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Commentary

TWO constitutional changes, each occurring independently of each other, have recently been announced and, while both of them appear on the surface to be no more than minor changes, they are indicative of the growth and importance of the electronic industry of this country.

The first of these is merely a change of title of the Radio and Telecommunications Section of the Institution of Electrical Engineers, whose Council has decreed that it shall now be known as the Electronics and Communications Section.

In a carefully worded note explaining this change, the Institution states that:—"In recent years the word 'Electronics' has been broadly used to cover the evolution of new techniques in fields other than communication and, although the basis of this work may well be attributable to those who have hitherto been regarded as engaged in the radio field, the final applications are often developed by other electrical engineers. Moreover, the incorporation of the word 'Electronics' into the name of the Section is intended to emphasize to the profession that the Institution is manifestly the learned society for those properly qualified electrical engineers who regard themselves as 'electronic' engineers."

Few will, we think, disagree with this change of title, for over a number of years this Section has become the largest within the Institution both in actual membership and in the number of papers it has presented.

What is implied in the statement is the Institution's awareness that the electronic engineer may feel he is a different kind of individual from the electrical engineer and that his needs cannot be met by an Institution which, although originally founded as the Society of Telegraph Engineers, has been predominantly 'heavy'.

He has, of course, much in common with his colleagues in the Measurement and Control Section and, indeed, it is not outside the bounds of possibility that the two sections may ultimately merge, for much of the present measurement and control is electronic.

The Institution is jealous—and rightly so—of its reputation and of the professional hallmark which its membership confers. The obvious desire is that there shall be no breakaway or formation of a new professional society and that the Institution shall be "the learned society for those properly qualified electrical engineers who regard themselves as electronic engineers".

The second change which is of more concern to the industry itself is the amicably arranged breakaway of the Electronic Engineering Association from its parent organization, the Radio Industry Council.

As is well known, the Radio Industry Council (RIC) has been since 1945 the co-ordinating body for the four associations of manufacturers representing all sections of the radio and electronic industry, namely, the British Radio Equipment Manufacturers' Association (BREMA), the Radio and Electronic Component Manufacturers' Federation (RECMF), the British Radio Valve Manufacturers' Association (BRVMA) and the Electronic Engineering Association (EEA).

The RIC has, on the whole, been extremely successful in welding together the many and diverse interests of the industry which it represents. It has among its many activities set standards of performance, organized exhibitions, appointed representatives to numerous committees where its interests are concerned and, what is most important, it has enabled the industry to speak as one voice and express its opinion on subjects ranging from purchase tax on replacement television tubes to the export of equipment to countries behind the Iron Curtain.

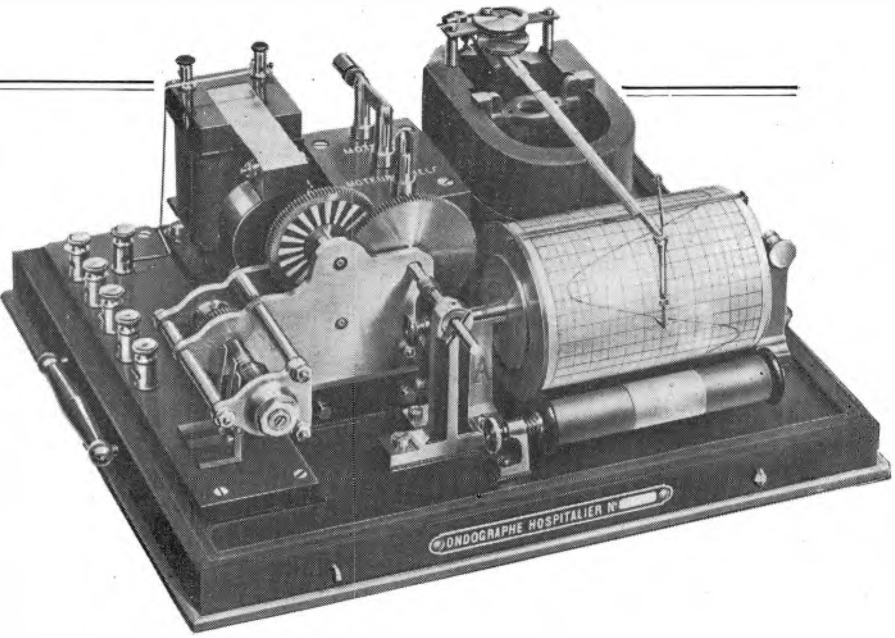
But what we have looked upon as the radio industry is, in fact, two industries, each with separate and distinct, although not necessarily conflicting, policies and objectives and it has become apparent that the two sections can no longer be lumped together.

The one is the 'radio' section catering for the vast domestic market for radio and television receivers and audio equipment. The other section, which has developed from the radio industry and which it is likely to outstrip, is the electronic capital goods industry supplying millions of pounds worth annually of electronic equipment to the world's markets comprising communication equipment, radar and radio navigational aids, computers, electronic measuring instruments and a wide range of apparatus for application to industrial purposes.

This latter section has had its interests safeguarded by the Electronic Engineering Association and it is indicative of the growth and importance of this section of the industry that its association now finds the moment opportune to break away and pursue its own path.

Its decision to do so can best be summarized in the words of the annual report which the EEA has just issued to its members:—"It remained a constituent of the Radio Industry Council during the period under review, during which time the four constituents reached the unanimous opinion that the capital goods side of the industry had developed in size and scope to the point at which capital goods and consumer goods could be recognized with advantage to all concerned as two distinct industries, each with its own objectives and policies. As from 1 January, 1959, therefore, the Association has given up its right to nominate representatives to the Radio Industry Council, thereby permitting the three remaining nominating bodies (BREMA, BRVMA and RECMF) to devote their attention to the affairs of the domestic broadcast entertainment industry, thus enabling the Association to take full responsibility for the capital goods interests of the industry." There will, of course, be the closest co-operation between the newly independent EEA and the remaining members of the RIC for electronic equipment, in whatever form, is built up of components and valves which are common to the domestic entertainment industry.

The Recording and Collocation of Waveforms (Part 1)



By R. J. D. Reeves*

Instrumentation for applied circuit analysis is conspicuously incomplete by the absence of oscillogram recorders. Observation, measurement and recording are the three steps to systematic analysis yet the last has not progressed beyond the simple concept of photographing the trace. As a procedure this is laborious, and as a record it is inadequate because the dimensions have no significance.

Before the advent of the cathode-ray tube it was the practice to record repetitive waveforms with a strobograph, which sampled the waveform with an almost synchronous commutator. The electronic equivalent of this process permits direct writing instruments to replace the c.r.o.-and-camera combination and introduce a new standard of refinement in presentation. By preserving the d.c. levels, recordings may be superposed for the true collocation of waveforms and the synthesis of families and nets.

In Part 1 of this article various aspects of strobography are discussed and in Part 2 a new general purpose instrument is described.

(Voir page 184 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 189)

THE cathode-ray oscillograph is familiar to all as the most ubiquitous of instruments, ranking with the camera in its power for functional analysis, not only in electric and electronic circuits but in any situation where electromechanical transducers can be brought to bear. It has enjoyed this dominant position since the commercial appearance of the c.r.t. removed the dynamic restrictions of the Duddell oscilloscope and offered an alternative to the mechanical types of strobing recorder which were the early strobographs.

The improvement in frequency response that this afforded, together with the simplicity of the electronic method made such dazzling extensions to observational techniques that the loss of recording facilities was overshadowed, and indeed from that time until the present day the facility of observation has ranked far above that of permanent recordings, so that now one is conditioned to expect nothing more.

It is only reasonable of course that observation comes first, and whatever process is being investigated the window of a cathode-ray oscillograph is the natural means to employ to study its behaviour. However, observation, measurement, and recording are the three steps to systematic analysis and in oscillography these are in ascending order of luxury. The measuring oscilloscope is already in an advanced state of evolution and accurate and versatile instruments are available commercially, but the possibility of recorded oscillograms has not developed from the earliest conception of photographing the trace, and such records are not suitable for subsequent measurements.

To make a significant advance one needs to turn to the strobing principle, a technique which was originally conceived for recording purposes, to see why it has not flourished and developed to take its place in modern instrumentation.

Strobing consists of sampling a repetitive waveform at what to all intents and purposes is an instant in the repetition period, and this implies that the sampling device (strobe) operates instantaneously. It is the finite duration of the strobe in a practical device which constitutes the fundamental limitation to the time resolution (frequency response) of the instrument, and when it is considered that the first strobographs employed a mechanical commutator for sampling their limitations can be readily appreciated. It requires the introduction of electronic sampling to remove this constraint. With this innovation the possibilities for strobographs become immense, matching the c.r.o. in speed and accuracy, and providing valuable characteristics of their own. In particular, the records that are produced are 'size stabilized' and measurements can be made with a

The above photograph shows a model of Hospitalier's 'Ondographe'

* Solartron Electronic Group Ltd, formerly E. K. Cole Ltd.

ruler at any subsequent time. This is a property not possessed by cathode-ray oscillograms.

In a strobing oscillograph the X axis of the paper is identified with the time scale, and as the pen traverses the paper in X direction its Y co-ordinate is made to track the input voltage waveshape. Such an arrangement is familiar when the time scale represented corresponds to the paper velocity for this is simply the ordinary recording oscillograph, but the essential feature of the strobograph is the use of stroboscopic principles to record waveforms on a time scale which is quite divorced from the actual velocity of X traverse. The possibility of doing this depends on the input waveform being repetitive, so that it can be sampled at corresponding instants in successive cycles. This has the effect of 'freezing' the input variations and providing a steady signal to the recorder. The relative instant or phase at which the sample is taken is controlled from the X co-ordinate of the pen, and this can be advanced arbitrarily slowly through the repetitive period to deliver the waveform, as it were, at dictation speed.

The Evolution of the Strobograph

The earliest use of the strobing principle in electrical work was Joubert's contact method[1] (1880), for the study of generator waveforms, whereby an electrostatic voltmeter was periodically connected to the generator by a commutator bar. By shifting the phase of the commutator and recording the voltmeter readings the complete waveform could be plotted.

In 1898 Prof. H. L. Callender demonstrated[2] how the process could be fully mechanized by using a recording voltmeter and coupling the paper movement to the commutator. The voltmeter was a self-balancing bridge, using a galvanometer detector and a motor driven potentiometer in much the same manner as the best modern recorders. His machine was therefore remarkable not only as the progenitor of the strobographic technique but also for being an error actuated instrument and unequivocally a servomechanism, and attention has been drawn to its historical significance in a recent review of servo-operated recorders in a paper by A. J. Maddock[3]. It was only unfortunate in being so far ahead of its time that the servomechanism was inordinately slow.

This drawback was largely avoided by E. Hospitalier[4] in 1904 by departing from the feedback principle and using a simple recording galvanometer in parallel with a storage capacitor. His machine, the 'Ondographe', was designed for commercial production and its success can be judged by the fact that it remained in production for thirty years, that is until cathode-ray oscillographs became commercially available. A model of the machine is now preserved in the Conservatoire National d'Arts et Metiers in Paris and a photograph of it is reproduced on page 130.

