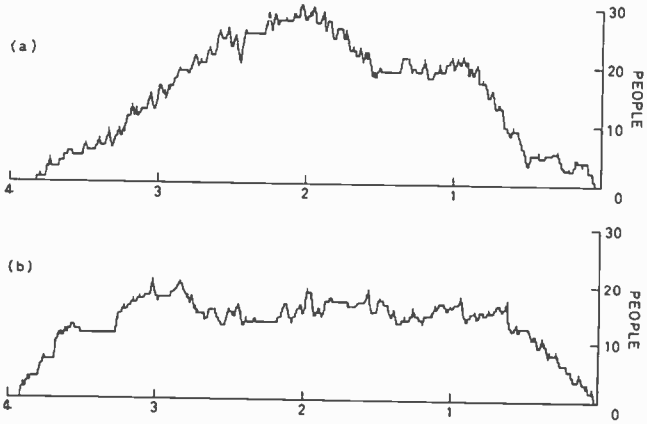


Fig. 3 (a). Distribution of patients before revision of appointments system (b). Resultant distribution utilizing instrument data to modify appointments system

operation of relay C causes C_3 to short-circuit the silicon diode and capacitor C_x is charged to the supply voltage; the 100Ω resistor acting as a current limiter. Relays H and I operate through B_4 and B_3, H_1 and I_1 close preparing the inhibit circuits and H_2 and I_2 and connects a short-circuit to ground on relays F and G.

Continuing a passage through the beams P_1 is now illuminated by the lamp L_1 and relay A is energized. Contact A_1 is now opened again but relay D is being held by D_2 and C_1.

A_3 disconnects relay H causing H_2 to remove the short-circuit from relay F. Relay C is held on via contacts D_3, D_4 and B_2.

When finally the beam from L_2 illuminates P_2 signifying a complete passage through the beams relay B is re-energized, B_2 disconnects relay C allowing C_1 and C_2 to open thus causing relay D to open a short time later. D_5 now connects the charged capacitor to relay F. The silicon diode MR_2 now presents a low forward resistance to capacitance C_x enabling it to discharge to ground via relay F energizing it for a short period. F_1 completes the circuit of the uniselector and steps it through one position registering a count.

Only when the correct sequence of beam interruption has been concluded will a count be recorded hence partial obscuration of one beam will not result in a count.

Inhibit Circuit

Prior to the inhibit circuit being incorporated, observation had shown that on some occasions a person would half enter the room obscure both beams and then leave

causing an erroneous count. Relays H and I were added to prevent this.

They function in the following manner. If both beams have been interrupted (still assuming L_1 is occluded before L_2) the relays A, B, C and D will be set up to register a count in the manner just described. If now the B relay is energized before the A relay i.e. signifying half-way entry into the room and then leaving again, the recording of a count will be inhibited in the following manner. When relay B is energized B_3 and B_4 will open but relay H will still be held on via H_1 and A_3 maintaining a short-circuit to ground on relay F via contact H_2. Relay C has been disconnected from the supply voltage by contact B_2 which in turn opens C_1 ready to release relay D.

As soon as relay A becomes energized contact A_1 disconnects relay D causing the charged capacitor C_x to be discharged to ground via D_3 and H_2. A short time later H is released but the slight delay in opening this relay is sufficient for C_x to be discharged completely. Relay I functions in a similar manner for half-entry conditions in the opposite direction.

Interpretation of the results is shown by reference to Fig. 3(a) and (b) reading from right to left.

Fig. 3(a) shows a record of a clinic whose appointments system has been based upon that of one patient every x minutes say. The gradual filling up of the waiting room is represented by the rise in the graph and exits from the waiting room by corresponding downward deflexions, the scale of the abscissae being in hours. When as in the illustration shown the inflow of patients is greater than the outflow the record shows a distinctive peak indicating that too many appointments are being made over that period of time.

Some records were observed to fall to zero before a particular clinic period was over and indicated too few appointments over that period of time.

A more even flow over the whole clinic period may be achieved by redesigning the appointments to give a relatively flat plateau. A typically balanced appointments system is shown in Fig. 3(b).

During a clinic period there are constant comings and goings by nurses and hospital staff calling in each patient. The instrument records these also but owing to their short duration relative to the flow of patients and visitors they appear as sharp spikes on the record and do not affect the overall picture.

Fig. 3 outlines a very simple description of the use made by the comparison of these chart recordings and is intended as an illustration of its use.

Detailed study of many such records allows a more elegant statistical analysis to be made of this problem.

Conclusion

In this article one method of approach has been described introducing semi-automatic techniques to tackle a complex problem. Electromagnetic methods have been employed for simplicity and cheapness.

It will be realized that this problem of waiting time not only involves the patient but that of the physician also, thus any lengthy delay between appointment times and actual time of consultation effects both equally. For instance, the time spent by the visitor with the patient may represent a number of working hours with subsequent loss of pay. Coupled with this is another factor that far larger waiting rooms are required, than is necessary for the number of patients involved.

Preliminary studies indicate that the average waiting time per patient is reduced. Further development along these lines would be justified if it results in the patients' time being saved and the efficiency of the appointments system being increased. Very little training would be required by clerical staff to form appointments systems with greater efficiency than that used at present in many out-patients departments.

The instrument was in continuous use for twelve weeks on a trial basis with constant supervision during each clinic period, and has proved to be reliable and error free.

Extension of the system to a twin entry/exit waiting room with a time sharing arrangement is under consideration.

Acknowledgments

The author wishes to thank Dr. J. C. Gilson Director of the Pneumoconiosis Research Unit and the Medical Research Council for permission to publish this article.

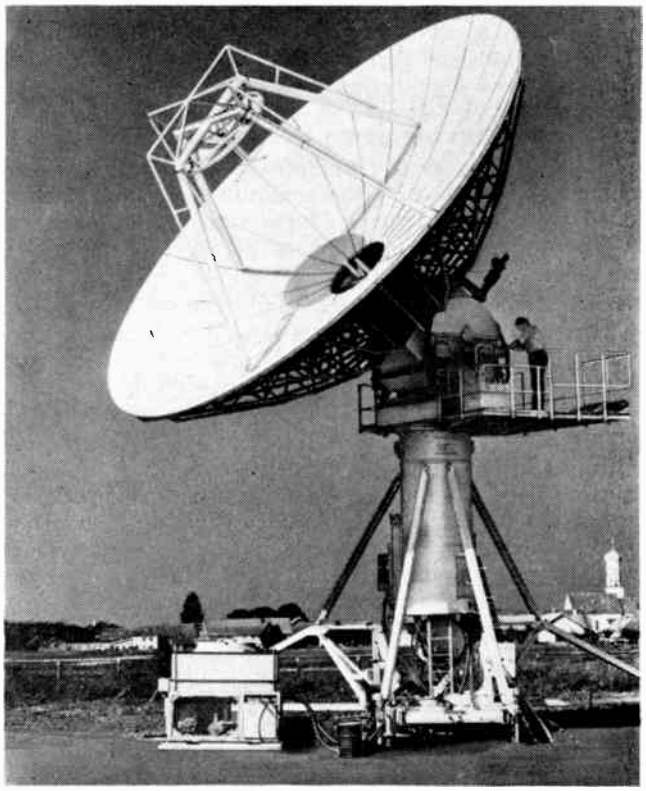
A Transportable Satellite Station

Germany's first transportable satellite ground station, designed and built by the International Telephone and Telegraph Corporation (ITT), New York, and installed by ITT's German affiliate Standard Elektrik Lorenz (SEL), Stuttgart, together with engineers of ITT and the German PTT, was put in operation at Raisting, Upper Bavaria, on 8 November, by the Federal Minister of the German PTT, Mr. Richard Stuecklen.

The terminal is capable of working with communication satellites of the Relay and Telstar type, providing 12 two-way voice channels. The equipment can handle facsimile, multichannel teleprinter circuits and high speed data transmission.

The station is completely self-contained. It travels in a van and three trailers, and can be shipped by sea, rail or road to any remote destination. Owner of the terminal at Raisting is the German PTT. Two ground stations of the same type are in operation in the United States, one in Brazil.

The transportable satellite ground station



A Digital Number Generator

By J. D. E. Beynon*, B.Sc., and K. G. Nichols†, M.Sc., A.Inst.P.

An apparatus is described which generates an eight digit binary number in serial form. Each non-zero digit of the number comprises a negative going pulse of 9V maximum amplitude and width from 1μsec up to a maximum determined by an ancillary pulse generator of normal laboratory pattern. The digit period is also determined by this latter generator. The digits of the required number may be selected by means of eight two-position switches and the number generated once, by a one-shot manual control or by input trigger signal, or repetitively, by a sequence of input trigger signals.

(Voir page 63 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 70)

IN the course of an investigation into a shift register circuit a need arose for an instrument capable of generating at choice any binary number, of up to eight digits, in serial form. The digits were to be equally spaced in time, the spacing being called the digit period. A non-zero digit was to be represented by a negative going pulse of amplitude variable in the range 0 to 9V and a zero digit was to be represented by the absence of such a pulse. Both the digit pulse width and the digit period were required to be variable from a few microseconds to many seconds and a further requirement was for an output synchronization pulse coincident with the leading edge of a digit pulse whether or not it be a zero digit. This latter pulse was of course required on a separate output.

It was further required that the number could be generated either once, following the operation of a manual control or application of a trigger pulse, or repetitively, in response to a train of input trigger pulses.

There did not appear to be a commercially available piece of equipment which fulfilled these requirements. Instruments described in the literature[1-3], were neither suitable nor could be easily modified for the present application. It was therefore decided to design and build an instrument of the required type. This article describes the generator which was evolved and which was designed to operate from a normal laboratory type pulse generator. The pulse width and period of the latter are taken as the digit width and digit period respectively.

Principle of Operation of the Generator

Basically the generator comprises a three-stage binary counter which, following the application of a start pulse, counts eight pulses from an input train and then closes its input gate. The input train of pulses is derived from the ancillary pulse generator.

Each of the eight pulses sets up a unique state in the counter and each of these states is used to control a gate corresponding to the particular pulse. An output is obtained from this gate in synchronism with its particular input pulse. Output pulses from a selection of such gates comprise the required number.

Fig. 1 is a block diagram of the instrument. For clarity only the first and fourth 'digit selecting AND gates' are shown fully connected. The non-zero digits of the number to be generated are selected by closing appropriate switches from the set S_1, S_2 . . . . S_8. For the sake of example it is supposed (see Fig. 1) that switches S_1 and S_4 only are closed. Negative pulses from the ancillary pulse generator are fed continuously into the 'input AND gate'; the other input of this gate is controlled by the bistable circuit AB. The B output of this bistable circuit is normally zero and inhibits the input AND gate. Under this circumstance no output is obtained from the gate when the input pulses are applied to it.

The bistable circuit may be switched to its other state in response to a trigger pulse or operation of the manual start switch. Either of these start signals causes the Schmitt circuit to switch twice and, by differentiating and clamping its output, a positive pulse is obtained which causes the bistable circuit to switch. The input gate is now uninhibited and the input pulses appear at its output. These pulses are thus applied to the input of the three-stage binary counter and also to the digit selection AND gates. Each of the eight states of the counter is arranged to uninhibit one, and only one, of the eight AND gates. Thus initially, the A_1, A_2 and A_3 bistable circuit outputs are all negative and AND gate number one is uninhibited. The first pulse allowed through the input AND gate thereby appears at the output of number one AND gate. In addition, its trailing edge switches the first stage of the counter. The second input pulse appears at the output of AND gate number two, and its trailing edge causes the counter to switch to its third state. This sequence continues until AND gate number eight opens and closes. The output of this gate is fed, through an emitter-follower, to a differentiating and clamping circuit. The positive pulse obtained from the latter switches the bistable circuit AB back to the state where the input pulses are vetoed and so the circuit again becomes quiescent.

Thus a group of eight pulses enters the generator, one pulse being obtained at the output of each digit selecting AND gate in synchronism with the corresponding input pulse. A selection of the AND gate outputs (numbers one and four in the present example) are fed to the inputs of the OR gate. Output pulses corresponding to the selected AND gates are obtained from the OR gate.

The pulse output from the OR gate is used to switch two Schmitt trigger circuits which in turn drive an emitter-follower. The Schmitt circuits improve the waveform and amplify the output pulse, while the emitter-follower enables the required binary number to be obtained from a comparitively low source impedance.

Description of the Circuit

A complete circuit will not be given as much of it is repetitive. Instead the details of the various component circuits will be discussed and their connexions to other parts of the circuit indicated.

The Bistable Circuits

The counter bistable circuits and the input gate control bistable circuit are of the conventional collector coupled type. The circuit for one of these is shown in Fig. 2. The first stage of the counter has some component values different from those in the later stages; these values are

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† *University of Southampton.*

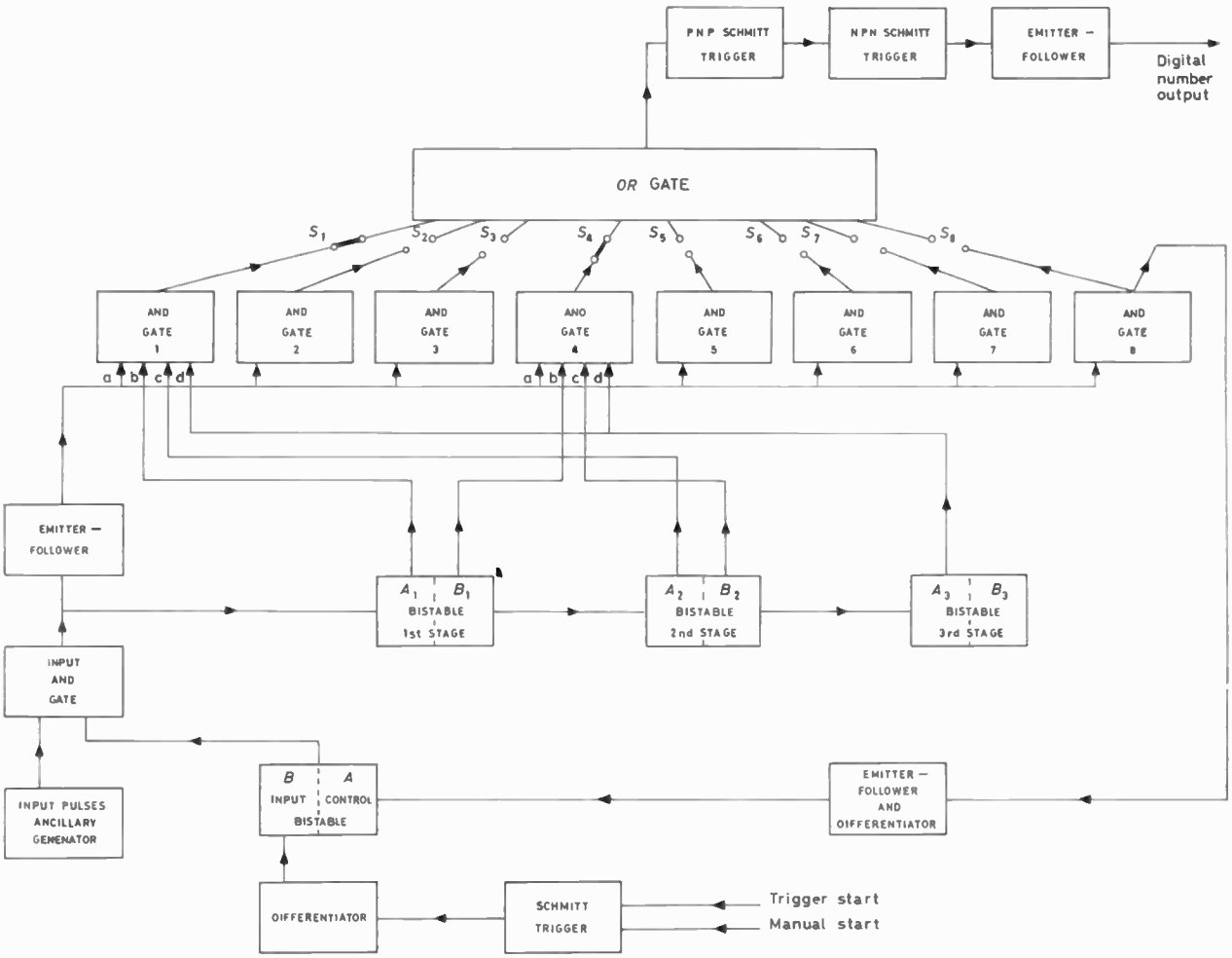


Fig. 1. The digital number generator

indicated in Fig. 2. These modifications allowed the maximum possible repetition rate for the first stage consistent with a reasonable waveform of output pulse. The pulse directing networks, C_2, R_4, D_1, are omitted from the bistable circuit which controls the input gate. For this circuit, the start signal from the Schmitt trigger is applied directly to the base of transistor VT_2 and the stop signal from the eighth AND gate to the base of VT_1.

Design techniques for this type of circuit are well known and will not be considered here. The one point worthy of mention is the load presented to the output of the counter stages. In addition to having to drive a subsequent stage a counter stage may, under adverse conditions, have to supply current to four of the AND gates and due allowance must be made for this fact in the design of the bistable circuits. The load presented to the counter stages by the AND gates is of course not known until these gates have been designed; the design of these in turn depends on the design of the OR gate which in

Fig. 2. The bistable circuits

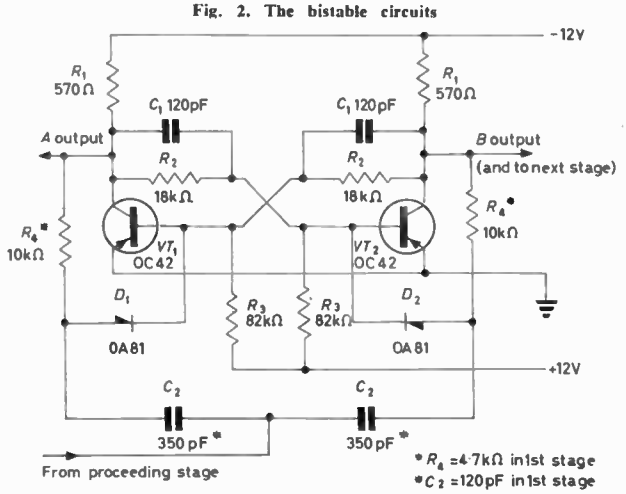
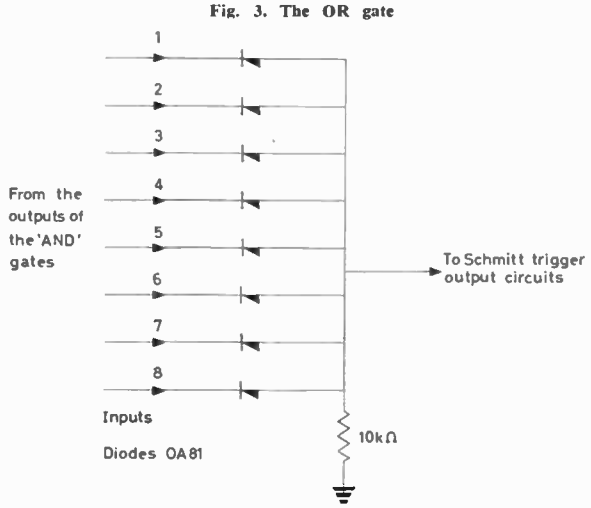


Fig. 3. The OR gate



fact formed the starting point for the design of the whole instrument.

The OR and AND Gates

The circuits for these gates are shown in Figs. 3 and 4. These gates are of commonplace design and do not warrant further comment. The input connexions to the digit selecting AND gates from the counter outputs are summarized in Table 1.

The input AND gate differs from the other AND gates only in that it has but two input diodes.

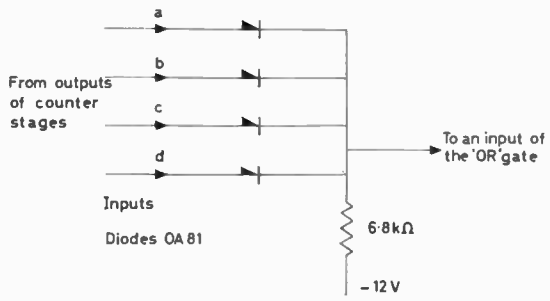


Fig. 4. The AND gates

The Reset Circuit

As explained previously, the output signal from the eighth AND gate is fed back through an emitter-follower and a differentiating and clamping network to the input control bistable circuit *AB*. The eighth pulse thus provides a switching pulse for this latter circuit which in turn inhibits the input AND gate. The circuits of the emitter-follower and the differentiating and clamping network are shown in Fig. 5. The diode in this circuit clips the negative going leading edge of the fed back pulse. The input control bistable circuit *AB* is thus switched on the trailing edge of the eighth input pulse. This also means that in the quiescent state the counters are always in the zero count condition, and so the first input pulse to be admitted after the next start signal is given, appears at AND gate number one.

The Starting Circuit

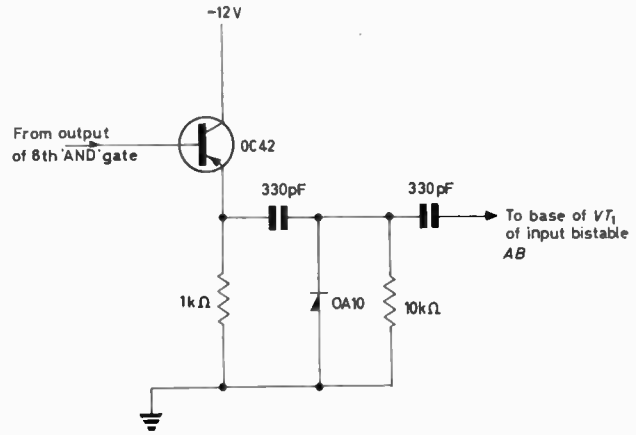
Fig. 6 shows the Schmitt trigger circuit, a pulse from which causes the input control circuit *AB* to switch and uninhibit the input AND gate. The base of transistor VT_1 is taken to a switch which selects manual or trigger input. In the manual position of the switch the base of VT_1 is normally held at a negative voltage and VT_1 conducts; VT_2 is cut-off. Operation of the manual start switch returns the base of VT_1 to earth cutting off this transistor and switching on VT_2. The positive step at the collector of VT_2 is then differentiated, clamped, and applied to the base of the VT_2 transistor of the input control circuit *AB*. This latter circuit then switches and uninhibits the input AND gate. On releasing the manual start switch, the

TABLE 1

Connexions to the Inputs of the Digit Selecting AND Gates

INPUTS	AND GATE NUMBER	1	2	3	4	5	6	7	8
	a	Pulse line from 'Input AND gate'							
	b	A1	B1	A1	B1	A1	B1	A1	B1
	c	A2	A2	B2	B2	A2	A2	B2	B2
	d	A3	A3	A3	A3	B3	B3	B3	B3

The numbers in the body of the table refer to the stage number of the counter



The reset line emitter follower and differentiator

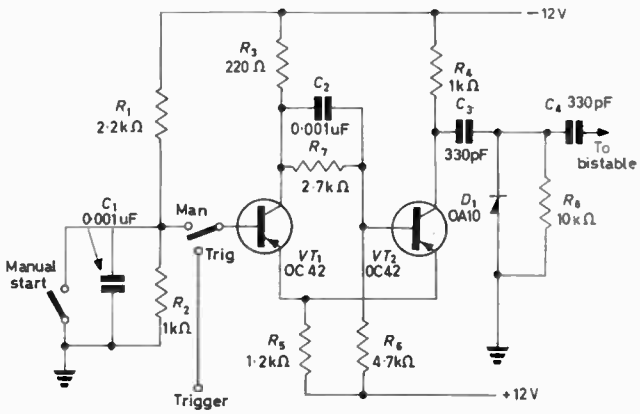


Fig. 6. The Schmitt trigger starting circuit

capacitor C_1 (see Fig. 6) charges very quickly and after approximately 1μsec, the Schmitt trigger switches back to its original state. The negative step produced at the collector of the VT_2 transistor of this circuit is clipped by the diode in the following differentiating and clamping network and thus does not alter the state of the bistable circuit *AB*.

In the trigger position of the selector switch, the base of VT_1 (Fig. 6) is driven up to zero voltage by positive going pulses*. For each such pulse an action as described for the manual operation then ensues. Either a single input trigger pulse or a train of pulses may be used.

The Output Circuits

The output pulses, comprising the digits of the number, from the OR gate are used to switch two Schmitt triggers in series cascade. The first Schmitt trigger uses pnp transistors and provides negative going pulses from about −6V to −12V (the supply line voltage). In order to convert these to pulses which are negative going from zero voltage they are used to switch a second Schmitt trigger constructed with npn transistors. The final output is taken from a pnp emitter-follower which is switched

* *The positive pulses obtainable from most laboratory pulse generators are in fact positive-going pulses from some negative voltage up to zero voltage. The circuit was designed with this consideration in mind.*

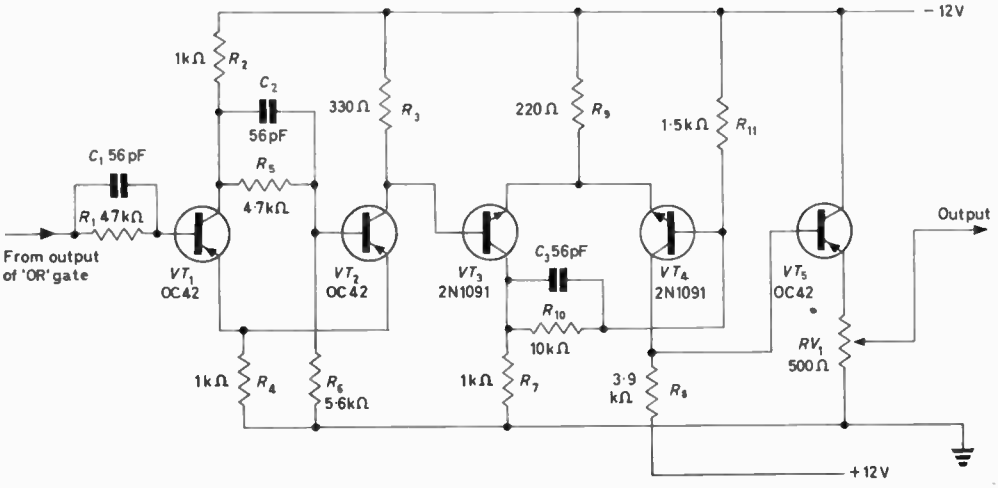


Fig. 7. The output circuits

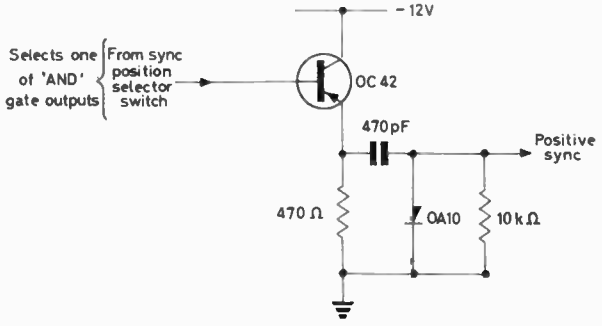


Fig. 8. The synchrooization output circuit

from cut-off to a non-saturating state by the output pulses from the second Schmitt trigger. The output circuits are shown in Fig. 7.

Transistors VT_1 and VT_2 of Fig. 7 form the first Schmitt trigger and VT_3 and VT_4 the second. The parallel components C_1 and R_1 are used to 'speed up' the first Schmitt trigger. The capacitor C_1 causes VT_1 to be voltage driven by the negative going leading edge of a digit pulse; thus VT_1 switches on quickly. However VT_1 may be driven into saturation in this way, and if it remained in saturation there would be delay in switching it off. The components C_1 and R_1 are chosen such that by the end of even the shortest digit pulse (1μsec) VT_1 is not saturated; hence a rapid switch off of VT_1 follows the positive going trailing edge of the digit pulse. The value of the resistor R_3 in the first Schmitt trigger circuit was chosen so that the second Schmitt trigger circuit operated satisfactorily without the need for a CR drive arrangement as for the first Schmitt trigger circuit.

The output is taken from the 500Ω potentiometer in the emitter lead of transistor VT_5. This arrangement provides a suitable pulse amplitude control and a sufficiently low output impedance for the required application. However if a lower output impedance was required it could be achieved by improved design of this part of the circuit.

Synchronization Output

One facility provided in the instrument is a synchronization pulse which may be used to trigger other apparatus used in association with the generator. This pulse may be chosen to be in synchronism with the leading edge of any digit whether it be a unit digit or zero digit. The circuit for this facility is shown in Fig. 8.

Performance of the Instrument

The instrument operates satisfactorily from any ancillary

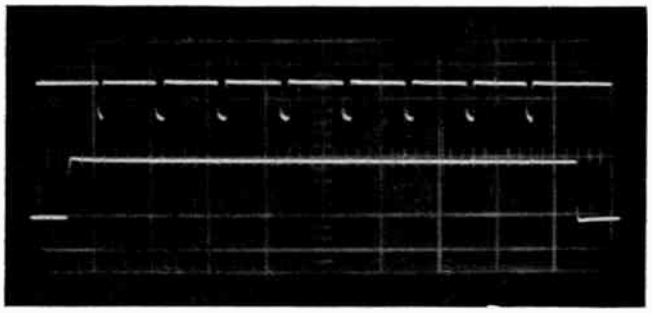


Fig. 9 (above). Binary number 11111111, 2μsec digit pulse, 16μsec digit period

Fig. 10 (below). Binary number 11101101, 20μsec digit pulse, 70μsec digit period

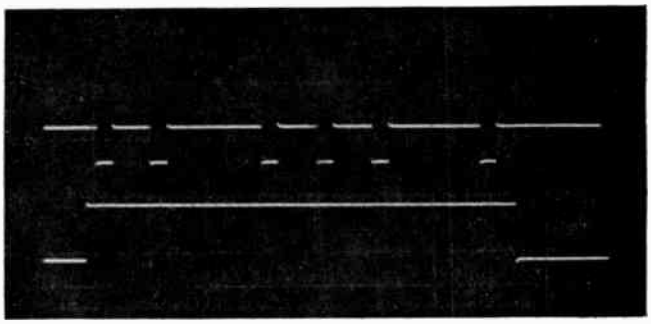
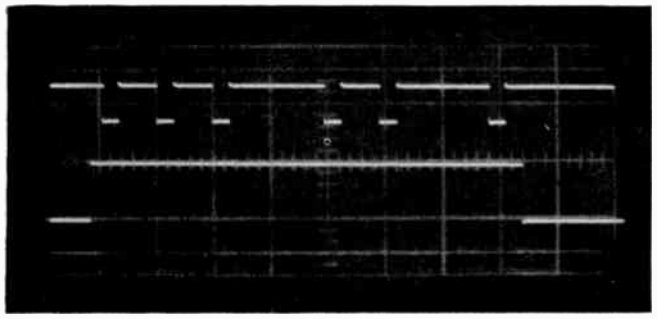
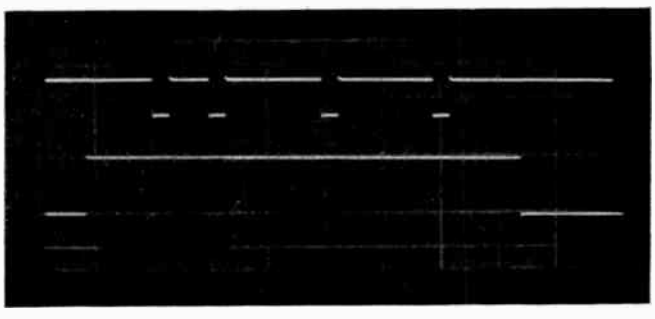


Fig. 11 (above). Binary number 11011101, 20μsec digit pulse, 70μsec digit period

Fig. 12 (below) Binary number 01101010, 20μsec digit pulse, 70μsec digit period





pulse generator providing up to 10V amplitude negative going pulses from an output resistance of less than 500Ω. These pulses need not form a regular train; in fact the instrument will operate reliably when driven by unequally spaced pulses of indefinite duration generated by the one-shot facility of the ancillary pulse generator. This extreme range is a consequence of direct coupling of all important sections of the number generator.

At the other extreme operation is possible with pulse widths as short as 1μsec and repetition periods of 2μsec. Fig. 9 shows the output of the instrument for 2μsec digit pulses and 16μsec digit period. Figs. 10, 11 and 12 are typical of the ouput waveforms obtainable in the middle range of the instrument. For each of these photographs the digit width is 20μsec and the digit period is 70μsec. The lower trace in the photograph is the trigger input waveform, the only essential part of which is the positive input step preceding the number. Any trigger input signal which rises to zero will suffice to operate the generator, the circuit being switched back to its quiescent state by the eighth digit pulse.

Acknowledgments

The authors would like to thank the University for facilities provided for this work and to thank Professor Zepler for his encouragement. They also wish to take this opportunity of expressing their gratitude to Mr. Bassett and his staff, in particular to Mr. Eastman who designed the layout of, and constructed, the instrument.

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An E.C.G. Recorder for Active Subjects

By H. Hirschberg*

A system built up around a miniature tape recorder for the recording of electrocardiograms in active subjects is described. The use of a tape recorder as the data acquisition element overcomes some of the disadvantages of radio-telemetry. Pulse frequency modulation is used, giving rise to a simple yet accurate system.

(Voir page 63 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 70)

THE introduction of miniature radio-telemetry equipment into the field of biological data acquisition has allowed the biological research worker greatly increased freedom in the design of his experiments. Subjects can now be 'observed' under almost normal conditions of exercise or stress without the hampering effects of connecting wires or large bulky equipment.

Radio-telemetry though, has brought with it its own inherent disadvantages, the most prominent being its limited range. Also, though f.m. transmission is almost exclusively used for such systems, variations in transmitter field strength have introduced artifacts which are difficult to eliminate.