In 1932 two papers[5,6] appeared proposing an extension to Joubert's contact method for measuring the harmonic content of low frequency waveforms, which was to have several equally spaced commutator bars and read the average of the samples taken throughout the cycle, but the method is not generally useful.

Within a few years of this date strobographic techniques atrophied and disappeared, and it was well into the post-war period that stroboscopic oscilloscopes were introduced.

In 1950 Janssen[7] described an experimental oscilloscope using an electronic sampling technique with a gate duration of 10mμsec. This was intended to display c.w. type waveforms, and an a.f.c. circuit pulled the sampling rate from a nominal 100kc/s to the nearest sub-harmonic of the displayed frequency. The range of application was, therefore, from 100kc/s to 50Mc/s.

Two years later McQueen[8] introduced a commercial stroboscopic oscilloscope which was designed to study the fast repetitive transients which characterize all modern pulse circuits. The gate length had the remarkably short value of 1mμsec and consequently it handles frequency components up to 300Mc/s, and it was this instrument more than any other which drew the author's attention to the dormant possibilities in strobography.

The function of a stroboscopic oscilloscope is to extend the range of application of cathode-ray tubes beyond the usual limitations of the tube and its associated amplifiers; within this frequency range it offers no advantage. It is clear, however, that a stroboscopic recording oscillograph has advantages at all frequencies and in Part 2 of this article a new instrument is described which has been designed to produce precise recordings on paper, with time scales ranging from 0·1 to 500μsec/in. This may be brought to bear in a very general class of analysis.

A specialized form of strobograph has been in use at the N.P.L.[9] since 1950 to record the output of a periodic analogue computer, this being intended to operate at the lower repetition rates from 10 to 50c/s, and another by Postlethwaite of the Admiralty Gunnery Establishment has been employed for the same purpose since 1954.

The technique is also being investigated at the Military College of Science, a recent paper[10] describing some experimental work carried out there, but apart from these

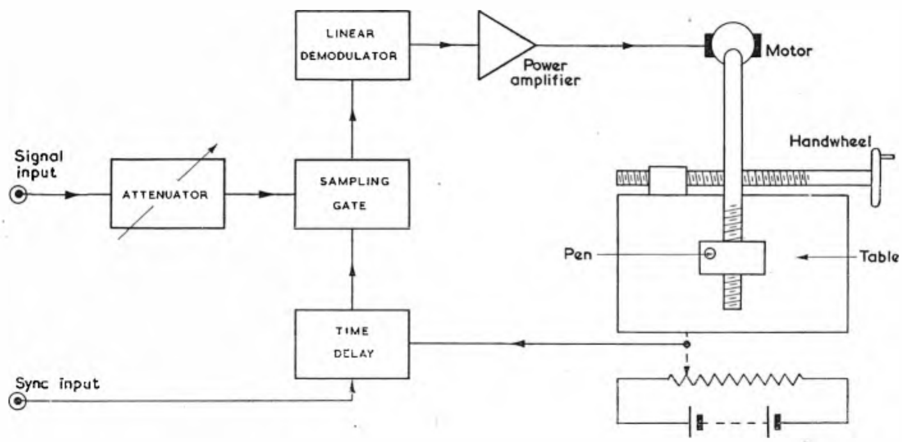


Fig. 1. Class 1 strobograph

instances the author is not aware that the method is in use, and it is the purpose of this article to describe the problems and possibilities which are associated with this technique.

Open and Closed Loop Classes

A strobograph constitutes a servo system in which the pen is tracking input voltage variations, and as such can be classified as an open or closed cycle type. Currently one tends to regard open cycle control systems as distinctly out of date, but in this application, with sampled data, there are advantages to be obtained which have to be weighed against the usual merits of closed loop systems.

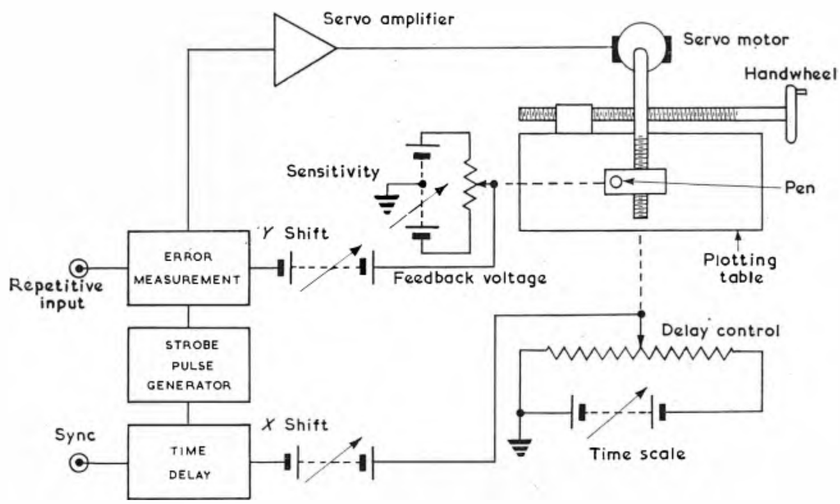


Fig. 2. Class 2 strobograph

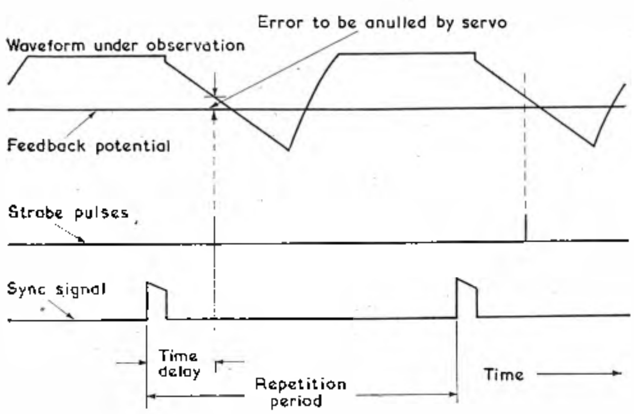


Fig. 3. Waveform relationships in a class 2 machine

A block schematic of an open cycle strobograph is shown in Fig. 1. This will be designated a Class 1 machine, the closed loop system being Class 2. The figure shows an amplifier and motor in the forward path, but this is to symbolize any type of actuator or recorder; and similarly although the X traverse is shown as motion of the table it may be equally well applied to the pen instead.

In this class of machine a measure of the signal voltage must be obtained at every gate instant, and this measure demodulated by clamping or averaging to provide a proportional signal to the recorder. The vertical calibration of the paper depends on this proportionality factor and therefore on everything in the forward path, and in particular the sampling circuit has to provide proportional measures for all input levels to be handled. In a general purpose instrument this could be an enormous dynamic range, but this requirement may be eased if the sensitivity control is in the form of an input (pre-gate) attenuator which brings all input signals to a common low level.

At low repetition rates the discontinuous nature of the incoming information will convey itself to the pen and unless the X traverse is correspondingly slow the recording will deteriorate, with discrete steps appearing. However, no tendency to malfunctioning occurs in this situation, the recording merely indicates the limitation of the strobing method. In the same situation the Class 2 machine is prone to instability.

Fig. 2 is a block schematic of a Class 2 machine, the essential difference from Fig. 1 being the position feedback from the pen to the sampling point. The sampling circuit does not now measure the input signal but compares it with the pen monitor voltage and indicates the sense of the difference (see Fig. 3). It still has to hold off the entire signal voltage between sampling times but only a limited range of error measure is required, and this only to render the servo loop designable. Input saturation is avoided by successful tracking, a feature which is beneficial in the design of the probe circuit but demands that the gate be synchronized to the signal frequency or a sub-harmonic thereof. This precludes special applications in which the signal is sampled more than once per repetition period for the purpose of harmonic analysis but although this resolves harmonics into groups a full analysis cannot be made, and so the loss of this feature is not serious.

The Class 2 machine has the overwhelming advantage, common to all feedback devices, that the accuracy of transfer depends primarily on the feedback path, which in this case is a d.c. circuit. It can therefore be very precise and is certainly easy to calibrate. Furthermore, it ensures that the d.c. level is preserved in the recording without the necessity for carrying d.c. through the servo amplifier.

D.C. preservation is of great importance in permitting the true superposition of successive recordings. This means that waveforms can be collocated on the voltage scale as well as the time scale, a feature rarely provided on multichannel cathode-ray oscillographs.

Accuracy is further enhanced by the elimination of the pre-gate attenuator.

Being a closed loop servo with discontinuous information this class of machine is prone to sampling instability at low repetition rates, and although means may be adopted to safeguard against this hazard, the Class 1 machine has the merit of greater simplicity when recording, for example, waveforms with 50c/s repetition rate.

In Table 1 the instruments referred to in the previous section are segregated according to the above classification, no distinction being made between strobographs and strobing oscilloscopes. Notice that there is so far no Class 2 strobing oscilloscope.

Strobe Generators and Modulators

The modern strobograph is characterized by electronic sampling which removes these limitations due to mechanical

TABLE 1

	CLASS 1	CLASS 2
1898		Callender
1904	Hospitalier (C. de. C.)	
1950	Janssen (Philips)	
1950	Blake (N.P.L.)	
1952	McQueen (Metrovick)	
1954	Postlethwaite (A.G.E.)	
1956	Gooder (M.C.S.)	
1957		Reeves (E. K. Cole)

commutation. Briefly these limitations may be said to be

(1) Inability to provide high repetition rates.

(2) Insufficiently brief 'make' period.

(3) Restriction to periodic waves only.

Before dismissing the method from this discussion it may be remarked that the recent introduction of high speed mercury jet switches[11] could provide a means of easing the first two limitations, but not the third.

The electronic technique is to generate a short pulse which either gates an amplifier circuit or closes an electronic switch in a manner analogous to mechanical commutation. There are, therefore, two aspects to the problem, the design of the pulse generator and the manner in which this pulse is employed. To consider the commutator as a

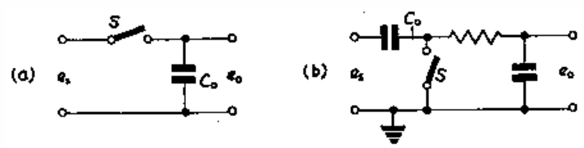


Fig. 4. Strobing by commutation

point of departure, Fig. 4 shows how this may be used as a series or shunt modulator to achieve the required result. In Fig. 4(a) the switch closes momentarily and causes the input waveform to charge the storage capacitor C_o to its instantaneous level. The voltage on C_o may then be displayed by a high impedance meter or recorder. Fig. 4(b) works in the same way but the positions of the switch and the storage capacitor are interchanged. In this case the voltage on C_o is more difficult to display because it is connected in series with the input waveform, and a filter is required to remove the extraneous signal. Furthermore, the d.c. level of the input waveform is lost, which is a serious limitation.

The commutation action symbolized by S in Fig. 4 may be realized by various forms of diode gate of which perhaps Fig. 5 is the most common example. In this the strobe gate pulse is applied through a transformer (represented by the winding T) and is of the appropriate polarity to drive the four diodes into conduction. The gate current that flows charges a biasing capacitor C_b to the peak voltage of the gate pulse and terminates this phase of the action. In order that current shall flow again on the receipt of the next gate pulse some charge must be permitted to leak away through a resistor R. While the diodes are conducting there is a low impedance path from A to B provided the signal current is less than the gate current, but between the strobe pulses the bias voltage on C_b prevents conduction unless the potential between A and B exceeds the bias, and these terminals can therefore be used in place of the commutating switch. A balancing potentiometer P is required if it is necessary to avoid a pedestal voltage on C_o.

If T is centre-tapped two diodes may be dispensed with, one possible configuration being shown in Fig. 7. This doubles the current carrying capacity of the switch compared with the four diode circuit but introduces a source of calibration error by putting biasing capacitors in the charging path of C_o. The transfer ratio depends upon the relative magnitude of C_b and C_o and these components would contribute to the errors of a Class 1 machine.

A slightly different configuration shown in Fig. 7 avoids this source of error by using the biasing capacitors simultaneously as the storage capacitor. In this dual role, however, it is hard to choose a value for this capacitor which

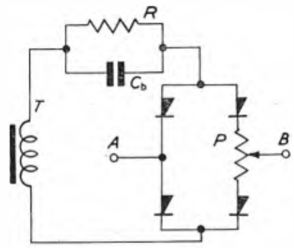


Fig. 5. The four-diode gate

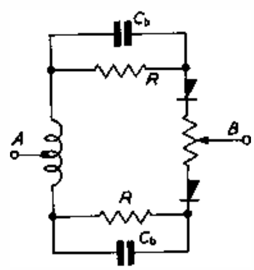


Fig. 6. The two diode gate

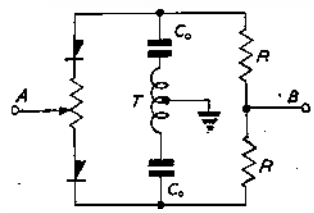


Fig. 7. Alternative two diode gate

satisfies the conflicting requirements of low repetition rates and high display frequencies and so it has restricted application.

For these reasons it will be seen that of the commutator type circuits the four diode gate is to be preferred, being easily designed and having a transfer ratio of unity. In all of these circuits the strobe pulse needs to be greater in amplitude than the peak-to-peak level of the input waveform.

A different approach to the modulator problem is to apply the input waveform to an amplifying valve in a conventional manner but to arrange the valve to be normally shut off and only activated for the duration of the strobe pulse. This provides a very high input impedance because the input is not loaded even when the modulator valve is switched on, and more important, there is the possibility of sampling high level signals with a low level pulse. Previous modulators have employed anode modulation or cathode modulation of a valve carrying the input waveform upon its control grid. The possibility of grid current restricts these forms to low level signals and they can only be extended to general purpose use by a pre-gate attenuator, which has to be carefully calibrated.

A modulated amplifier more suitable for high level work is the multi-grid valve, carrying the input signal on its second control grid and being gated on its first. The ability of the signal to overcome the shut-off bias is then reduced by the inner μ and is no longer a serious consideration. With this arrangement high level signals can be tracked by a Class 2 machine without using a pre-gate attenuator, and accuracy is correspondingly improved.

The only unfortunate point about this technique is that this mode of operation has not been envisaged for conventional hexode and pentagrid valves and the limitations upon their use although not severe are likely to be the first limitations of a high performance strobograph. For example, the permissible p.d. between the signal grid (g_3) and other electrodes in a typical valve is stated to be 200V and this is uncomfortably low for this purpose. Secondly, the electrode structure of the valve is not such as to give maximum isolation of the signal grid and a clean layout appropriate to the conveyance of the highest frequency components that can be resolved by a modern machine.

Finally, the question of high-level working is beset by the problem of neutralization. A short strobe gate results in quite a small charge being deposited on the stray capacitance of the anode circuit, and the signal level here is, therefore, correspondingly small. Consequently it is important to properly screen the anode from the signal grid, and although pentagrids are designed to do just this, the residual capacitances between them is still large enough to require neutralizing. For this reason, and for true comparison of input signals with the reference potential, twin input valves should be used, followed by a differential pulse amplifier.

Going on to consider the design of the strobe pulse generator, there is no doubt that pulse generation is a typical requirement in electronic apparatus and a variety of methods are known, but one is faced with the challenge, quite typical in the design of measuring instruments, to produce something that is an order of magnitude better in quality than the apparatus to which it is applied. What this means in this case is a pulse shorter than the pulses and transients that are typically encountered in practice, and currently this implies something very brief indeed.

Strobe pulse generation is synonomous with the problem of generating a large current step because the stray capacitances at the source and load discontinuities require a large charging current to follow a short pulse. For example, a rate of rise of 10V/mμsec requires 0·1A/10pF of stray capacitance. Also, of course, in the case of the commutating gate the gate current must exceed the signal charging current.

Perhaps the most effective method of producing a current step is to close a simple mechanical switch, but this method would re-introduce the first and third limitations of mechanical strobographs listed above. Thyratron valves, which can be triggered into conduction by ionizing the gas are also limited in repetition rate by the de-ionization time, and are subject to slight uncertainty in the instant of conduction.

Hard valves on the other hand are not limited to a maximum repetition rate and, therefore, if comparable rise-times can be achieved they are to be preferred. It is well known that the blocking oscillator configuration for a hard valve produces a very large pulse of cathode current but it is not generally realized that the performance of such pulse generators may be made comparable in speed to any other circuit technique (as distinct from bunching techniques in electron streams).

The success of this method depends very much on the design of the regenerative transformer of course, but good results are surprisingly easy to get, and in the second part of this article a design will be described which will produce a pulse about 2 to 3mμsec long, using a single television line output pentode. The pulse amplitude is quite large, and by using only the extremity of the pulse for gating the effective gate duration is of the order of 1mμsec.

To obtain a resolution which is substantially better than this it would be necessary to resort to the distributed components and field techniques which are associated with such frequencies and it is interesting to speculate on the possibility of a specially constructed electron gun for performing the two operations of strobe generation and modulation. It has been demonstrated elsewhere[12] that electron streams may be chopped by deflecting them past a slit and then velocity modulated to produce bunches which are collected at the final anode in the space of a very few micro-micro-seconds. It seems reasonable to propose that if these bunches were deflected by the input waveform before being collected by some form of discriminating anode this tube could be the nucleus of a strobograph with a frequency resolution corresponding to the transit time of the bunches through the deflectors. It is of no consequence if the bunches disperse considerably between deflexion and collection.

Although such an arrangement offers the possibility of recording on paper some extremely high frequencies one cannot hope to extend into this part of the spectrum those merits of a strobograph which depend upon the connexion of the recorder leaving the circuit undisturbed. Since the deflectors of the electron gun would need to be embodied as an integral part of the circuit under observation this would preclude the possibility of collocating on the voltage scale the different waveforms in the circuit. For this reason it may be said that the province of the strobograph is properly that part of the spectrum roughly corresponding to the use of lumped circuit techniques.

Synchronizing

In order to relate the strobe position to the input waveform it is necessary to obtain a synchronizing signal, which serves to identify a particular phase of the recurrent cycle. Furthermore, it is necessary to identify this phase in every recurrent cycle in which the strobe gate opens if it is desired to avoid the assumption that the input signal is truly periodic and not merely repetitive.

Such an assumption is only reasonable if the input waveform is of c.w. form and some kind of resonant or flywheel effect sustains its short-term stability. Relaxation oscillators, to which most pulse generators are referred are not controlled in this way and some pulse to pulse jitter is typical. Therefore, for the largest class of work a synchronizing signal should be obtained in every repetition cycle, and used to initiate the strobe delay. Of course, the waveform under observation may itself be used as a synchronizing signal, but this arrangement is not always satisfactory.

The familiar difficulty is that the input waveform may not offer an identifiable trigger point prior to the earliest feature it is required to display. Triggering from a later phase in the previous repetition cycle again presupposes that the signal is truly periodic rather than merely repetitive.

Another point is that a strobograph offers the possibility of particularly high input impedance at the strobe head by arranging that the input valve is the gated valve and is therefore only switched on for the duration of the strobe pulse.

The synchronizing channel, however, would not be conspicuous for its high input impedance and to connect it in parallel with the signal channel would degrade this particular feature.

But assuming a synchronizing waveform is available which is jitter free with respect to the event to be recorded, the strobing can be performed satisfactorily even when the repetition rate is not periodic but recurring in some unspecified way.

To record c.w. signals on the other hand, jittering is not a problem and synchronizing can be achieved by adopting a.f.c. techniques. For example the strobe repetition frequency may be controlled by a voltage tuned oscillator which in turn is controlled by a phase discriminator. The phase discriminator compares the c.w. frequency with the strobe rate, and a phase lock is maintained where the closed loop is degenerative.

It is not unusual to have the strobe recurring at a lower frequency than the repetition frequency of the signal, and this is referred to as sub-harmonic working. From the point of view of the recording it is only necessary to obtain signal measures sufficiently often to avoid sampling ripple (in the record) or sampling instability in the mechanism and if the signal frequency is much higher than this, which of course is usually the case, then sub-harmonic working may be employed. This simplifies the design of the strobe rate oscillator by permitting it to run at frequencies much below the highest frequency it is called upon to lock to. For example, a relaxation oscillator working at 10kc/s can be locked to frequencies of several hundred kilocycles per second. But far from being merely expedient, in some circumstances it is obligatory to use sub-harmonic working. This is typified in the case where the time delay method is of the paralysing type which cannot accept further synchronizing pulses until the strobe trigger output has been delivered. Obviously then the strobe repetition period cannot be shorter than this delay time, and since this is a function of the X position of the pen some means must be adopted to constrain the repetition period to be longer than the maximum X displacement of the pen, i.e. full paper width. If this is not done the repetition frequency will exhibit jumps as the pen traverses the paper and small shifts in the locking phase will produce discontinuities in the plot. Electronic time delay circuits which reconstitute a pulse rather than actually delay it are invariably of the paralysing type, and since these are the simplest and most flexible 'delay' units sub-harmonic working is typical when a strobograph is plotting a complete cycle of the input signal. This situation is quite familiar in cathode-ray oscillography where it is axiomatic that the time sweep recurrence period cannot be shorter than the displayed time-base, but is not necessarily true in strobography.

Time Delay Systems

The Delay Line

The requirement is to produce a strobe trigger pulse from the synchronizing pulse after a controlled time interval has elapsed. The delay time is to be linearly related to the table position and it is desirable to introduce an additional variable delay for the purpose of X shift.

Whether the delay is achieved by actually passing the synchronizing pulse through a delay line or by the more artificial method of generating a delayed trigger pulse with electronic circuits is open to choice.

The delay line method has two features which cannot be matched by other systems. Firstly it does not paralyse while a pulse is passing through it: it can carry many pulses simultaneously, and consequently the strobe rate is quite independent of the delay time and high sampling rates can be maintained (bounded by the signal recurrence frequency, of course) even when the paper scale represents a long time interval.