A system has been developed around a miniature, commercially available, tape recorder (weight 900 grams) for the recording of electrocardiograms which overcomes these disadvantages. Also the equipment can be used completely unattended thus freeing the experimentor for other work during the time of the experiment, which may last several hours. A cardiotachometer is also included in the system so that the beat to beat heart rate can be obtained along with the electrocardiogram.

A block diagram of the entire system is shown in Fig. 1. Since the frequency spectrum of the e.c.g. falls below the frequency response of the tape recording process some type of carrier system must be employed.

Pulse frequency modulation[1] has been selected since the modulation and demodulation equipment required is generally simpler than for other methods, and tape drop-outs are not as critical.

The electrocardiograph amplifier and pulse frequency modulator are shown in Fig. 2(a). The amplifier is single ended for simplicity and reduced size, and since the equipment is generally used out of doors, no problems with mains frequency pick-up have been encountered.

The input impedance of the amplifier should be reasonably high (50kΩ to 100kΩ) so as to minimize the effects of changes in electrode impedance. VT_1 being an emitter-follower has sufficient input impedance to satisfy this requirement. VT_2, VT_3 and VT_4 comprise a three stage common emitter a.c. amplifier. The pulse frequency modulation circuit consists of a unijunction transistor (VT_5) relaxation oscillator, whose repetition frequency is controlled by the current in VT_4.

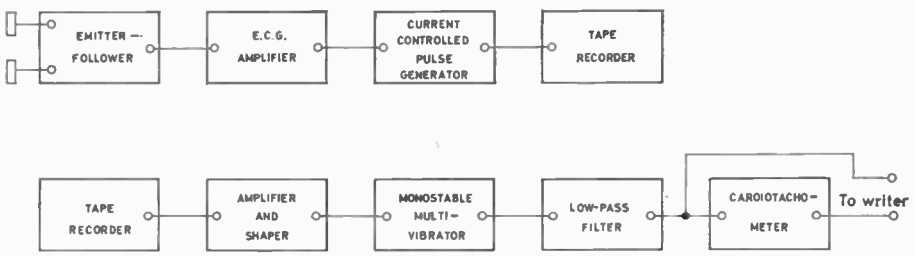

Fig. 1. The complete system

The capacitor C_t is charged by the collector current of VT_4. The time-constant associated with this charge is composed of the output impedance of VT_4 and the capacitor C_t. This time-constant is large compared to the pulse repetition time and so the charging current is nearly a constant, thus ensuring reasonable linearity of the pulse repetition rate as a function of base current. When the voltage across C_t reaches the firing voltage of VT_5, VT_5 is driven into its low positive resistance region, discharging C_t. The discharge current gives rise to a short duration pulse at base 2 of VT_5. These pulses are coupled to the recording amplifier of the miniature tape recorder and

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are subsequently recorded on the tape. The pulses are recorded at a very high level, which completely saturates the magnetic tape. Since the pulses are used only as triggering pulses in the demodulation process, pulse distortion is of little consequence.

A gain control is included in the amplifier but generally its setting need not be altered from experiment to experiment.

The demodulator and cardiotachometer circuits are shown in Fig. 2(b). The demodulator is basically a direct reading frequency-meter[2]. The recorded f.m. pulses are amplified and shaped in VT_1. The shaped pulses are then used to trigger VT_2, VT_3 which together comprise a monostable multivibrator. The output of the monostable, which consists of constant energy, variable frequency pulses, is fed, via an emitter-follower VT_4, to a low-pass filter which extracts the average value of the pulse train. Since response to d.c. was not required the low-pass filter is a.c. coupled thus eliminating the d.c. offset voltage caused by the average value of the carrier.

An ordinary e.c.g. pen recorder can be used to make a permanent record.

The frequency response of the entire system is 0·5 to 150c/s determined mainly by the output filter.

The demodulated electrocardiogram is also coupled to a cardiotachometer, VT_5 to VT_8 (Fig. 2(b)). The R spike of the total e.c.g. waveform after amplification and shaping in VT_5 is used to trigger the monostable VT_6, VT_7. The monostable in turn controls the starting and resetting time of a linear ramp function generated by VT_8. The height attained by this ramp is then a measure of the time between beats or equal to 1/pulse rate. Fig. 3 shows both a sample e.c.g. and rate recording.

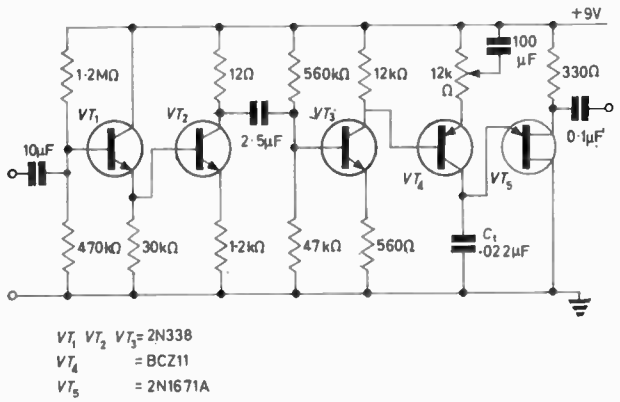

Fig. 2(a). The amplifier and pulse frequency modulator

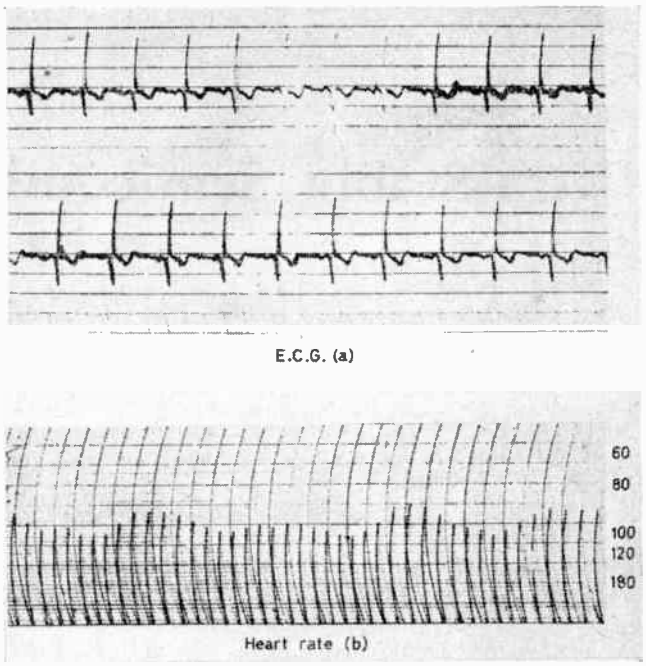

Fig. 3. A sample e.c.g. and rate recording

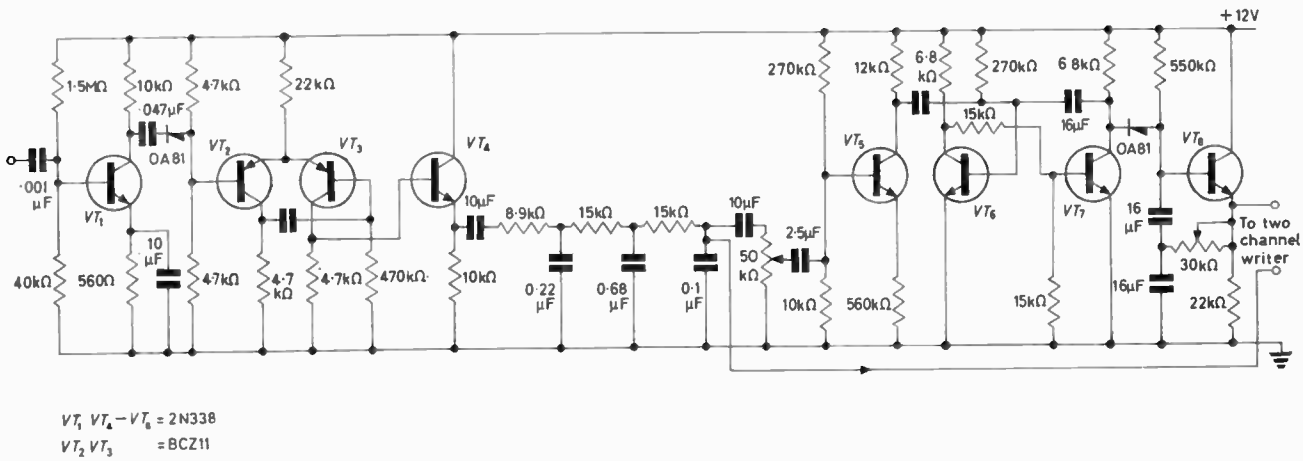

Fig. 2(b). The demodulator and cardiotachometer circuits

The maximum continuous recording time without changing tape canisters is limited to half hour. In experiments where it is inconvenient to stop the subject to change tapes a small electronic timer is used to turn the tape recorder on for a period of one minute. The off time can be varied from one to nine minutes giving a maximum undisturbed experiment time of five hours.

The e.c.g. recorder has been used in a variety of experiments including a 60km cross country ski race with satisfactory results.

Amplifiers for the recording of the e.c.g. and e.m.g. have also been constructed and circuits for the multiplexing of more than one function (i.e. e.c.g. and temperature) and now under construction.

Acknowledgment

The author wishes to acknowledge the assistance of Dr. K. Lange-Andersen, Helge Skare, Asbjorn Nordby, and Hakon Buset.

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Ultra-Stable Semiconductor Reference Diodes

By R. H. Murphy*, B.Sc.

Progress is reviewed in the art of manufacturing silicon reference diodes and processing them for ultra-stability and high reliability. The extent to which these semiconductor devices are now able to meet the low voltage drift and temperature coefficient criteria demanded of precision voltage references is then discussed in relationship to pre-conditioning procedures, life testing methods and measurement accuracies. In conclusion documentation of the life histories of individual units during extensive testing is presented and justified as a technique of guaranteeing the long-term stabilities of the devices when operated under specified conditions.

(Voir page 63 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 70)

RECENT advances in semiconductor device technology have produced regulator or Zener diodes capable of being used as ultra-stable voltage references. Extremely low temperature coefficients coupled with negligible voltage drift during operating and storage life are the direct results of a new approach to the fabrication of these devices.

This development has been necessitated by the requirement for compact portable voltage references capable of reliable operation in severe environments, such as those encountered in guided weapon and space vehicle equipment. Precision power supplies, voltage comparators, potentiometers, and highly accurate digital voltage measuring equipments designed for these environments demand references superior in many respects to conventional standard cells.

To this end extensive data relating to the device technology that conditions stability as a function of time and temperature independence of voltage are being accumulated. In addition an increasing knowledge of failure modes is being fedback to the device development and fabrication teams in order to eliminate all failures or potential failures directly attributable to faults in construction. This knowledge of failure modes is being generated by comprehensive life tests which are producing reliability assurance figures to sufficiently high confidence levels for the types of equipment referred to above.

The ultimate objective of this development programme is to produce a solid state device capable of gaining general acceptance as a primary voltage standard, but production lines for less sophisticated devices are already inheriting the acquired techniques.

Device Technology

The reverse voltage-current characteristic of a silicon junction diode exhibits a sharp ' breakdown ' region, which, provided it is distributed uniformly across the junction and limited in power dissipation to lie within the designed capability of the device, is completely reversible and non-destructive. This breakdown is due to a combination of two mechanisms known as Zener effect and avalanche multiplication. The former results from a carrier emission caused by electric field intensity, and the latter a carrier multiplication due to ionizing collisions analogous to those causing gaseous discharge phenomena. An important characteristic which differentiates the two mechanisms is the temperature coefficient; this being negative for Zener effect and positive for avalanche multiplication.

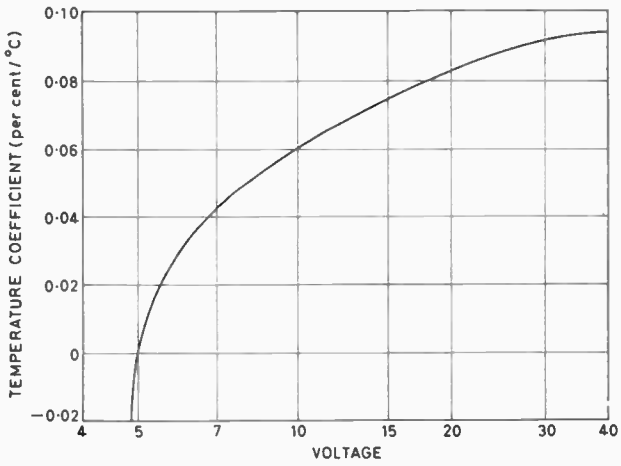


Fig. 1. Dependence of temperature coefficient on reverse breakdown voltage

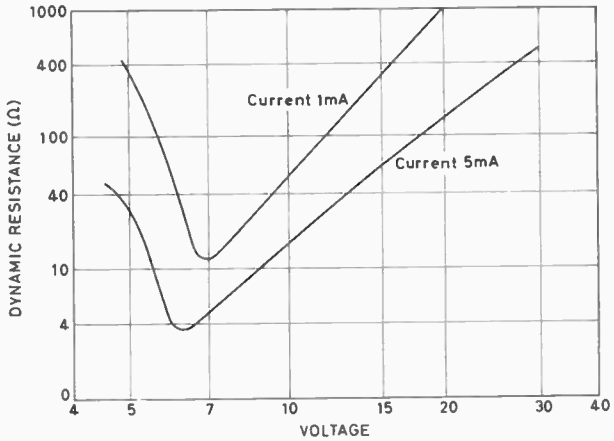


Fig. 2. Variation of dynamic resistance with breakdown voltage and reverse current

The curve of temperature coefficient against breakdown voltage drawn in Fig. 1 illustrates how avalanche multiplication becomes the predominant mechanism in devices fabricated for reference voltages higher than 5 to 6V. Devices falling in the range 4·5 to 5·5V have very low temperature coefficients, but the dependence of this para-

* *Transitron Electronic Ltd.*

meter on the operating voltage and hence on the current and temperature tends to be severe since the slope of Fig. 1 is also steepest in this region. In addition the magnitude of the dynamic resistance or slope of the $V-I$ characteristic in the breakdown region remains fairly high as shown in Fig. 2, and since minimum dynamic resistance is a very desirable attribute of a voltage regulator it is preferable to choose the range 5·5 to 7·5V according to the desired operating current.

The temperature coefficient of a unit yielding minimum dynamic resistance is typically +0·03 per cent/°C, but a reduction can be achieved by connecting a forward biased

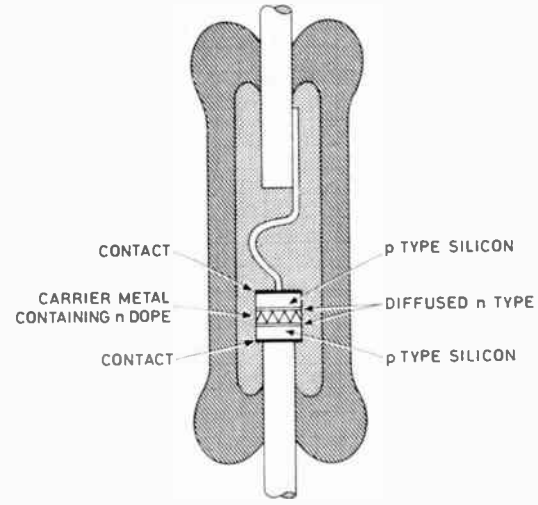


Fig. 3. Cross-sectioned view of the alloy-diffused reference diode

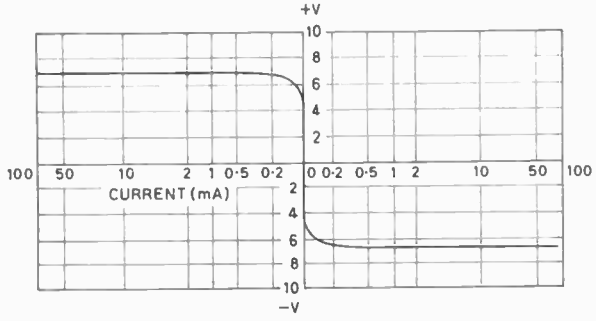


Fig. 4. Typical d.c. characteristic of alloy-diffused reference diodes

silicon diode in series; the temperature coefficient of the latter being characteristically negative and of the order −1·5 to −2·5mV/°C. For example, a 5·6V regulator exhibiting a +1·5mV/°C voltage change may be combined with a forward biased diode (Stabistor) of −1·5mV/°C change to produce zero overall temperature coefficient. The forward biased diode adds approximately 0·6V to the reference and 4Ω to the dynamic resistance yielding a 6·2V unit of typically 8 to 15Ω dynamic resistance at 5mA. This technique may be extended to produce references of higher voltage by increasing the number of Stabistors and matching to higher voltage regulators. Thus two Stabistors in series may be combined with a 7V regulator to produce an 8·2V reference.

Limitations of Silicon Alloy References

Manufacture of reference diodes by series combination of separate forward and reversed biased diodes produced by the silicon alloy process in the manner described above was a standard technique until the inception of the diffused process (to be subsequently described). It did, however, present several rather difficult problems. Possibly the most difficult proved to be obtaining a high yield of regulators to the required voltage tolerance. With the alloy process the only variable that could be used to control this parameter was the resistivity of the silicon. Accurate matching of regulators and forward diodes required controlling the regulator voltage to 1·5 per cent which demanded a resistivity control to within 10 per cent. The resistivity of a typical n-type silicon crystal may, however, be expected to vary by up to 100 per cent along its length so that only a small portion of each crystal could yield regulators to the required accuracy. The matching process then involved the additional problem of choosing pairs with identical positive and negative coefficients over a wide temperature range and assembling them in a single encapsulation in such a way that no accidental mis-match was introduced; all measurements in this process necessitating accuracies of better than 1mV in 6V.

The Alloy-Diffusion Process

It was found that by using boron doped silicon (p-type) and a graded junction formed by diffusion, the above problems could be minimized. The voltage yield could now be controlled by the duration and temperature of the diffusion in addition to the resistivity of the semiconductor material. Moreover, a much more effective utilization of the silicon could be obtained since the resistivity of a boron doped crystal varies typically only 10 per cent along its length.

However, the low voltage required for reference diodes dictated very heavily doped silicon and this in turn resulted in the junction formed by gaseous diffusion lying very close to the crystal surface. This extremely shallow depth made both the surface preparation before diffusion, and the contact formation afterwards, very critical. It was therefore decided to use the alloy-diffusion process to overcome these limitations. This allowed the formation of a graded junction by alloy diffusion from n-doped material into boron doped silicon by heating under closely controlled conditions.

It was also found convenient using this technique to form the regulator and compensating forward biased junctions simultaneously and thus overcome the matching problem as well. This is done by placing the n-doped material between two slices of p-type silicon and proceeding with the alloy-diffusion process as above.

A cross-section of the complete assembly is shown in Fig. 3 and typical electrical characteristics are illustrated in Fig. 4. Since the characteristics are symmetrical, either polarity of the applied voltage may be used. The units are usually marked to indicate the polarity which yields the most desirable combination of dynamic resistance and temperature coefficient. The typical dynamic resistance at 7·5mA is of the order 10Ω. The process concentrates the voltage distribution in a very narrow range, with a high percentage of finished diodes having a temperature coefficient much less than 0·001 per cent/°C.

Temperature Dependent Stability Considerations

Fig. 5 shows a plot of change in voltage of a typical 0·01 per cent/°C reference diode against variations in operating temperature. From 0°C to 100°C the voltage varies linearly with temperature (i.e. the temperature coefficient is constant), while for negative temperatures

appreciable departure from linearity is observed. In measuring the temperature coefficient on a 100 per cent basis for conformity to specification, changes in voltage between +25°C and +100°C and between +25°C and −55°C are observed and the highest value quoted. Thus if operation is to be limited to positive temperatures only, figures one-third or less of the quoted value (i.e. 0·003 per cent/°C in this case) may normally be assumed.

Dependence of the temperature coefficient on diode current for a series of units is illustrated in Fig. 6. This shows the coefficient to be a minimum when the current is of the order of 7·5mA but in the IN827 series shown it is well

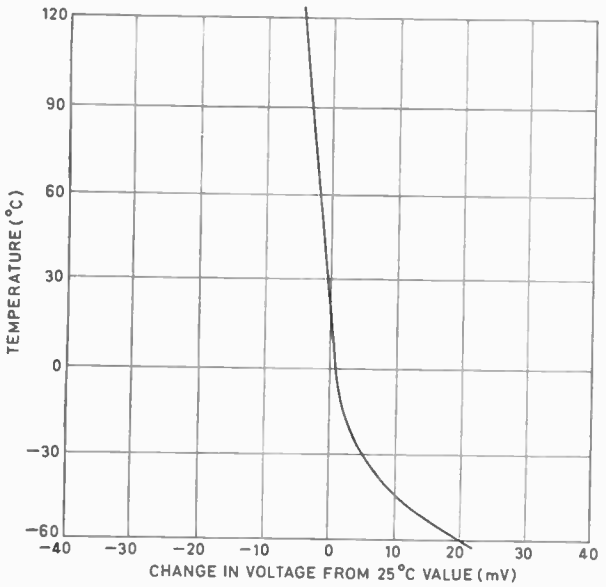


Fig. 5. Variation of breakdown voltage with temperature

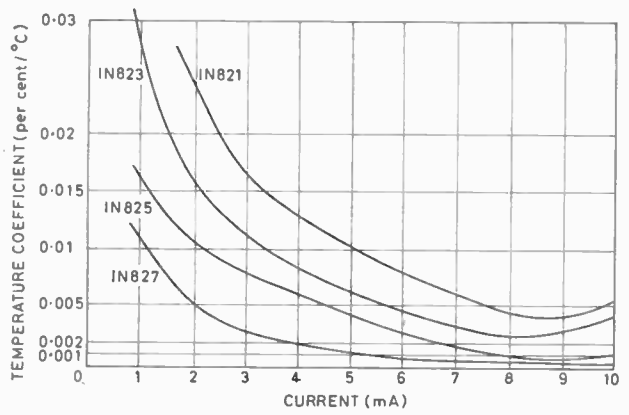


Fig. 6. Variation of the temperature coefficient of the alloy-diffused reference diodes with reverse current

below 0·001 per cent/°C within the range 5 to 10mA. The noise level resulting from voltage fluctuations in the normal current range is typically 50μV, which is about ten times lower than is commonly found in alloy junction reference diodes.

Long Term Stability

Accelerated ageing of the devices in the form of a 'burn-in' at over current (e.g. 50mA) removes failures that would occur early in life, i.e. it brings a given lot of devices to the condition exhibiting extremely low constant or steadily decreasing failure rates due to unpredictable random causes by eliminating the failures directly attributable to faulty construction, contamination and similar 'infant mortality' phenomena. Notice that in this context 'failure' implies a drift in any of the major parameters rather than an absolute or catastrophic failure. Further changes in breakdown voltage, dynamic impedance, noise and temperature coefficients may be minimized by the application of this pre-conditioning process; the longer the burn-in time, the more stable the unit tends to become, provided that the burn-in current level and duration used are well chosen. This choice, which can only be based on considerable experience, lies between a low current which would take a very long time to eliminate all the units susceptible to infant mortality, and a high value which would thermally induce failures of good units before the end of even a short pre-conditioning period. For example, a 50 hour burn-in that removes from a population of devices 62 per cent of all units that would fail in the first 10 000 hours of life if operation were continued at the current level used during burn-in, would be considered an efficient screening process. A 1 000 hour burn-in at the same level would remove perhaps a further 18 per cent of what would be considered good units at the much lower current levels used during normal operating life. The following results of operational life tests on units of the IN821 series that had received such a burn-in illustrates this point effectively:

Test Conditions: Zener current, $I_z = 15$mA at 25°C

Failure Criteria at $I_z = 7{\cdot}5$mA:

Change in Zener voltage, $\Delta V_z \geqslant \pm 0{\cdot}1$V

Temperature Coefficient $\geqslant 0{\cdot}025$ per cent/°C

Dynamic Resistance $Z_z \geqslant 20\Omega$

Scope of Data: 11 509 648 unit hours

Observed Failure Rate: 0·020 per cent per 1 000 hours

The Certified Reference

For devices to be used in precision voltage circuits such as reference voltage sources for gyroscope and servo systems, or in fact any precision measurement field requiring 'standard cell' stability, predictions of stability and life expectancy are not enough and a more rigorous approach is used. This takes the form of documentation of the histories of individual units over a stabilization period of at least 1 000 hours, at the end of which they may be certified as having guaranteed stabilities comparable with those of the standard cell.

During the stabilization period the leakage current is observed. This has been proved an accurate gauge of long-term reliability. It represents the sum of surface and bulk leakage currents and thus reflects the care taken in the process of assembly. The test series commences with an energized high temperature storage which reveals premature failures such as drift in reference voltage and therefore increase in dynamic impedance and/or leakage current. Hot and cold temperature cycles are then alternated in order to detect by thermal shock any weak mechanical bonds or imperfections in the structure. Finally, extended storage and operating life tests and ability to withstand intermittent stresses are observed.

At the beginning and end of all such tests voltage readings are taken in special equipment designed for an ambient temperature repeatability of $\pm 0{\cdot}1$°C and an energizing current repeatability of $\pm 1\mu$A. The voltage measuring techniques involve a total system precision, which, at worst case, comprises the following accuracies over the duration of the tests (up to 5000 hours):

	Absolute	*Stability*
	(parts in 10^6)	
Saturated Standard Cells	±5	±1
Potentiometer	±3	±1
Current Supply	±2	±1
Circuit Errors (thermal e.m.f.'s, leakage currents, induced e.m.f.'s, galvanic action and residual charges due to dielectric absorption)	±2	±2
	±12	±5

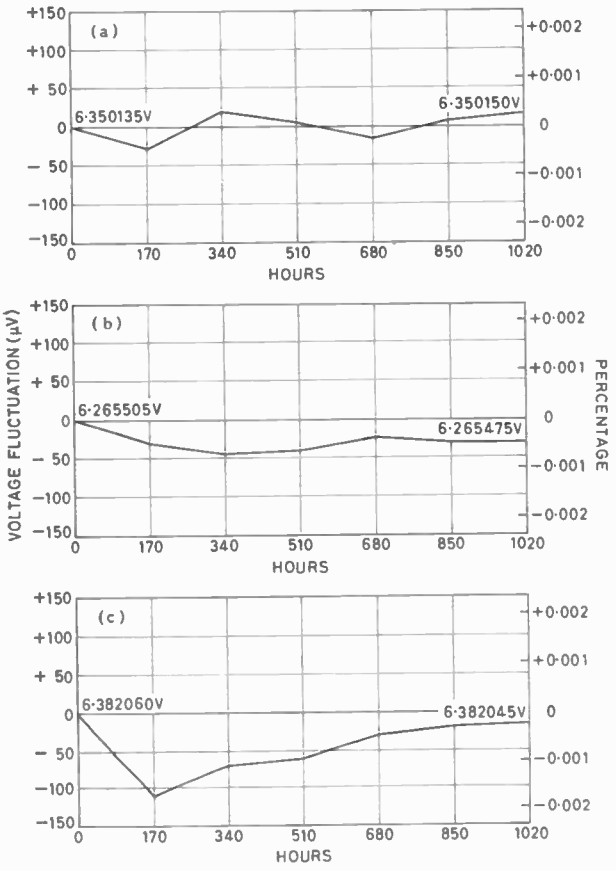


Fig. 7. 1 000 h behaviour curves of typical certified reference diodes

It is entirely conceivable that some of these drifts cancel each other, so that the absolute accuracy of the system is probably better than ±10 in 10^6 with a repeatability of better than ±3 in 10^6. The absolute accuracy relies on comparison with the 'absolute volt' kept by the U.S. National Bureau of Standards. For this purpose one reference bank of standard cells and two transfer banks are maintained; these being periodically checked by the N.B.S.

During the 1 000 hours minimum of continuous changes in the operating conditions of each unit, sufficient documentation of stability is obtained to enable them to be individually certified as falling into stability categories ranging from ±0·01 down to ±0·002 per cent per 1 000 hours. Experience shows that in all cases stability over subsequent 1 000 hour periods will then fall well within these classified categories. The behaviour histories during the stabilization period of typical units of the IN3501 series certified in this way are shown in Fig. 7. Other specifications on this series include:

Voltage range at $I_z = 7{\cdot}5$mA at 25°C : 6·2 to 6·5V

Max. temperature coefficient (+25 to 100°C) at $I_z =$ 7·5mA : ±0·0005 or ±0·001 per cent/°C.

Max. dynamic resistance $I_z = 7{\cdot}5$mA at 25°C : 12Ω

Storage temperature range : −65 to +150°C

Max. operating temperature at $I_z = 7{\cdot}5$mA : +125°C

Max. altitude of operation : Any.

Conclusions

The alloy-diffused process is capable of producing low temperature coefficient reference diodes with greatly improved stability. The control of voltage inherent in the process optimizes both the dynamic resistance and the temperature coefficient, and these parameters can be made as low as 8Ω and 0·0005 per cent/°C respectively.

The process also enhances long term stability and reliability; maximum variations in reference voltage of 1mV over 5 000 hours and 0·1mV over consecutive 10 hour periods are typical of life test results on alloy-diffused units. These results compare favourably with long and short term stabilities of 5 and 1·5mV respectively typical of alloy type reference diodes.

Careful analysis of historical data plus an understanding of the physical mechanisms of the devices has resulted in very accurate identifications from burn-in data of those devices most likely to fail in early life even though they may not have failed during burn-in. This has further improved the reliability standard of devices allowed to reach the user. A subsidiary benefit from burn-in is the immediate generation of information concerning failure modes that can be fed-back to the manufacturing process, and there result in removal of the causes of infant mortality.

One of the most significant factors affecting any reported failure rate is the criteria by which a unit under test is judged to have failed. Some reliability data reports only catastrophic failures, i.e., units which go either open- or short-circuit. Since the usual mode of failure is a degradation of one or more parameters, the tallying of only catastrophic failures will give an impressively low failure rate assurance figure which is usually of little value to the user. The failure rates included in this report show clearly the criteria upon which they are based and though these are somewhat severe, they reflect the precision usage envisaged for these devices.

The burden of the voltage drift of the certified references is observed to occur during approximately the first 400 hours of life. This emphasizes that pre-ageing is a requirement for stability. Neither a limit to the time during which drifts continue to decrease nor the incidence of a wear-out phase has been discovered for devices operated well within their ratings. The 1 000 hour stabilization period is considered a necessity for assurance of the certified stability percentage.

Reports of these certified reference diodes in missile and satellite applications show that, when used in circuits of adequate design, they closely approach the working standard cell in stability and do so under conditions of shock, temperature, altitude, and changes in position that the latter could not withstand.

Acknowledgments

This article has been based on Internal Memoranda by Windsor H. Hunter and Sirio A. Sconzo of the Transitron Electronic Corporation. Acknowledgement is also due to the Directors of Transitron Electronic Ltd for permission to publish the material presented.

Short News Items

The Electronics Section of the South Midland Centre of the Institution of Electrical Engineers and the West Midland Section of the British Institution of Radio Engineers are arranging a joint one-day symposium on 'Electronics in the automobile industry' to be held in the Electrical Engineering Department, University of Birmingham, on 7 April 1964.

The symposium will review the application of electronics in automobile research and development and in the production of vehicles and their component parts.

In addition various aspects of traffic control and general co-ordination will be included.

Further details and registration forms may be obtained from Mr. G. K. Steel, College of Advanced Technology, Department of Electrical Engineering, Gosta Green, Birmingham 4.

The Electronic Engineering Association has produced a "Guide to the Design and Construction of Electronic Equipment". It provides under one cover a summary of the many considerations involved in the design and construction of certain categories of electronic equipment.

The subjects covered by the guide include, environmental and design considerations, constructional practices, post manufacturing and customers service, an index to specifications etc., and a model equipment specification.

Copies of the Guide are available at a cost of 2 guineas each from the Electronic Engineering Association, 11, Green Street, Mayfair, London, W.1.

The Compagnie Generale de Telegraphie Sans Fil (CSF) has recently supplied 450 type MF.933 transmitter-receivers to the Compagnie Generale des Voitures à Paris for installation in their taxi fleet.

The type MF-933 equipment works on the 66 to 88Mc/s band and has an output power of 12W.

The General Electric Co. Ltd. has received an order valued at £3/4 million from the Hellenie Telecommunications Organization for the supply of equipment for s.h.f. and u.h.f. microwave radio systems. The main route will run along the west coast of Greece and will consist of two bothway s.h.f. channels between Patras in the south and Michalakades on the island of Corfu, with a baseband switching station at Thyrrion. There will be two intermediate repeater stations, one between Patras and Thyrrion and the other between Thyrrion and Michalakades. A spur route using similar equipment will run between Thyrrion and Ioannina with one intermediate repeater station. The radio equipment for these routes will operate in the 6000Mc/s band and each radio channel has a capacity of up to 960 telephone speech channels.

Two other routes will be equipped with u.h.f. microwave radio equipments operating in the 2000Mc/s band, one between Michalakades and Kerkyre and the other between Thyrrion and Agrinion.

All the equipment conforms to CCIR recommendations.

The Management School of the College of Aeronautics. Cranfield, Bucks, is introducing a 10-week course to be known as the Cranfield Management Development Programme. Two sessions of this Programme will be held in 1964, the first from April to June, and the second from October to December. The Programme will include eight weeks of participative training at Cranfield and two weeks visiting Paris, Brussels, Berlin, Frankfurt and Milan, to get first hand experience of manufacturing, trade unions, banking and government on the Continent.

The fee of £550 includes tuition, residence, books, case study material, and the cost of European travel.

Further information is available from

R.G.A. Boland,
Dept. of Production & Industrial Administration,
The College of Aeronautics,
Cranfield, Bletchley, Bucks.

The Paul Instrument Fund Committee of the Royal Society has made the following grants for the development of physical instruments of novel design:

£12 800 to Mr. A. H. W. Beck, lecturer in engineering, University of Cambridge, for the construction of apparatus for the amplification and generation of extremely high frequency electromagnetic waves (below 1mm).