Secondly the delay time is absolutely free of jitter and on short time scales this is a matter of prime importance. In fact, delay lines probably constitute the best system within their range of application, but unfortunately this range is greatly restricted. Engineering difficulties and sheer physical considerations combine to limit their application. The delay line has to be explored along its length by a pick-off probe and a typical requirement is to resolve at least five hundred parts in the width of the paper. This dictates not only a continuous line but a continuous exploration of that line. If calibration is to be permanent then long-term stability and a low temperature coefficient are needed. Furthermore, a different line is needed for every range and a universal strobograph would require more than a dozen lines, extending to such long delays that some propagation medium other than electric lines would need to be employed.

Re-circulating lines need to be augmented with means for removing the time ambiguity, and in any case are then subject to paralysis.

Therefore, while the delay line system may be unimpeachable in concept, in the present state of the art their use is restricted to a narrow range of delays, and they need to be constructed to a high engineering standard if their performance is to be satisfactory.

A more practical approach would be to employ a universal delay system capable of operating in a uniform manner throughout the whole range of paper scales and then, if in a particular application the special merits of delay lines are required it should not be a difficult modification to couple the moving pick-off of an external delay line to the X traverse, and substitute this for the internal delay.

Voltage Controlled Delay System

Such a universal delay system may be obtained by recourse to a voltage sawtooth waveform working in conjunction with a pick-off circuit. A sawtooth waveform provides a linear relationship between voltage and elapsed time and constitutes a scale whereby voltage measurements may be interpreted as time measurements, the accuracy of results therefore depending on the linearity of the waveform. The delay time is defined by the slope of the sawtooth and the difference between a 'start' potential and a pick-off potential, one of which is variable. If the linear stroke of the sawtooth is initiated by the synchronizing pulse it is the function of the pick-off circuit to trigger the strobe pulse when the sawtooth voltage traverses this second potential. In this way the delay time is voltage controlled.

This method is extremely convenient because a voltage medium is a natural one to use in connexion with thermionic valves and the design of sawtooth generator and pick-off circuits has been much investigated in other fields. The range of delays that can be obtained is virtually unlimited, the ranges are very simply switched and also it is a simple matter to relate the time delay to the X co-ordination of the plot by means of a precision potentiometer.

The drawbacks that are characteristic of this or any other artificial system that does not actually pass the synchronizing signal through a delay line are firstly a synchronizing paralysis time, somewhat greater than the delay time, which limits the strobe rate, and secondly the introduction of jitter by the cascade of triggered circuits, which has been introduced. The original synchronizing pulse now triggers a delay waveform, the waveform triggers a pick-off circuit, and the pick-off circuits trigger the strobe generator. These processes are subject to interference by extraneous circuit waveforms and hum from the valve heaters and the net result is a small time jitter on the strobe pulse about the nominal setting, which reduces either the resolution or the linearity of the system.

Phase Controlled Delay System

A Class 2 strobograph is conspicuous for a Y scale accuracy that is difficult to match with c.r.o. techniques, and it is interesting to debate whether this benefit can be extended to the X scale.

Time measurements on a c.r.o. are referred to the sawtooth type of delay circuit described in the previous section. This same type of circuit is also commonly used for delay measurements in radar ranging systems for both range displays and non-visual tracking systems. In this connexion it is stimulating to recall that certain radar systems of high precision augment the sawtooth generator with a sine wave reference signal[15] which is coherent with the transmitted pulse train and provides a time scale of much greater accuracy. The sawtooth is retained to remove the cycle to cycle ambiguity of the reference wave. The improved accuracy derives from the fact that the reference wave frequency can be maintained extremely accurately, and phase-angle measurement (by goniometer) is not referred to voltage standards. In considering whether this method can be employed in a strobograph to create a precise time delay there is a complicating factor to be taken into account. In a radar system the radiated pulse can be locked to a continuous reference wave, but in a strobograph the synchronizing pulses which indicate the start of the delay period are not under control, and have to be accepted at an arbitrary rate, wihch is not necessarily truly periodic. Therefore, the reference wave has to be generated by a triggered ringing circuit rather than a continuously maintained oscillator if phase coherence is to be maintained, and this introduces a new problem. The difficulty is not in making a precision ringing circuit but it is no longer possible to use resonant multipliers or dividers to produce related frequencies for the different ranges. Therefore, each range must be calibrated separately instead of all being referred to a common standard, and then economy dictates that nothing more extravagant than high quality tuned circuits should be used. Notice, however, that this still promises significantly greater precision than the sawtooth waveform. A tuned circuit can be made stable to much better than 1 per cent and even a comparatively inaccurate goniometer need not be a limitation if the sawtooth can be relied upon to remove ambiguity in a high frequency reference wave.

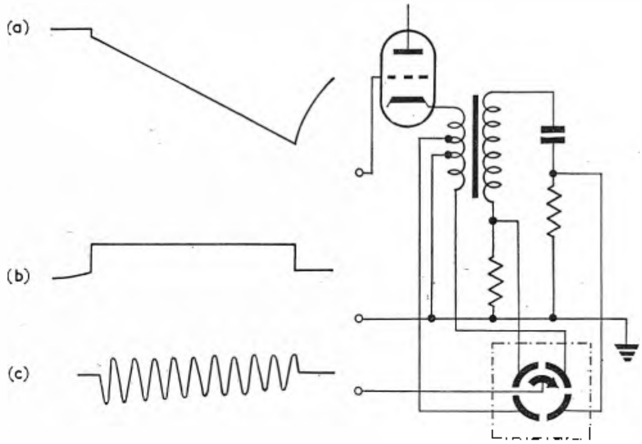


Fig. 8. Variable phase ringing circuit

To illustrate these ideas a specimen arrangement is shown in Fig. 8. A sawtooth waveform at (a) is used as a coarse index for the desired delay, and the sawtooth generator simultaneously provides a square gating waveform (b) of the same duration. This gates a precision ringing circuit (which may be artificially sustained if necessary) dividing the time interval into 10 parts. The inductance waveform may be picked-off in balanced form by suitable taps, and balanced quadrature signals are obtained from two small resistors in the tuned circuit. From this low impedance four phase source some form of goniometer, capacitive or electrolytic resolver is used to obtain any intermediate phase, the result being a 'screw thread' waveform (c). The goniometer is ganged to the coarse index and indicates ambiguously the zeros of waveform (c), which can be used as trigger points for an output pulse. The cyclic errors of the goniometer are reduced by the degree of ambiguity, and the calibration depends primarily on the ring frequency. In this circuit non-linearities due to the starting transient will be extremely brief.

Repetition Phase Controlled Delay System

A restricted form of phase control is realized when the strobe pulse position is referred to the phase of the repetition rate generator and not an independent time standard as in the previous section. By this means the repetition period may be presented as a phase scale on the paper, with good linearity but with a referred time calibration. In certain situations where, for example, the strobograph has a fixed application to a periodic source of known frequency or where a phase base is more relevant than a time-base this is a perfectly acceptable technique, and it can be very simple to arrange.

This was exemplified by the old mechanical strobographs where, in effect, the input brush could be moved round the sampling commutator so that brush angle was synonymous with phase-angle, and this was linked to the paper movement. Thus although the phase co-ordinate was explicit the paper could only be calibrated as a time scale in terms of the angular frequency of the commutator, which was synchronized to the generator under observation.

In the N.P.L. strobograph where the repetition frequency is not defined by a rotating shaft a repetition phase scale is achieved in a more elegant way, and since the repetition rate is known the phase scale may be interpreted as a time scale. The strobe pulse and what has been called the pre-pulse are both derived from a crystal oscillator by counting down with binary stages, the division ratio being slightly different in the two cases. The resulting difference frequency thus defines the time taken for the strobe pulse to pass through the repetition period and the quotient of the repetition frequency/difference frequency defines the number of samples within that period. It will be observed that this process does not involve the position of the recording paper, and so further means must be adopted to relate the paper speed to the difference frequency.

Two Channel System

Just as in a cathode-ray oscillograph the time-base may be removed from the X plates and another signal applied, so in a strobograph the X displacement may be dissociated from the phase of the strobe (time scale) and a second sampling channel provided. This is referred to as two-channel working, and enables one repetitive (or d.c.) signal to be plotted against another, with the time scale appearing as a parameter along the convolutions of the curve. When the repetition rates are harmonically related, as they must be if they are to be sampled with a common strobe, then sufficient exploration of the time scale will produce a closed curve or cyclogram. Such displays on cathode-ray tubes are typically mobile ones, which indicates that the two inputs are not synchronous, this indeed being a popular method of frequency comparison, but two-channel strobographs cannot deal with waveforms that are non-synchronous unless the difference frequency falls within the mechanical bandwidth. The especial merit of the strobograph in this mode of operation (as in the single channel mode) is its capacity for multiple presentation, which allows the synthesis of families of curves correctly related to one another by virtue of the d.c. transfer.

In general, families of curves on the X-Y plane are doubly parametric functions, $Y = f_1 (t, \phi)$ $X = f_2 (t, \phi)$ one parameter being explored continuously as each curve is delineated and the other in discrete steps as successive curves are added. Although the time scale t has been described as the continuously variable parameter, equally well the strobe time could be advanced in discrete steps while the external ϕ parameter is swept. The superposition of the family produced by the second method (contours

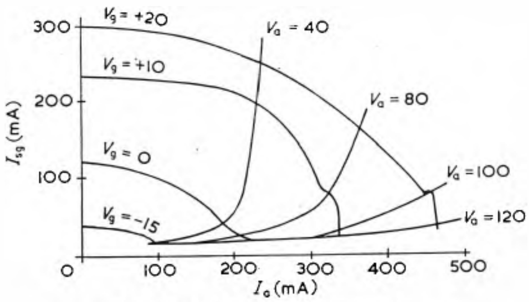


Fig. 9. 807 partition characteristics

of constant t) on that produced by the first (contours of constant ϕ) forms a net which is highly descriptive of the X-Y-ϕ-t relationship, with the minimum of annotation. When the two families are orthogonal the net may be thought of as a relief map of ϕ or t on the X-Y plane.

In some cases neither of the net parameters is the time scale, for the strobe phase may be left fixed while two non-temporal parameters are explored, in which case if t has any significance at all it is as a parameter of the complete net and not of the individual curves.

Degenerate cases occur when one of these parameters is tracked directly by one of the co-ordinate channels (X for example) so that $Y = f(X, t)$ or $Y = f(X, \phi)$, and a one-parameter family of non-cyclic curves or graphs is produced.

Examples of these various classes of maps can be given in connexion with the plotting of valve characteristics.

If the anode voltage and grid voltage of a valve are considered the variable parameters, and the X channel is made to follow anode voltage, and Y channel a voltage proportional to anode current, then $Y = f(X, V_g)$, where $Y = I_a, X = V_a$, which is the anode characteristics of the valve. This is a one-parameter family (V_g) and the complementary net of V_a contours simply reproduces the ordinates on X.

If V_a and V_g are d.c. quantities then t has no significance and this is not a strobing technique, but if V_a or V_g (or even independently V_{sg}) is pulsed for the purpose of exploring the characteristics beyond the continuous dissipation boundaries, then t becomes a parameter of the whole family. When measured from the start of the pulse it indicates how long current had been flowing in the valve when the points were recorded, which is significant in connexion with cathode fatigue under pulse conditions.

On the other hand, the t parameter might be associated with the X scale by pulsing the anode voltage with a ramp function instead of a flat topped pulse, so that V_a can be explored by shifting the sampling phase on a one-channel machine.

An example of the more general doubly-parametric net is afforded by what might be called the partition characteristics of a tetrode, obtained in the following manner: X channel to I_a, Y channel to I_{sg}, the parameters being V_a and V_g, one of which is pulsed. The families of V_a constant and V_g constant intersect to form a net similar to that sketched in Fig. 9 which is useful in studying the 'bottoming' behaviour.

Having recorded a valve's characteristics under pulse or d.c. conditions the valve may be embedded in a circuit, being excited by a periodic waveform and a new characteristic recorded, superposed on the old, under the dynamic constraint of that particular circuit. When the circuit is reactive this produces an opened locus or cyclogram. The background net of the static characteristics, of course, indicate in a very explicit manner the instantaneous working conditions of the valve. If apparatus can be constructed to periodically impress prescribed initial conditions on the network then instead of a periodic waveform the relaxation behaviour of the network can be recorded, or, if it is unstable, the approach to the limit cycle from various parts of the plane.

By this sort of technique phase plane analysis may be readily extended to experimental research instead of being confined to theoretical work, and in fact, the strobograph by Postlethwaite at the Admiralty Gunnery Establishment has the two dimensional feature and is employed on an analogue computer for phase plane records.

These examples of two-channel working applied to valve behaviour serve to illustrate how extremely informative strobograms may be synthesized by multiple recording, and it will no doubt be readily appreciated how such a machine (which is in effect a high-speed X-Y plotting table) may be brought to bear on a host of other problems. In all but the most trivial applications, of course, auxiliary apparatus is required to form test gear of which a two-channel strobograph is the nucleus, and it is therefore difficult to point out applications which are specifically the province of a strobograph, indeed, the previous inability to depart very much from the time-base type of presentation tends to impede the mental reorientation necessary for the two-dimensional point of view. It remains to be seen how truly useful is this enlargement of facilities.

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(To be continued)

Measurement of Magnetic Fields by Nuclear Resonance

By G. C. Lowe*

A simple feedback circuit is described which employs the phenomenon of nuclear magnetic resonance to measure magnetic fields over a wide range with a minimum of readjustment of the circuit elements to an accuracy of at least 0·01 per cent.

(Voir page 184 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 189)

CONVENTIONAL methods of measuring magnetic field strengths give a low accuracy unless each measurement is preceded by elaborate calibration. Thus, if accuracies of greater than about 2 per cent are required, considerable effort has to be put into the measurement. In 1945 the first experiments were performed in the field of nuclear magnetic resonance. This phenomenon is proving of great value in the accurate measurement of magnetic fields. The accuracy is limited only by the measurement of frequency and of course the homogeneity of the magnetic field. Standard equipment is used apart from the actual nuclear resonance detector.

The Phenomenon of Nuclear Magnetic Resonance

It has been found that the nuclei of many elements have a nuclear magnetic moment. Consider, for example the nucleus of hydrogen, a proton, having a magnetic moment μ. When placed in a magnetic field B it will tend to rotate into one of two stable positions, parallel to the field with energy $-\mu B$ or anti-parallel with energy $+\mu B$.

The transition between these two energy levels is accompanied by the emission or absorption of a quantum of electromagnetic radiation of frequency ν related to the energy difference ΔE by the quantum mechanical expression

$$\Delta E = h\nu = 2\mu B \text{ or } \nu = (2\mu B/h) \quad \ldots\ldots\ldots (1)$$

Since Planck's constant h and nuclear moment μ are known, B can be deduced from a measurement of frequency ν alone.

The net effect of interaction with a large number of nuclei in thermal equilibrium at temperature T is absorption from the electromagnetic field, since the relative numbers N_1 and N_2 of nuclei in the low and high energy levels are given by the Boltzmann distribution

$$N_2/N_1 = e^{-h\nu/kT} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

where k is Boltzmann's constant.

For a field B of 1Wb/m², substituting the value for the nuclear moment of the proton in equation (1) one finds that $\nu = 42{\cdot}577$Mc/s. If this value is substituted in equation (2) one finds that at normal temperatures the fractional difference $(N_1-N_2)/(N_1+N_2)$ between N_1 and N_2, and hence the net absorption, is very small.

For a detailed discussion of the physical principles of nuclear magnetic resonance see, for example, Andrew[1].

Choice of Specimen and Design of Detector

The choice of specimen is governed by several factors,

(a) Range of field strengths to be measured.

(b) Relative magnitude of absorption.

(c) Dielectric loss.

The proton has the largest nuclear magnetic moment and so for a given field its frequency ν, and hence from equation (2) its magnitude of absorption, are the greatest. The frequency 42·6Mc/s, corresponding to 1Wb/m², the highest field likely to be met in practice, is still conveniently in the radio-frequency range. Water contains a large number of hydrogen atoms per unit volume but has a high dielectric loss. Glycerol has a slightly lower density of hydrogen atoms, but its very low loss results in greatly increased sensitivity and permits more latitude in probe design.

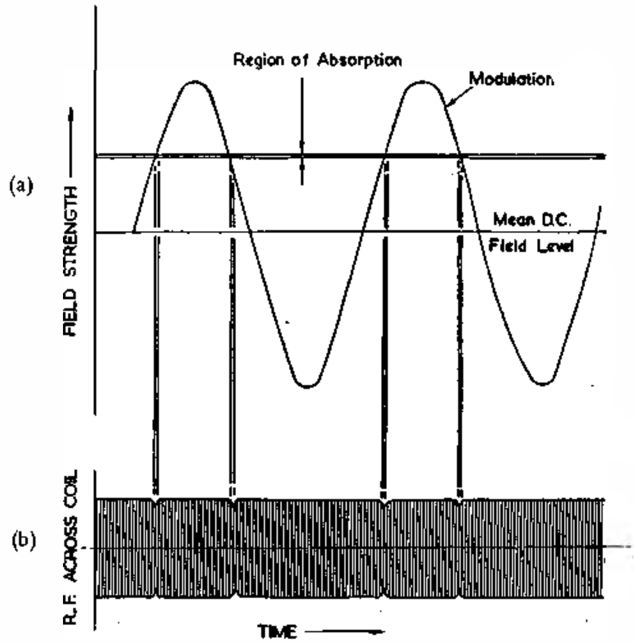


Fig. 1. Power absorption and its effect on a tuned circuit

The most important factor in the design of the oscillator is the necessity to maintain it near the verge of oscillation over a wide frequency range with the minimum of readjustment, so that the very small power absorption on resonance produces a sufficiently high signal-to-noise ratio.

Practical Circuit Arrangements

To obtain an output suitable for display on an oscilloscope, the region where absorption occurs must be swept. This can be accomplished by frequency modulating the r.f. source, or modulating the field through the specimen. The former method is difficult because of the other requirements of the r.f. source and hence the latter method is adopted. The region of absorption must not be swept too quickly, since the specimen will not have time to absorb power. This places a limit on the frequency and magnitude of the modulation. A suitable frequency is 50c/s and magnitude 5 to 50 × 10^{-5}Wb/m².

The specimen will absorb power twice per cycle as shown in Fig. 1(a). If the absorption lines are equally spaced the frequency ν is proportional to the mean field. If the oscilloscope is scanned at twice the modulation frequency, when ν is correct the pulses will be coincident, which forms a convenient method of setting ν.

There are two main methods of obtaining suitable outputs, both of which rely on the fact that the amplitude of r.f.

* *Royal Radar Establishment.*

across a tuned circuit drops when absorption occurs, because the power absorbed constitutes an extra loss or an effective drop in Q of the circuit; see Fig. 1(b).

Bridge Methods

The principle behind these methods is that the reduction of Q unbalances a bridge circuit producing an output. These systems, though sensitive, are awkward to adjust and are therefore not considered here.

Marginal Oscillator Methods

Here as in the other methods the coil of a tuned circuit is wound round the specimen and is used in the grid circuit

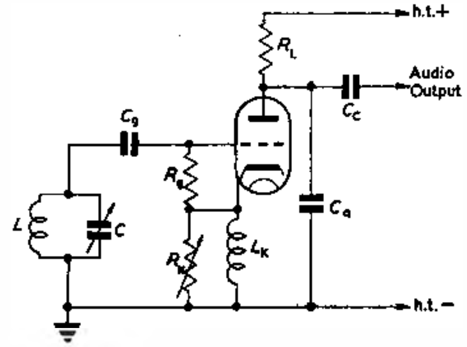


Fig. 2. Hopkin's circuit

of an oscillator; for convenience of probe manufacture this is usually of the two terminal type. The amplitude of oscillation should be controllable, low and constant over the whole range of the tuning capacitor. This latter condition implies that some form of feedback control is required. This can be done by amplifying the r.f. output, rectifying it, and using the resultant d.c. signal to control the oscillator gain; this system requires a tuned r.f. amplifier which complicates adjustment.

The other possibility is to use the oscillator as a grid rectifier, as in a grid leak detector, and then amplify the d.c. output before feeding it back; this is the basic idea of the circuit to be discussed.

The basic circuit used was Hopkin's autodyne[2] shown in Fig. 2 which behaves as a cathode-follower at r.f. with an inductive cathode load. This causes a negative resistance to appear across the tuned circuit due to the capacitance between grid and cathode, which allows the tuned circuit to oscillate, the amplitude being controlled by R_k. Some amplitude stabilization occurs due to the grid rectification, but was found to be by no means sufficient.

The modified circuit devised to increase the stabilization is shown in Fig. 3. A d.c. voltage proportional to the r.f. amplitude is derived from the cathode of the oscillator, amplified and fed back to the screen via a cathode-follower to maintain the gain of the d.c. amplifier. This circuit gives a variation across the cathode from 0·05 to 0·055V compared with a variation for Hopkin's circuit from 0·05 to 0·5V over the tuning range. The oscillator has a high a.f. gain and its output is further amplified and 50c/s components filtered out before being applied to the Y plates of an oscilloscope.