£1 000 as a supplementary grant, to Dr. S. Evans, senior assistant in polar research, University of Cambridge, for the development of an instrument for measuring the depth of continental ice sheets by a radar technique.

£5 690 to Professor J. Ring, Department of Applied Physics, University of Hull, for the construction of apparatus for research into the applications of Moire fringes as analogue Fourier transformers.

£2 300 to Dr. T. H. Wilmshurst, Department of Electronics, University of Southampton, for the construction of an electron spin resonance spectrometer for examining shortlived paramagnetic species produced by a pulsed light source.

An International Conference on Maguetic Recording will take place during the week beginning 6 July 1964, and will be held at the Institution of Electrical Engineers, London.

The Conference is sponsored by the British Institution of Radio Engineers, the Institute of Electrical and Electronics Engineers and the Institution of Elec-

trical Engineers, and is the first occasion on which the European Region of the Institute of Electrical and Electronics Engineers working through its United Kingdom and Eire Section, has been a co-sponsor in an International Conference.

The Conference will cover all magnetic recording on moving media and will include sessions on audio, video, computers and data recording.

Further details concerning the Conference and registration forms are obtainable from the International Conference on Magnetic Recording Secretariat, c/o the Institution of Electrical Engineers, Savoy Place, London, W.C.2.

The Royal Society has awarded the Hughes Medal to Professor F. C. Williams, C.B.E., F.R.S., professor of electrical engineering in the University of Manchester, for his distinguished work on early computers.

The Electronic Engineering Association has prepared a further guide on the handling of punched paper tape which has been written primarily for data processing purposes, but the conventions may have wider applications.

The adoption of these conventions will increase the efficiency of operators handling punched paper tapes associated with computer systems and ancillary equipment. The conventions will also assist those concerned with the design of future punched tape equipment.

Copies of the guide are available free of charge from Electronic Engineering Association, 11, Green Street, Mayfair, London, W.1.

The Compagnie Francaise Thomson-Houston (CFTH) has recently installed what is claimed to be the longest microwave link on the continent of Africa between Lourenco-Marques and the port of Beira.

This link is over 1 000km in length and has three relay stations at Namaocha, Malvernia and Monti Xiluvo. Operating on the 830 to 960Mc/s band it provides a capacity of 60 channels.

The transmitter has an output of 1kW using parametric amplifiers. The microwave antenna system with its parabolic reflectors 20 metres in diameter are directly mounted on the ground so avoiding the use of costly towers.

The Instrumentation Division of Southern Instruments Limited, Camberley, have secured a contract from the Central Electricity Generating Board, for a special multi-channel oscillograph recording equipment for use by the Central Electricity Research Laboratories at Leatherhead.

The oscillograph has six measuring channels for resolving waveforms with components up to 1Mc/s. These channels have 10kV insulation to each other and earth. The dynamic range is from 40mV to 2000V peak to peak.

This equipment is being developed to this high level of insulation to undertake a programme of tests on the super grid network.

The Marconi Company has received an order valued at £4¼ million from the Ministry of Aviation for communication equipment. The equipment, which is already in use by the Army throughout the world, is in the form of mobile and static communication stations, known in the Army as the S.R. D11/R234.

This high-frequency transmitter/receiver equipment, provides the latest h.f. radio communication facilities including s.s.b./i.s.b. telephony and f.s.k. telegraphy for a teleprinter channel. The output power of the transmitter is rated at 350w over the frequency range 2 to 21·999Mc/s. A feature of the equipment is that the D11 transmitter and the R234 receiver may be set to any operating frequency by decade controls, directly calibrated in megacycles and kilocycles.

The equipment is designed and manufactured by Marconi's who, under these contracts, are also installing it in Army 1-ton trucks. As well as being installed in vehicles, the equipment is available in a transportable container to form a complete radio station which may be moved by helicopter, ship or vehicle trailer.

An electronic device for the measurement of distances of the order of 50 meters with an accuracy of about 0·05mm has been developed by R. H. Bradsell of the National Physical Laboratory.

Known as the 'mekometer' this device projects a light beam which is elliptical polarization-modulated at 9·375Gc/s by a crystal of ammonium dihydrogen phosphate (ADP) subjected to a microwave field. This light beam is returned through the crystal by a distant reflector and hence its ellipticity is either increased or decreased depending on whether the modulation wave in the reflected light is in phase or out of phase with the alternating microwave field. The distance between the ADP crystal and the reflector can be varied by a measured amount so that the antiphase condition is reached and there is then an exact number of modulation half-waves in the distance to be evaluated. This operation is repeated for several different modulation frequencies. A knowledge of the amount by which the distance to be measured differs from an integral number of half-wavelengths at each modulating frequency together with a knowledge of the velocity of light under the ambient conditions allows the distance to be evaluated, without ambiguity, from a simple calculation.

The Plessey Company (U.K.) Ltd under contract to the General Post Office has developed a device which permits medium-speed transmission of commercial or scientific data between distant subscribers over normal telephone lines.

The equipment is known as GPO Data Transmission Set 1A and will accept serial or binary digital data signals from customer-owned data processing equipment and convert them into voice-frequency f.m. signals suitable for transmission over private or public telephone lines at rates up to 1 200 bauds. At the receiving end the f.m. signals are converted back into the same form as the original input.

As well as the necessary f.m. modulator and demodulator, the unit contains auxiliary control and switching circuits. A supervisory channel is also available for transmission in the reverse direction at modulation rates of up to 75 bauds. This channel may be used for returning check signals or requesting repetitions.

"Radio Services—from shore to ship; ship to shore," is a new booklet which has just been issued by the G.P.O., and it is obtainable at main post offices free of charge. It gives a brief description of the services and details on how to address radio telegrams for maximum speed and accuracy. A map of the world shows the zones into which it is divided for charging Radiotelephone calls.

The volume of traffic handled on the Post Office Ship-Shore services has grown considerably since pre-war days. In 1938 radiotelegrams exchanged between ship and shore totalled less than 6 000 000 words and only 3 000 radiotelephone calls were connected. The corresponding figures for 1962 were 12 000 000 and 150 000.

These commercial communications are in addition to the vital safety services operated by the Post Office coast stations. In 1962 Distress and Urgency calls from ships and aircraft totalled 233 and there were 188 cases where broadcasts were made on behalf of shore authorities about overdue vessels, sightings of distress flares and other urgent matters. In addition, 12 500 weather bulletins, gale warnings and navigational warnings were broadcast to ships.

British European Airways has placed a contract valued at £2¼m with the Univac Computer Division of Remington Rand Ltd for an automatic electronic seat reservation system for installation at the BEA's West London Air Terminal.

The equipment which initially will consist of two Univac 490 Central Processors is to be installed by the middle of this year and will begin operating in two successive stages as from January 1965.

The provision of two Univac 490 computers permits a continuous day and night reservation service to be given since a single processor handles the entire reservations workload so that the other processor is constantly available for other work and for regular preventive maintenance. Periodically, the role of the computers is switched.

The basic requirement of a system to handle data on a real-time basis is a

massive storage capacity. The configuration used by BEA will include 32 768 words of core store in each 490 processor and a combination of FH880 drum units, each of which stores some 4 000 000 characters with an average access time of 17 milliseconds and Fastrand drum units, each with a 65 000 000 character capacity and an average access time of 92 milliseconds.

In addition some 200 Unisets (to be manufactured by Sperry Gyroscope Ltd) are to be installed at the BEA's boating offices to enable the computer to be interrogated direct.

The UNISET comprises three sub-units—a console, a keyboard unit and a printer. Though each of these functions independently, the three together form an integrated unit which provides all the necessary facilities for interrogation and booking.

Using the UNISET a booking clerk will be able to query the 490 as to the availability of seats on any flight scheduled up to ten months ahead. Within four seconds an answer will come back on UNISET. Bookings or cancellations will be made by the same method though in these cases the customer's name, address and telephone number will be included in addition to identification of the flight.

Trinity House Lightship No. 20, which has recently been completed, has been fitted with comprehensive radio beacon equipment designed and manufactured by Redifon Ltd, Wandsworth, S.W.18. A similar installation is to be fitted to a second vessel which is now being built.

The installation consists of two type G142 transmitters, each with an output power of 80 watts. Together with the transmitters are failure alarm units, a beacon control unit, twin chronometer and code senders. Transmitter output power can be altered to suit the requirements of any beacon chain in which the station is to operate.

Inter-ship and ship-shore communication will be by Redifon GR161B 15/20 watt transistorized radio telephones for service in the marine i.f. band.

One of the lightships will serve on the East Goodwin station, and will mark a notorious hazard on what is probably the most congested shipping lane in the world.

The new system of traffic control designed for the Municipality of Metropolitan Toronto consists of a network of traffic signals and traffic detectors connected by wire lines to a Univac 1107 thin film memory computer. The computer will continuously and automatically analyse the movement of vehicles within the controlled area. Traffic flow will be speeded and congestion will be minimized by the computer's second-by-second control of the phasing and duration of 'stop' and 'go' signals located at approximately 1 000 critical intersections.

One hundred traffic signals have been connected to the computer and are now being directly controlled by the computer. By the end of this year traffic flow through 1 000 intersections will be controlled by the computer.

The number of registered vehicles in Metropolitan Toronto increased from 330 000 in 1953 to 585 000 in 1962, a gain of more than 75 per cent. During the same period population rose from 1 174 000 to 1 625 405 a rise of 38·4 per cent.

There are now 2·8 persons per vehicle in the area (compared to 3·6 persons per vehicle in 1953) giving Metropolitan Toronto one of the highest ratios of car ownership to population on the North American Continent.

The Automatic Telephone and Electric Company Limited, working in collaboration with the City of Liverpool's Engineers' Department and the Ministry of Transport, has designed a linked traffic signal system covering eleven intersections and pedestrian crossings in the centre of Liverpool.

The 'master timer'—an ATE Type 54 Controller—takes continuous samples of traffic flow by means of road detectors and automatically brings into operation the most suitable of three pre-set plans.

Push-button pedestrian control at certain crossings will enable pedestrians to cross safely with the minimum delay to traffic which will be allowed to flow in regulated 'blocks'. Vehicles travelling at a predetermined speed will be given a progression of 'greens'.

A second phase of the development programme includes the provision of 38 new traffic signals for vehicles and pedestrians at major junctions. Nine others will be modified to bring them into the linked system and some 15 pedestrian crossings will be fitted with push-button signal control.

All these schemes have been designed with an eye on the future when it will be possible to regulate the flow of traffic throughout a large area by controlling signals from instant information processed by an elecronic computer.

Telefunken have recently installed eighteen 20kW automatic transmitters at the high power h.f. transmitting station at Elmshorn in West Germany near the Danish border.

This transmitting station, together with its associated receiving station at Lürchou, is automatically controlled from Hamburg.

In all a total of 35 transmitters are now installed at Elmshorn designed to handle daily some 4 000 overseas telegrams and telex messages.

The BBC's new high-power Band III transmitter at Wenvoe, to be used for the separation of the BBC television service to Wales from that to the English Regions, will be brought into service on 8 February.

This new BBC television service for Wales from Wenvoe will be on the present 405-line standard but the transmission will be in Band III on Channel 13 (vision 214·75Mc/s, sound 211·25Mc/s) with vertical polarization. They will serve most of the South Wales area covered by the existing Band I transmitter at Wenvoe which will continue to use Channel 5 and carry the network programme (BBC-1) and those items appropriate to the West of England.

The BBC's new combined television and v.h.f. sound station at Haverfordwest, which will serve most of Pembrokeshire, is also nearing completion and will be opened early this year. It will transmit the BBC Television Service for Wales on Channel 4 (vision 61·75Mc/s sound 58·25Mc/s) with horizontal polarization. It will also transmit the Home, Light and Third Network programmes on v.h.f.

The new transmitter at Wenvoe and Haverfordwest and existing ones at Blaen plwyf, Llandrindod Wells and Llanddona together with others to be built at Moely-Parc, Carmarthen, Machynlleth and Holyhead will form a network bringing BBC Wales to 85 per cent of the population.

The Electronic Reading Automaton (E.R.A.) which reads cash register tally rolls at high speed has been handed over by its designers and manufacturers, the Solartron Electronic Group Ltd, of Farnborough, Hampshire, to Montague Burton Ltd, of Leeds. This is the first machine reading conventional printed digits optically to come into full commercial operation in Europe, and is believed to be the first tally roll reader in the world.

The machine, which comprises three double 6ft bays of equipment and an operator console, bridges the gap in automatic data processing between the printed original document and the computer. It does this by recognizing normal printed characters on account tally rolls, using a video scanner technique, and transfers the information into punched cards. The tally rolls are printed with details of customer transactions by Bell Punch D.P. Cash Registers at each of Montague Burton's many branches throughout the country. These details are then used daily for up-dating many of the hundreds of thousands of individual accounts in the permanent records at head office.

The British Standards Institution has published an addition to B.S. 448 Electronic-valve Bases, Caps and Holders as follows:

Section B9A/D/1.1—B9A/D Base
B9A/D/1.2—B9A/D/Pin and Tubulation postiion gauge
B9A/D/1.3—B9A/D Pin straightening tool.

This section is issued as a separate publication and may be obtained from the B.S.I. Sales Branch, 2 Park Street. London, W.1. Price 3s each. (Postage will be charged extra to non-subscribers).

BOOK REVIEWS

Progress in Semiconductors Volume 7

By A. F. Gibson and R. E. Borgess. 238 pp. Royal 8vo. Heywood & Co. 1963. Price 65s.

WITH the ever-increasing volume of original scientific work being done, well-presented review articles are becoming more essential. Over the past several years collected reviews on specialist topics have appeared in the annual editions of 'Progress in Semiconductors'. In the current volume four separate reviews, by different authors, are presented. These are entitled: 'Bismuth', 'The Physical Properties of Single Crystal Bismuth Telluride', 'The Interaction of Impurities with Dislocations in Silicon and Germanium' and 'Effects of Pressure on the Properties of Germanium and Silicon'.

Bismuth is not a semiconductor, since the conduction valence bands overlap slightly. It is a semi-metal. As such it forms a natural bridge between semiconductors and metals, and therefore earns its place in this volume. A comprehensive account is given of its properties. Bismuth-telluride is an important thermoelectric material, about which knowledge is limited to some extent, because of the fragility of single crystals and the difficulty in producing low conductivity specimens. Again a general account of its properties is given. It is to be noted that the manuscripts of these two articles were received more than two years ago!

The importance of impurities in semiconductors is well known: the third article reviews present knowledge of the mechanism by which impurities precipitate at dislocations. In the final article a detailed account of the effect of pressure on the basic electrical and optical properties of germanium and silicon is discussed and related to equivalent effects in intermediate compounds. It is a pity that the marked effect of pressure on the resistivity of n-type silicon, which is made use of in strain gauges, was not brought out. Semiconductors are only of interest because they can be used in practical applications.

F. J. HYDE.

Microwave Tubes and Semiconductor Devices

By G. D. Sims and I. M. Stephenson. 208 pp. Med. 8vo. Blackie & Son. 1963. Price 75s.

THE authors describe the object of this book as "to present a survey of the principles of operation of microwave valves and their uses, which is both up to date and readable", and in this they have largely succeeded. They acknowledge the difficulty of achieving the first part of their object in a rapidly developing field, but in fact seem to have found a place for all the currently fashionable topics: there are chapters covering electron guns, klystrons, travelling wave tubes and their derivatives, slow wave structures, magnetrons and their derivatives, parametric amplifiers, cyclotron wave tubes, masers and semiconductor devices. It is good to see in an introductory chapter the ideas of energy interchange and space charge waves presented as a starting point, though in fact their usefulness as unifying principles is not perhaps so fully exploited later as it might be.

The question of 'readability' is one where opinions may differ. The authors adopt the principle of describing physical principles in words where possible, simple quoting mathematical results, or sometimes relegating their development to appendices; in a broad survey of this kind most readers will find this appropriate. However there are places where the confident style of the authors seems less to shed an aureole than to throw up a smoke screen around the central hard facts. A mastery of this style, with particular attention to the glossary of terms provided in an appendix, will equip the assiduous student to hold his own in professional disputation, but his understanding may be less than he imagines. Thus for example (p. 193) he will believe that M-type devices are explained by cyclotron wave interactions, analogous to the space charge waves of the O-type device, which is certainly not the case; there *are* cyclotron waves in M-type beams, but the magnetron, M-type amplifier and backwards wave oscillator do not depend on them. He will gather (p. 263) that the travelling wave parametric amplifier is similar to the travelling wave tube, 'where the kinetic energy in the electron beam is gradually transferred to the slow and fast space charge waves'. This bizarre account of the mechanism of travelling wave tubes does little to illuminate the similarity to the parametric case.

In summary, the authors have provided an up-to-date and readable survey, but there is little that is original, and a certain amount that is erroneous, in their presentation. Many users of microwave devices will find it a useful guide to a complex field, but they should not believe all that they read.

A. REDDISH.

Flight Test Instrumentation Vol. 2

Edited by M. A. Perry. 256 pp. Med. 8vo. Pergammon Press. 1963. Price 80s.

This volume contains an edited collection of papers presented at the Second International Symposium held at Cranfield in 1962 and sponsored by the Department of Flight of the College of Aeronautics.

Some of the subjects covered in the papers presented in this book are flight techniques to measure the recovery factors of air thermometer systems, flight flutter testing, flight test instrumentation for V/STOL Aircraft, instrumentation for the flight testing of an advanced weapon system and digital data acquisition systems.

Advances in Electron Tube Techniques Vol. 2

By D. Slater. 280 pp. Demy 4to. Pergamon Press. 1963. Price £7

This book contains papers presented at the Sixth U.S. National Conference, sponsored by the Advising Group on Electron Devices, Office of the Director of Defence, Research and Engineering, and held in New York in September 1962.

They cover the general area of Electron Tube Techniques with emphasis on newly developed approaches to the problems involved in the construction of electron tubes. The contents of this volume show some of the newer techniques used or proposed by the scientific staffs of a number of major electron tube manufacturers, as well as fundamental considerations of the emission, vacuum, and structural technologies.

American Subminiature Electronic Component Parts Data Annual 1963-64

Edited by G. W. A. Dummer and J. Mackenzie Robertson. 679 pp. Demy 4to. Pergamon Press. 1963. Price £7

This annual aims at presenting, in concise form, technical information and applications data on a selected range of small-size electronic component parts currently available in the U.S.A. The selection parameters have been small size, quality, and anticipated design interest.

This book is one of a series of electronics data annuals being widely distributed in America, Europe and the Far East, and is therefore of importance in world export markets. It also indicates the present state of the art in the American ultra-miniature component parts field.

British Miniature and Microminiature Electronic Assemblies Data Annual 1963-64

Editors G. W. A. Dummer and J. Mackenzie Robertson. 335 pp. Demy 4to. Pergamon Press. 1963. Price 105s.

This new book is based on the 'Assemblies' section of the British Miniature Electronic Components and Assemblies Data Annual which—after two years in combined form—is now being divided to permit fuller and more adequate coverage of developments in miniature and microminiature electronic assemblies.

The increasing use of thin film, solid state and small printed or potted transistorized units has now made this edition necessary. In addition to information on the above techniques users will also find in this volume data on liminates, finishes, processes, fine soldering equipment, etc.

The format is based on that of the recently issued companion volume the American Miniature and Microminiature Electronic Assemblies Data Annual, and it is hoped that these books will assist those interested in acquiring information on trends and techniques both in Britain and in the U.S.A.

Kleines Lexikon der Elektrotechnik (A short Dictionary of Electrical Engineering)

By Dipl.-Ing. E. P. Pils. 378 pp. Med. 8vo. Frankh'sche Verlagshandlung. 1964. Price DM 29.50

This is an unusual book based on technical training courses for office staff organized in the Siemens Group. It covers the whole field from fundamentals to power engineering. nuclear reactors, communications and data processing in seven major sections.

The main advantage to those using it abroad arises from the narrative description of each subsection, giving 1 500 indexed technical terms in the context in which they are used in German. This will not only be of assistance to technical office staff dealing with German literature but also to experienced translators not sure which of the many alternative terms in English-German dictionaries are the right ones to use in a given field.

While not written for the purpose, it could also be used as suitable reading material by those trying to acquire a working knowledge of technical German, giving the basis for the understanding of scientific papers.

British Transistor Diode and Semiconductor Devices Data Annual 1963-64

Editors G. W. A. Dummer and J. Mackenzie Robertson. 1610 pp. Many figs. Demy 4to. Pergamon Press. 1963. Price £10

In this second edition of the "British Transistor, Diode and Semiconductor Devices Data Annual', the Editors again present a comprehensive selection of data on a wide range of semiconductor products available from United Kingdom sources.

The opening 'Construction and Properties' section has been revised and extended for this new issue, and is now separately indexed. Extended data on the applications and use of the products described has been provided by the manufacturers concerned, and this includes information supplied by firms not previously represented in the Annual. The increasing trend towards planar and epitaxial structures is covered both from the applications information and the individual data sheet points of view, and once again use has been freely made of pictorial and schematic reproductions to assist in interpreting the information given.

LETTERS TO THE EDITOR

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

Transistors as Rectifiers

DEAR SIR,—During the course of some recent work aimed at improving the linearity of a sensitive instrument rectifier system it became apparent that the principal limitation in the linearity of systems employing simple circuits was that imposed by the characteristics of the rectifiers used to convert the a.c. input to the system into a unidirectional current flow.

It was found that a considerable improvement could be made in the performance of simple instrument rectifier systems by the use of transistors, in place of the normal junction rectifiers, when these are connected so that the collector-emitter path is in parallel with the base-emitter path, as shown in Fig. 1.

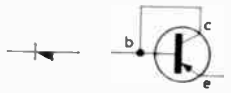


Fig. 1. Transistor connected as augmented or 'super' diode (CB/E)

Transistors connected in this configuration may be used, with some advantage, in all the circuit positions where diodes are normally employed where the lower forward voltage drop of this mode of connexion is desirable.

The forward rectification characteristics of a series of point contact and junction diodes, and transistors connected in the 'super-diode' configuration of Fig. 1 are shown graphically in Fig. 2.

It will be seen from this graph that transistors used in this mode of connexion exhibit a sharp forward turnover characteristic, which is particularly pronounced in the case of the silicon types, and therefore lend themselves conveniently to use as low voltage stabilizer elements.

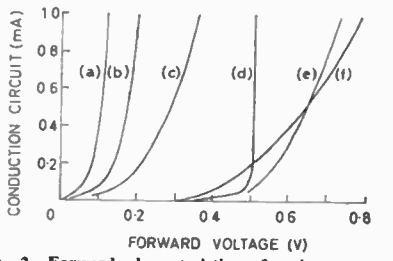


Fig. 2. Forward characteristics of point contact and junction rectifiers

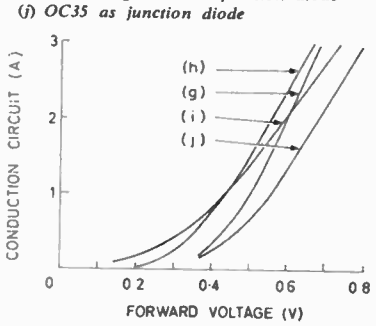
(a) OC83 and TK31C transistors (CB/E)
(b) OC83 as junction diode
(c) Germanium point contact diode
(d) OC202 silicon junction transistor (CB/E) connected
(e) OC202 as junction diode
(f) Copper oxide rectifier

The reduced forward voltage drop, at a given current, which is characteristic of this type of connexion, appears to derive from transistor type conduction between emitter and collector at a collector voltage equal to the forward voltage drop and with a base current typical of the emitter base junction of the transistor acting as a junction diode.

The comparative performance of 'super-diode' connected power transistors (Mullard type OC35 and GEC type GET573) and a germanium junction power rectifier (GEC type 541) is shown in Fig. 3. From this it would seem that this configuration offers the possibility of the manufacture of semiconductor rectifier stacks having lower forward power losses.

Fig. 3. Forward characteristics of junction and 'super' diode power rectifiers

(g) GET573 transistor (CB/E) connected
(h) OC35 transistor (CB/E) connected
(i) GEX541 germanium junction diode
(j) OC35 as junction diode



The applications described above are the subject of a British Patent Application No. 37,400/63.

Yours faithfully,

J. L. LINSLEY HOOD,
British Cellophane Ltd,
Bridgwater.

A Simple D.C. Sensing Device

DEAR SIR,—In recent issues of your journal several d.c. stabilizers were described[1]. When rather large currents are to be stabilized, say over 1A, the reference resistor presents a problem. If

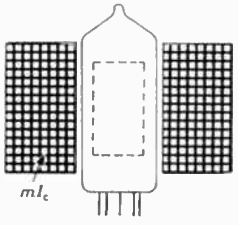


Fig. 1. Magnetically controlled pentode

the use of a d.c. coupled amplifier is proposed for the stabilizer, the voltage drop on this resistor must be of the order of 1V at least, with respect to the grade of stabilization usually required. Therefore, the power lost in the reference resistor attains a rather high value, which is not economical and causes considerable resistor temperature rise, resulting in poorer stabilizer quality. If, on the contrary, the power loss and temperature

rise should be reduced, then either more complicated and expensive arrangements must be applied, e.g. modulator techniques, thermostatically controlled reference resistor etc., or poorer stabilization must be tolerated.

A simple current sensing device eliminating these shortcomings may be found in the magnetically controlled pentode[2], Fig. 1. It functions as follows: if its electrode system is placed in a magnetic field parallel with the system axis, the emission current distribution between anode and screen grid changes with the field intensity according to Fig. 2. For a broadcast power pentode, EL83 or similar, with an air coil fitted tightly to the valve bulb, the current distribution changes roughly linearly within the range of 250 and 500At, which corresponds to approximately 30 to 60 gauss. The obvious cause of this effect is the curvature of electron paths by their flight in a perpendicular magnetic field, which multiplies their strikings with the screen grid wires and results in an anode current decrease and a screen grid current rise. If the total emission current is held constant by a large cathode resistor, the two respective currents change by equal amounts with opposite signs. The field-controlled pentode then functions like a symmetrical stage (long-tailed pair) with its well-known advantages.

Instead of the reference resistor with the necessary voltage drop and inherent power loss rising considerably with the current to be stabilized, the magnetic field of a coil may be used for controlling a pentode. It acts theoretically without or, at least, with reduced power loss depending mainly on the coil dimensions, is practically independent of stabilized current value and with zero effect of its resistance change. Therefore the magnetron-like controlled pentode represents a simple and efficient device for magnetic field or d.c. sensing.

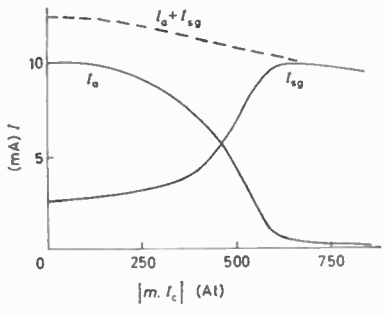
Using this element several stabilizers were built for currents ranging from 40mA to 15A with one-hour relative stability of 2.10^{-3} or better[3]. Another use was a magnetic induction indicator used as a "magnetic field lens" for relative mass scale establishment in a mass spectrometer[4]. Precise and stable indication of relative differences of 10^{-4} of magnetic induction was attained with an instrument containing only one valve, i.e. the sensing pentode. Further utilization might be permanent magnet reference for d.c. stabilizers, and contactless d.c. coupling without the necessity of modulation.

The common broadcast pentode with ferromagnetic electrode system biasing the controlling field and with imperfect central symmetry, which reduces the sensitivity, is not fully adequate for the rather exacting applications given above. However, it helped to solve them quite successfully.

Sincerely yours,

M. PACÁK,
Institute of Physical
Chemistry CSAV,
Prague.

Fig. 2. Anode and screen current distribution



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3. HLADEK, L., RALEK, M. Combined Control of Thermionic Valves by Current and Voltage Signals (in Czech). *Ibid. 22*, 355 (1961).
4. PACAK, M. A Valve Indicator of Magnetic Induction (in Czech). *Ibid. 21*, 661 (1961).

Use of an Analogue Computer to Calculate Rise-Times in Transistor Logic Stages

DEAR SIR,—Transistor switching may be satisfactorily explained in terms of the establishing of charge in the base region.

The collector current resulting from application of a step input of base current I_{on}, rises according to the relation $I_c = \beta I_{on}[1 - \exp(-t/\beta T_c)]$. This can be recognized as the time domain equivalent of a transfer function of form $1/1+sT$. A similar, but more complicated, expression describes the case where a transistor is turned off suddenly.

When a number of building blocks are placed in series, as in any logic chain of a digital computer, calculation of the rise, fall, and delay times by means of the basic charge differential equations become very difficult, as the current and voltage waveforms become complex. If worse case design is used, by which all components and voltages are toleranced to the worst conditions statistically possible, the accurate determination of the rise and fall times may be quite important, for example, it may fix the basic cycle time of a memory store.

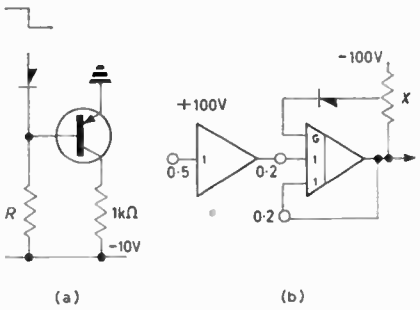


Fig. 1. Representation of simple circuit

The analogue computer can be used in this case, with the particular advantage that worst case conditions can be easily catered for by altering the appropriate potentiometer.

The switching of current into loads can be represented by a number of transfer functions in series together with the appropriate delays, and voltage limiting caused by catching, feedback or bottoming.

Thus the circuit shown in Fig. 1(a), where the transistor parameters are $\beta = 50$, $T_c = 10$nsec and $R = 10$kΩ, can be represented by the circuit of Fig. 1(b).

X is adjusted to cause limiting at about 10V, 1V representing 1mA, and the transfer function $1/(1 + s.5) \times 10^{-7}$ time scaled to $1/(1+s(5))$.

Similarly the circuit of Fig. 2(a), where $R_1 = 1$kΩ and $C_1 = 20$pF, can be simulated by Fig. 2(b).

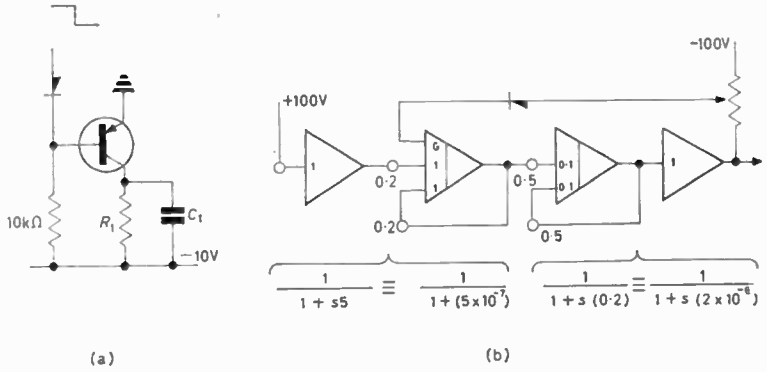


Fig. 2. Circuit simulation

Successive stages representing voltage and then current. Ramp, step and exponential waveforms can be easily obtained; by means of relay comparators, delays and rectangular waveforms can be obtained (although in this case separate schemes are required for front and back edges of a switching waveform) and the results read off on a pen recorder.

This technique could be extended to include the pulse response of diodes, and the switching behaviour of the newer epitaxial devices.

Yours faithfully,

E. M. STAFFORD,
Loughborough College of Technology,
Leicestershire.

ELECTRONIC EQUIPMENT

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

(Voir page 57 pour la traduction en français; Deutsche Übersetzung Seite 64)

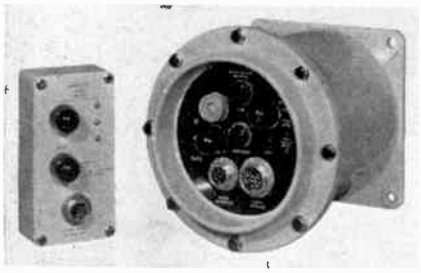
RADIATION MONITOR

The Redcliffe Radio and Engineering Co. Ltd, Emery Road, Brislington, Bristol, 4

(Illustrated below)

The latest gamma area monitor to be designed by the Atomic Energy Authority is now commercially available from Redcliffe Radio and Engineering Co. Ltd, who are manufacturing under licence.

Known as the type 1796B it has a water-tight case and can be readily pre-set to a predetermined alarm level within the range 10mr/h to 500r/h. The unit consists of an ionization chamber, detector and electrometer trigger circuit with local lamp indication showing whether the gamma dose-rate is above or below the pre-set warning level. Additional remote lamp indication is provided



by the use of a separate lamp unit. The equipment operates from a 22 to 29V d.c. supply, or, in conjunction with an appropriate power unit, from an a.c. mains supply.

A further facility is provided by an interlocking unit which provides mains operation for three alarm detectors, and also provides monitoring of the individual dose-rate levels.

The main unit is wall mounting with overall dimensions of approximately 8in cube, and power consumption 12W.

EE 65 751 *for further details*

INSTRUMENT TROLLEY

Avon Communications aod Electronics Ltd, 16 High Street, Christchurch, Hampshire

(Illustrated above right)

Avon Communications and Electronics Ltd announce a new high grade heavy duty test instrument trolley known as the Avoncel TM2SE, for use where it is necessary to move items of telecommunications, electronic or similar test instruments to the site of static equipment installations for routine maintenance, test and repair purposes.

The basic trolley is constructed of heavy gauge square and rectangular section steel tubing strongly welded to provide two side sections to which the top and bottom shelves are bolted. Trolley height is adjustable between 30 and 36in. The main shelves are 42 × 24in, ¼in steel plate, and 18in apart. The whole trolley is mounted on heavy duty Flexello castors using ball bearing swivels for maximum manoeuvrability. Finish is stove enamel hammer grey with chromium plated handles and support bars, and cadmium plated castor assemblies.