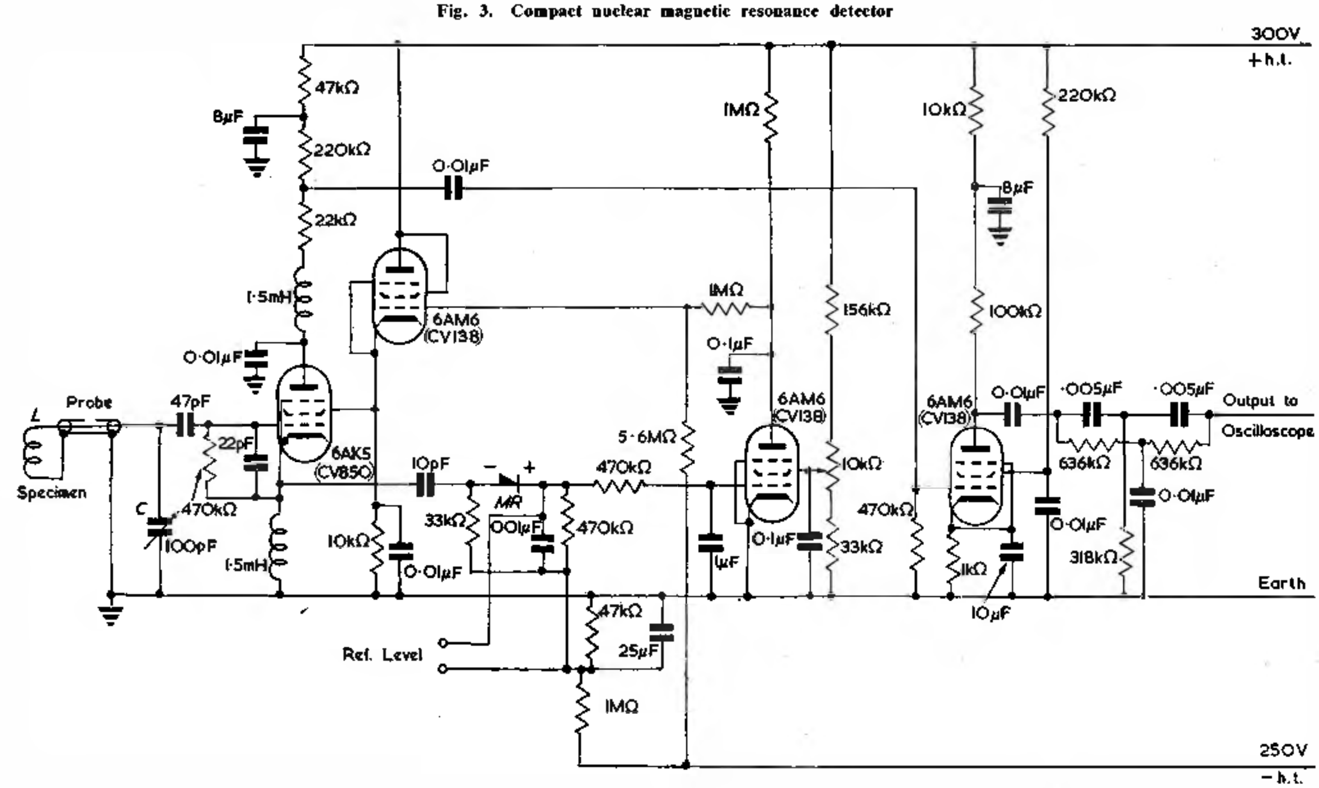
Fig. 4 shows the details of the probe used. The specimen size is kept as small as possible since variation of field strength across it due to field inhomogeneity leads to absorption over a corresponding wide range of frequencies and a reduction in sensitivity. The use of glycerol with its low dielectric loss permits complete immersion of the coil in the specimen resulting in close coupling. The coil shown covers 20 to 50Mc/s which corresponds to about 0·47 to 1·1Wb/m².

This design of probe used in conjunction with the above circuit was found to give a marked improvement in signal-to-noise ratio compared with other methods tried.

Operation

To carry out a measurement the following steps are

Fig. 3. Compact nuclear magnetic resonance detector



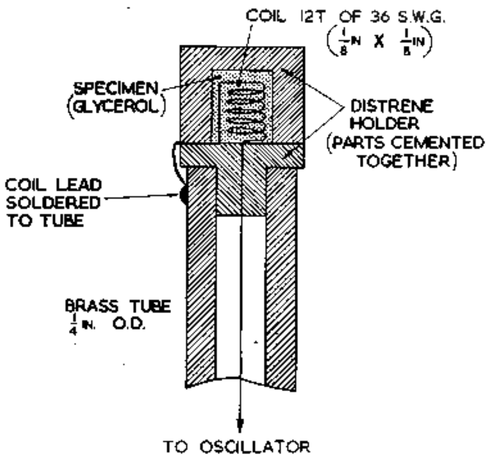


Fig. 4. Typical probe design

necessary:

(1) The modulation amplitude is set to 5 to 50 × 10^{-5}Wb/m² at 50c/s.

(2) The oscillator is set to give 0·03 to 0·05V at reference level (Fig. 3).

(3) The oscilloscope is set to sweep at 100c/s.

(4) The tuning is swung throughout the range, the pulses are located and set to coincidence.

(5) The frequency ν is measured, and the field strength is given by

$$B = (\nu/42{\cdot}577)\ \mathrm{Wb/m^2}$$

Acknowledgment

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A Sensing System for Punched Cards or Continuous Punched Foil

By S. Morleigh, A.M.I.E.E., A.M.Brit. I.R.E.

Traditional methods of supplying input information to digital computers generally employ either mechanical or electrical elements for sensing data. This is usually presented in the form of holes punched in particular positions corresponding to rows and columns of the input medium. In addition to being complicated and expensive these methods suffer from other disadvantages, and are relatively slow in operation.

A description is given of an alternative system, employing a method of capacitive sensing, by which any column of a punched card can be represented as two distinct arms, say C_1 and C_2 of a simple type of capacitance bridge. Hence the position of any punched hole can be readily identified by particular output potentials corresponding to the values of these capacitors. Further applications of this device could lead to the possible replacement of some existing punched card installations by continuous tape or foil.

(Voir page 184 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 189)

INPUT systems extensively used at present are mainly those in which punched cards, having up to 80 independent columns each with 12 possible hole positions, or continuous paper tape with 5 hole positions per column, are employed. For many clerical and scientific applications the punched card has certain advantages over tape, due mainly to the greater ease with which specified items of information can be located.

The device to be described is more applicable to punched card systems, and in these sensing is usually carried out by one or other of two alternative methods. The first utilizes mechanical elements which automatically locate all of the holes punched in any card, and operate various relays in the encoding system, thus enabling the input information to be translated into data usable in the computer. This method has the disadvantages inherent in any complicated mechanical system, particularly in view of the 960 elements necessary for sensing an 80 column card. The second system relies upon electrical contacts made by brushes, through the punched holes. The number of brushes required is dependent upon either the number of card rows or columns according to the method of card feed adopted, i.e., broadside or endwise. All difficulties associated with electrical contact, such as dust, dirt and card fluff, are here encountered. An alternative method which is becoming increasingly employed is photo-electric sensing by means of light projected through the punched holes, but this method is expensive due to the cost and complexity of the necessary optical system, including the photocells and the associated amplifiers.

The proposed device, which would be mainly applicable to cards fed endwise, utilizes a method of capacitive sensing. Each card column during its passage under the sensing elements would have the appearance of two arms of a ratio detector or an elementary type of capacitance bridge. The relative values of these capacitors would vary over a range of discrete steps corresponding to the different hole positions. Sensing by this means would be fast, simple and economical in equipment, although the modifications necessary to the card would make this item a little more expensive.

An Examination of Capacitive Sensing

The dielectric constant of standard card material is approximately 2. From this it can be shown that a capacitor using this dielectric and having an area equivalent to that of a punched hole would have a value of about 2pF, which is about twice the value as with an air dielectric. Hence, although it is theoretically possible to detect the presence of a hole punched in a standard card by examining the capacitance of each possible hole position, the results would be unreliable due to stray capacitance. Also a large number of sensing elements would be needed. The contemplated system would give greater reliability using fewer sensing elements, although some modifications to the existing types of card are essential.

Consider a card formed of a dielectric sandwiched between a metallic surface and parallel strips of a conducting medium. The card would be similar in width to those now in use, while the width of each conducting strip would be slightly less than that of a punched hole. Positioning of these strips on the card would be such as to correspond to

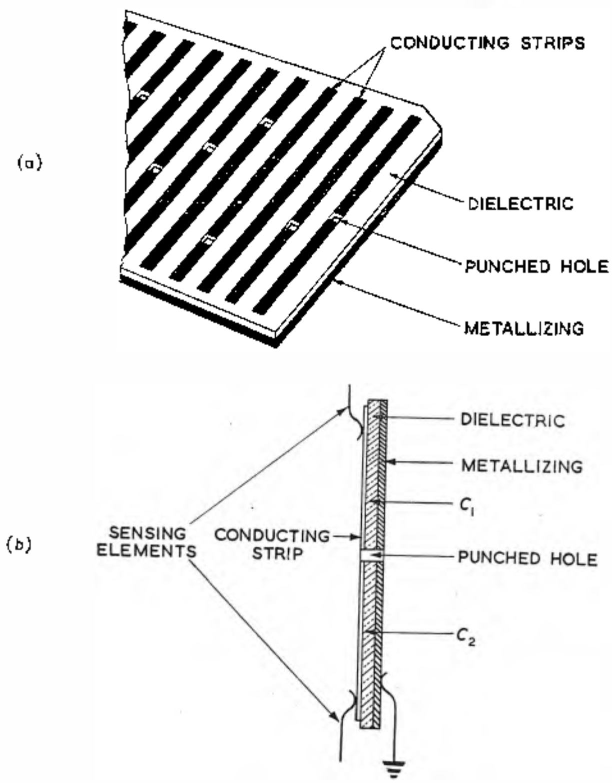


Fig. 1. Dielectric card showing capacitive columns broken by a hole thus forming arms C_1 and C_2 of the capacitance bridge

(For simplicity only a single curtate has been represented)

(a) Proposed dielectric card or foil
(b) Section through a punched hole

the column positions of a standard card. For the purposes of coding information the 12 hole positions on a card column are regarded as comprising two independent sections, i.e. that containing positions 1 to 9, and that containing positions 10, 11, 12. These are called the lower and upper curtates respectively, and in the proposed type of card they would be separated by a narrow groove in the conducting material cut parallel with the card edge.

Now consider a single curtate. Each column would have a specific value of capacitance which would be divided into two distinct components by any hole punched in the card. If there were two sensing stations, contacting the column at its extremities, then different values of capacitance would be measured at these points according to the position of any hole (assuming no more than one hole punched per column). Therefore, if the two capacitors so formed, say C_1 and C_2, are used as separate arms of a bridge network, an output dependent upon their particular values can be obtained. Thus the position of any card hole can be clearly defined by a particular output level. These output potentials can without great difficulty, be used to operate encoding circuits to convert the original decimal or other information into binary form. There will be a high order of discrimination between the presence or absence of information in any particular column, and this may be readily used for the automatic recording of zeros.

It appears reasonable to suppose that variations in dielectric thickness are more likely to take place along the length, rather than the width, of the card. Variations in capacitance between the individual columns of a card need not affect the sensitivity of this unit as, if the measurements are carried out by means of a ratio detector, a definite reference value for purposes of discrimination is not necessary. Variations of up to about 3 per cent in capacitance along individual columns, due to possible changes in strip width and dielectric thickness can probably be tolerated.

Additional Application

This principle could also be applied to mark sensing, a system by which information is first written on cards manually and then automatically punched. The mark could be made by means of a pointed instrument in order to interrupt the column strip at any particular position. This position could then be easily identified by the ratio detector, and the process of punching would be eliminated.

Possible Modifications Required for Existing Computers

If cards are fed endwise then only 4 sensing stations would be required, i.e. 2 per curtate. This could result in a considerable reduction in the cost of sensing, and in less mechanical trouble.

Card material could be supplied in rolls, and could be easily cut to the size required for specific applications. This would remove any restrictions imposed by the card feed on the size of card (i.e. the number of columns) to be used for particular purposes. A continuous length of card or metallic foil, analogous to punched tape, could also be used if desired.

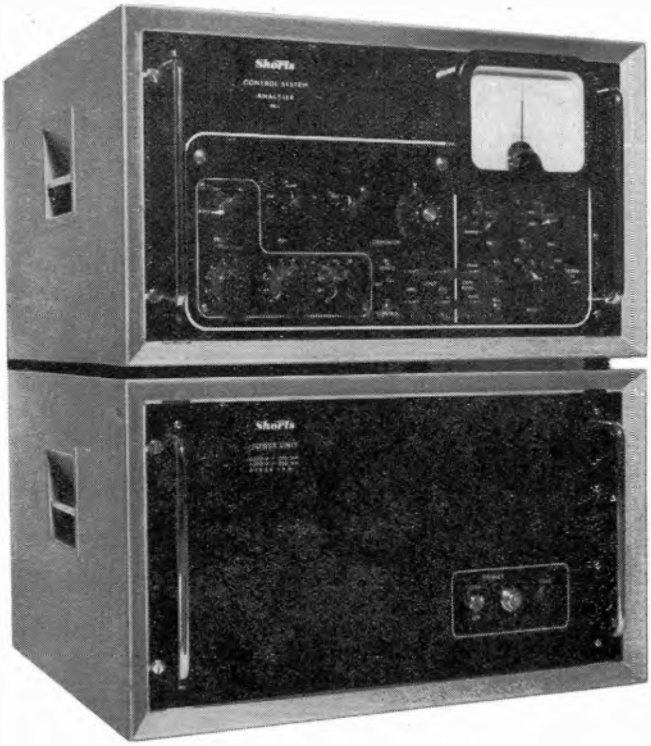
The existing method of card punching could be used with this system, but the method can be simplified. The capacitive strip representing a card column can be interrupted by a slot instead of a hole, and this need not penetrate the dielectric. Alternatively, the hole or slot could be cut by means of an h.f. spark.

Card Material

It is possible to increase the dielectric properties of standard card material by some sort of impregnation, but this would produce a greasy surface which could not easily be coated with a conducting medium, and would in any case be difficult to handle. One method of producing the proposed type of card would be to use copper sheet, of say 0·003in or 0·004in thickness, as a base, and to coat this with a layer of high-K dielectric, which need be only 0·0005in or so thick. This surface could then itself be coated with thin conducting strips. The capacitance per column could thus be made considerably higher than that obtainable with standard card material. An alternative method would be to use a suitable dielectric as a base and to spray this with metallic paint.

Conclusions

This method of sensing should certainly repay further investigation. Card feed and punching systems can be simplified. Sensing would become considerably simpler and more economical, although cards would prove more expensive than those now in use. A careful examination of the relative costs of complete installations in addition to the cost of cards would be of great assistance in the evaluation of this system.



Measurement of Phase and Amplitude at Low Frequencies

By R. J. A. Paul*, B.Sc., A.M.I.E.E., A.I.Mech.E., and M. H. McFadden†, B.Sc.

A description is given of a low frequency oscillator and phase measuring equipment. The frequency range of both pieces of equipment can be extended to below 0·01c/s and to above 10kc/s. The main application of the combined apparatus is the testing of feedback control systems under open and closed loop conditions. Two methods of phase measurement are outlined based essentially on the use of analogue computing amplifiers. The theory of operation is given and some performance figures are included.

(Voir page 185 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 190)

IN stability investigations of a feedback control system a common method is to plot the response curve of the open loop system or components of the system to a steady state sinusoidal input. Such a curve, frequently referred to as a Nyquist plot is obtained by applying a sinusoidal voltage at a controlled amplitude and frequency to the input of the system and measuring the amplitude and phase of the output voltage with respect to input voltage.

The feedback control system will, in some cases, introduce distortion due to saturation and other non-linear effects and to deal with these cases the measuring equipment should be capable of accepting only the fundamental frequency and ignoring the harmonics resulting from the distortion as well as any more products which may be present.

In many applications the behaviour of the system at very low frequencies approaching zero frequency is of importance and thus the oscillator and measurement equipment should have a lower limit of frequency or the order of 0·01c/s. The oscillator should moreover produce its sinusoidal output with the minimum uni-directional error level and harmonic distortion. The design of an oscillator and measuring equipment to fulfil these requirements is outlined.

Basic Equipment

General Review

A block diagram of the basic equipment is shown in Fig. 1.

The output from the oscillator is connected to the input of the system or component under test. This output is also connected as a reference source, to the measuring equipment whose purpose is to measure the amplitude and phase of the output of the system with respect to the input voltage to the system. A cathode-ray tube display unit may also be incorporated for monitoring waveforms or alternatively to display the actual Nyquist plot.

In using the apparatus the output voltage of the oscillator should be maintained at a constant level, the actual magnitude of which is determined by the characteristics of the system under test. In particular, care should be taken that the system does not saturate due to the presence of excessive input signal. In so-called linear systems, however, there is usually some non-linearities present in addition to noise sources such as finite potentiometer wire resolution or commutator ripple. Thus the output signal will, in some cases, suffer from noise and distortion. The measuring equipment should discriminate against these sources of errors. There are instruments available which meet these requirements but their lowest frequency of operation is limited to 1c/s. Below this frequency readings become difficult because of insufficient time-constant in the meter circuits to achieve adequate smoothing. Another important feature of such apparatus is that the oscillator should have a minimum value of uni-directional error (i.e. d.c. content) since many systems under open loop conditions contain one or more integral terms. The presence of these terms cause the integration of the d.c. component with respect to time so the amplitude of d.c. content should be less than that which when integrated over the period of measurement would result in operating the system over a different part of its characteristic or in the extreme, under saturation conditions. The oscillator waveform in addition must obviously have minimum distortion.

The display of the measured output should preferably be directly in the form of amplitude and phase with respect to the input signal or alternatively in the form of a direct Nyquist plot. The design and description of the oscillator and measuring equipment will be now outlined in more detail.

The Oscillator

The basic circuit from which the oscillator is derived is shown in Fig. 2(a). The units 1, 2 and 3 are high gain d.c.

The above photograph shows the Short control system analyzer.

* Formerly Short Brothers and Harland Ltd., now College of Aeronautics, Cranfield.
† Short Brothers and Harland Ltd.

amplifiers with feedback such that unit 1 is an adder, producing an output voltage equal to the sum of the inputs and units 2 and 3 are integrators each producing an output equal to $1/CR$ times the integral of the input. If the output voltage of unit 3 is assumed to be V_o then the output of unit 2 must be $-CR\ (dV_o/dt)$ (negative because each unit also produces a sign change) and the output of unit 1 must be $(CR)^2\ (d^2V_o/dt^2)$. But since the output of unit 1 is the sum of its inputs:

$$(CR)^2\ (d^2V_o/dt^2) = -(V_o + V)$$

or

$$(CR)^2\ (d^2V_o/dt^2) + V_o = -V$$

The circuit is in fact solving this equation.

A similar equation can be written for the LC circuit with no losses shown in Fig. 2(b).

$$LC\ (d^2V_o/dt^2) + V_o = V$$

So this can be regarded as an analogous circuit. If a step voltage is applied to either circuit the output voltage V_o

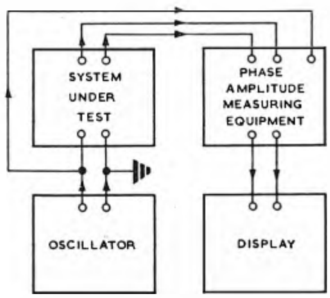


Fig. 1. The basic equipment used in frequency response testing

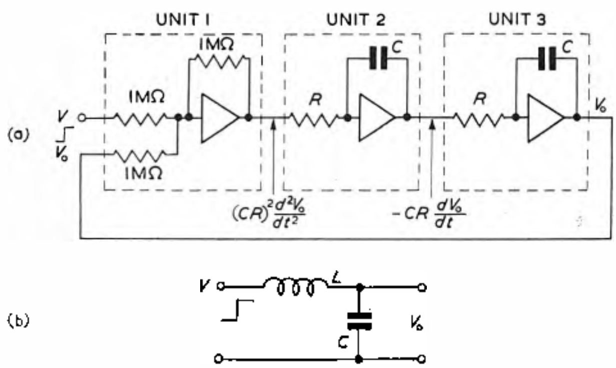


Fig 2(a). Basic oscillator circuit
(b) Analogous LC circuit

in both cases is an undamped sinusoidal waveform whose peak amplitude is the amplitude of the applied step voltage as shown in Appendix 1. Appendix 1 also shows that the frequency of oscillation in the circuit in Fig. 2(a) is $f = (1/2\pi RC)$ (similarly the resonant frequency of the circuit in Fig. 2(b) is $f = (2\pi LC)$).

With the feedback components shown and with equal time-constants in the two integrators the peak amplitude of voltage from units 1 and 2 are both equal to V (the amplitude of the input step). The outputs of units 1 and 2 are true cosine and sine waves respectively (i.e. when the step voltage is applied the output from unit 2 starts from zero and the output from unit 1 starts from a peak value. The oscillator output is taken from unit 2 and a 90° displaced output is also available from unit 1. This basic circuit is well known especially to users of analogue computers and it has been employed in wide range oscillators[1].

Because of various inevitable imperfections in the units in Fig. 2(a) it is not possible to generate a sine wave which is completely free from damping. The finite bandwidth and gain of the amplifiers, leakage and absorption effects in the integration capacitors and stray capacitance across the resistors give rise to phase-angle errors in the loop and it can be shown[2,3,4] that such phase errors introduce an unwanted damping term into the equation. The damping term may be positive, caused by a leading phase-angle error and resulting in an exponentially decaying oscillation or may be negative caused by a lagging phase-angle error and resulting in an exponentially increasing amplitude of oscil-