Many extra features are available for the TM2 basic trolley to ensure its maximum utilization. These include two extra side extension shelves of 15 × 24in for the top main shelf (these are stored vertically on trolley sides when not in use); rack for storage of technical manuals; two top supplementary shelves of 39 × 8in which have height adjust-

ment and can be fitted under either top or bottom main shelves; two collapsible extension support bars contain hooks for electronic test leads and clips for holding drawings; an asbestos insulated holder for electric soldering irons under the top supplementary shelf. Power distribution on the trolley is effected by use of a Lexor Dis-board fitted with a main switch, neon indicator and using 5 × 13A or 5 × 5A 3 pin sockets plus 30ft of three-core mains cable; two of the castors are fitted with braking facilities. The special equipment trolley TM2SE contains all these additional features.

The overall weight of the complete trolley is approximately 225lb and it is capable of carrying a safe load of some 800lb.

EE 65 752 *for further details*

RATEMETER

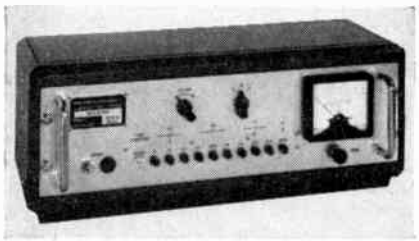
Research Electronics Ltd, Bradford Road, Cleckheaton, Yorkshire

(Illustrated above right)

A versatile wide range counting ratemeter for use in industrial and nucleonic applications is announced by Research Electronics Ltd. Designated the model 9031, the instrument has applications as complementary equipment to scaling units where the instantaneous rate of count is required to be indicated directly on a meter. It is suitable for use with all forms of radiation detector including Geiger, scintillation and proportional counters, as well as electromechanical and photo-electric transducers and pick-ups for engineering applications such as speed of revolution measurement.

The instrument covers a wide compass in nine switched ranges conveniently selected by push-buttons from 3 counts per second for full scale meter deflexion on the lowest range, to 30 000 counts per second on the highest range, with a correspondingly adequate range of integrating time-constants from 125sec to 0·2sec.

Power supplies for subsidiary units and a high voltage supply for the polarization of Geiger tubes and certain types of photo-electric cell are incorporated.



The instrument may thus be used as a complete self-contained nucleonic counting equipment and the internal loudspeaker makes it particularly suitable for use as a contamination monitor for continuous audible monitoring of laboratory 'background'.

Pulse output and analogue output sockets are provided enabling external meters or recorder to be connected.

EE 65 753 *for further details*

SOUND LEVEL INDICATOR

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

(Illustrated on page 51)

To meet the increasing demand for equipment for general noise surveys, Dawe Instruments Ltd has designed the new type 1408E sound level indicator. This is a fully transistorized pocket-sized unit intended for rapid noise checks and for noise surveys calling for a simple, robust yet accurate instrument without the input and output facilities provided by a sound level meter.

The new instrument comprises a moving-coil microphone (housed within the plastic casing), a high-gain amplifier, weighting networks, attenuators and an indicating meter. The weighting networks correspond with those specified in I.E.C. publication 123 and in BS 3489:1962.

The attenuator enables sound levels from 40dB to 120dB (referred to a stan-

Leadership in Semiconductors

TEXAS INSTRUMENTS

Silicon transistors increase power supply reliability

Industrial applications for military transistors

This power supply has been designed with **silicon** semiconductor devices throughout to produce stable, reliable operation to 100° C.

The reason? Manufacturers have found that specifying military-type silicon transistors originally developed for high temperature, severe environment applications is good design practice... even in less demanding situations. The end result: high reliability.

Even at lower temperatures where germanium transistors can operate, the lower, stable leakage current of silicon devices gives you a greater reliability advantage for long term operation. Ready availability is assured from TI's three modern, expanding European semiconductor plants as well as from TI's facilities in the United States.

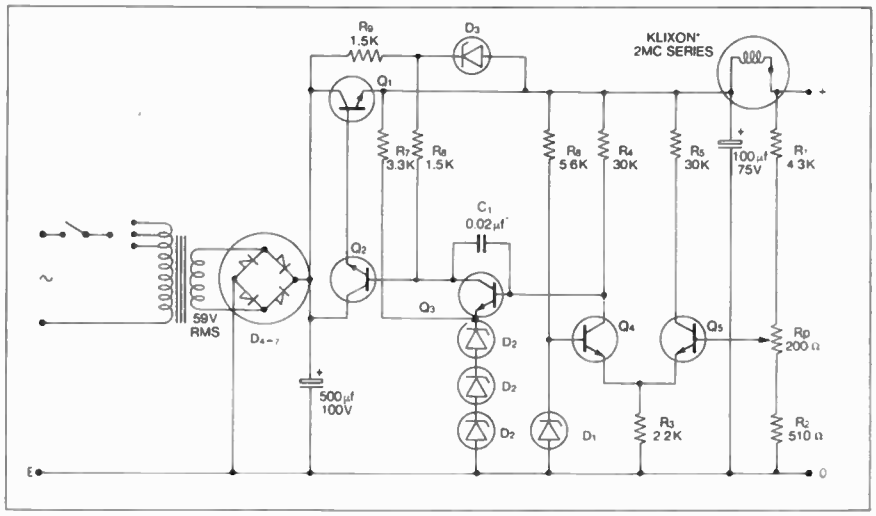
Circuit description

This typical power supply gives an output of 50 volts at 100 to 500 milliamps. Operating temperature range is -50 to +100° C. Output resistance is less than 1 ohm. Regulator source voltage can vary from 60 to 90 volts, including peaks due to mains ripple, allowing a ± 10% change in mains input voltage.

The circuit designed to meet these requirements uses Texas silicon diffused power and planar devices, close tolerance zener diodes and a magnetic overload trip.

A 2S723 conventional series regulator, Q_1, is used as the control element driven in compound connection by a 2S019 (or 2N656) current amplifier, Q_2.

The reference element D_1 is a zener diode, 1S7051A (or 1N751A), selected for a minimum temperature coefficient and low resistance. The combination of the zener diode and the differential amplifier Q_4 and Q_5, produce excellent temperature stability.

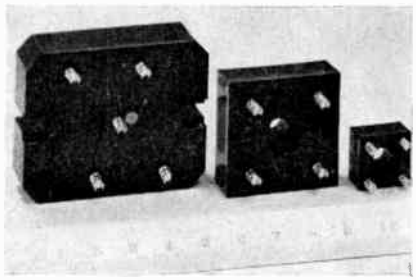


Components list

D_1	- 1S7051A	D_{4-7}	- 1B20K10	Q_3	- 2N1711
D_2	- 1S7056	Q_1	- 2S723	Q_4	- 2S104
D_3	- 1S7056	Q_2	- 2S019	Q_5	- 2S104

Overload protection is provided by the Klixon* 2MC series 500mA instant trip device which will break a 200% overload within 20ms.

Potted assemblies



The single-phase potted bridge power rectifier, 1B20K10, is used in this circuit. It is one of a series of 0.5, 1, 2 and 4 amp single-phase and 3 and 6 amp three-phase potted bridges.

The epoxy resin method of encapsulation provides excellent environmental protection and saves space by permitting close mounting of other components. The larger surface area increases cooling effectiveness. Single or twin bolt mountings cut assembly time.

Other potted components are available to meet your specific requirements. Silicon controlled rectifier bridges for motor control, high voltage rectifier stacks and diode modulators are examples.

Total capability from TI

The broad range of devices developed through TI's advanced technology assures you the right device for your needs. For more information on designing reliability into your power supplies with a variety of silicon devices, write for the TI Application Report on power supply design. And for continuing current information on the complete TI product line, circuit ideas and reliability data, ask to receive regularly the TI NEWSLETTER.

1954-1964: Ten years ago TI announced the first silicon transistor

* *Trademark Texas Instruments*

TEXAS INSTRUMENTS LIMITED
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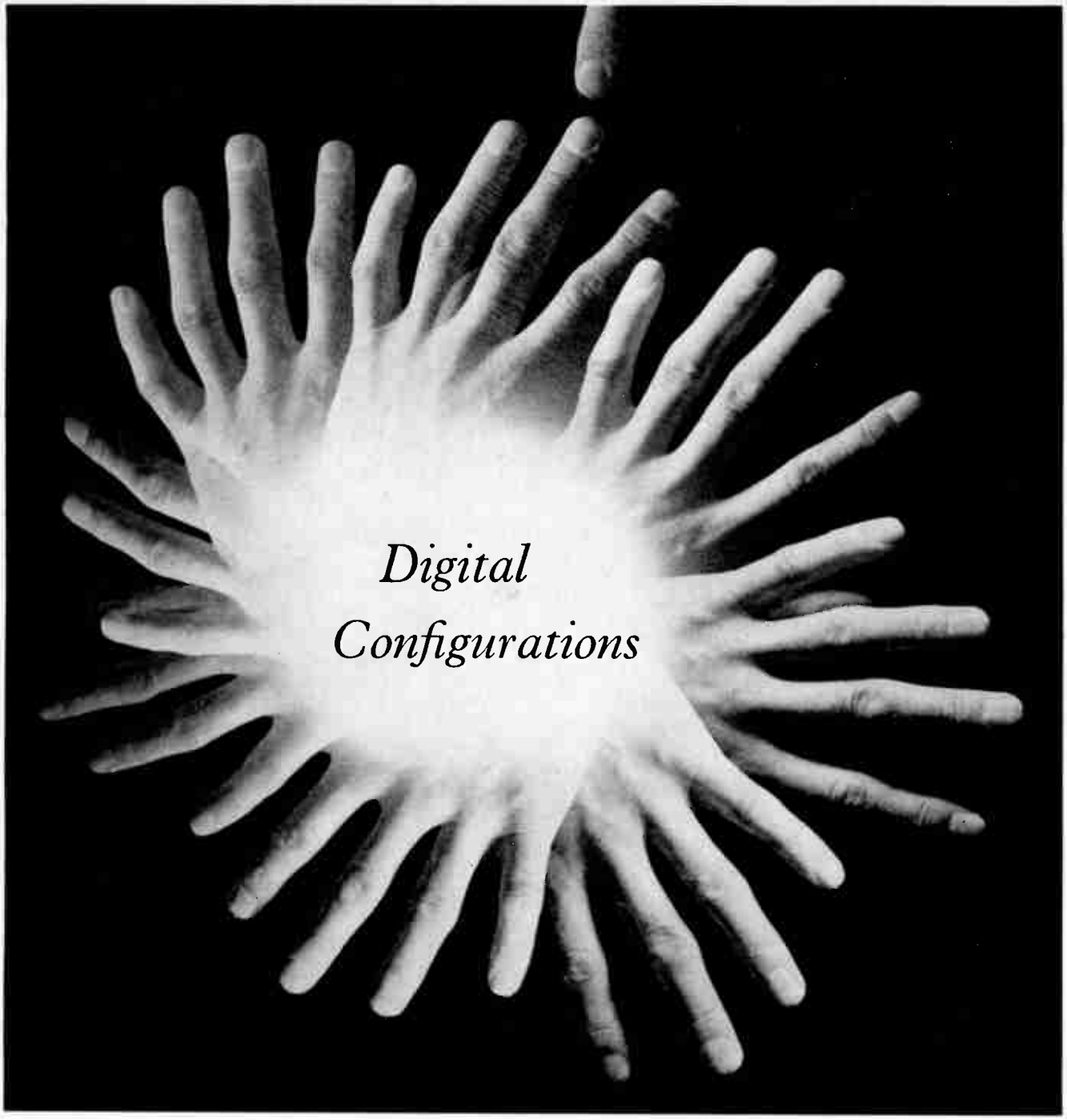

Digital Measurements Limited now offer engineers a new range of 40 standard Digital Data Loggers providing all the advantages of digital recording at economical prices. A number of basic units are used to make up the standard Data Logger configurations, and systems with single inputs, or up to 20, 40 or 80 inputs are available in the price range £1100 to £2680. The Data Loggers have resolutions down to 10μV, speeds of up to 18 words per second and the outputs are recorded either by automatic electric typewriter, paper strip printer or paper tape punch; the punch output can be in any standard computer code using 5, 6, 7 or 8 hole tape.

Digital Measurements Limited specialise in the field of digital instrumentation and manufacture a wide range of Digital Voltmeters and special purpose Data Logging systems. The latter are employed in such diverse fields as Road Research, Aircraft Research, Shipbuilding, Ventilation Engineering, etc. Please write for fuller details to:—

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dard sound pressure level of 0·0002 dyn/cm²) to be measured in six overlapping ranges. The amplifier provides a stable gain over the temperature range from 0°C to 45°C (32° to 113°F) and is virtually unaffected by variations in transistor parameters and supply voltage. Power is provided by a single 9V dry cell (Ever Ready PP4 or equivalent), adequate for about 70 hours of operation.

The use of end-mounted components in a printed circuit results in an extremely compact design, the overall dimensions being 6 × 3 × 2¼in. The weight, complete with battery, is only 14oz.

The instrument should find wide use for the survey of noise in factories and offices, for traffic noise checks, for quick quality tests on production lines by comparing the noise levels of such.

EE 65 754 *for further details*

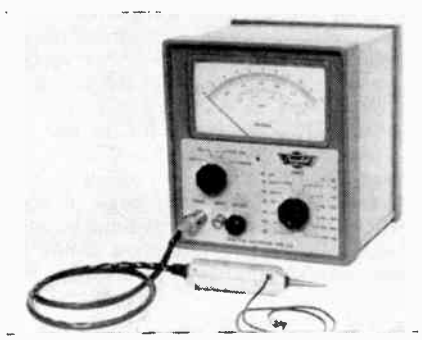
TRANSISTOR-VOLTMETER

Furzehill Laboratories Ltd, Theobald Street, Borehamwood, Hertfordshire

(Illustrated below)

As part of a new range of solid-state equipment, Furzehill Laboratories Ltd are introducing a new sensitive voltmeter covering a range of 10μV to 300V over a frequency range of 10c/s to 10Mc/s.

A printed circuit is used, employing semiconductor techniques throughout. The basic instrument draws its power from the mains supply but provision is made for a rechargeable battery to be incorporated as an optional extra. This is a useful facility for field or laboratory work, ensuring complete absence of hum and earth-loop problems.



A linear meter is used scaled 0 to 3·5, 0 to 10, reading 1mV full scale on the most sensitive range and 300V on the highest range. Substantial negative feedback ensures an accuracy better than 2 per cent over the majority of the frequency range. The meter is also scaled in decibels relative to 1mW in 600Ω. The input impedance is 3MΩ with 25pF shunt capacitance. A low capacitance probe (3MΩ, 5pF) having a gain of unity is available as an optional extra.

EE 65 755 *for further details*

PORTABLE FREQUENCY STANDARD

Advance Components Ltd, Roebuck Road, Hainault, Ilford, Essex

(Illustrated below)

The frequency standard type OFS1 is phase locked to the 200kc/s carrier of the BBC Light Programme transmitter

at Droitwich and thus has a long term accuracy which is better than 5 parts in 10^9.

The OFS1 which may be mains or battery operated provides square wave outputs at 100kc/s and 1Mc/s. The short term accuracy is better than 3 parts in 10^8 for any period up to 5sec and better than 1 part in 10^8 in any period of 5 to 50sec.

The sensitivity is such that an internal aerial may be used in most parts of England.

EE 65 756 *for further details*

OSCILLOSCOPE

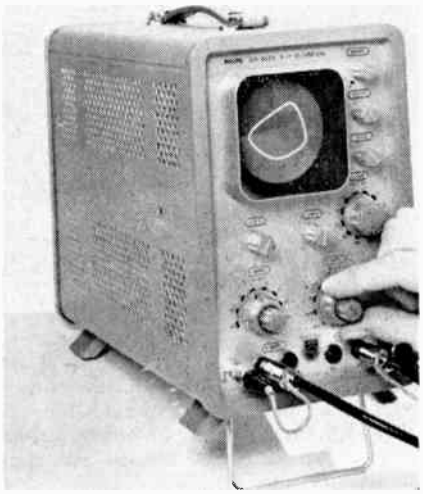
Distributed by: Research & Control Instruments Ltd, Instrument House, 207 King's Cross Road, London, W.C.1

(Illustrated above right)

The latest addition to the Philips range of oscilloscopes is type GM5605, a compact *X-Y* model with a 3in diameter tube. It is claimed to have an extensive field of application, and to be particularly suitable for service work and educational purposes.

The *X* and *Y* amplifiers are identical, and the relationship between two independent variables can be accurately displayed. Frequency and phase relationships, for instance, can be readily assessed.

Both amplifiers have a frequency range



of d.c. to 200kc/s, and the phase difference between their outputs is less than 3°. The c.r.t. graticule is divided into 6mm divisions, and the sensitivity of both amplifiers is the same, giving an overall vertical sensitivity of 10mV per division and a horizontal sensitivity of 30mV per division. Both sweeps may be expanded to ×3.

The sensitivity on each axis can be reduced to 30V per division by step attenuator and continuous gain controls. The calibration accuracy of the step attenuators is +3 per cent.

In addition to its application as an '*X-Y*' instrument, the GM5605 may be used as a conventional oscilloscope. The built-in time-base has a sweep speed variable between 0·02 and 100msec per scale division. Triggering may be internal or external, and trigger level is adjustable.

The instrument may be operated from any normal mains voltage. It measures 10 × 6½ × 13½in and weighs 22lb.

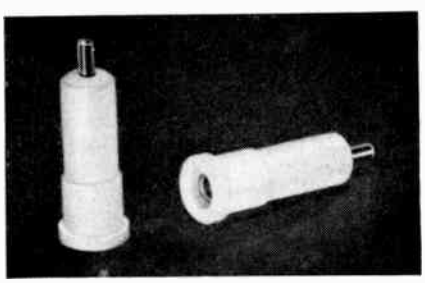
EE 65 757 *for further details*

TEST POINT JACKS

Sealectro Corporation, Hersham Trading Estate, Walton-on-Thames, Surrey

(Illustrated below)

The SKT-0807 is a new 'Press-Fit' Teflon test-point jack which can be used in combination with a metal chassis and a printed wiring-circuit. The jack is inserted into the chassis in the standard 'Press-Fit' manner, thus insulating the jack from the metal chassis. The beryllium copper contact (0·050in diameter) extends through the Teflon body to mate with a receptacle on the printed circuit board. The contact in the SKT-0807 will mate with a 0·080in probe, 0·280in long.



As with all Sealectro 'Press-Fit' Teflon test-point jacks, units are available in any of the standard EIA colours for colour-coding chassis test points.

EE 65 758 *for further details*

INDUCTIVE PROXIMITY SWITCHES

Intersonde Ltd, The Forum, High Street, Edgware, Middlesex

(Illustrated below)

Intersonde Ltd have announced the production of two new inductive proximity switches. Designated types QD19 and QD20 the switches provide a simple and inexpensive method of detecting the presence of either ferrous or non-ferrous metal objects including thin foils.

Both types of switch use silicon semiconductors throughout and both produce an output of 120mA over an operating temperature range of 0°C to +60°C. The switches are self-contained, measure 5½in long by 1$\frac{1}{16}$in diameter, and will operate from either a 12 or 24V d.c. supply. All the switch components are potted in epoxy resin and performance is unaffected by vibration, dust, or

moisture. Both units are provided with 6ft of cable which, in the case of the type QD20, is enclosed in flexible conduit.

Although primarily intended for industrial batch counting applications the switches may be used in place of conventional limit switches on machine tools, conveyors, lifts, and generally in applications where switch operation must be initiated without physical contact.

EE 65 759 *for further details*

COUNTER CONVERTOR

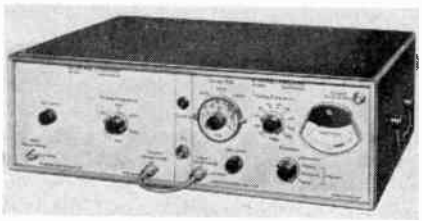
Marconi Instruments Ltd, St. Albans, Hertfordshire

(Illustrated above right)

Marconi Instruments Ltd have announced a new convertor, which extends the range of the Marconi TF 1417 series of counters to 510Mc/s.

The new equipment comprises two units. The basic TF 2 400 extends frequency measurements to 110Mc/s. The input range is 20kc/s to 110·5Mc/s with an input sensitivity of 10mV r.m.s. Signals in the range 20kc/s to 10·5Mc/s are amplified and so improve the counter sensitivity. For signals above 10Mc/s a heterodyne technique is used, in which the signal to be measured is mixed with a harmonic of 10Mc/s, so that the resultant difference frequency is below 10Mc/s and can be measured by the counter.

Although the instrument is primarily designed for wide-band use, provision is made for tuning input signals, correct tuning being shown by maximum



deflexion on a meter; the meter is also used to show when there is sufficient level from the convertor to drive the counter. In addition, a wavemeter is incorporated so that an approximate indication of the unknown frequency may be obtained.

The TM 7164 provides 100 to 510Mc/s coverage, with inputs down to 100mV. The principle of this unit is similar to that of the TF 2400, except that the input signal is mixed with an appropriate harmonic of 100Mc/s.

The TF 2400 is supplied in a full-width case with blank panel. Installation of the TM 7164 can be easily carried out by the customer in the event of it being bought at a later date.

Semiconductor devices and printed circuits are used throughout. The weight of the TF 2400 is 16 lb, and the combined weight of the two units is 18½ lb. A rack-mounting version of the equipment is available.

EE 65 760 *for further details*

MICROWAVE MILLIWATTMETER

Griffin & George Ltd, Ealing Road, Alperton, Wembley, Middlesex

(Illustrated below)

The type 15A milliwattmeter is used to measure the power in a waveguide or coaxial line, in conjunction with a suitable thermistor mount.

In many instances an existing laboratory mount will be satisfactory, provided the thermistor resistance is correct at 200Ω for the type 15A.

The thermistor is connected in the negative feedback arm of a low distortion Wien bridge oscillator.

When r.f. power is supplied to the thermistor, the amount absorbed is indicated on the meter.

This direct reading instrument is extremely simple to operate and exhibits

a high zero stability after a few minutes' warm-up period. Correct operation is ascertained instantly from a built-in calibration check.

The accuracy of the instrument is ±4 per cent and the range is 0 to 2·5mW f.s.d. The frequency range is determined by the thermistor mount.

EE 65 761 *for further details*

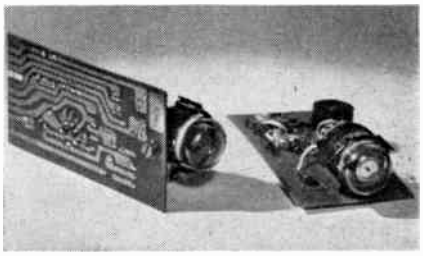
PLUG-IN DECADE ASSEMBLY

Panax Equipment Ltd, Holmethorpe Industrial Estate, Redhill, Surrey

(Illustrated below)

Panax are now producing an inexpensive plug-in decade assembly ready to build into electronic counting equipment for industrial, laboratory and school science purposes. The unit, which is produced in two versions, is identical with that used in the Panax SA-102 series nucleonic scaler and employs a high-quality printed circuit and reliable components.

The type TD.1 has scaling rates of up to 5 000 counts per second and a



resolving time of 200μsec. The alternative unit, type TD.2, has a maximum scaling rate of 50 000 counts per second and a 20μsec resolving time. The decade tube is the Mullard Z504S and Z505S respectively.

Each type requires a 12V power supply and input pulses of 12V amplitude, positive. Overall dimensions are 5½in long by 2½in high by 1½in wide.

EE 65 762 *for further details*

STANDARD FREQUENCY RECEIVER

The Wayne Kerr Laboratories Ltd, Coombe Road, New Malden, Surrey

(Illustrated on page 53)

A fully transistorized superheterodyne receiver specially designed for the reception of all International frequency transmissions is announced by Wayne Kerr Ltd. Known as the Wayne Kerr-Gertsch model RHF-1, its high sensitivity permits reception of these standard frequency transmissions anywhere in the world.

Because of its excellent reception, the model RHF-1 is suitable for the checking of oscillator calibration and frequency standards to an accuracy of up to one part in 10^7. It has a wide range of applications including precision time measurements, reception of standard audio frequencies and pulse code modulation. Beat frequencies may be observed by the connexion of oscilloscopes to output termi-

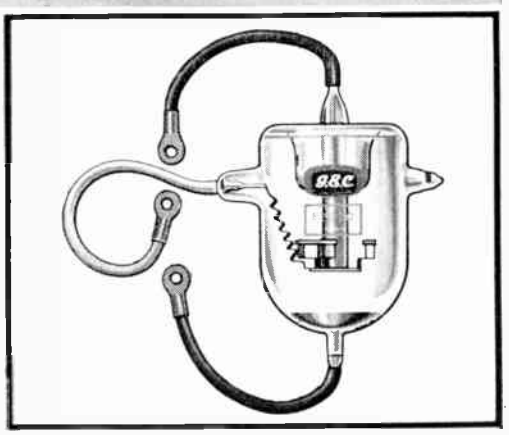
M-O V
ARMED CIRCUIT PROTECTION THAT NEVER SLEEPS

Special M-O V agent E3020 is a triggered *cold cathode* gas discharge device to divert lawless surges. That means *no heater supply, no baffle supply, no bias supply*, and *no gas clean-up!* Compact, reliable E3020 doesn't cost much, and was designed to protect electronic equipment from flash arc damage and other voltage breakdown effects.

It dispenses with the need for expensive high speed fuses, and replaces hot-cathode thyratrons in circuits already using electronic protection – for instance in "crowbar" service in radio transmitters. The E3020 Surge Diverter features:

fast operation—less than 1 μs · high fault current—2000 A · wide voltage range—600-6000 V

E3020 is the first of a new M-O V range, and full circuit accessories are available.



G.E.C.

Our technical information centre is ready to help with your application problems. Write for full data sheets on these or other M-O V products, or telephone RIVerside 3431. Telex 23435.

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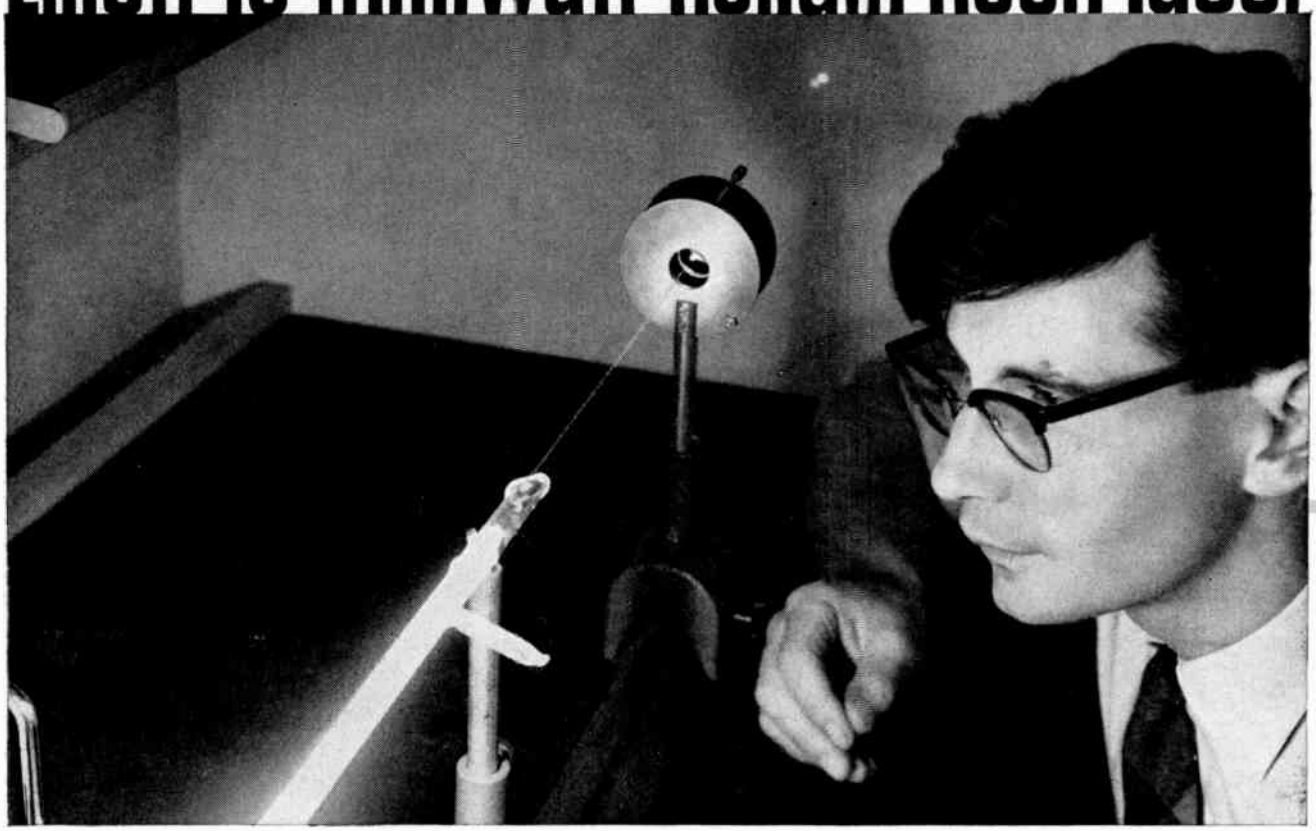

Versatile optical bench mounted gas laser for operation in the visible red ·6328 microns or in the infra red 1·1523 microns is ideal for both research and teaching. Minimum beam divergence and maximum output are combined with great beam stability. Confocal mirrors eliminate the need for tedious and delicate adjustments. Meticulous manufacturing techniques ensure long tube life. Brewster angle windows optically finished to a small fraction of a wavelength for complete optical coherence in a single phase wavefront. This inexpensive rugged laser is presently available for immediate despatch. Write for particulars and prices to:—

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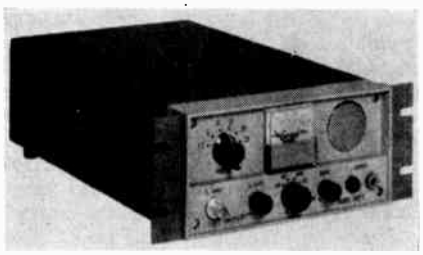
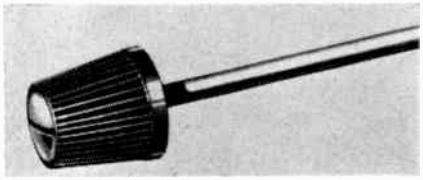


nals provided on the rear of the instrument.

The power source can be either 115/230V a.c. mains or a 12V battery. Operating frequencies are normally 2·5, 5, 10, 15, 20 and 25Mc/s, but up to three frequencies between 2·5 and 25Mc/s may be added. The usable sensitivity is 1μV, and the signal plus noise to noise ratio is better than 10dB at 3μV input.

The receiver is designed as a bench model measuring 7½in wide, 3½in high, and 13in deep, but is easily adapted to standard half-rack mounting

EE 65 763 *for further details*



COLLET KNOBS

The Plessey Co. (U.K.) Ltd, Titchfield, Hampshire

(Illustrated above)

A new range of miniature collet knobs has been developed by The Plessey Company (UK) Ltd to meet the requirements of DEF 5221. A feature of the design is that the same basic phenolic moulding can be fitted to shafts of both ¼in and $\frac{3}{16}$in diameter, using alternative collets.

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

EE 65 764 *for further details*

INSTRUMENT C.R.T.

English Electric Valve Co. Ltd, Chelmsford, Essex

(Illustrated below)

A new 5in cathode-ray tube has been developed by English Electric Valve Co. Ltd for use in wide-band, high speed oscilloscopes.

The special features of this tube are:

(1) Deflexion sensitivities in the *Y* and *X* directions of 3V/cm and 9V/cm respectively.

(2) Excellent brightness enabling high writing speeds to be employed.

(3) Good resolution due to the small spot size (typical line width 0·4mm).

These features are achieved by the use of a post deflexion accelerator mesh positioned a few millimetres from the phosphor screen, and an improved gun design.

Since the region between the mesh and the screen in which the beam is accelerated is short, raster distortion is kept to a minimum while an improved *X* deflexion sensitivity is achieved by having a large *X* plate to mesh spacing.

A further advantage of this position of the mesh is the improved stability in *X* and *Y* deflexion sensitivity with changes of temperature.

The deflexion sensitivity of the tube makes it particularly suitable for use with deflexion circuits employing transistors.

The tube is available with two phosphors: T948H—blue green afterglow (phosphor equivalent to P31) and T948N—yellowish green afterglow (phosphor equivalent to P2). Both versions have medium short persistence.

EE 65 765 *for further details*

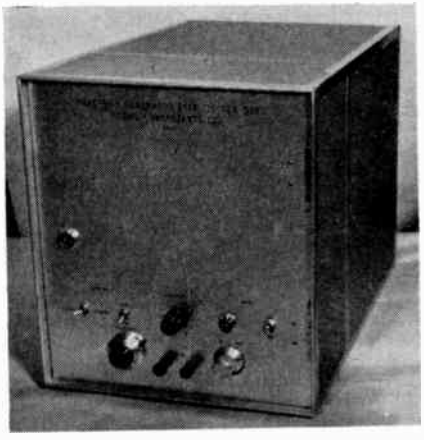
WAVEFORM GENERATOR

Servo Consoltants Ltd, 162-6 Kensal Road, London, W.10

(Illustrated below)

This instrument produces a cyclic voltage waveform of any shape. The voltage waveform is produced by means of waveform pattern disks several of which are supplied with each intrument. In addition, the voltage waveform can be generated from a pattern which can be easily produced by the user without any special tools or apparatus. A box containing 100 specially printed master patterns is supplied with each instrument. These pattern blanks are large enough for preparation of patterns with an accuracy of at least 0·3 per cent by any person without special instruction or skill.

The patterns are simply plotted over graticule markings overprinted on blank patterns. The required pattern is then cut out from a blank using ordinary scissors. As the patterns are not subject to any wear whatsoever while being used in the instrument, they can be used over and over again and after use easily stored for future reference. The user can thus accumulate a library of patterns which may be used whenever needed. The very low cost of pattern blanks makes it possible to experiment with various waveform shapes. Further supplies of pattern blanks are available from Servo Consultants Ltd at a reasonable price.



The output from the instrument is a voltage signal which can be of considerable amplitude. In addition to this, the signal is available at relatively low impedance and relatively large currents can be taken from the instrument. The instrument can be thus used to feed directly into analogue computers, having ±50V input levels. Process controllers which require current signal of, say, 50mA maximum amplitude, can be also catered for. In many applications the pattern required is in form of 'on' and 'off' conditions rather than changing voltage levels. Ordinary signal type relays whether 6, 12, 24 or 50V can be connected directly to the output of the instrument. As the patterns are generated without the use of any moving contacts, the instrument can thus be used to study the fatigue free life of machinery which requires complex programming.

The instrument has two frequency ranges, covering from 0·2c/s to 50c/s and ·002c/s to 0·5c/s.

EE 65 766 *for further details*

OPTICAL SHAFT ENCODERS

Digital Measurements Ltd, 25 Salisbury Grove, Mychett, Aldershot, Hampshire

(Illustrated below)

Digital Measurements Ltd, in conjunction with Winston Electronics Ltd, are now producing an improved version of their high resolution optical shaft encoder.

This new version has been designed to meet rigorous military requirements, and it has the ability to maintain reliable operation in extremely unfavourable environments. The changes include an increased maximum read-out rate of 6100 per second, higher signal outputs, and optional hermetic sealing.

The output of the standard encoder is in Gray binary code, but other codes can be supplied to special order. For each revolution of the shaft, the encoder makes 2^{13} counts, giving the high angular resolution of 2min 38sec; full read-out resolution can be maintained up to speeds of 45 rev/min.

The Winston-DM encoder has only one moving part and uses no gears, brushes or contacts for its operation. Backlash is eliminated, while moment of inertia, torque, friction and wear are reduced to an absolute minimum. The only two bearings employed have precision ballraces, sealed and permanently lubricated with a silicone oil. The encoder is housed in a small case with a NATO size 23 mounting flange and its weight is 1 lb 5 oz.

These optical shaft encoders have a wide variety of applications as digital position-feedback elements in many kinds of servo systems, in machine tool control systems, in the monitoring of radar aerial rotation, stable platforms, weapon systems, etc.

EE 65 767 *for further details*

PORTABLE OSCILLATOR

Standard Telephones & Cables Ltd, Connaught House, 63 Aldwych, W.C.2

(Illustrated above)

The 74306-A is a portable general-purpose transistorized oscillator. It covers the frequency range 10kc/s to 20Mc/s and will deliver signals over a wide range of output levels into 75Ω circuits.

Printed-circuit techniques are used, and the components are housed in a light-alloy case fitted with a carrying handle and a detachable lid. Power supplies are provided by dry cells housed in the case, but an external d.c. supply may be used if desired. A safety switch is fitted to disconnect the batteries when the lid is in position, and a warning indicator is operated automatically by the on-off switch to indicate when the supply is switched on.

The frequency range of 10kc/s to 20Mc/s is covered in eight bands. The six lowest bands use the same transistor oscillator stage, but the top two bands have separate stages to avoid high-frequency switching. The oscillator circuits are all of the Hartley type and use a thermistor to stabilize the output voltage.

The oscillator output is applied to an amplifier which, in conjunction with a low-impedance output stage, prevents changes of frequency with varying loads. The low-impedance output is achieved by using an emitter-follower stage, at which point the output level is monitored by a quasi-peak-reading meter circuit. Two outlets are provided, one being fed direct from the monitoring point and the other being fed via a 0 to 50dB attenuator.

A control is provided for varying the gain of the amplifier over a small range. In conjunction with the attenuator, which can be adjusted in steps of 1dB, this permits any output level to be obtained over a range of 50dB. The level is determined by reference to the attenuator setting and the reading of the meter, which is graduated at +1·0, +0·5, 0, −0·5, and −1·0dB.

Facilities are provided for checking the supply voltage (either internal or external) on the meter.

EE 65 768 *for further details*

TRANSISTOR TESTER

Grundy & Partners Ltd, 3 The Causeway, Teddington, Middlesex

(Illustrated below)

This tester is designed for use in conjunction with multi-range meters of 1mA basic movement or better, preferably with inbuilt overload protection. The mounting terminals enable the unit to be mounted directly on to a Universal Avo-Meter.

Transistor measurements include collector-emitter, and collector-base leakage current I_{co}' and I_{co} respectively, at a potential of 4·5V.

Diodes are tested in the forward direction by passing a current of up to 10mA on the forward resistance. The reverse current is checked at a potential of 9V.

A useful measurement of current gain (β) can be made of transistors up to 800mW dissipation and a reasonable indication is given for higher powers. Four switched base input currents are available of 10, 50, 100 and 500μA. The collector voltage being fixed at 4·5V.

It is possible, using the two sets of terminals provided, to match or compare two similar transistors or diodes in a minimum of time under exactly the same conditions.

Provision is made for testing the internal battery under load, thus eliminating the possibility of error due to battery failure.

EE 65 769 *for further details*

PEAK PROGRAMME METER

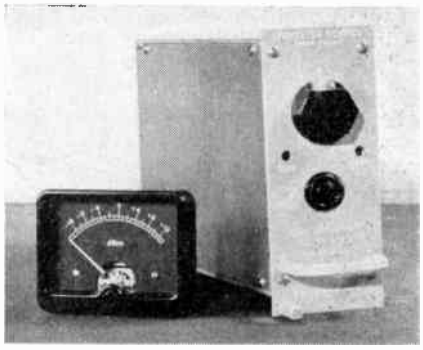
Livingston Control Ltd, Retcar Street, London, N.19

(Illustrated above right)

Manufactured by Livingston Control Ltd, to a BBC design, the peak programme meter type LC.201 is used to measure and indicate programme volume, enabling more effective control to be achieved of outside broadcast programmes, recordings fed into a studio desk, the output echo channels, and for other situations where a standard meter is employed subsequently in the chain.

Basically, the standard peak programme meter measures programme in close conformity with long-established BBC practice, that is, the programme is full-wave rectified and applied to a capacitive load with a charge time-constant of 2·5msec and discharge time-constant of 1sec. The resulting quickly rising and slowly falling pulses are amplified and displayed on a moving-coil meter.

The frequency response of the unit is flat within 0·25dB, over the range 40c/s



to 15kc/s, and it can be seen from the photograph that the scale calibrations are evenly spaced for ease of reading.

One important facility is the ability to adjust the instrument quickly, and precisely at three well-spaced points on the meter calibration, and as a result little opportunity exists for error in the intermediate positions. Compensation ensures that accuracy is maintained under conditions of supply or temperature change.

The unit is made up in three modules, the peak programme meter, stabilized power supply and meter module, and is available in instrument type case or rack mounting form. With regard to the latter, it is intended that the actual indicating meter will be mounted on a control console or desk, with the rest of the unit in a rack which can be sited at any convenient point.

EE 65 770 *for further details*

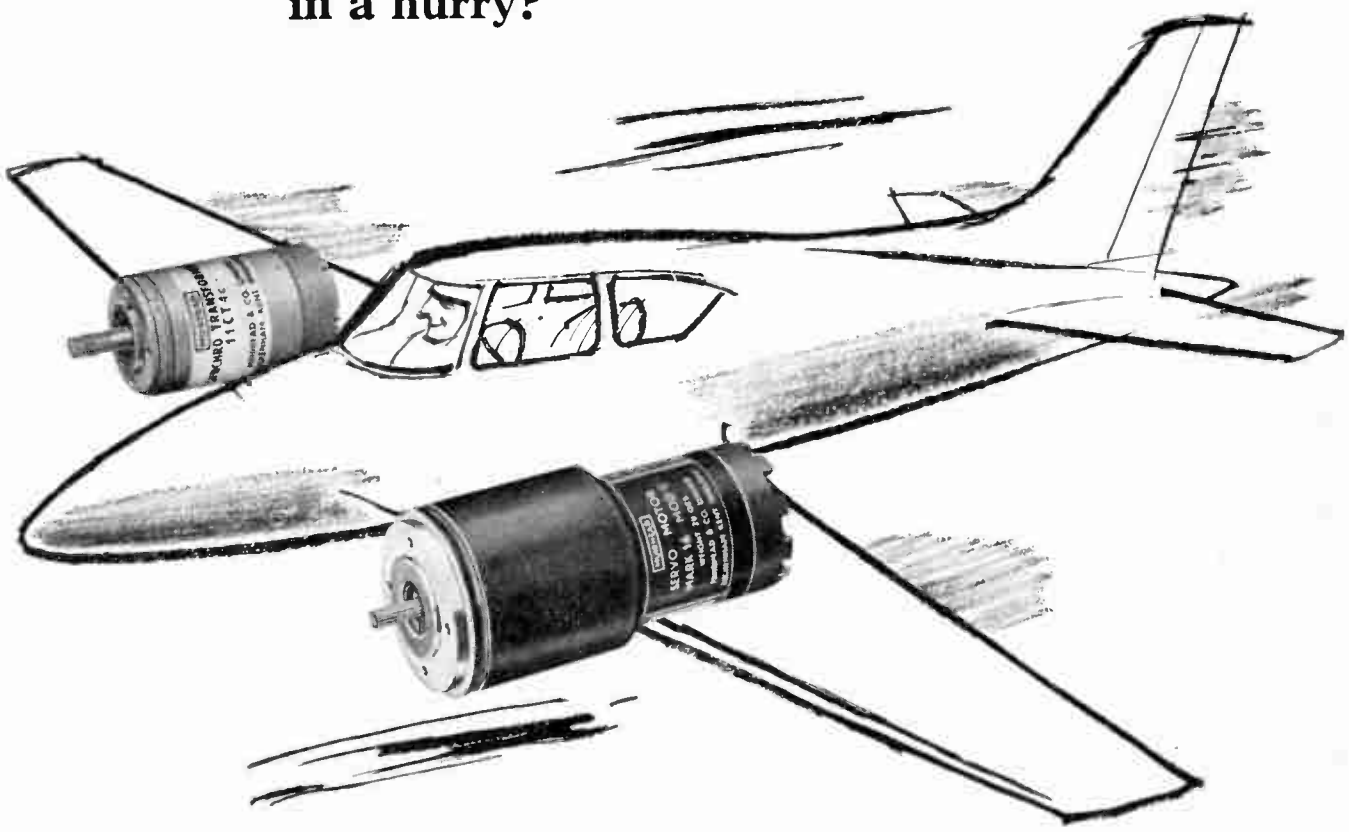
ELECTROMETER

Electronic Instruments Ltd, Richmond, Surrey

(Illustrated on page 55)

Electronic Instruments Ltd have recently introduced an improved general-purpose vibrating-capacitor electrometer, using the well-known Vibron unit. The model 33B-2 is based on an earlier instrument which is in widespread use all over the world. The ranges cover from 0 to 10mV to 0 to 1000mV with an input resistance better than $10^{14}\Omega$ on the 1000mV range. New features include a

Synchros or Servos in a hurry?



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Let us send you a copy of the broadsheet describing the full range of synchros and servomotors. Data sheets are also available quoting electrical and mechanical performance characteristics for each instrument.

ENVIRONMENT TEST APPARATUS . . .

. . . at the Exhibition of the Institute of Physics and Physical Society, Stand 124, January 6th-9th, the Royal Horticultural Society's Old and New Halls, Westminster, S.W.1.
We are exhibiting the new High and Low Temperature Accuracy Test Apparatus which positions rotating components in any one of 72 equi-spaced positions, to an accuracy of 15 seconds of arc over the temperature range –65° C. to +150° C.

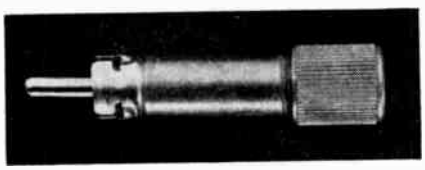
MUIRHEAD ***PRECISION ELECTRICAL INSTRUMENTS***

Muirhead & Co. Limited, Beckenham, Kent, England. Telephone: Beckenham 4888
Muirhead Instruments Limited, Stratford, Ontario, Canada. Tel.: Area Code 519, No. 271-3880
Muirhead Instruments Inc., 1101 Bristol Road, Mountainside, New Jersey, U.S.A.
Telephone: Code 201, No. 233-6010

652

variable back-off voltage with a range of ±1300mV and provision for plug-in input components. The drift rate is very low (less than 0·1mV in 12 hours). Accessories include a current and voltage measuring unit capable of measuring currents down to 10^{-12}A full-scale and resistance up to $10^{16}\Omega$ as well as a pH measuring accessory which is believed to be the most sensitive and accurate yet made, having an accuracy and discrimination of ±0·002pH and a full-scale reading of 0·1pH.

EE 65 771 *for further details*



ATTENUATOR PLUG

Associated Electrical Industries Ltd, 51-53 Hatton Garden, London, E.C.1

(Illustrated above)

A new coaxial attenuator plug introduced by the Telecommunications Division of Associated Electrical Industries Ltd, provides a simple method of introducing any required attenuation of signal level between two electronic units without the necessity to modify the internal circuits of either. Developed by the Radio Components Department, the plug is designed to enable a ¼W resistor (value dependent upon application) to be wired within the body of the plug.

The plug, produced in electro-tinned brass, with an inner conductor of nickel-plated brass will, in the standard form, accept coaxial cables up to $\frac{3}{16}$in overall diameter. Termination is simple. The cable is passed through a threaded cap which serves to clamp the cable to the plug body so that there is no strain on internal connexions. The centre conductor of the cable is soldered to an eyelet incorporated in a separate nylon anchor-bush and, at the same time, the required resistor is soldered to the same point. The plug is then reassembled so that the other end wire of the resistor projects through the centre pin, where it is soldered and the surplus cut off.

Suitable for use with the existing range of AEI single- and multi-way coaxial sockets, the new plug has a maximum overall diameter of 0·430in, and when in use the height above the socket connector is approximately 1¼in.

EE 65 772 *for further details*

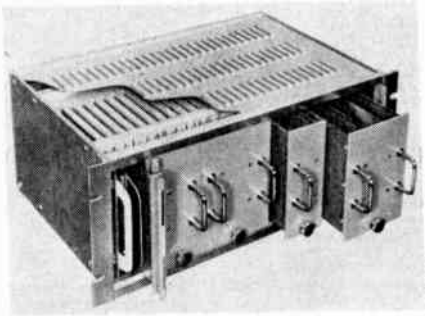
CHASSIS FRAMES

Alfred Imhof Ltd, Ashley Works, Cowley Mill Road, Uxbridge, Middlesex

(Illustrated below)

The versatility of Imhof's modular chassis system has been increased by the addition of a new type of chassis frame, designed for housing unedged printed circuit cards and chassis. These frames are available in two sizes (7in and 8¼in high—both of which are 19in wide by 11⅞in deep) and feature a new type of plastic guide incorporating a polarizing and connector retaining block. The removal of any edge connector is simple and each guide incorporates colour coding facilities.

These chassis frames will accept many of the existing components from Imhof's modular chassis system and, in addition, many new parts have been added to the range to suit these new frames. Both frames will accept chassis and printed circuit cards up to 8¼in deep and these may be up to $5\frac{7}{16}$in high on the 7in model and $7\frac{3}{32}$in high on the 8¼in model.



EE 65 773 *for further details*

H.F. INDUCTORS

Distributed by: Steatite Insulations Ltd, 31 George Street Loyells, Birmingham, 19

Stettner & Co. of Western Germany have recently added some new types of high constancy silver wire wound inductors with ceramic formers to their range.

These new types differ from those previously manufactured in that the winding is now of silver wire which is firmly fixed to the ceramic body by glass flux. This makes a very close and firm bond between the ceramic body and the winding, which as a result of temperature changes, is forced to follow the same expansion or contraction as the ceramic body, and therefore acts virtually in the same manner as a 'burnt-in' reinforced silver winding.

The new types of coils have a high constancy of inductance. The temperature coefficient is about 15×10^{-6}/°C. At the same frequencies these coils have substantially better Q values, an improvement of between 10 per cent and 50 per cent being achieved.

Although with the new coils the silver wire is completely embedded in the glaze the winding can be tapped as it is possible to remove the glaze from the wire for soldering purposes. The start and the finish of the winding is hard soldered on the glazed pins, there is therefore no risk of the joint becoming disconnected even if the connexions to the pin are soldered several times.

These inductors are available in several forms including types for printed circuit use; they are also available in fixed and variable versions (with a carbonyl iron screw plunger). The coils are available with from 3 to 20 turns which gives an inductance range of about 0·1μH to 1·45μH.

EE 65 774 *for further details*

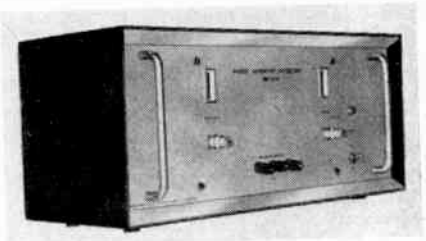
PHASE SENSITIVE DETECTOR

Brookdeal Electronics Ltd, Myron Place, Lewisham, London, S.E.13

(Illustrated below)

The PD 629 is a general purpose phase sensitive detector which may be used in r.f. and microwave measurements, servo systems or as an a.c. bridge detector.

The frequency range of the PD 629 is 10c/s to 100kc/s. The reference input required is 2V r.m.s. sine wave or 6V



peak-to-peak square wave; the signal input may be up to 6V peak-to-peak. The input impedance on both channels is 0·5MΩ, 10pF. The d.c. output voltage is −1V ±0·5V unbalanced or ±1V balanced; the output impedance being 1kΩ unbalanced and 2kΩ balanced. The zero drift in the balanced condition is 0·25 per cent of f.s.d. per hour after 1min and 0·05 per cent of f.s.d. per hour after 1 hour.

The unit is suitable for either rack or bench mounting.

EE 65 775 *for further details*

DIGITAL VOLTMETER

Gloster Equipment Ltd, Gloucester

The model BIE 2123 'Digimeter' is a three digit a.c./d.c. voltmeter having four ranges 0-0·999 up to 0-999V with manual polarity and range changing facilities. Accuracy on d.c. measurement is the greater of ±0·2 per cent of reading or ±1 digit, and on the a.c. ranges ±0·5 per cent of reading or ± 1 digit.

The unit is designed for a sampling rate of 1 reading per 2sec with 'press to read' facilities. The frequency response characteristics allow precision measurements to be made over the entire audio range.

Input impedance on the a.c. ranges is approximately 180kΩ at 50c/s. and on d.c. either 1 or 15MΩ depending on range selected.

EE 65 776 *for further details*

MEETINGS THIS MONTH

BRITISH INSTITUTION OF RADIO ENGINEERS

All London meetings will be held at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, unless otherwise stated.

Joint Brit. I.R.E.-I.E.E. Medical Electronics Group

Date: 22 January. Time: 6 p.m.
Lecture: Non-Canulated Methods of Measuring Blood Flow.
By: A. Guz and C. A. F. Joslin.

South Wales Section

Date: 8 January. Time: 6.30 p.m.
Held at: The Welsh College of Advanced Technology, Cardiff.
Lecture: Stereophonic Sound.
By: F. H. Brittain.

North Eastern Section

Date: 8 January. Time: 6 p.m.
Held at: The Institute of Mining and Mechanical Engineers, Westgate Road, Newcastle upon Tyne.
Lecture: Some Results of Tests at the Goonhilly Earth Station.
By: F. J. D. Taylor.

Southern Section

Date: 7 January. Time: 6.30 p.m.
Held at: The Lanchester Theatre of the University of Southampton.
Lecture: Solid State Switching.
By: A. C. Savage.

Electro-Acoustics Group

Date: 15 January. Time: 6 p.m.
Symposium on: Acoustical Filters.
Papers by: J. D. Nudd, R. L. Kell and W. V. Richings.

Joint Brit. I.R.E.-I.E.E. Computer Groups

Date: 27 January. Time: 5.30 p.m.
Held at: The Institution of Electrical Engineers, Savoy Place, London, W.C.2.
Colloquium on: The Interconnexion of Peripheral Equipment.

Television Group

Date: 29 January. Time: 6 p.m.
Symposium on: Television Receiver Production Techniques.

West Midlands Section

Date: 23 January. Time: 7 p.m.
Held at: Electrical Engineering Department, University of Birmingham, Edgbaston.
Lecture: Teaching Machines.
By: M. Sime.

South Western Section

Date: 22 January. Time: 6.30 p.m.
Held at Bristol University, Engineering Lecture Rooms, Bristol.
Lecture: Ballistic Missile Early Warning Systems.
By: G. G. Boyts.

Scottish Section

Date: 8 January. Time: 7 p.m.
Held at: The Department of Natural Philosophy, The University, Drummond Street, Edinburgh.
Lecture: Transistors in Television Receivers.
By: P. L. Mothersole.
Date: 9 January. Time: 7 p.m.
Held at: The Institution of Engineers and Shipbuilders, 39 Elmbank Crescent, Glasgow.
Lecture: Transistors in Television Receivers.
By: P. L. Mothersole.

Yorkshire Section

Date: 8 January. Time: 6.30 p.m.
Held at: Department of Electrical Engineering, The University, Woodhouse Lane, Leeds.
Lecture: A Multi-Function Static Switching System.
By: C. G. Cargill.

THE INSTITUTION OF ELECTRICAL ENGINEERS

All meetings will be held at Savoy Place, commencing at 5.30 p.m. unless otherwise stated.

Electronics Division

Date: 6 January.
Lecture: Operational Experience with Wide Band Radio Links.
By: D. G. Jones.
Date: 8 January. Time: 6 p.m.
Held at: London School of Hygiene and Tropical Medicine.
Discussion: 'Non-Canulated Methods of Measuring Blood Flow'.
Opened by: A. Guz and C. A. F. Joslin.
Date: 13 January.
Discussion: 'Getter Ion Pumps'.
Opened by: W. F. Gibbons.
Date: 15 January.
Lecture: The Quest for Controlling Thermonuclear Reactions.
By: A. A. Ware.
Date: 16 January.
Lecture: A Variational Integral for the Propagation Coefficient of a Cylindrical Waveguide with Imperfectly Conducting Walls.
By: P. N. Robson.
Lecture: An Investigation into the Use of Over-Moded Rectangular Waveguide for High-Power Transmission.
By: J. S. Butterworth, A. L. Cullen and P. N. Robson.
Lecture: Rectangular-Waveguide Attenuation at Millimetre Wavelength.
By: F. A. Benson and D. H. Stevens.
Lecture: More Coaxial Cables or Waveguides for Long Distance Communications.
By: H. E. M. Barlow.
Lecture: Waveguide Structures for Low Loss Transmission around Sharp Bends in Circular Waveguides.
By: H. E. M. Barlow and P. Vuorinen.
Date: 27 January: Time: 2.30 and 5.30 p.m.
Colloquium: The Interconnexion of Peripheral Equipment.

Power Division

Date: 16 January.
Lecture: Focal Point Protection System for Power Reactors.
By: D. D. Bowen.
Date: 22 January.
Lecture: 'Concept of Synchronous Generator Stability' and 'Influence of Governors on Power-System Transient Stability'.
By: J. L. Dineley and M. W. Kennedy.
Lecture: Study of Power-System Stability by a Combined Computer.
By: J. L. Dineley.
Lecture: Power-System Governor Simulation.
By: J. L. Dineley and E. T. Powner.
Date: 28 January.
Discussion: Maintenance Techniques for Transmission and Distribution Systems.
Opened by: W. G. Todd, N. L. W. Hills and A. J. Ruddock.

Science and General Division

Date: 7 January.
Lecture: Simulation Assessment of Tandem Cold Rolling Mill Automatic Gauge Control Systems.
By: G. F. Bryant and M. H. Butterfield.
Date: 14 January.
Lecture: Non-Linear Circuit Theory.
By: J. C. West.
Date: 20 January.
Discussion: Low-Pressure Switching Devices.
Opened by: D. A. Swift.
Date: 21 January.
Discussion: 'R.M.S.'.
Opened by: A. Felton.
Date: 24 January.
Discussion: Polymide High-Temperature Resins.
Opened by: R. Snadow and W. Manz.
Date: 28 January.
Discussion: Automatic Start-up of Power Stations.
Opened by: P. D. Aylett, C. Ayers and E. B. Johnson.

THE TELEVISION SOCIETY

Date: 23 January. Time: 7 p.m.
Held at: The Conference Hall, I.T.A., 70 Brompton Road, London, S.W.3.
Lecture: An Historical Survey of Band Shared Colour Television Systems.
By: I. Macwhirter.

PUBLICATIONS RECEIVED

TUFNOL LTD have recently published a trio of leaflets, each dealing separately with the uses of their laminated plastics material in the mechanical, electrical and chemical industries. Well illustrated with application photographs, the leaflets also contain useful technical data, in tabulated form, on the various brands of Tufnol. Copies are available on request to Tufnol Ltd, Perry Barr, Birmingham 22b.

ALL-WEATHER LANDING AND TAKE-OFF is a summary based on the verbatim discussions during the Fifteenth IATA Technical Conference in Lucerne from 26 April to 5 May, 1963, on all-weather landing and take-off. It also includes an IATA Appraisal of Current Status of all-weather landing and take-off, taking into account the proceedings of the Conference. During the Conference, a number of organizations amplified the information contained in the working papers by showing movie films or slides dealing with their projects. A list of film or slide presentations given during the Conference is given in an Appendix. This Report is published by the International Air Transport Association, 1060 University Street, Montreal 3, P.Q., Canada.

SOLARTRON 247 ANALOGUE COMPUTER SYSTEM is the title of an illustrated guide published by the Solartron Electronic Group Ltd, Farnborough, Hampshire. The introduction describes the role of the analogue computer in modern industries such as the chemical, process and mechanical engineering, heavy electrical, electronic and control, aircraft, missile, marine and automobile engineering. The computer's advanced features, central address system, potentiometer setting, automatic address commutator, dual digital timer, integrator time constants and non-standard networks are dealt with in full detail. Requests for copies of the comprehensive booklet should be addressed to The Solartron Electronic Group Ltd, Farnborough, Hampshire.

COAXIAL CONNECTORS—Greenpar Engineering Ltd have recently issued a set of assembly instructions for the Series C, u.h.f. and BNC coaxial connectors manufactured by them. The assembly instructions for the Series C connectors may also be used for the Series N connectors. This information is available from Greenpar Engineering Ltd, Electronics Division, Station Works, Cambridge Road, Harlow, Essex.

GARDNERS TECHNICAL DATA SHEETS, AT.1-AT.4, show the new range of standardized transformers for transistor audio frequency power and are issued as supplements to their Audio Transformer Leaflet, GT4. Requests for copies should be addressed to Gardners Transformers Ltd, Somerford, Christchurch, Hants.

NUCLEAR ENGINEERING ABSTRACTS, Vol. 4, No. 1, January 1963 has recently been published by Silver End Documentary Publications Ltd. This book is published three times a year and the annual subscription is £9 6s. Further information and subscription forms are available from the publishers at 9-11 Tottenham Street, London, W.1.

ARCOLECTRIC SWITCHES & SIGNAL INDICATOR LAMPS, catalogue supplement number 135 has recently been published by Arcolectric Switches Ltd and describes new switches and indicator lamps recently introduced by the company. This is a supplement to the main list number 133/B. Copies are freely available on request to Arcolectric Switches Ltd, Central Avenue, West Molesey, Surrey.

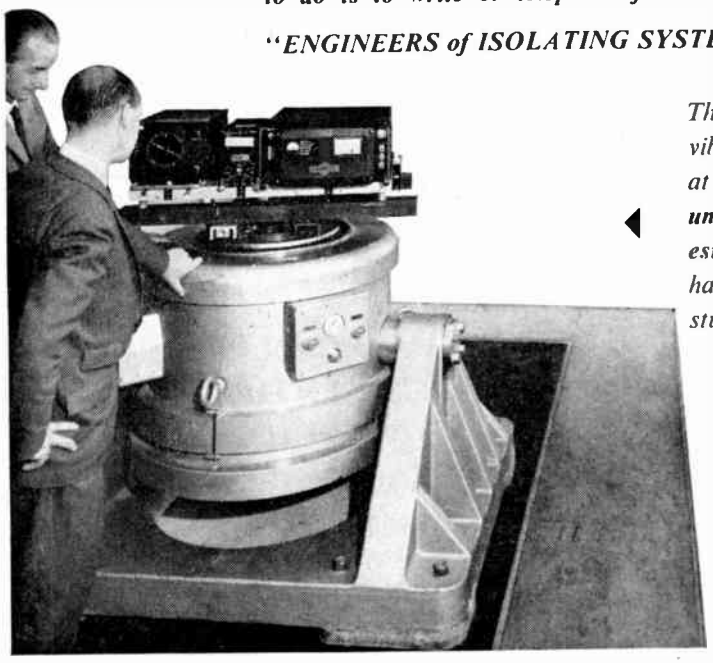
our concern is with "Q"

The transmissibility of a system at resonance is referred to as the "Q" of a system—a fact of which the vast majority of the readers of this Journal will be seized.

"Q" may be regarded as the measure of the efficiency with which our Isolators and Shockmounts function.

Many thousands of BARRYMOUNT Vibration and Shock Isolators are in service in aircraft on air routes all over the world. Similarly thousands of delicate instruments employed in fighting and other vehicles on land, and in ships at sea, are protected against shock and vibration by one or another of the various Isolators and Shockmounts which we design and manufacture. ***Increasingly they are being used in industry to protect modern control and recording equipment.***

Every engineer who is concerned with "Q" should have at hand a full set of these Product and Data Sheets . . . all you have to do is to write or telephone for our publication entitled "ENGINEERS of ISOLATING SYSTEMS".



The illustration (left) shows the large moving coil vibrator which is a unit of equipment in the Laboratories at our Works at Hersham; ***this is one of the largest units of its kind to be installed in an independent establishment.*** *It is typical of the resources we have developed with which we carry out environmental studies and testing.*

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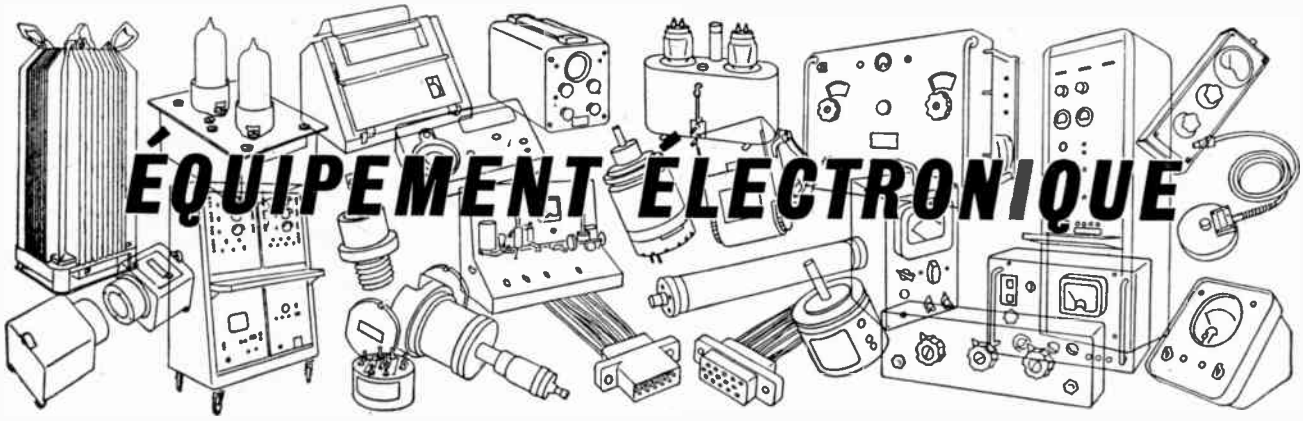


ÉQUIPEMENT ÉLECTRONIQUE

Une description basée sur des renseignements fournis par les fabricants de nouveaux organes, accessoires et instruments d'essai

Traduction des pages 50 à 55

CONTRÔLEUR DE RADIATIONS

The Redcliffe Radio and Engineering Co. Ltd, Emery Road, Brislington, Bristol, 4

(*Illustration à la page 50*)

Le tout dernier modèle de contrôleur de zone gamma conçu par le Commissariat britannique à l'énergie atomique peut être obtenu maintenant de la Redcliffe Radio and Engineering Co Ltd, qui fabriquent ce matériel sous licence.

Le contrôleur type 1796B comporte un coffret étanche qui peut être préréglé aisément à un niveau d'alarme prédéterminé dans la gamme de 10 mr/h à 500 r/h. L'appareil se compose d'une chambre d'ionisation, d'un circuit de déclenchement électrométrique et de défection avec indication par lampe locale si l'intensité d'irradiation gamma est au-dessus ou au-dessous du niveau d'avertissement préréglé. Une indication supplémentaire par lampe éloignée est fournie au moyen d'un élément à lampe à part. L'appareil fonctionne sur tension continue de 22 à 29 V ou conjointement avec un bloc de puissance approprié à partir d'une source de courant secteur alternatif.

Le contrôleur est muni en outre d'un élément de verrouillage qui assure le fonctionnement sur courant secteur de trois détecteurs d'alarme et assure le contrôle des niveaux individuels d'intensité d'irradiation.

L'élément principal est à montage mural et son volume total est d'environ 8 pouces cubes, la consommation électrique étant d'environ 12 W.

EE 65 751 *pour plus amples renseignements*

TROLLEY À INSTRUMENTS

Avon Communicatioos and Electronics Ltd, 16 High Street, Christchurch, Hampshire

(*Illustration à la page 50*)

La société Avon Communications and Electronics Ltd vient de présenter un nouveau trolley à instruments de contrôle de puissance d'un modèle perfectionné, le AVONCEL TM2SE, conçu pour le transport d'instruments de télécommunications, d'électronique ou d'appareils de contrôle analogues vers l'emplacement d'installations de matériel statique pour l'entretien courant, les essais et les réparations.

Le trolley de base est en tubes d'acier épais fortement soudés de façon à constituer deux sections latérales auxquelles les étagères supérieures et inférieures sont boulonnées. La hauteur du trolley est réglable entre 76,2 cm et 91,4 cm. Les étagères principales sont formées de plaques d'acier mesurant 106,6 cm × 106,6 cm, d'une épaisseur de 0,31 cm et espacées de 45,72 cm. L'ensemble du trolley est monté sur roues Flexello de puissance dont la grande manoeuvrabilité est due a des paliers articulés. Le trolley est de couleur gris fer et les poignées et barres de soutènement sont chromées, les assemblages des roues étant cadmiés.

Afin d'assurer une utilisation maxima au modèle de base TM2, de nombreux dispositifs supplémentaires lui ont été ajoutés. Ces derniers comprennent deux étagères supplémentaires de 38,1 cm × 60,9 cm pour l'étagère principale supérieure (ces étagères sont rangées verticalement sur les côtés du trolley lorsqu'elles ne sont pas employées); un bâti pour ranger les manuels techniques; deux étagères supérieures supplémentaires de 100 cm × 20 cm dont la hauteur est réglable et qui peuvent être fixées sous les étagères principales supérieures ou inférieures; deux barres de soutien servant de rallonges amovibles et contenant des crochets pour câbles d'essai électroniques et des pinces pour tenir les plans; un support en amiante isolé pour fers à souder électriques sous l'étagère supplémentaire supérieure. La distribution de courant sur le trolley se fait au moyen d'une plaquette Lexor munie d'un interrupteur principal, d'un indicateur au néon et utilisant des douilles à prises de 5 × 13A ou de 5 × 5A; 3 broches, ainsi que 10 mètres de câble secteur à trois conducteurs; deux des roues sont munies de dispositifs de freinage. Le trolley spécial TM2SE comprend tous ces avantages supplémentaires.

Le poids total du trolley complet est d'environ 100 kg et il peut transporter une charge d'environ 360 kg.

EE 65 752 *pour plus amples renseignements*

COMPTEUR

Research Electronics Ltd, Bradford Road. Cleckheaton, Yorkshire

(*Illustration à la page 50*)

Un compteur d'une grande souplesse d'emploi pour applications nucléaires et électroniques vient d'être réalisé par la société Research Electronics Ltd. Le compteur modèle 9031 trouve en effet de nombreux usages en tant que matériel complémentaire de démultiplicateurs exigeant l'indication directe sur un instrument de lecture du taux de comptage instantané. Il peut être utilisé avec tous les types de détecteurs de radiations y compris les compteurs Geiger, les compteurs de scintillations et les compteurs proportionnels, ainsi que les transducteurs électromécaniques et photo-électriques et les capteurs pour applications techniques telles que la mesure de vitesse de tours.

L'instrument couvre neuf gammes à commutation pouvant être aisément choisies par boutons poussoirs de 3 comptages par seconde pour une déviation totale de l'échelle sur la gamme la plus basse à 30 000 comptages par seconde sur la gamme la plus haute, avec une gamme adéquate correspondante de constantes de temps d'intégration de 125 sec à 0,2 sec.

L'instrument comprend des alimentations pour éléments subsidiaires et un bloc d'alimentation haute tension pour la polarisation de tubes Geiger ainsi que certains types de cellules photo-électriques. Il peut être utilisé comme instrument entièrement autonome de comptage nucléaire et le haut-parleur intérieur le rend particulièrement indiqué pour l'emploi comme contrôleur de contami-

nation pour le contrôle audible continu des bruits de fond de laboratoires.

Des douilles de sortie d'impulsions et de sortie analogique permettent de relier des compteurs ou des enregistreurs extérieurs.

EE 65 753 *pour plus amples renseignements*

INDICATEUR DE NIVEAU SONORE

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

(Illustration à la page 51)

Pour répondre à la demande croissante d'appareils pour la mesure du niveau sonore, la société Dawe Instruments Ltd, a réalisé un nouvel indicateur de niveau sonore, type 1408E. Il s'agit d'un instrument de poche entièrement transistorisé pour les vérifications rapides de bruit et pour la mesure du bruit exigeant un appareil qui soit à la fois simple, robuste et précis, sans les dispositifs d'entrée et de sortie d'un enregistreur de niveau sonore.

Le nouvel instrument comprend un microphone à cadre mobile (logé dans le coffret en matière plastique), un amplificateur à gain élevé, des réseaux de pondération, des atténuateurs et un indicateur. Les réseaux de pondération correspondent à ceux prévus dans la publication I.E.C. 123 et dans la spécification BS 3489 : 1962.

L'atténuateur permet de mesurer des niveaux sonores de 40dB à 120dB (soit un niveau de pression sonore standard de 0,0002 dyn/cm²) dans six gammes se recouvrant. L'amplificateur assure un gain stable dans la gamme de température de 0° C à 45° C (32° à 113° F) et il est pratiquement insensible aux variations de paramètres de transistors et de tension d'alimentation. La puissance est fournie par une seule cellule sèche de 9 V (Ever Ready pp4 ou équivalente) suffisant à environ 70 heures de fonctionnement.

L'emploi de composants montés aux extrémités d'un circuit imprimé résulte en une réalisation extrêmement compacte dont les dimensions hors-tout sont de 15,24 cm × 7,62 cm × 5,71 cm. Le poids, batterie comprise, n'est que de 396 grammes.

L'instrument devrait pouvoir être extrêmement utile pour la mesure du bruit dans les usines et les bureaux, pour le contrôle des bruits de la circulation, pour les essais rapides de qualité sur les lignes de production en comparant leurs niveaux sonores.

EE 65 754 *pour plus amples renseignements*

VOLTMÈTRE À TRANSISTOR

Furzehill Laboratories Ltd, Theobald Street, Borehamwood, Hertfordshire

(Illustration à la page 51)

La société Furzehill Laboratories Ltd vient de créer une nouvelle gamme de matériels constitués de corps solides, dont un nouveau voltmètre sensible couvrant la gamme de 10 μV à 300 V dans une gamme de fréquences de 10 Hz à 10 MHz.

Ce voltmètre à semi-conducteurs comporte un circuit imprimé. L'instrument de base tire sa puissance de l'alimentation secteur mais on peut ajouter une batterie rechargeable constituant un accessoire facultatif. C'est un dispositif des plus utiles pour travaux en laboratoire ou pratiques, assurant une absence complète de bourdonnement ou de problèmes de cadre de terre.

Un indicateur linéaire échelonné de 0 à 3,5 et de 0 à 10, donne une lecture de 1 mV sur la totalité de l'échelle sur la gamme la plus sensible et de 300 V sur la gamme la plus élevée. Une contre-réaction sensible assure une précision supérieure à 2 % sur la plus grande partie de l'échelle de fréquence. L'indicateur est également échelonné en décibels par rapport à 1 mW dans 600 Ω. L'impédance d'entrée est de 3 MΩ avec une capacité shunt de 25 pF. Une sonde de faible capacité (3 MΩ, 5 pF) à gain d'unité élevé est livrable comme accessoire facultatif.

EE 65 755 *pour plus amples renseignements*

ÉTALON DE FRÉQUENCE STANDARD

Advance Components Ltd, Roebuck Road, Hainault, Ilford, Essex

(Illustration à la page 51)

L'étalon de fréquence standard type OFSI est à phase asservie à la porteuse de 200 kHz de l'émetteur du programme de la BBC à Droitwich et sa précision à long terme est donc supérieure à 5 parties dans 10^9.

L'étalon OFSI fonctionne sur batterie ou sur secteur et fournit des sorties d'onde carrées à 100 kHz et à 1 MHz. La précision à court terme est supérieure à 1 partie dans 10^8 pour n'importe quelle période jusqu'à 5 sec et elle est supérieure à 1 partie dans 10^8 pour n'importe quelle période de 5 à 50 sec.

Sa sensibilité est telle qu'une antenne intérieure peut être utilisée dans la plupart des régions d'Angleterre.

EE 65 756 *pour plus amples renseignements*

OSCILLOSCOPE

Distributeurs: Research & Control Instruments Ltd, Instrument House, 207 King's Cross Road, London, W.C.1

(Illustration à la page 51)

La gamme des oscilloscopes Philips vient d'être complétée par un modèle compact X-Y à tube de 7,5 cm, désigné par la référence GM5605. Cet oscilloscope aurait un champ étendu d'applications et serait particulièrement utile pour les travaux militaires et pour l'enseignement.

Les amplificateurs X et Y sont identiques et le rapport entre les deux variables indépendants peut être affiché avec précision. Les rapports de phase et de fréquence, par exemple, peuvent être facilement déterminés.

Les deux amplificateurs ont une gamme de fréquences allant du courant continu à 200 kHz, la différence de phase entre leurs sorties étant inférieure à 3°. Le micromètre cathodique est en divisions de 6 mm, donnant ainsi une sensibilité verticale hors-tout de 10 mV par division et une sensibilité horizontale de 30 mV par division. Les deux balayages peuvent être étendus à 3x.

La sensibilité sur chaque axe peut être réduite à 30 V par division par atténuateur à plots et par commandes de gain continu. La précision d'étalonnage des atténuateurs à plots est de +3%.

En plus de son application en tant qu'instrument X-Y, le GM5605 peut être utilisé comme oscilloscope classique. La base de temps est incorporée à une vitesse de balayage variant de 0,02 à 100 msec par division d'échelle. Le déclenchement peut être intérieur ou extérieur et le niveau de déclenchement est réglable.

L'instrument peut être utilisé sur n'importe quelle tension de secteur normale. Il mesure 25,4 cm × 16,5 cm × 34,29 cm et son poids est de 10 kg.

EE 65 757 *pour plus amples renseignements*

JACKS DE POINT D'ESSAI

Sealectro Corporation, Hersham Trading Estate, Walton-on-Thames, Surrey

(Illustration à la page 51)

Le SKT-0807 est un nouveau jack de point d'essai Telfon "Pressfit" pouvant être utilisé en combinaison avec un châssis métallique et un circuit de bobinage imprimé. Le jack est inséré dans le châssis de la manière standard "Press-fit" en isolant ainsi le jack du châssis métallique. Le contact en cuivre de béryllium (0,14 cm de diamètre) s'étend sur toute la longueur du corps de Telfon pour s'accoupler à un récipient sur la plaquette de circuit imprimé. Le contact du SKT-0807 peut s'accoupler à une sonde de 0,20 cm de diamètre et d'une longueur de 0,71 cm. Comme pour tous les jacks de point d'essai "Press-fit" Telfon, il existe des modèles dans toutes les couleurs standard EIA pour le codage en couleurs des points d'essai du châssis.

EE 65 758 *pour plus amples renseignements*

COMMUTATEURS INDUCTIFS DE PROXIMITÉ

Intersonde Ltd, The Forum, High Street, Edgware, Middlesex

(Illustration à la page 52)

Intersonde Ltd vient d'annoncer la production de deux nouveaux commutateurs de proximité inductifs. Ces commutateurs, types QD19 et QD20, constituent un moyen simple et peu coûteux de détecter la présence d'objets métalliques ferreux ou non-ferreux, y compris les feuilles minces de métal.

Les deux modèles sont entièrement à semi-conducteurs au silicium et leur puissance de sortie est de 120 mA dans une gamme de températures de service de 0°C à +60°C. Ils sont tous deux autonomes, mesurent 13,97 cm de longueur sur 2,69 cm de diamètre et

fonctionnent sur alimentation de 12 ou de 24 V c.c. Tous les composants sont sous moulage en résine d'époxyde et leur rendement est insensible aux vibrations, à la poussière ou à l'humidité. Les deux modèles sont munis d'un câble de 1,90 m qui, dans le cas du modèle QD.20, est contenu dans un tube souple.

Bien que prévus à l'origine pour le comptage des lots, ils peuvent être utilisés également à la place des commutateurs de limite classiques sur les machines-outils, les convoyeurs, les ascenseurs et monte-charges et, en général, pour toutes les applications où la commutation doit être effectuée sans contact physique.

EE 65 759 *pour plus amples renseignements*

COMPTEUR CONVERTISSEUR

Marconi Instruments Ltd, St. Albans, Hertfordshire

(Illustration à la page 52)

Marconi Instruments Ltd vient de réaliser un nouveau convertisseur qui étend la gamme de puissance de la série des convertisseurs Marconi TF1417 à 570 MHz.

Le nouvel appareil comprend deux éléments. L'élément de base TF2400 étend les mesures de fréquence à 110 MHz. La gamme d'entrée va de 20 kHz à 110,5 MHz, la sensibilité d'entrée étant de 10 mV efficaces. Les signaux dans la gamme de 20 kHz à 10,5 MHz sont amplifiés et améliorent ainsi la sensibilité du compteur. Pour les signaux de plus de 10 MHz, on utilise une technique hétérodyne par laquelle le signal est mesuré à un harmonique de 10 mHz, de sorte que la différence de fréquence qui en résulte est inférieure à 10 MHz et peut être mesurée par le compteur.

Bien que l'instrument soit essentiellement prévu pour l'emploi sur large bande, on peut accorder des signaux d'entrée, l'accord correct étant indiqué par une déviation maxima sur un indicateur. Ce dernier indique également si le niveau de puissance du convertisseur suffit à entraîner le compteur. L'appareil comprend, en outre, un ondemètre permettant d'obtenir une indication approximative de la fréquence inconnue.

Le TM7164 couvre une gamme de 100 à 510 MHz, les puissances d'entrée allant jusqu'à 100 mV. Le principe de cet appareil est semblable à celui du TF2400, sauf que le signal d'entrée est mélangé à un harmonique de 100 MHz.

Le TF2400 est fourni dans un boîtier de largeur complète avec panneau vierge. Le TM7164 peut être aisément installé par le client au cas où il serait acquis par la suite.

Ces convertisseurs sont entièrement munis de dispositifs semi-conducteurs et de circuits imprimés. Le poids du TF2400 est 7,5 kg et le poids total des deux éléments est de 8,5 kg. Il existe également un modèle pour montage sur bâti.

EE 65 760 *pour plus amples renseignements*

MILLIWATTMÈTRE MICROONDES

Griffin & George Ltd, Ealing Road, Alperton, Wembley, Middlesex

(Illustration à la page 52)

Le milliwattmètre type 15A a été réalisé pour mesurer la puissance dans un guide d'onde ou une ligne coaxiale, en liaison avec un support à thermistance approprié.

Dans de nombreux cas, un support de laboratoire déjà fixé suffira à l'emploi de l'appareil, à condition que la résistance à thermistance soit bien à 200 Ω pour le type 15A.

La thermistance est reliée dans le bras de contre-réaction d'un oscillateur à pont de Wien à faible distorsion.

Lorsque la puissance HF est fournie à la thermistance, la quantité absorbée est indiquée sur l'instrument de mesure.

Cet instrument à lecture directe est d'un fonctionnement extrêmement simple et il présente une stabilité à zéro élevée après quelques minutes de temps de chauffe. La régularité du fonctionnement peut être vérifiée instantanément au moyen d'un dispositif incorporé d'étalonnage.

La précision de l'instrument est de ±4% et sa gamme s'étend de 0 à 2,5 mW sur la totalité de l'échelle. La gamme de fréquence est déterminée par le support de thermistance.

EE 65 761 *pour plus amples renseignements*

ENSEMBLE À DÉCADES INTERCHANGEABLE

Panax Equipment Ltd, Holmethorpe Industrial Estate, Redhill, Surrey

(Illustration à la page 52)

La société Panax produit à présent un ensemble à décades peu coûteux pouvant être incorporé au matériel de comptage électronique pour usages industriels, de laboratoire et d'enseignement scientifique. Cet appareil, réalisé en deux modèles, est identique à celui qui est utilisé dans l'intégrateur nucléonique Panax série SA-102 et comporte un circuit imprimé de haute qualité et des composants fort sûrs.

Le type TD.1 a des taux de comptage allant jusqu'à 5000 coups par seconde et un temps de résolution de 200 μsec. Le type TD.2 a un taux de comptage maximum de 50000 coups par seconde et un temps de résolution de 20 μsec. Les tubes à décades sont les modèles Mullard Z504S et Z505S respectivement.

Les deux versions de cet appareil exigent une alimentation de 12 V et des impulsions d'entrée positive de 12 V d'amplitude. Les dimensions hors-tout de l'appareil sont: 14 cm de longueur × 4,4 cm de largeur.

EE 65 762 *pour plus amples renseignements*

RÉCEPTEUR DE FRÉQUENCE STANDARD

The Wayne Kerr Laboratories Ltd, Coombe Road, New Malden, Surrey

(Illustration à la page 53)

La société Wayne Kerr Ltd vient d'annoncer la mise au point d'un récepteur superhétérodyne entièrement transistorisé pour la réception de toutes les transmissions de fréquences internationales. La haute sensibilité de l'appareil Wayne Kerr-Gertsch, type RHF-1, permet en effet la réception de ces transmissions de fréquence standard en n'importe quelle partie du globe.

Grâce à cette excellente réception, le modèle RHF-1 convient pour le contrôle d'étalonnage d'oscillateurs et d'étalons de fréquence à un degré de précision pouvant aller à une partie dans 10^7. Il trouve une variété étendue d'applications dont la mesure de temps précise, la réception de fréquences acoustiques standard et la modulation par impulsions codées. Les fréquences de battement peuvent être observées en branchant les oscilloscopes à des bornes de sortie prévues à l'arrière de l'instrument.

La source de puissance peut être soit de 115/230 V c.a. secteur soit de 12 V sur batterie. Les fréquences de travail sont normalement de 2,5, 5,10, 15,20 et 25 MHz, mais on peut ajouter jusqu'à trois fréquences entre 2,5 et 25 MHz. La sensibilité utilisable est de 1μV et le rapport signal-plus-bruit/bruit est supérieur à 10 dB pour une entrée de 3μV.

Le récepteur est conçu comme modèle de banc d'essai mesurant 19 cm de largeur × 9 cm de hauteur × 33 cm de profondeur, mais il est essentiellement étudié pour le montage sur demi-bâti standard.

EE 65 763 *pour plus amples renseignements*

BOUTONS DE PINCES DE SERRAGE

The Plessey Co. (U.K.) Ltd, Titchfield, Hampshire

(Illustration à la page 53)

Une nouvelle gamme de boutons miniature de pinces de serrage vient d'être réalisée par The Plessey Company (UK) Ltd, afin de répondre aux conditions du DEF.5221. La conception de ces boutons est caractérisée par le fait que le même moulage de base phénolique peut être adapté à des axes de 0,31 cm et 0,47 cm de diamètre avec des pinces différentes.

Les assemblages de boutons nécessitent une cannelure radiale dans l'axe et une fente à travers son extrémité. En serrant la vis de verrouillage on contracte la pince qui vient se loger dans la cannelure radiale, ce qui a pour effet d'empêcher que le bouton ne soit arraché de l'axe. L'entraînement, cependant, est transmis par une clef qui s'engage dans l'extrémité à fente de l'axe.

EE 65 764 *pour plus amples renseignements*

TUBE CATHODIQUE D'INSTRUMENT

English Electric Valve Co. Ltd, Chelmsford, Essex

(Illustration à la page 53)

Un nouveau tube à rayons cathodiques

de 12,7 cm vient d'être mis au point par la English Electric Valve Co. Ltd à l'usage des oscilloscopes à large bande et à grande vitesse.

Les caractéristiques particulières de ce tube sont les suivantes:

(1) Sensibilités de déviation dans les directions Y et X de 3 V/cm et 9 V/cm respectivement.
(2) Haute brillance permettant d'employer des vitesses d'enregistrement élevées.
(3) Bonne sensibilité due à la dimension réduite du spot (largeur de ligne typique: 0,4 mm).

Ces caractéristiques sont réalisées d'une part grâce à la maille d'accélération de post-déviation placée à quelques millimètres de l'écran luminescent et, d'autre part, grâce au dessin perfectionné du canon.

Vu la faible distance entre la maille et l'écran sur laquelle le faisceau est accéléré, la distorsion de la trame est réduite au minimum, la sensibilité de déviation X perfectionnée étant obtenue par un grand espacement entre la plaque X et la maille.

L'avantage supplémentaire de cette position de la maille réside dans la stabilité améliorée de la sensibilité de déviation X et Y en fonction des changements de température.

La sensibilité de déviation du tube le rend particulièrement indiqué pour l'emploi avec les circuits de déviation à transistors.

Le tube peut être fourni avec deux substances luminescentes: T9484—phosphorescence vert (substance luminescente équivalant à P31) et T948N—phosphorescence vert jaunâtre (substance luminescente équivalant à P2). Les deux versions ont une persistance de courte durée moyenne.

EE 65 765 *pour plus amples renseignements*

GÉNÉRATEUR DE FORME D'ONDES

Servo Consultants Ltd, 162-6 Kensal Road, London, W.10

(Illustration à la page 53)

Cet instrument produit une forme d'onde de tension cyclique de n'importe quelle forme. La forme d'onde de tension est produite au moyen des disques de mire de forme d'onde, dont plusieurs sont fournis avec chaque instrument. De plus, la forme d'onde de tension peut être produite à partir d'un dessin de mire facilement réalisable par l'utilisateur et sans outils ou appareils spéciaux. Une boîte contenant 100 modèles de dessins de mire imprimés est fournie avec chaque instrument. Ces modèles sont d'une grandeur suffisante pour préparer les mires avec une précision d'au moins 0,3% par n'importe quel utilisateur, sans formation ou habileté spéciales.

Les mires sont simplement tracées sur des marques micrométriques imprimées sur des modèles en blanc. La mire voulue est ensuite découpée sur un modèle en blanc à l'aide de ciseaux ordinaires. Etant donné que les mires ne sont pas sujettes à usure quand elles sont utilisées dans l'instrument, elles peuvent être employées indéfiniment et facilement rangées après usage pour pouvoir s'y référer par la suite. L'utilisateur peut ainsi se constituer une bibliothèque de mires pouvant être utilisées à n'importe quel moment. Le coût fort réduit des modèles en blanc permet d'expérimenter avec diverses configurations de formes d'ondes. Des modèles de mires en blanc en quantités supplémentaires peuvent être obtenues auprès de la société Servo Consultants Ltd. à un prix modique.

La sortie de l'instrument est un signal de tension pouvant être d'une amplitude considérable. De plus, le signal est fourni à une impédance relativement réduite et des courants relativement élevés peuvent être obtenus de l'instrument. Il peut être injecté directement dans des calculateurs analogiques à niveau d'entrée de ± 50 V. Des contrôleurs de processus exigeant un courant de signal d'environ 50 mA d'amplitude maxima peuvent également être prévus. Dans de nombreuses applications, la mire requise correspond à des conditions de "marche" et "arrêt" plutôt qu'à des niveaux de tension changeants. Des relais à signaux de type courant de 6, 12, 24 ou 50 V peuvent être reliés directement à la sortie de l'instrument. Etant donné que les mires peuvent être produites sans l'emploi de contacts quels qu'ils soient, l'instrument peut donc être employé pour étudier la durée de fonctionnement sans l'aide d'appareillages exigeant une programmation complexe.

L'instrument a deux gammes de fréquences allant de 0,2 Hz à 50 Hz et de 0,002 Hz à 0,5 Hz.

EE 65 766 *pour plus amples renseignements*

ENCODEURS D'ARBRE OPTIQUES

Digital Measurements Ltd, 25 Salisbury Grove, Mychett, Aldershot, Hampshire

(Illustration à la page 53)

La société Digital Measurements Ltd, en liaison avec la société Winston Electronics Ltd, produit maintenant une version perfectionnée de son encodeur d'arbre optique à haute résolution.

Ce nouveau modèle a été réalisé pour répondre à des spécifications militaires très strictes et il a la faculté de pouvoir conserver la sûreté de son fonctionnement dans des conditions d'emploi extrêmement défavorables. Les améliorations comportent un taux de lecture maximum accru de 6100 coups par seconde, des sorties de signaux supérieures et un scellement hermétique facultatif.

La sortie de l'encodeur standard est en code binaire gris, mais d'autres codes peuvent être fournis sur commande spéciale. Pour chaque tour de l'arbre, l'encodeur effectue 2^{13} comptages, donnant la résolution angulaire élevée de 2 minutes 38 secondes. Une résolution de lecture totale peut être maintenue jusqu'à des vitesses de 45 tours/minute.

L'encodeur Winston-DM n'a qu'une seule partie mobile et n'exige ni engrenages, ni balais ni contacts pour son fonctionnement. Tout effet réactif est éliminé et le moment d'inertie, la torsion, le frottement et l'usure sont réduits au minimum absolu. Les deux seuls paliers utilisés comportent des roulements à billes de précision, scellés et lubrifiés de façon permanente à l'huile de silicone. L'encodeur est logé dans un petit coffret avec flasque de montage NATO format 23 et son poids est de 0,5 kg.

Ces nouveaux encodeurs d'arbre optiques ont une variété étendue d'applications: ils peuvent servir d'éléments à réaction de position numérique dans les systèmes de commande de machine-outils, ainsi que pour le contrôle de rotation d'antennes radar, pour les plateformes stables, pour les systèmes d'armes, etc.

EE 65 767 *pour plus amples renseignements*

OSCILLATEUR PORTATIF

Standard Telephones & Cables Ltd, Connaught House, 63 Aldwych, W.C.2

(Illustration à la page 54)

L'oscillateur 74306A est un appareil portatif universel transistorisé. Il couvre la gamme de fréquences de 10 kHz à 20 MHz et fournit des signaux dans une gamme étendue de niveaux de sortie dans des circuits de 75Ω.

Les méthodes de circuits imprimés sont utilisées et les composants sont logés dans un coffret en alliage léger muni d'une poignée de support et d'un couvercle détachable. L'alimentation est fournie par piles sèches logées dans le coffret, mais une alimentation extérieure en courant continu peut être appliquée si nécessaire. Un commutateur de sûreté permet de débrancher les batteries lorsque le courant est fixé tandis qu'un indicateur d'avertissement est actionné automatiquement par le commutateur arrêt-marche qui s'éclaire lorsque l'alimentation est branchée.

La gamme de fréquences de 10 kHz à 20 MHz est couverte en huit bandes. Les six bandes inférieures emploient le même étage d'oscillateurs à transistors, cependant que les deux bandes supérieures comportent des étages séparés qui empêchent la commutation à haute fréquence. Les circuits oscillants sont tous du type Hartley à thermistance afin de stabiliser la tension de sortie.

La sortie de l'oscillateur est appliquée à un amplificateur qui empêche, en liaison avec un étage de sortie à faible impédance, les changements de fréquence en fonction des charges variables. La sortie à faible impédance est obtenue au moyen d'un étage suiveur d'émetteur, le niveau de sortie étant contrôlé par un circuit de mesure à quasi-lecture de pointe. Deux prises de sortie sont prévues, l'une étant alimentée directement à partir du point de contrôle et l'autre étant alimentée au moyen d'un atténuateur de 0 à 50 dB.

Une commande permet de varier le gain de l'amplificateur dans une gamme

réduite. Cette commande permet également, en liaison avec l'atténuateur qui peut être réglé en plots de 1 dB, d'obtenir n'importe quel niveau de sortie dans une gamme de 50 dB. Le niveau est déterminé en se référant au calage de l'atténuateur et à la lecture du dispositif de mesure, gradué à +1,0 +05,0 −0,5 et −1,0 dB.

On peut, en outre, vérifier la tension d'alimentation (interne ou externe) sur l'instrument de mesure.

EE 65 768 *pour plus amples renseignements*

CONTRÔLEUR DE TRANSISTORS

Grundy & Partners Ltd, 3 The Causeway, Teddington, Middlesex

(Illustration à la page 54)

Ce contrôleur est destiné à l'emploi en liaison avec des instruments de mesure multi-gammes d'un mouvement de base de 1 mA ou davantage, de préférence avec disjoncteur à maxima incorporé. Les bornes de montage permettent de fixer l'appareil directement sur un "Avo-Meter" universel.

La mesure de transistors comprend les courants de fuite $I_{co'}$ et I_{co} au collecteur-émetteur et au collecteur-base respectivement, à un potentiel de 4,5 V.

Les diodes sont contrôlées dans la direction avant en faisant passer un courant qui peut aller jusqu'à 10 mA selon la résistance avant. Le courant inverse est contrôlé à un potentiel de 9 V.

La mesure utile du gain de courant (B) de transistors peut être effectuée jusqu'à une dissipation de 800 mW et une indication raisonnable est donnée pour des tensions plus élevées.

Quatre courants d'entrée de base à commutation sont prévus sur 10, 50, 100 et 500 μA. La tension au collecteur est fixée à 4,5 V.

On peut, à l'aide des deux jeux de bornes, adapter ou comparer deux transistors ou deux diodes semblables dans un minimum de temps dans des conditions exactement pareilles.

En outre, on peut contrôler la batterie intérieure sous charge, éliminant ainsi la possibilité d'erreur due à un défaut de batterie.

EE 65 769 *pour plus amples renseignements*

INDICATEUR DE PROGRAMME DE POINTE

Livingston Control Ltd, Retcar Street, London, N.19

(Illustration à la page 54)

L'indicateur de programme de pointe LC.201 produit par la Livingston Control Ltd selon un dessin de la BBC est utilisé pour mesurer et indiquer le volume du programme, permettant ainsi d'effectuer un contrôle plus efficace des programmes de télévision en extérieurs, d'enregistrements injectés à un pupitre de studio, de voies d'échos de sortie ainsi que pour d'autres cas où il est nécessaire d'employer par la suite dans la chaîne un indicateur standard.

Fondamentalement, l'indicateur standard du programme de pointe mesure le programme en conformité étroite avec une méthode établie de longue date à la BBC, c'est à dire que le programme est redressé sur toute la longueur d'onde puis appliqué à une charge capacitive avec une constante de temps de charge de 2,5 msec et une autre constante de temps de charge de 1 sec. Les impulsions à montée et à chute rapides qui en résultent sont amplifiées et affichées sur un indicateur à cadre mobile.

La réponse de fréquence de l'appareil est linéaire à 0,25 dB dans la gamme de 40 Hz à 15 kHz et on peut voir par la photographie que les étalonnages d'échelle sont à intervalles réguliers afin de faciliter la lecture.

Un avantage important de l'indicateur est la possibilité de réglage rapide soit, plus précisément, à trois points bien espacés de l'étalonnage de l'indicateur, de sorte que la possibilité d'erreur est infime dans les positions intermédiaires. La compensation assure le maintien de la précision dans les conditions d'alimentation ou de changement de température.

L'appareil consiste en trois modules: l'indicateur proprement dit de programme de pointe, l'alimentation stabilisée et le module de mesure et il est fourni soit sous forme d'instrument à coffret soit pour le montage sur bâti. Dans ce dernier cas, l'indicateur doit être monté sur une console ou un pupitre de commande, le reste de l'appareillage étant dans un bâti pouvant être placé à n'importe quel endroit voulu.

EE 65 770 *pour plus amples renseignements*

ELECTROMÈTRE

Electronic Instruments Ltd, Richmond, Surrey

(Illustration à la page 55)

La société Electronic Instruments Ltd a récemment mis au point un électromètre perfectionné condensateur-vibrateur de type universel à élément Vibron dont l'utilité est bien établie. Le modèle 33B-2 est basé sur un appareil antérieur d'un usage mondialement étendu. Les gammes vont de 0 à 10 mV et de 0 à 1000 mV avec une résistance d'entrée supérieure à $10^{14}\Omega$ dans la gamme de 1000 mV. Les nouvelles caractéristiques comprennent une tension variable d'une gamme de ±1300 mV et la possibilité d'insérer des composants d'entrée interchangeables. Le taux de dérive est très faible (moins de 0,1 mV par 12 heures). Les accessoires comprennent un élément de mesure de courant et de tension pouvant mesurer des courants allant jusqu'à 10^{-12} A sur la totalité de l'échelle et une résistance allant jusqu'à $10^{16}\Omega$, ainsi qu'un élément de mesure de pH qui serait d'une précision et d'une sensibilité encore inégalées, sa précision et sa discrimination étant de ±0,002 pH et sa lecture sur la totalité de l'échelle de 0,1 pH.

EE 65 771 *pour plus amples renseignements*

ATTÉNUATEUR

Associated Electrical Industries Ltd, 51-53 Hatton Garden, London, E.C.1

(Illustration à la page 55)

Le nouvel atténuateur coaxial introduit par la Division de Télécommunications de la Associated Electrical Industries Ltd constitue un moyen simplifié d'effectuer n'importe quel degré voulu d'atténuation dans le niveau du signal entre deux éléments électroniques sans qu'il soit nécessaire de modifier les circuits internes de l'un ou de l'autre des éléments. Réalisé par le Service des Composants Radio, cet atténuateur est étudié pour permettre de monter une résistance de ¼ W (dont la valeur dépend de l'application) à l'intérieur du corps de l'atténuateur. Ce dernier est en laiton électro-étamé avec un conducteur intérieur en laiton nickelé et il peut, sous sa forme standard, recevoir des câbles coaxiaux d'un diamètre hors-tout maximum de 0,47 mm. La terminaison est simple: le câble passe à travers un capuchon fileté qui permet de le serrer sur le corps de l'atténuateur de manière à empêcher toute contrainte sur les connexions intérieures. Le conducteur central du câble est soudé à un oeillet fixé dans une douille en nylon séparée et, en même temps, la résistance nécessaire est soudée au même point. L'atténuateur est ensuite réassemblé de sorte que l'autre fil d'extrémité de la résistance dépasse de la broche centrale à laquelle il est soudé, l'excédent étant coupé.

Le nouvel atténuateur peut être employé avec la gamme actuelle de douilles coaxiales AEI univoie et multivoies: son diamètre hors-tout maximum est de 0,43″ et durant l'usage la hauteur au-dessus du connecteur de la douille est d'environ 3,81 cm.

EE 65 772 *pour plus amples renseignements*

CADRES DE CHÂSSIS

Alfred Imhof Ltd, Ashley Works, Cowley Mill Road, Uxbridge, Middlesex

(Illustration à la page 55)

La souplesse d'emploi du système de châssis modulaires Imhof a été accrue par l'addition d'un nouveau type de cadre de châssis, conçu pour loger des cartes et des châssis sans bords de circuits imprimés. Ces cadres sont fournis en deux longueurs, soit 17,78 cm et 22,22 cm, toutes deux ayant 48,26 cm de largeur sur 30,16 cm de profondeur, et ils comportent un bloc de polarisation et de support de connecteur. N'importe quel connecteur de bord peut être aisément enlevé et chacun des guides comprend un dispositif de codage de couleurs.

Ces câdres de châssis peuvent recevoir bon nombre des composants actuels du système de châssis modulaires Imhof et, en outre, de nombreuses pièces ont été ajoutées à la gamme afin de pouvoir les adapter à ces nouveaux cadres. Les deux modèles de cadres peuvent recevoir des cartes de circuits imprimés et des châssis dont la profondeur peut aller jusqu'à

20,95 cm. Ces cartes peuvent avoir 13,81 cm de hauteur pour le modèle de 17,78 cm et 18 cm de hauteur pour le modèle de 22,22 cm.

EE 65 773 *pour plus amples renseignements*

INDUCTEUR HF

Distributeurs: Steatite Insulations Ltd, 31 George Street Loyells, Birmingham, 19

La société Stettner & Co. d'Allemagne Occidentale vient d'ajouter à sa gamme de composants quelques nouveaux types d'inducteurs à bobinage d'argent à haute constance avec mandrins en céramique.

Ces nouveaux inducteurs diffèrent des modèles précédents par leur bobinage d'argent, fermement fixé au corps en céramique par fondant de verre. Ce procédé assure une liaison très ferme et étroite entre le corps en céramique et le bobinage, liaison qui est forcée, par suite des changements de température, d'avoir la même dilatation ou la même contraction que le corps en céramique et agit donc pratiquement de la même manière qu'un bobinage en argent renforcé "par cuisson".

Les nouveaux types de bobines ont une inductance de grande constance. Le coefficient de température est d'environ $15 \times 10^{-6}/°C$. Aux mêmes fréquences, ces bobines ont des valeurs Q sensiblement supérieures, soit une amélioration de 10% et de 50%.

Bien que le fil d'argent des nouvelles bobines soit entièrement enrobé de vernis, le bobinage peut être muni de prises et on peut enlever le vernis du fils pour le soudage. Les deux bouts du bobinage sont soudés sur broches vernies; il n'y a donc aucun risque que la jonction ne dépasse, même si les connexions de la broche ont été ressoudées à plusieurs reprises.

Ces inducteurs sont livrables en plusieurs modèles, dont ceux pour circuits imprimés. Il sont également fournis en versions fixes ou variables (avec plongeur à vis en fer carbonylique). Les bobines sont prévues en types de 3 à 20 tours, donnant une gamme d'inductance d'environ, 0,1 μH à 1,45 μH.

EE 65 774 *pour plus amples renseignements*

DÉTECTEUR SENSIBLE AUX PHASES

Brookdeal Electronics Ltd, Myron Place, Lewisham, London, S.E.13

(Illustration à la page 55)

Le détecteur PD629 est un appareil universel sensible aux phases et pouvant être utilisé pour la mesure de haute fréquence et de microondes, pour les systèmes d'asservissement ou comme détecteur en pont à courant alternatif.

La gamme de fréquences du PD629 est de 10 Hz à 100 kHz. L'entrée de référence exigée est de 2 V efficaces sinusoïdaux ou de 6 V crête à crête. L'impédance d'entrée sur les deux canaux est de 0,5 MΩ, 10 pF. La tension continue de sortie est de $-$IV $\pm$ 0,5 V non équilibrés ou de $\pm$1V équilibré; l'impédance de sortie est de 1 kΩ non équilibré et de 2 kΩ équilibré. La dérive à zéro à l'état équilibré est de 0,25% sur la totalité de l'échelle par heure et après 1 minute et de 0,05% sur la totalité de l'échelle par heure et après 1 heure.

L'appareil peut être monté sur bâti ou sur banc d'essai.

EE 65 775 *pour plus amples renseignements*

VOLTMÈTRE NUMÉRIQUE

Gloster Eqoipment Ltd, Gloucester

Le "Digimeter" modèle BIE est un voltmètre c.a./c.c. à trois chiffres comportant quatre gammes de 0-0999 jusqu'à 0-999 V avec polarité manuelle et facilités de changement de gamme. La précision de la mesure de courant continu est supérieure à $\pm$0,2% de la lecture ou $\pm$1 chiffre et sur les gammes de courant alternatif de $\pm$0,5% de la lecture ou $\pm$1 chiffre.

L'appareil est conçu pour un taux d'échantillonnage de 1 lecture par deux secondes avec possibilités de lecture "par pression". Les caractéristiques de réponse de fréquence permettent d'effectuer des mesures de précision sur toute la gamme acoustique.

L'impédance d'entrée sur les gammes de courant alternatif est d'environ 180 kΩ à 50 Hz et sur le courant continu elle est soit de 1Ω soit de 15 MΩ, selon la gamme choisie.

EE 65 776 *pour plus amples renseignements*

Résumés des Principaux Articles

Une nouvelle méthode pour mesurer la différence de profondeur de modulation des faisceaux dirigés par G. G. Gouriet

Résumé de l'article aux pages 2 à 7

Cet article examine une nouvelle méthode pour mesurer la différence de profondeur de modulation entre deux faisceaux dirigés des systèmes d'atterrissage par instruments utilisés par les avions pour le guidage d'approche des pistes. Cette méthode assure la mesure précise des valeurs de différence de profondeur de modulation à moins de 0,01 %, qui devraient être suffisantes pour répondre aux nouveaux besoins issus du développement des systèmes d'atterrissage automatique. L'article décrit brièvement un instrument réalisé pour le Royal Aircraft Establishment.

Le calcul et la mesure des gains d'antennes directionnelles multiples à très haute fréquences et hyperfréquences par R. G. Manton

Résumé de l'article aux pages 8 à 11

L'auteur traite des méthodes graphiques pour calculer les gains d'antennes directionnelles multiples sur la base de leur courbe de radiations. Deux types d'antennes sont examinés en détail, à savoir:
(a) un faisceau linéaire de dipôles mi-ondes
(b) un faisceau à diagramme de rayonnement cylindrique symétrique.
L'article montre la manière dont ces méthodes peuvent être appliquées à des antennes typiques de réception VHF et UHF telles que les Yagis simples et multiples. Des qualités spéciales de papier graphique ont été conçues pour cette application.
La technique de mesure du gain par comparaison directe avec une dipôle mi-onde est également décrite.

L'application du synthétiseur de fonction à répétition à la production de signaux et de bruits à très faible fréquence par J. R. James et M. H. N. Potock

Résumé de l'article aux pages 12 à 15

La souplesse d'emploi du synthétiseur de fonction à répétition, qui a été décrit dans un article précédent, en fait un instrument fort utile pour le contrôle des systèmes et des composants à signaux et à bruits arbitraires de très faible fréquence.
L'étude des qualités de l'appareil sous ce rapport démontre qu'il s'agit, en effet, d'un instrument compact de contrôle général pour mécanismes d'asservissement et pour calculatrices analogiques offrant une gamme étendue de possibilités.

Applications d'un commutateur à déclenchement périodique contrôlé aux circuits de puissance à courant continu
par M. J. Wright

Résumé de l'article aux pages 16 à 20

Le commutateur à déclenchement périodique contrôlé est effectivement un redresseur piloté au silicium pouvant être mis sur "marche" ou "arrêt" à la borne de déclenchement. Cette possibilité rend le dispositif particulièrement indiqué pour la commutation à grande puissance et pour le contrôle des circuits excités par courant continu.

Un circuit équivalent cst présenté, ainsi que les caractéristiques d'importance dans la réalisation des circuits. Les principales applications considérées sont les suivantes:

(a) Générateurs d'impulsions à déclenchement et à marche libre.
(b) Amplificateurs de puissance à courant continu.
(c) Régulateurs de tension continue.
(d) Commande de vitesse de moteurs électriques à courant continu.
(e) Commande de tension de générateurs rotatifs.

Bon nombre des circuits à haute puissance décrits sont plus simples que les circuits à transistors correspondants à des niveaux de puissance inférieurs.

Un milliampèremètre électronique de conception simple par P. Schagen et G. F. Weston

Résumé de l'article aux pages 21 à 23

Il s'agit ici d'un indicateur expérimental à décharge luminescente dont la longeuur de la colonne luminescente est une fonction linéaire du courant. Le longueur peut être lue avec une précision de 5% et le tube peut donc être utilisé à des fins qui nécessitaient jusqu'à présent un indicateur de courant. Les paramètres se rapportant à la gamme de la totalité de l'échelle sont indiqués dans l'article. Le tube a été mis au point par les méthodes classiques de pulvérisation qui assurent de bonnes caractéristiques initiales et de durée.

Redresseurs au deutérium à haute tension commandés par la grille par B. O. Baxter et R. J. Wheldon

Résumé de l'article aux pages 24 à 29

Le redresseur au deutérium à cathode chaude et commandé par la grille qui fait l'objet de cet article y est comparé à d'autres dispositifs à cathode chaude. Par rapport à ces derniers, il semble qu'il ait certains avantages aux tensions de 25kV et aux tensions supérieures. Les facteurs qui entrent en ligne de compte dans sa réalisation sont, selon cet article, les champs électrostatiques, la nature et la pression du gaz, l'effet des surfaces actives et l'efficadité de la cathode thermionique. Une efficacité nettement accrue peut être obtenue par l'emploi du deutérium au lieu de l'hydrogène, tant en ce qui concerne la facilité de l'amorçage de la grille qu'en ce qui concerne le pouvoir d'écarter des tensions élevées.

Ces principes de réalisation ont été appliqués à la mise au point de deux redresseurs, à savoir les modèles E.2746 et E.2816, prévus pour des puissances nominales de courant moyen de 25kV-350mA et de 40kV-3,5A respectivement.

Ces redresseurs ont permis de fabriquer des blocs d'alimentation à haute tension très compacts, tout en étant robustes et économiques. Ces principes peuvent être étendus à des tensions plus élevées par l'emploi de structures à "boites multiples," ainsi qu'à des courants plus éléves par refroidissement approprié des électrodes.

"Contrôleur de Patients" pour dispensaires d'hôpitaux par J. A. Reynolds

Résumé de l'article aux pages 30 à 33

Cet instrument compte automatiquement le nombre de personnes entrant et quittant une chambre. Il enregistre le nombre de personnes se trouvant dans une salle à n'importe quel moment et affiche ce nombre numériquement sur un banc d'indicateurs "Digitron". Une tension proportionnelle au comptage est fournie à un rengistreur standard à diagramme afin d'assurer un enregistrement continu. L'analyse de ces enregistrements permet d'établir un tableau de rendez-vous à temps d'attente minimum.

Un générateur de chiffres binaires par J. D. E. Benyon et K. G. Nichols

Résumé de l'article aux pages 34 à 38

L'appareil dont il est question dans cet article produit sous forme de série un nombre binaire à huit chiffres. Chacun des chiffres de ce nombre, à l'exclusion des zéros, comprend une impulsion négative d'une amplitude maxima de 9 volts et d'une largeur variant de 1 microseconde à un maximum déterminé par un générateur d'impulsions auxiliaire du type normal de laboratoire. Ce générateur détermine également la période des chiffres. Les chiffres du nombre voulu peuvent être choisis au moyen de huit commutateurs à deux directions et le nombre peut être produit en une fois par commande manuelle à un coup ou par signal de déclenchement d'entrée, ou encore de manière répétée par une séquence de signaux de déclenchement d'entrée.

Un enregistreur d'électrocardiogrammes de sujets actifs par H. Hirschberg

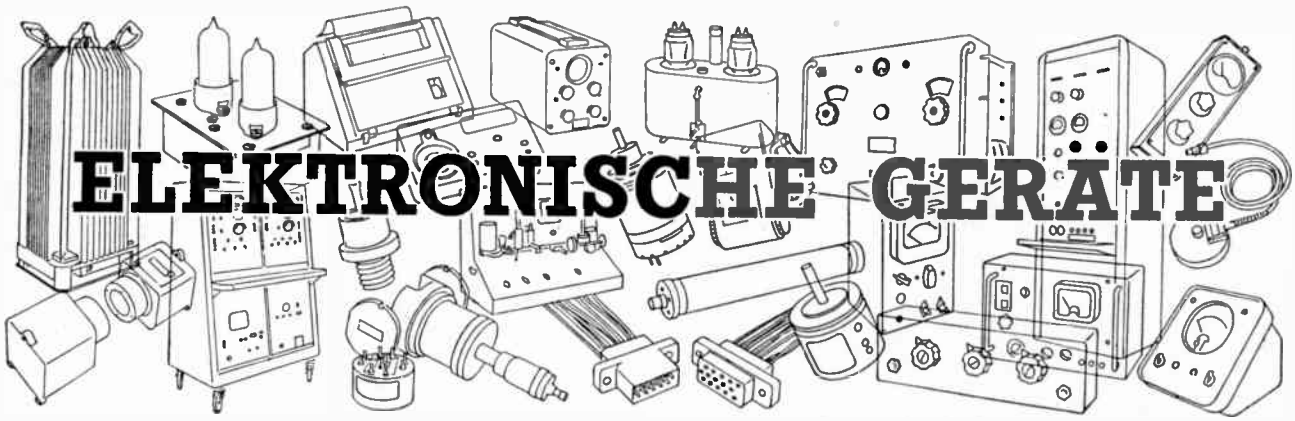
Résumé de l'article aux pages 38 à 39

L'auteur décrit un système basé sur l'emploi d'un magnétophone miniature pour l'enregistrement d'électrocardiogrammes de sujets actifs. L'utilisation d'un magnétophone pour obtenir des données obvie à certains des désavantages de la radiotélémesure. Le système en question est à modulation de fréquence des impulsions qui lui assure simplicité et précision.

Diodes de référence semi-conductrices ultra-stables par R. H. Murphy

Résumé de l'article aux pages 40 à 43

L'auteur passe en revue les progrès réalisés dans l'art de fabriquer les diodes de référence au silicium et de les traiter afin de leur assurer ultra-stabilité et grande sécurité de fonctionnement. Il examine ensuite la mesure dans laquelle ces dispositifs semi-conducteurs peuvent actuellement répondre à la dérive de faible tension et aux critères de coefficients de température exigés pour les références de tension de précision par rapport aux méthodes de préconditionnement, de contrôle de durée et de mesure de précision. En conclusion, il présente une documentation sur les cas d'éléments individuels au cours d'essais prolongés. Ces techniques se justifient par le fait qu'elles garantissent la stabilité à long terme de ces dispositifs dans des conditions d'emploi déterminées.



ELEKTRONISCHE GERÄTE

Beschreibung neuer Bauelemente, Zubehörteile und Prüfgeräte auf Grund der von Herstellern gemachten Angaben.

Übersetzung der Seiten 50 bis 55

Strahlungsüberwachungsgerät

The Redcliffe Radio and Engineering Co. Ltd, Emery Road, Brislington, Bristol, 4

(Abbildung Seite 50)

Das neuste von der Britischen Atombehörde entwickelte Gamma-Flächenüberwachungsgerät kann nunmehr kommerziell von der Radcliffe Radio and Engineering Co Ltd bezogen werden, die es unter Lizenz herstellt.

Das als Type 1796B bezeichnete Gerät hat ein wasserdichtes Gehäuse und kann ohne Schwierigkeiten auf ein vorgewähltes Alarmniveau zwischen 10 mr/h und 500 r/h eingestellt werden. Das Gerät besteht aus Ionisationskammer, Nachweisgerät und Elektrometer-Triggerschaltung mit eingebauten Signallampen, die anzeigen, ob die Gamma-Dosisleistung über oder unter dem vorgewählten Alarmniveau liegt. Bei Verwendung eines getrennten Lampenfeldes kann auch Fernanzeige erfolgen.

Ausserdem gibt es noch ein Kontrollgerät, das drei Nachweisgeräte vom Netz speist und auch die einzelnen Dosenleistungsniveaus überwacht.

Die Abmessungen des für Wandmontage ausgelegten Hauptgerätes sind 203 × 203 × 203 mm, der Stromverbrauch 12 W.

EE 65 751 *für weitere Einzelheiten*

Instrument-Fahrtisch

Avon Communications and Electronics Ltd, 16 High Street, Christchurch, Hampshire

(Abbildung Seite 50)

Avon Communications and Electronics Ltd kündigt den neuen hochbelastbaren Qualitäts-Fahrtisch Avoncel TM2SE für Testausrüstungen an, auf dem Nachrichtenverkehrsgeräte, elektronische und ähnliche Testgeräte zu statischen Installationen gebracht werden können, die Routineüberprüfung, Test oder Reparatur untergehen.

Der Fahrtisch selbst ist aus schweren runden und vierkantigen, in zwei Seiten zusammengeschweissten Stahlrohren konstruiert, an die die oberen und unteren Regalplatten gebolzt werden. Die Höhe des Fahrtisches ist zwischen 76 und 91 cm einstellbar. Die Hauptregale haben eine Fläche von 107 × 61 cm bei einem Abstand von 46 cm. Der Fahrtisch hat hochbelastbare, auf Kugellagern schwenkbare Flexello-Laufrollen für höchste Manövrierfähigkeit. Der Tisch ist in grauem Hammerschlaglack ausgeführt, die Handgriffe und Halteschienen verchromt, der Laufrollenzusammenbau kadmiert.

Zur grösstmöglichen Ausnutzung gibt es noch viele Zusatzeinrichtungen zur Grundausführung des Fahrtisches TM2, wie z.B. zwei Seitenklappen von 38 × 61 cm Fläche; ein Gestell für Handbücher; zwei zusätzliche obere Regale von 99 × 20 cm Fläche mit verstellbarer Höhe, die an das obere oder untere Hauptregal angebaut werden können; zwei zusammenlegbare Halteschienen für elektrische Testschnüre und zum Anklammern von Zeichnungen; einen asbestisolierten Halter für Löteisen unter dem oberen Zusatzregal. Für die Stromversorgung hat der Fahrtisch einen Lexor-Verteilerkasten mit Netzschalter und Glimmlampe sowie fünf dreipolige Steckdosen für 5 A oder 13 A und 9 m dreiadriges Kabel. Zwei der Laufrollen sind mit Bremsen ausgerüstet. Der Spezial-Fahrtisch TM2SE ist mit allen oben genannten Zusätzen ausgestattet.

Der komplette Fahrtisch wiegt ungefähr 102 kg und hat eine Tragfähigkeit von rund 365 kg.

EE 65 752 *für weitere Einzelheiten*

Ratemeter

Research Electronics Ltd, Bradford Road, Cleckheaton, Yorkshire

(Abbildung Seite 50)

Ein vielseitiger Grosssbereich-Zählgeschwindigkeitsmesser für Industrie und Kerntechnik wurde von Research Electronics Ltd angekündigt. Das Ratemeter 9031 hat Anwendungsmöglichkeiten als Zusatz zu Untersetzern, wenn die momentane Zählgeschwindigkeit direkt auf einem Messgerät angezeigt werden soll. Es ist für Verwendung mit allen Strahlungsmessgeräten, einschliesslich Geiger-, Szintillations- und Proportionalzählern sowie elektromechanischen und fotoelektrischen Messwertgebern und Messköpfen im Maschinenbau, z.B. zum Messen von Umdrehungsgeschwindigkeiten, geeignet.

Das Gerät überstreicht mit neun drucktastengewählten Bereichen den grossen Messumfang von 3 Imp/s Vollausschlag im niedrigsten Bereich bis zu 30 000 Imp/s im höchsten mit einem entsprechenden Bereich integrierender Zeitkonstanten von 125 s.... 0,2 s.

Stromversorgungen für Zubehör sowie eine Hochspannungsversorgung für die Polarisation von Geiger-Röhren und gewissen Fotozellentypen sind eingebaut. Das Gerät kann als in sich geschlossenes kerntechnisches Zählgerät eingesetzt werden und ist wegen seines eingebauten Lautsprechers besonders für Verwendung als Versuchswarngerät sowie zur laufenden Tonüberwachung des Laborniveaus geeignet.

Buchsen für Impuls- und Analogausgänge zum Anschluss externer Mess- oder Registriergeräte sind vorhanden.

EE 65 753 *für weitere Einzelheiten*

Schallpegelanzeiger

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

(Abbildung Seite 51)

Dawe Instruments Ltd hat einen neuen Schallpegelanzeiger 1048E entwickelt, um den wachsenden Bedarf an Geräten zur Bestimmung des Lärmspiegels zu decken. Es ist ein volltransistorisiertes Gerät in Taschengrösse, das für schnelle Lärmkontrollen und Lärmspiegelbestim-

mungen, die ein einfaches, robustes und doch genaues Instrument ohne die Ein- und Ausgangseinrichtungen eines Schallpegelmessers erfordern, gedacht ist.

Das neue Gerät besteht aus einem Tauchspulmikrofon in Kunststoffgehäuse, einem leistungsfähigen Verstärker, Bewertungsnetzwerken, Abschwächern und einem Anzeigeinstrument. Die Bewertungsnetzwerke entsprechen den Vorschriften der IEC-Veröffentlichung 123 und der britischen Norm BS 3489 : 1962.

Der Abschwächer ermöglicht die Bestimmung von Schallpegeln zwischen 40 und 120 dB (auf einen Standard-Schalldruckpegel von 0,0002 Dyn/cm²) in sechs überlappenden Bereichen. Der Verstärker hat im Temperaturbereich 0 ... 45° C konstante Verstärkung und wird durch Schwankungen in Transistorparametern und Versorgungsspannung praktisch nicht beeinflusst. Speisung erfolgt aus einer 9-V-Trockenbatterie (Ever Ready PP4 oder entsprechender Typ), die für 70 Betriebsstunden ausreicht.

Aus der senkrechten Montage der Bauelemente auf der Leiterplatte ergibt sich eine äusserst kompakte Konstruktion mit Aussenabmessungen von nur 152,4 × 76,2 × 57,2 mm bei einem Gewicht von rund 400 g einschliesslich Batterie.

Das Instrument sollte für die Bestimmung des Lärmspiegels in Werkstätten und Büros, Kontrolle von Verkehrslärm und schnelle Qualitätsprüfungen an Fertigungsstrassen durch Vergleich von Schallpegeln weitgehende Verwendung finden.

EE 65 754 *für weitere Einzelheiten*

Transistor-Voltmeter

Furzehill Laboratories Ltd, Theobald Street, Borehamwood, Hertfordshire

(Abbildung Seite 51)

Im Rahmen eines neuen Programmes für Festkörpergeräte führt Furzehill Laboratories Ltd ein neues, empfindliches Voltmeter mit gedruckter Schaltung und voller Halbleitertechnik ein, das in einem Frequenzbereich von 10 Hz ... 10 MHz einen Messumfang von 10 µV ... 300 V hat.

In der Grundform hat das Gerät Netzanschluss, gegen Aufschlag kann jedoch eine aufladbare Zelle eingebaut werden, was im Aussendienst und Labor nützlich ist, da Brummen und Erdschleifenprobleme dann nicht auftreten können.

Ein lineares Messgerät ist von 0 ... 3,5 und 0 ... 10 geeicht und gibt im empfindlichsten Bereich Vollausschlag bei 1 mV, im höchsten Bereich bei 300 V. Weitgehende Gegenkopplung ergibt für den grössten Teil des Frequenzbereiches eine Messgenauigkeit von besser als 2%. Das Messgerät ist auch in Dezibel bezogen auf 1 mW an 600Ω geeicht. Der Eingangswiderstand ist 3 MΩ mit 25 pF Parallelkapazität. Als Sonderzubehör ist ein Messkopf mit niedriger Kapazität (3 MΩ, 5 pF) lieferbar.

EE 65 755 *für weitere Einzelheiten*

Tragbares Frequenznormal

Advance Components Ltd, Roebuck Road, Hainault, Ilford, Essex

(Abbildung Seite 51)

Das Frequenznormal OFS1 ist mit dem 200-kHz-Träger des BBC-Senders Droitwich für das "Leichte Programm" phasenstarr und hat daher eine Langzeitgenauigkeit, die besser als 5×10^{-9} ist.

Das Modell OFS1 kann vom Netz oder Batterien betrieben werden und gibt Rechteckwellen bei 100 kHz und 1 MHz ab. Die Kurzzeitgenauigkeit ist für jede beliebige Periode bis zu 5 Sekunden besser als 3×10^{-8} und für jede Periode von 5...50 Sekunden besser als 1×10^{-8}.

Die Empfindlichkeit reicht in fast allen Teilen Englands für Betrieb mit eingebauter Antenne aus.

EE 65 756 *für weitere Einzelheiten*

Oszillograf

Vertrieb: Research & Control Instruments Ltd, Instrument House, 207 King's Cross Road, London, W.C.1

(Abbildung Seite 51)

Das neuste Modell im Philips-Programm für Oszillografen ist die Type GM5605, ein kompaktes X-Y-Gerät mit 76-mm-Schirm. Es wird für umfangreiche Anwendungsmöglichkeiten mit besonderer Eignung für Service und Schulung angeboten.

Die X- und Y-Verstärker sind identisch, und die Beziehung zwischen zwei unabhängigen Veränderlichen kann genau dargestellt werden. So können z.B. Frequenz- und Phasenbeziehungen ohne Schwierigkeiten festgestellt werden.

Beide Verstärker haben einen Frequenzbereich von 0...200 kHz, und die Phasendifferenz zwischen ihren Ausgängen ist niedriger als 3°. Das Raster des Schirmes der Elektronenstrahlröhre hat ein Grundmass von 6 mm, die Empfindlichkeit der beiden Verstärker ist dieselbe, so dass sich eine vertikale Gesamtempfindlichkeit von 10 mV und eine horizontale von 30 mV je Unterteilung ergibt. Beide Ablenkungen können 3fach gedehnt werden.

Die Empfindlichkeit jeder Achse kann durch Stufenteiler und kontinuierlichen Verstärkungsregler auf 30 V je Unterteilung reduziert werden. Die Eichgenauigkeit des Stufenteilers ist +3 %.

Das Modell GM5605 kann nicht nur als X-Y-Gerät, sondern auch als herkömmlicher Oszillograf benutzt werden. Die Durchlaufgeschwindigkeit der eingebauten Zeitablenkung ist zwischen 0,02 und 100 ms per Skalenteilung regelbar. Triggerung erfolgt intern oder extern, die Triggerspannung ist einstellbar.

Das Gerät kann mit jeder üblichen Netzspannung betrieben werden. Bei Abmessungen von 254 × 165 × 345 mm wiegt es 10 kg.

EE 65 757 *für weitere Einzelheiten*

Testpunkt-Klinke

Sealectro Corporation, Hersham Trading Estate, Walton-on-Thames, Surrey

(Abbildung Seite 51)

SKT-0807 ist eine neue "Pressitz"-Teflon-Testpunktklinke, die mit einem Metallchassis und einer gedruckten Schaltung benutzt werden kann. Die Klinke wird nach dem Standard-"Pressitz"-Verfahren in das Chassis eingesetzt und somit vom Chassis isoliert. Der Berylliumkupferkontakt (1,27 mm Durchmesser) reicht durch den Teflonkörper hindurch und greift in eine Buchse der gedruckten Schaltung ein. Der Kontakt in der SKT-0807 passt mit einer Sonde von 2 mm Durchmesser und 7,1 mm Länge zusammen. Wie alle anderen Sealectro "Pressitz"-Teflon-Testpunktklinken kann auch diese in allen EIA-Standardfarben zur Farbkennzeichnung von Chassis-Testpunkten geliefert werden.

EE 65 758 *für weitere Einzelheiten*

Induktive Nahwirkungsschalter

Intersonde Ltd, The Forum, High Street, Edgware, Middlesex

(Abbildung Seite 52)

Die Aufnahme der Fertigung von zwei neuen induktiven Nahwirkungsschaltern wird von Intersonde Ltd bekanntgegeben. Die als Typen QD19 und QD20 bezeichneten Schalter können als einfaches und preiswertes Mittel zur Entdeckung vorhandener eisen- und nichteisenhaltiger Metallobjekte, einschliesslich dünner Folien, eingesetzt werden.

Beide Schaltertypen sind durchweg mit Silizium-Halbleitern bestückt und können in einem Betriebstemperaturbereich von 0...+60° einen Ausgangsstrom von 120 mA abgeben. Die Schalter sind in sich geschlossen, 140 mm lang und haben 27 mm Durchmesser. Sie können mit 12 oder 24 V Gleichstrom betrieben werden. Alle Bauelemente der Schalter sind in Epoxydharz vergossen, und die Leistung wird durch Vibration, Staub oder Feuchtigkeit nicht beeinflusst. Beide Bausteine werden mit 1,80 m Zuleitung geliefert, die bei Typ QD20 mit biegsamem Schutzrohr umgeben ist.

Obgleich die Schalter in erster Linie für die industrielle Vorwahlzählung von Partien bestimmt sind, können sie in vielen Fällen anstelle der herkömmlichen Endschalter an Werkzeugmaschinen, Förderanlagen, Fahrstühlen und im allgemeinen überall dort Verwendung finden, wo der Schalter ohne Berührung betätigt werden muss.

EE 65 759 *für weitere Einzelheiten*

Zählgerät-Umsetzer

Marconi Instruments Ltd, St. Albans, Hertfordshire

(Abbildung Seite 52)

Marconi Instruments Ltd stellt einen neuen Umsetzer vor, der den Bereich der

Marconi-Zähler der Serie TF1417 auf 510 MHz erweitert.

Die neue Ausrüstung besteht aus zwei Geräten. Das Grundgerät TF2400 erweitert den Frequenzmessbereich auf 110 MHz. Der Eingangsbereich ist 20 kHz...110,5 MHz mit einer Eingangsempfindlichkeit von 10 mV_{eff}. Signale im Bereich 20 kHz...10,5 MHz werden verstärkt und damit die Empfindlichkeit des Zählers erhöht. Für Signale über 10 MHz wird die Überlagerungstechnik benutzt, in der das zu messende Signal mit einer Harmonischen von 10 MHz gemischt wird, so dass die sich ergebende Differenzfrequenz unter 10 MHz liegt und vom Zähler gemessen werden kann.

Trotzdem das Gerät hauptsächlich für Breitbandeinsatz ausgelegt ist, kann es auch auf Eingangssignale abgestimmt werden, und korrektes Einstellen wird durch maximalen Ausschlag eines Messwerkes angezeigt. Das Instrument wird auch benutzt, um festzustellen, ob der Umsetzer einen zum Treiben des Zählgerätes ausreichenden Pegel abgibt. Ausserdem ist ein Wellenmesser eingebaut, mit dessen Hilfe eine ungefähre Anzeige der unbekannten Frequenz abgelesen werden kann.

Der TM7164 überstreicht den Bereich 100...510 MHz für Eingänge bis zu 100 mV herunter. Im Prinzip arbeitet dieses Gerät wie der TF2400, doch wird das Eingangssignal mit einer geeigneten Harmonischen von 100 MHz gemischt.

Der TF2400 wird in einem Gehäuse voller Breite mit einem Leerfeld geliefert, und der Kunde kann den TM7164 ohne Schwierigkeiten selbst einbauen, falls er ihn nachkauft.

Es werden durchweg Halbleiter und gedruckte Schaltungen benutzt. Der TF2400 wiegt 7,25 kg und die beiden Geräte zusammen 8,4 kg. Eine Ausführung für Gestelleinbau kann auch geliefert werden.

EE 65 760 *für weitere Einzelheiten*

Mikrowellen-Milliwattmesser

Griffin & George Ltd, Ealing Road, Alperton, Wembley, Middlesex

(Abbildung Seite 52)

Der Milliwattmesser 15 A wird in Verbindung mit einem Thermistormesskopf zum Messen der Leistung in Hohlleitern und Koaxialleitungen eingesetzt.

In vielen Fällen wird ein vorhandener Labormesskopf genügen, vorausgesetzt dass er den für das Modell 15 A korrekten Thermistorwiderstand von 200 Ω hat.

Der Thermistor ist in den Gegenkopplungszweig eines Wien-Brückenoszillators mit niedrigem Klirrfaktor geschaltet.

Bei Speisung von HF-Leistung in den Thermistor wird die aufgenommene Menge von dem Messinstrument angezeigt.

Das direktanzeigende Instrument ist äusserst einfach zu bedienen und hat nach einer Einlaufzeit von wenigen Minuten eine hohe Nullkonstanz. Eine eingebaute Eichkontrolle erlaubt, die korrekte Arbeitsweise augenblicklich nachzuprüfen.

Die Messunsicherheit des Gerätes ist ±4 % und der Messbereich 0...2,5 mW Vollausschlag. Der Frequenzbereich wird durch den Thermistormesskopf bestimmt.

EE 65 761 *für weitere Einzelheiten*

Dekadischer Einschubbaustein

Panax Equipmeot Ltd, Holmethorpe Industrial Estate, Redhill, Surrey

(Abbildung Seite 52)

Der Fertigungsanlauf eines preisgünstigen dekadischen Einschubbausteins für Einbau in elektronische Zählgeräte für Industrie, Labors und Unterricht wird von Panax Ltd bekanntgegeben. Der in zwei Ausführungen hergestellte Baustein ist mit dem in den kerntechnischen Zählgeräten der Serie Panax SA-102 verwendeten identisch und benutzt gedruckte Schaltungen hoher Güte sowie zuverlässige Bauelemente.

Type TD.1 hat Zählraten bis zu 5000 Impulsen je Sekunde und ein Auflösungsvermögen von 200 μs. Der andere Baustein, Type TD.2, hat eine Höchstzählrate von 50 000 Impulsen je Sekunde und ein Auflösungsvermögen von 20 μs. Als Dekadenzählrohr werden die Mullard-Typen Z504S bzw. Z505S verwendet.

Beide Typen erfordern eine 12-V-Stromquelle und Eingangsimpulse von +12 V Amplitude. Die Gesamtabmessungen sind 140 mm lang, 66,7 mm hoch und 44,5 mm breit.

EE 65 762 *für weitere Einzelheiten*

Normalfrequenzempfänger

The Wayne Kerr Laboratories Ltd, Coombe Road, New Malden, Surrey

(Abbildung Seite 53)

Wayne Kerr Ltd kündigt einen volltransistorisierten Überlagerungsempfänger für den Empfang aller internationalen Normalfrequenzausstrahlungen an. Die Empfindlichkeit dieses als Wayne-Kerr-Gertsch RHF-1 vorgestellten Modells ist so hoch, dass Empfang dieser Normalfrequenzsendung überall in der Welt möglich ist.

Auf Grund seines ungewöhnlich guten Empfanges ist das Modell RHF-1 zum Nachprüfen der Oszillatoreichung und von Frequenznormalen mit einer Genauigkeit von bis zu 1×10^{-7} geeignet. Seine Anwendungsmöglichkeiten sind sehr umfassend, unter anderem für Präzisionszeitmessungen, Empfang von Normaltonfrequenzen und Pulszahlmodulation. Bei Anschluss eines Oszillografen an die rückseitigen Ausgangsklemmen können Schwebungsfrequenzen beobachtet werden.

Als Stromquelle können entweder 115/230 V~ oder eine 12-V-Batterie verwendet werden. Betriebsfrequenzen sind üblicherweise 2,5, 5, 10, 15, 20 und 25 MHz; es können jedoch noch weitere drei Frequenzen zwischen 2,5 und 25 MHz vorgesehen werden. Die nutzbare Empfindlichkeit ist 1 μV, und das Verhältnis Signal + Rauschen zu Rauschen ist bei 3 μV Eingang besser als 10 dB.

Der Empfänger ist als Tischmodell 190,5 mm breit, 89 mm hoch und 330 mm tief konstruiert, kann aber ohne weiteres für Einbau in ein Standard-Halbgestell modifiziert werden.

EE 65 763 *für weitere Einzelheiten*

Klemmringknopf

The Plessey Co. (U.K.) Ltd, Titchfield, Hampshire

(Abbildung Seite 53)

Die Plessey Company (UK) Ltd hat eine neue Auswahl von Miniatur-Klemmringknöpfen entwickelt, um den Anforderungen des Pflichtenblattes DEF 5221 zu entsprechen. Ein Konstruktionsmerkmal ist, dass derselbe Phenolharz-Pressling mit wahlweisen Klemmringen für Wellendurchmesser von ¼" (3,2 mm) und 3/16" (4,8 mm) ausgerüstet werden kann.

Für die Knopfmontage sind eine Radialnute und ein Schlitz im Wellenende erforderlich. Beim Anziehen der Schraube wird der Ring zusammengeklemmt und greift in die Nute ein, wodurch Abziehen des Knopfes von der Welle verhindert wird. Der Antrieb erfolgt jedoch über eine Feder, die in das geschlitzte Wellenende eingreift.

EE 65 764 *für weitere Einzelheiten*

Instrument-Elektronenstrahlröhre

English Electric Valve Co. Ltd, Chelmsford, Essex

(Abbildung Seite 53)

English Electric Valve Co Ltd hat eine neue 127-mm-Elektronenstrahlröhre für Verwendung in Breitbandoszillografen für schnellablaufende Vorgänge entwickelt.

Besondere Eigenschaften dieser Röhre sind:

(1) Ablenkfaktoren in Y- und X-Richtung von 3 V/cm bzw. 9 V/cm.

(2) Ausgezeichnete Helligkeit erlaubt hohe Schreibgeschwindigkeiten.

(3) Gute Auflösung durch kleine Punktgrösse (typische Linienbreite 0,4 mm).

Diese Eigenschaften werden durch eine Nachbeschleunigungs - Maschenelektrode in einigen Millimetern Abstand vom Leuchtschirm sowie eine verbesserte Strahlsystemkonstruktion erzielt.

Da der Abstand zwischen Maschen und Schirm, durch den der Strahl beschleunigt wird, sehr kurz ist, treten nur sehr geringe Rasterverzerrungen auf; eine im Verhältnis zum Maschenabstand grosse X-Platte gibt einen besseren X-Ablenkfaktor.

Diese Position der Maschenelektrode bringt als weiteren Vorteil eine verbesserte Konstanz der X- und Y-Ablenkfaktoren bei Temperaturänderungen mit sich.

Die Röhre eignet sich durch ihre Ablenkfaktoren besonders für mit Transistoren bestückte Ablenkschaltungen.

Die Röhre ist mit zwei Leuchtschirmen lieferbar: T948H—blaugrünes Nachleuchten (Leuchtstoff P31 gleichwertig) und T948N—gelbgrünes Nachleuchten (Leuchtstoff P2 gleichwertig). Beide Ausführungen haben mittelkurze Nachleuchtdauer.

EE 65 765 *für weitere Einzelheiten*

Wellenformgenerator

Servo Consultants Ltd, 162-6 Kensal Road, London, W.10

(Abbildung Seite 53)

Das Gerät erzeugt jede beliebige periodische Spannungswellenform. Die Spannungswellenform wird mittels Wellenform-Musterscheiben erzeugt, von denen einige mit jedem Gerät geliefert werden. Ausserdem kann die Spannungswellenform von einem Muster erzeugt werden, das der Benutzer ohne Spezialwerkzeuge oder -apparate selbst leicht herstellen kann. Zu jedem Gerät gehört ein Karton mit 100 besonders bedruckten Scheiben, die gross genug sind, um Muster mit 0,3 % Genauigkeit herzustellen, ohne dass der Laborant besondere Anweisungen oder Fachkenntnisse braucht.

Die Muster werden einfach auf die mit Rastermarkierungen überdruckten Scheiben aufgetragen. Das gewünschte Muster wird dann mit einer normalen Schere ausgeschnitten. Da die Musterscheiben bei Verwendung im Gerät keiner Abnutzung unterliegen, können sie immer wieder benutzt und dann für weitere Verwendung aufbewahrt werden. Es ist daher möglich, eine Mustersammlung aufzubauen, die immer für Gebrauch zur Verfügung steht. Die niedrigen Kosten der mit Raster bedruckten Scheiben erlauben Versuche mit den verschiedensten Wellenformen. Weitere Scheiben zur Selbstherstellung von Mustern können von Servo Consultants Ltd preisgünstig bezogen werden.

Das vom Gerät abgegebene Signal hat eine beträchtliche Spannungsamplitude. Ausserdem ist der Ausgang relativ niederohmig, und dem Gerät können verhältnismässig hohe Ströme entnommen werden. Das Gerät kann daher direkt in einen Analogrechner mit Eingangspegeln von ± 50 V speisen. Ausserdem können Verfahrensregler gesteuert werden, die ein Stromsignal von ungefähr 50 mA Höchstamplitude benötigen. In vielen Fällen wird das Muster die Form von 'Ein'- und 'Aus'-Zuständen und nicht von Spannungspegeländerungen darstellen. Normale signalbetätigte Relais können unabhängig davon, ob sie für 6, 12, 24 oder 50 V ausgelegt sind, an den Ausgang des Gerätes angeschlossen werden. Da das gewünschte Muster ohne irgendwelche bewegliche Kontakte erzeugt wird, kann das Gerät zur Untersuchung der ermüdungsfreien Lebensdauer von Maschinen, die komplexes Programmieren erfordern, eingesetzt werden.

Das Gerät hat zwei Frequenzbereiche, die 0,2...50 Hz und 0,002...0,5 Hz überstreichen.

EE 65 766 *für weitere Einzelheiten*

Optischer Drehgeber

Digital Measurements Ltd, 25 Salisbury Grove, Mychett, Aldershot, Hampshire

(Abbildung Seite 53)

Digital Measurements Ltd hat in Verbindung mit Winston Electronics Ltd die Fertigung einer verbesserten Ausführung ihres optischen Drehgebers mit hoher Apflösung aufgenommen.

Diese neue Ausführung wurde entwickelt, um den rigorosen Anforderungen der militärischen Ausrüstungen gerecht zu werden; sie kann auch unter den ungünstigsten Umgebungsbedingungen zuverlässiges Arbeiten gewährleisten. Unter den Änderungen sind zu nennen: eine erhöhte Höchstanzeigerate von 6100 je Sekunde, höhere Signalabgabe und wahlweise hermetische Abdichtung.

Signale des Standardgebers werden im Gray-Binärkode abgegeben, aber gegen Sonderauftrag können andere Verschlüsselungen geliefert werden. Für jede Umdrehung der Welle gibt der Drehgeber 2^{13} Impulse ab, was der hohen Winkelauflösung von 2 Minuten 38 Sekunden entspricht; die volle Anzeigeauflösung kann bis zu Geschwindigkeiten von 45 RPM aufrechterhalten werden.

Der Winston-DM-Drehgeber hat nur einen beweglichen Teil und arbeitet ohne Getriebe, Bürsten oder Kontakte. Spiel ist ausgemerzt und Trägheits-, Dreh- und Reibungsmomente sowie Verschleiss auf ein absolutes Minimum reduziert. Die beiden einzigen Lager sind als Präzisionskugellager ausgeführt, abgedichtet und für Dauerschmierung mit Silikonöl gefüllt. Der Drehgeber ist in einem kleinen Gehäuse mit NATO-Anbauflansch Grösse 23 untergebracht und wiegt 595 g.

Der optische Drehgeber hat eine grosse Anzahl von Verwendungsmöglichkeiten als digitales Positions-Rückführungselement in vielen Servosystemen, in der Werkzeugmaschinensteuerung, in der Umdrehungsüberwachung von Radarantennen, stabilisierten Plattformen, Waffensystemen, usw.

EE 65 767 *für weitere Einzelheiten*

Tragbarer Oszillator

Standard Telephones & Cables Ltd, Connaught House, 63 Aldwych, W.C.2

(Abbildung Seite 54)

Modell 74306-A ist ein tragbarer transistorisierter Mehrzweckoszillator, der den Frequenzbereich 10 kHz...20 MHz überstreicht und über einen grossen Ausgangspegelbereich Signale an 75-Ω-Schaltungen abgibt.

Das Gerät ist in Druckschaltungstechnik ausgeführt, und die Bauelemente sind in einem Leichtmetallgehäuse mit Traggriff und abnehmbarem Deckel untergebracht. Die Stromversorgung erfolgt durch Trockenelemente im Gehäuse, jedoch können auf Wunsch auch externe Gleichstromquellen benutzt werden. Die Batterien werden durch einen Sicherheitsschalter bei Auflegen des Deckels abgeschaltet, und der Ein-Ausschalter betätigt automatisch eine Warnanzeige, die angibt, ob der Strom eingeschaltet ist.

Der Frequenzbereich 10 kHz...20 MHz wird in acht Teilbereichen überstrichen. Die sechs niedrigsten benutzen dieselbe Transistor-Oszillatorstufe, die beiden höchsten haben dagegen getrennte Stufen, um HF-Umschalten zu vermeiden. Die Oszillatorstufen sind alle in Hartley-Schaltung ausgeführt und benutzen einen Thermistor zur Konstanthaltung der Ausgangsspannung.

Der Oszillatorausgang wird einem Verstärker zugeführt, der zusammen mit einer niederohmigen Endstufe Frequenzänderungen mit schwankender Belastung verhindert. Der niederohmige Ausgang wird durch Verwendung eines Emitterfolgers erreicht und der Ausgangspegel an diesem Punkt mittels einer quasispitzenanzeigenden Messschaltung überwacht. Zwei Ausgänge sind vorhanden, und zwar ein direkt vom Überwachungspunkt gespeister und einer, der über einen Abschwächer von 0...50 dB gespeist wird.

Für die Regelung der Verstärkung über einen kleinen Bereich ist ein Bedienelement vorgesehen. Zusammen mit dem Abschwächer, der in 1-dB-Stufen regelbar ist, ermöglicht die Verstärkungsregelung Einstellung jedes beliebigen Ausgangspegels über einen Bereich von 50 dB. Der Pegel wird unter Bezugnahme auf die Abschwächereinstellung und die in $+1{,}0$, $+0{,}5$, 0, $-0{,}5$ und $-1{,}0$ dB geeichte Messgerätanzeige bestimmt.

Einrichtungen zum Kontrollieren der Speisespannung (entweder intern oder extern) mit dem Messinstrument sind vorhanden.

EE 65 768 *für weitere Einzelheiten*

Transistor-Tester

Grundy & Partners Ltd, 3 The Causeway, Teddington, Middlesex

(Abbildung Seite 54)

Dieser Tester wurde für Einsatz zusammen mit einem Mehrbereich-Messgerät mit Grundmesswerk für 1 mA oder besser, vorzugsweise mit eingebautem Überlastungsschutz, ausgelegt.

Bei Transistoren können unter anderem der Kollektor-Emitterstrom I_{co}, und der Kollektor-Basisreststrom I_{co} mit einer Spannung von 4,5 V gemessen werden.

Dioden können in Durchlassrichtung mit einem vom Durchlasswiderstand abhängigen Strom von bis zu 10 mA gemessen werden. Der Sperrstrom wird bei einer Spannung von 9 V geprüft.

Messen der Stromverstärkung (β) gibt für Transistoren von bis zu 800 mW Verlustleistung zweckdienliche Resultate

und für höhere Leistungen eine annehmbare Anzeige.

Vier umschaltbare Basis-Eingangsströme von 10, 50, 100 und 500 μA sind vorhanden. Die Kollektorspannung liegt bei 4,5 V fest.

Auf Wunsch können Anschlussklemmen zweifach vorgesehen werden, so dass es möglich ist, zwei ähnliche Transistoren oder Dioden schnell und unter denselben Bedingungen miteinander zu vergleichen oder zu paaren.

Die interne Batterie kann unter Last geprüft werden, was Fehler durch Versagen der Batterie vermeidet.

EE 65 769 *für weitere Einzelheiten*

Spitzenspannungs-Aussteuerungsmesser

Livingstone Control Ltd, Retcar Street, London, N.19

(Abbildung Seite 54)

Der von Livingstone Control Ltd entsprechend einer BBC-Entwicklung hergestellte Spitzenspannungs-Aussteuerungsmesser LC.201 wird zum Messen und Anzeigen des Programmvolumens benutzt und ermöglicht bessere Kontrolle von Aussenreportagen, den in die Studiokonsole gespeisten Aufnahmen, den Ausgangs-Echokanälen und anderen Situationen, in denen ein Aussteuerungsmesser in der Kette benutzt wird.

Im Grunde genommen misst der Standard - Spitzenspannungs - Aussteuerungsmesser das Programm in enger Übereinstimmung mit der von der BBC seit langem eingeführten Praxis, d.h. das Programm wird nach Vollweggleichrichtung an eine kapazitive Last mit einer Ladezeitkonstanten von 2,5 ms und einer Entladezeitkonstanten von 1 s gelegt. Die entstehenden schnell ansteigenden und langsam abfallenden Impulse werden verstärkt und auf einem Drehspulinstrument angezeigt.

Der Frequenzgang des Gerätes ist 0,25 dB über einen Frequenzbereich von 40 Hz...15 kHz, und—wie auf dem Foto ersichtlich—ist die Skala zum leichteren Ablesen gleichmässig unterteilt.

Ein Merkmal des Gerätes ist die Möglichkeit, das Instrument schnell nachzuregeln, und zwar an drei Punkten mit gutem Abstand voneinander, so dass für die Zwischenposition kaum ein Fehler auftreten kann. Kompensation gewährleistet Messgenauigkeit bei Netz- und Temperaturschwankungen.

Das Gerät besteht aus drei Teilen, dem Spitzenspannungs-Aussteuerungsmesserbaustein, dem Konstantstromversorgungsbaustein und dem Anzeigebaustein und ist im Gehäuse oder für Gestelleinbau lieferbar. Im letzteren Falle wird angenommen, dass das Anzeigemessgerät in der Kontrollkonsole installiert wird und der Rest des Gerätes im Gestell, das in jeder beliebigen Position stehen kann.

EE 65 770 *für weitere Einzelheiten*

Elektrometer

Electronic Instruments Ltd, Richmond, Surrey

(Abbildung Seite 54)

Electronic Instruments Ltd hat jetzt ein verbessertes Mehrzweck-Schwingkondensator-Elektrometer mit der bekannten Vibron-Einheit herausgebracht. Das Modell 33B-2 stützt sich auf ein früheres Modell, das in der ganzen Welt weitgehende Verwendung fand. Die Bereiche überstreichen von 0...10 mV bis zu 0...1000 mV mit einem Eingangswiderstand von über 10^{14} Ω im 1000-mV-Bereich. Unter den neuen Merkmalen sind eine Gegenspannung mit einem Bereich von ±1300 mV und Eingangsbauelemente in Einstecktechnik zu nennen. Die Driftrate ist sehr niedrig (weniger als 0,1 mV in zwölf Stunden). Strom- und Spannungsmesszubehör zum Messen von Strom bis zu 10^{-12} A Vollausschlag herunter und Widerstand bis zu 10^{16} Ω, auch pH-Zubehör, das anscheinend das empfindlichste und genauste bisher erhältliche ist und eine Genauigkeit und Unterscheidung von ±0,002 pH bei einem Skalenendwert von 0,1 pH hat, kann geliefert werden.

EE 65 771 *für weitere Einzelheiten*

Abschwächerstecker

Associated Electrical Industries Ltd. 51-53 Hatton Garden, London, E.C.1

(Abbildung Seite 55)

Ein von der Telecommunications Division der Associated Electrical Industries Ltd eingeführter neuer, koaxialer Abschwächerstecker vereinfacht das Abschwächen des Signalpegels zwischen zwei elektronischen Geräten auf jeden gewünschten Wert ohne Änderung der internen Schaltungen. Der von der Abteilung Radiobauelemente entwickelte Stecker ist so ausgelegt, dass ein für 1/8 W bemessener Widerstand, dessen Wert vom Verwendungszweck abhängt, in den Steckerkörper eingelötet werden kann.

Der aus galvanisch verzinntem Messing hergestellte Stecker mit Innenleiter aus vernickeltem Messing ist in Standardform und zur Aufnahme von Koaxialkabel bis zu 4,7 mm Aussendurchmesser ausgelegt. Der Anschluss ist einfach: das Kabel wird durch eine Gewindekappe geführt, die es am Steckerkörper festklemmt; die internen Verbindungen sind also mechanisch belastungsfrei. Der Innenleiter des Kabels wird dann in eine Öse in einer getrennten Nylon-Verankerungsbuchse eingelötet, und zwar gleichzeitig mit dem erforderlichen Widerstand. Der Stecker wird dann wieder so zusammengebaut, dass der andere Anschlussdraht des Widerstandes den Steckerstift durchdringt. Der Überschuss wird nach Einlöten abgeschnitten.

Der neue Stecker ist für Verwendung mit der bereits vorhandenen Auswahl der von AEI geführten Ein- und Mehrfach-Koaxialbuchsen geeignet und hat einen maximalen Aussendurchmesser von 10,9 mm; im Einsatz steht er ungefähr 38 mm über die Buchse heraus.

EE 65 772 *für weitere Einzelheiten*

Chassisrahmen

Alfred Imhof Ltd, Ashley Works, Cowley Mill Road, Uxbridge, Middlesex

(Abbildung Seite 55)

Die Anpassungsfähigkeit des Imhof-Chassisbaukastensystems wurde durch Aufnahme eines neuen Chassisrahmentypes erhöht, der für die Aufnahme von Leiterplatten ohne Federleiste und Chassis ausgelegt ist. Diese Rahmen sind in zwei Grössen (178 mm und 222 mm hoch, beide 19 Zoll breit und 302 mm tief) lieferbar und durch eine neue Kunststoff-Führung mit Block zur Aufnahme von unvertauschbaren Steckerleisten gekennzeichnet. Das Abnehmen einer beliebigen Federleiste ist ganz einfach; Farbkennzeichnung ist vorgesehen.

Mit diesen Chassisrahmen können zwar viele Bauelemente des Imhof-Chassisbaukastensystems benutzt werden, doch wurde das Sortiment durch neue, besonders für diese Rahmen geeignete Teile erweitert. Beide Rahmen nehmen Chassis und Leiterkarten bis zu 210 mm Tiefe auf, die für das 178-mm-Modell bis zu 138 mm und für das 222-mm-Modell bis zu 180 mm hoch sein können.

EE 65 773 *für weitere Einzelheiten*

HF-Spulen

Vertrieb: Steatite Insulations Ltd. 31 George Street Loyells, Birmingham. 19

Die westdeutsche Firma Stettner & Co hat vor kurzem ihr Fertigungsprogramm durch einige neue Typen hochkonstanter, mit Silberdraht auf Keramikkörper gewickelter Spulen erweitert.

Diese neuen Typen unterscheiden sich von den bisher hergestellten dadurch, dass die Wicklung jetzt aus Silberdraht besteht, der mit Glasur fest auf den Keramikkörper aufgebracht ist. Dadurch wird eine sehr enge und feste Verbindung zwischen Keramikkörper und Wicklung erstellt, die bei Temperaturänderungen zwangsläufig der Ausdehnung und Schrumpfung des Keramikkörpers folgt; sie reagiert daher praktisch genau so wie die "eingebrannte", verstärkte Silberwicklung.

Die neuen Spulentypen haben eine hohe Induktivitätskonstanz. Der Temperaturbeiwert ist ungefähr 15×10^{-6}/°C. Für dieselben Frequenzen haben die Spulen wesentlich bessere Q-Werte, und zwar werden Verbesserungen zwischen 10% und 50% erzielt.

Trotzdem der Silberdraht bei den neuen Spulen völlig in die Glasur eingebettet ist, kann die Wicklung angezapft

werden, da man zum Löten die Glasur vom Draht entfernen kann. Anfang und Ende der Wicklung sind an die glasierten Stifte hartgelötet, und es besteht daher selbst bei mehrfachem Löten der Stifte keine Gefahr, dass die Verbindung unterbrochen wird.

Diese Spulen sind in verschiedenen Ausführungen einschliesslich Typen für gedruckte Schaltungen, als Festinduktivität oder veränderlich mit Karbonyleisen-Schraubkernen lieferbar. Standard-Spulentypen haben 3 ... 20 Windungen und einen Induktivitätsbereich von rund 0,1 μH ... 1,45 μH.

EE 65 774 *für weitere Einzelheiten*

Phasenempfindlicher Gleichrichter

Brookdeal Electronics Ltd, Myron Place, Lewisham, London, S.E.13

(*Abbildung Seite 55*)

Der phasenempfindliche Mehrzweck-Gleichrichter PD 629 kann für HF- und Mikrowellenmessungen sowie Servosysteme oder als Anzeigegerät für Wechselstrombrücken benutzt werden.

Der Frequenzbereich des PD 629 ist 10 Hz ... 100 kHz. Als Bezugseingang sind entweder 2 V_{eff} sinusförmig oder 6 V_{SS}-Rechteckwellen erforderlich; das Eingangssignal kann bis zu 6 V_{SS} haben. Die Eingangsimpedanz beider Kanäle ist 0,5 MΩ. 10 pF. Die Ausgangsgleichspannung ist -1 V $\pm 0{,}5$ V unsymmetrisch oder ± 1 V symmetrisch; der Ausgangswiderstand ist 1 kΩ unsymmetrisch und 2 kΩ symmetrisch. Die Nullpunktdrift ist im symmetrischen Zustand nach 1 Minute 0,25% des Skalenendwertes pro Stunde und nach 1 Stunde 0,05% des Skalenendwertes pro Stunde.

Das Gerät ist für den Arbeitsplatz oder Gestelleinbau geeignet.

EE 65 775 *für weitere Einzelheiten*

Digital-Voltmeter

Gloster Equipment Ltd, Gloucester

Das 'Digimeter' BIE 2123 ist ein dreistelliges Voltmeter für Gleich- und Wechselstrom mit vier Bereichen von 0...0,999 bis zu 0...999 V sowie manueller Polaritäts- und Bereichumschaltung. Für Gleichstrom ist die Messgenauigkeit besser als $\pm 0{,}2$ % der Anzeige oder ± 1 Ziffer, für die Wechselstrombereiche $\pm 0{,}5$ % oder ± 1 Ziffer.

Das Gerät ist für Ausführung einer Messung alle zwei Sekunden sowie mit Drucktastenbetätigung ausgelegt. Der Frequenzgang erlaubt genaue Messungen über den gesamten Tonfrequenzbereich.

Die Eingangsimpedanz für Wechselstrombereiche ist ungefähr 180 kΩ bei 50 Hz und für Gleichstrom in Abhängigkeit vom eingestellten Bereich entweder 1 oder 15 MHz.

EE 65 776 *für weitere Einzelheiten*

Zusammenfassung der wichtigsten Beiträge

Eine neue Einstellung zum ILS-Modulationstiefenvergleich von G. G. Gouriet

Zusammenfassung des Beitrages auf Seite 2-7

Der Beitrag beschreibt ein neues Verfahren zum Messen des Modulationstiefenabstandes (DDM) der zwei von Flugzeugen zum Landebahnanflug benutzten ISL-Funkleitstrahlen. Zuverlässige Messungen von Abstandswerten der Modulationstiefen unter 0,01% sind mit dieser Technik möglich, die damit den durch Entwicklung von Blindlandesystemen entstandenen neuen Anforderungen genügen sollte. Ein im Royal Aircraft Establishment entwickeltes Gerät wird kurz beschrieben.

Berechnen und Messen der VHF- und UHF-Längsstrahlerverstärkung von R. G. Manton

Zusammenfassung des Beitrages auf Seite 8-11

Graphische Verfahren zur Berechnung der Verstärkung von Längsstrahlern aus ihrer Strahlungscharakteristik werden beschrieben. Zwei Antennentypen werden eingehend behandelt, und zwar

(a) ein lineares Richtstrahlfeld von Halbwellendipolen und

(b) ein Feld, das eine zylinderförmig-symmetrische Strahlungscharakteristik hat.

Es wird gezeigt, dass diese Verfahren für typische VHF- und UHF-Empfangsantennen wie Einzel- und Mehrfach-Yagi-Antennen anwendbar ist. Für diesen Zweck wurden besondere Koordinatenpapiere entworfen.

Die Technik der Verstärkungsmessung an Hand eines direkten Vergleiches mit einem Halbwellendipol wird auch beschrieben.

Einsatz eines Synthetisators für periodische Funktionen zur Erzeugung von Signalen sehr niedriger Frequenz und Geräuschen von J. R. James und M. H. N. Potok

Zusammenfassung des Beitrages auf Seite 12-15

Die Anpassungsfähigkeit eines bereits früher beschriebenen Synthetisators für periodische Funktion macht ihn zu einem sehr nützlichen Gerät für das Prüfen von Systemen und Bauelementen mit Signalen sehr niedriger Frequenz und Geräuschen.

Bewertung des Gerätes von diesem Gesichtspunkt aus deutet auf die Entwicklung eines äusserst vielseitigen und kompakten Universaltestgerätes für Servomechanismen und Analogrechner hin.

Verwendungsmöglichkeiten eines torgesteuerten Schalters in Hauptgleichstromkreisen von M. J. Wright

Der torgesteuerte Schalter ist ein steuerbarer Silizium-Gleichrichter, der vom Toranschluss aus ein- und ausgeschaltet werden kann. Dieses Bauelement eignet sich dadurch besonders zum Hochleistungsschalten und -regeln gleichstromerregter Schaltungen.

Eine Ersatzschaltung erläutert die für den Schaltungsentwurf wichtigen Eigenschaften. Als Hauptverwendungsmöglichkeiten werden in Betracht gezogen:

(a) getriggerte und freilaufende Impulsgeber
(b) Gleichstrom-Leistungsverstärker
(c) Gleichspannungsregler
(d) Geschwindigkeitsregelung von Gleichstrommotoren
(e) Spannungsregelung von Maschinengeneratoren

Viele der beschriebenen Hochleistungsschaltungen sind einfacher als die entsprechenden Transistorschaltungen für niedrigere Leistungspegel.

Zusammenfassung des Beitrages auf Seite 16-20

Ein einfaches elektronisches Milliamperemeter von P. Schagen und G. F. Weston

Ein versuchsmässiger Glimmentladungsanzeiger wird beschrieben, in dem die Länge der Glimmentladung eine lineare Funktion des Stroms ist. Die Länge kann mit 5 % Genauigkeit abgelesen werden, und die Röhre kann daher überall dort eingesetzt werden, wo zur Zeit ein anzeigender Strommesser benutzt wird. Parameter, die Skalenendwerte beeinflussen, werden gegeben. Behandlung der Röhre nach Standard-Kathodenzerstäubertechnik gewährleistet gute Anfangs- und Lebensdauereigenschaften.

Zusammenfassung des Beitrages auf Seite 21-23

Gittergesteuerte deuteriumgefüllte Hochspannungsgleichrichter von B. O. Baker und R. J. Wheldon

Der gittergesteuerte deuteriumgefüllte Glühkathodengleichrichter wird mit anderen Glühkathodenentladungsapparaten verglichen; bei Spannungen von 25 kV und mehr werden gewisse Vorteile festgestellt. Die die Konstruktion dieser Gleichrichter bestimmenden Faktoren, wie z.B. elektrostatische Felder, Beschaffenheit und Druck der Gasfüllung, Einfluss der aktivierten Oberflächen, sowie der Wirkungsgrad der Glühkathode, werden besprochen. Durch Verwendung von Deuterium anstelle von Wasserstoff können sowohl für die Erleichterung der Gitterzündung als auch für die Sperrung von Hochspannungen wesentliche Vorteile erzielt werden.

Diese Konstruktionsgrundsätze fanden in der Entwicklung von zwei Gleichrichterröhren Anwendung, die mit E2746 und E2816 bezeichnet werden und für folgende Nennwerte bemessen sind: 25 kV, 350 mA (Mittelwert) bzw. 40 kV, 3,5 A (Mittelwert).

Diese Röhren ermöglichen die Konstruktion sehr kompakter sowie robuster und wirtschaftlicher Hochspannungsstromversorgungen. Bei Benutzung von "Mehrfachgehäuse"-Strukturen können die Grundsätze auf höhere Spannungen, bei Verwendung von Elektrodenkühlung auf höhere Ströme ausgedehnt werden.

Zusammenfassung des Beitrages auf Seite 24-29

Patientenkontrolle in Polikliniken von J. A. Reynolds

Das Gerät zählt automatisch die einen Raum betretenden oder verlassenden Personen. Die zu jedem beliebigen Zeitpunkt im Raum Anwesenden werden registriert und das Ergebnis ziffernmässig auf "Digitron"-Anzeigern dargestellt. Eine der Zählung proportionale Spannung ist für Anschluss eines Streifenschreibers für kontinuierliche Aufzeichnung vorhanden. Auf Grund der Analyse dieser Protokolle können Anmeldungen mit der geringsten Wartezeit geplant werden.

Zusammenfassung des Beitrages auf Seite 30-33

Ein Binärzahlengeber von J. D. E. Beynon und K. G. Nichols

Dieses Gerät erzeugt eine achtstellige Binärzahl in Serienform. Jede Stelle der Zahl, die nicht Null ist, besteht aus einem negativgehenden Impuls von 9 V_{max} Amplitude und einer Dauer von 1 Mikrosekunde bis zu einem Maximum, das durch einen zusätzlichen Impulsgeber in normaler Laborausführung begrenzt wird, der auch die Stellendauer bestimmt. Die Ziffern der gewünschten Zahl können mit Hilfe von acht Zweistellungsschaltern eingestellt werden. Die Zahl kann einmal—durch manuelle Steuerung oder Eingangstriggersignal—oder wiederholt—durch eine Folge von Eingangstriggersignalen—erzeugt werden.

Zusammenfassung des Beitrages auf Seite 34-38

Ein EKG-Registriergerät für aktive Objekte von H. Hirschberg

Ein mit einem Miniatur-Magnetbandgerät als Kernstück aufgebautes System für die Aufzeichnung von Elektrokardiogrammen aktiver Objekte wird beschrieben. Einsatz eines Magnetbandgerätes als Messwerterfassungselement überkommt die Nachteile der Funktelemetrie. Bei Benutzung von Pulsfrequenzmodulation ergibt sich ein einfaches und trotzdem genaues System.

Zusammenfassung des Beitrages auf Seite 38-39

Ultrakonstante Halbleiter-Bezugsdioden von R. H. Murphy

Fortschritte in der Herstellung von Silizium-Bezugsdioden und ihrer Behandlung zur Erzielung von Ultrastabilität und hoher Zuverlässigkeit werden besprochen. Wie weit diese Halbleiterelemente den an ein Präzisionsspannungsnormal gestellten Anforderungen an niedrige Spannungsdrift und Temperaturbeiwerte genügen, wird daraufhin unter Berücksichtigung der Vorkonditionierungsverfahren, Lebensdauerprüfungsmethoden und Messunsicherheit untersucht. Abschliessend werden Unterlagen für die Lebensgeschichte der einzelnen Dioden während ausgedehnten Prüfungen beigebracht und damit eine Technologie unter Beweis gestellt, die langfristige Stabilität der Elemente garantiert, soweit sie unter vorgegebenen Bedingungen betrieben werden.

Zusammenfassung des Beitrages auf Seite 40-43