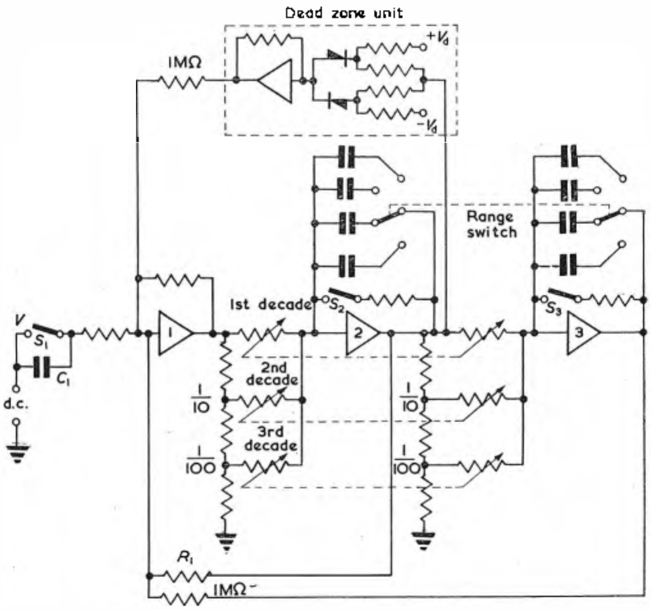


Fig. 3. The oscillator

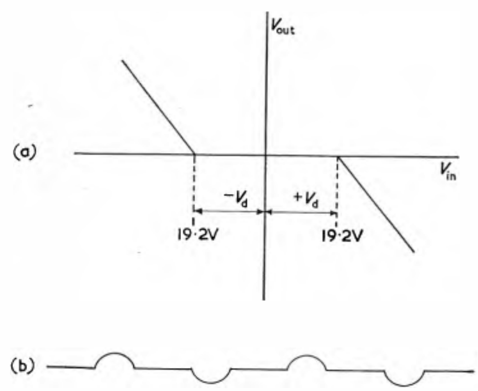


Fig. 4(a) Gain characteristics of the 'dead zone' unit
(b) Typical output waveform of the 'dead zone' unit

lation. It is necessary therefore to include in the circuit, some automatic means of maintaining constant amplitude. The method used to achieve this is shown in Fig. 3. First some negative damping is purposely applied by the feedback resistor R_1 which is just sufficient to ensure that at any frequency over the range the amplitude tends to increase. A positive damping connexion is then made through the 'dead zone' unit. The 'dead zone' unit has the gain characteristics shown in Fig. 4(a) and the dead zone voltages V_d are adjusted to be just less than the input step voltage. This unit produces an output, and very severe positive damping, only when its input voltage exceeds the dead zone voltage and a typical output is shown in Fig. 4(b). The action of the circuit is more easily understood and analysis simplified if the waveform in Fig. 4(b) is broken down into its harmonic components. Consider it to be composed of a fundamental $k_1V \sin \omega t$ and harmonics $k_3V \sin 3\omega t$, $k_5V \sin 5\omega t$ etc., where $V \sin \omega t$ is the output of unit 2. The function of the 'dead zone' unit therefore is to introduce a positive damping term $k_1CR\,(dV_o/dt)$ into the equation in Appendix 1 to offset the negative damping introduced by the resistor R_1. The third, fifth, etc. harmonics can be added in with the step voltage to calculate the distortion which they cause. The amplitude of oscillation V increases because of the negative damping until k_1 increases to a magnitude which brings the total circuit damping to zero.

The amplitude of the n^{th} harmonic of the waveform shown in Fig. 4(b) is k_nV and

$$k_n = (1/\pi)\left[\frac{2 \sin (n-1)\phi}{n(n-1)} - \frac{2 \sin (n+1)\phi}{n(n+1)}\right]$$

where $\phi = \cos^{-1}(V_d/V)$.

Fig. 5 shows k_1, k_3 and k_5 plotted against V. The circuit has been operated very satisfactorily with $V = 1{\cdot}04\,V_d$ by adjustment of the negative damping resistor R_1. Under these conditions $k_1 = 0{\cdot}01$. If the inherent circuit damping changes, due to changes in stray capacitances or any of the other factors which influence damping, by say 20 per cent the output amplitude V will increase or decrease to bring about a new state of damping equilibrium. Reference to Fig. 5 will show that k_1 increases by 20 per cent (from 0·01 to 0·012) for an increase in V from $1{\cdot}04\,V_d$ to $1{\cdot}047\,V_d$ which is less than 1 per cent. The control on amplitude is therefore very rigid and could be made even more rigid by increasing the gain of the 'dead zone' unit.

The amplitude of third and fifth harmonics according to Fig. 5 are each approximately 0·008V and applying this figure to the expression in Appendix 2 which gives the circuit gain with respect to harmonics, it may be shown that the third harmonic output from unit 2 is approximately 0·3 per cent and the fifth harmonic is less than 0·2 per cent. A distortion measurement carried out on the oscillator indicates that the total harmonic distortion is less than 0·5 per cent.

Appendix 3 shows that the d.c. component present in the output from unit 2 is equal to the grid referred zero error voltage of unit 3 and with the continuously drift corrected amplifiers used[5] this is less than 50μV over a period of one hour.

The oscillator covers a frequency range of 0·01 to 110c/s and the frequency is adjusted with three decade switches. The integrator time-constant (CR) required for a frequency of 0·01c/s is $CR = (1/2\pi f) = 15{\cdot}9$sec and a 2MΩ resistor and an 8μF capacitor achieves this to within 1 per cent. It is necessary to arrange the first decade switch so that a number of 2MΩ resistors, corresponding to the numbered switch position are effectively connected in parallel. Thus on position 7 for example, the required resistance is (2/7)MΩ giving a time-constant of 2·28sec and the indicated frequency of 0·07 c/s. The switch arrangement is shown in Fig. 6. In the second and third decades 20MΩ and 200MΩ resistors respectively require to be connected in parallel in similar fashion to the first decade. To avoid the use of these high valued and less reliable resistors the potentiometer arrangement shown in Fig. 3 is used at the outputs of units 1 and 2. The voltages applied to the second and third decades are one-tenth and one-hundredth respectively of that applied to the first decade. All three switches are then similar to Fig. 6. Four frequency ranges are provided by selecting four values of C (8, 0·8, 0·08 and 0·008μF) with the range switch.

The two integrators are fitted with clamping relays to discharge the capacitors when the oscillator is stopped and to ensure that their outputs start from zero when oscillation is re-started. To avoid an abrupt cessation of oscillation when the oscillator is stopped, high valued resistors (of the order of 1MΩ) are connected in series with these relays. This causes the oscillator to stop with the amplitude decaying exponentially. The unit under test is therefore not subjected to damaging transients. A capacitor C_1 is connected

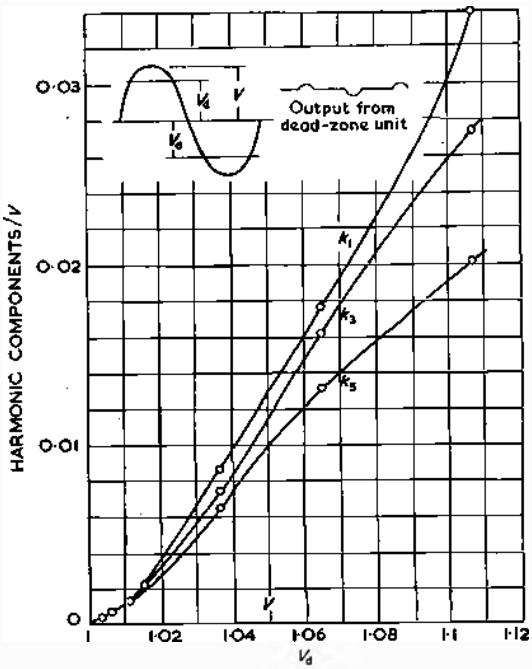


Fig. 5. Plot showing harmonic content of 'dead zone' unit output voltage

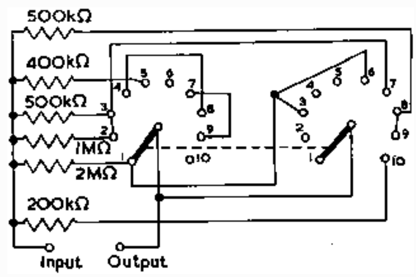
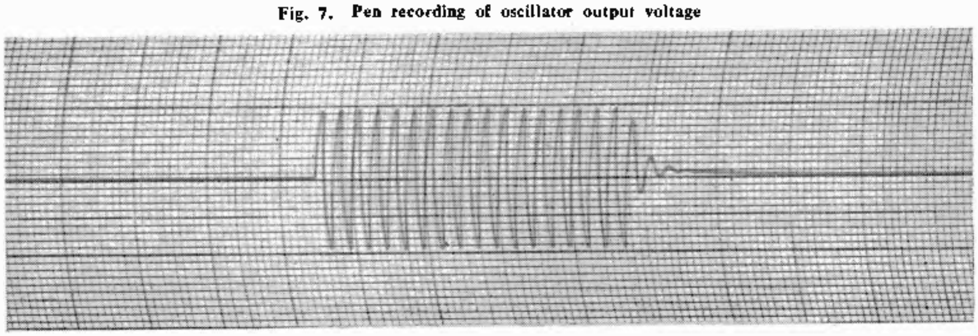


Fig. 6. Decade switch arrangement

Fig. 7. Pen recording of oscillator output voltage



in the step input circuit to avoid transients caused by sudden removal of the step. Fig. 7 is a pen recording of the oscillator output showing the sine wave starting from zero and decaying exponentially after switch off.

The peak amplitude is 20V (the amplitude of the input step voltage) and the dead zone voltages are set at + and −19·2V.

The oscillator is started by operating a front panel switch which unclamps the integrators (i.e. opens S_2 and S_3) and applies the step voltage (i.e. closes S_1) and the amplitude of oscillator output voltage is adjusted by a calibrated potentiometer or switched attenuator connected at the output of unit 2.

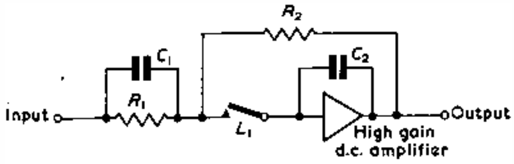
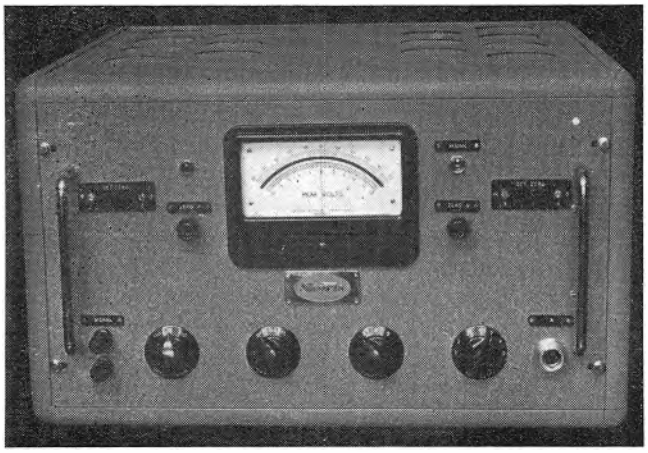


Fig. 8. Basic sampling circuit



Phase indicating voltmeter (scheme A)

Amplitude and Phase Measurement

Two schemes for amplitude and phase measurement are described which will resolve a voltage under test into two components, one in phase with the reference voltage and the other in quadrature. To obtain satisfactory operation at the very low frequencies, which are not adequately catered for by commercially available instruments, these two components are presented to the meters as d.c. voltages.

Scheme A

The 'in phase' component of a sinusoidal waveform is its instantaneous amplitude at the instant when the reference voltage is at a positive peak, and the 'quadrature' component is its instantaneous amplitude at the instant when the reference voltage passes through zero, from negative to positive. The circuit used to measure these instantaneous voltages is shown in Fig. 8. This is a high gain amplifier with feedback components C_1, C_2, R_1 and R_2 and a relay L_1. When the relay is closed and if $C_1 = C_2$ and $R_1 = R_2$ the unit acts as a simple sign reverser with unity gain since the output to grid and input to grid impedances are equal and the gain of such a circuit is the ratio of these two impedances. When L_1 opens the capacitor C_2 will retain the charge across it and the output voltage of the amplifier will be a d.c. voltage equal to that existing at the instant when L_1 opened.

A phase indicating voltmeter using two of the sampling circuits described is shown in Fig. 9. The sampling circuits are preceded by a feedback amplifier with switched gains of 1, 10 and 100 so that a fairly large range of

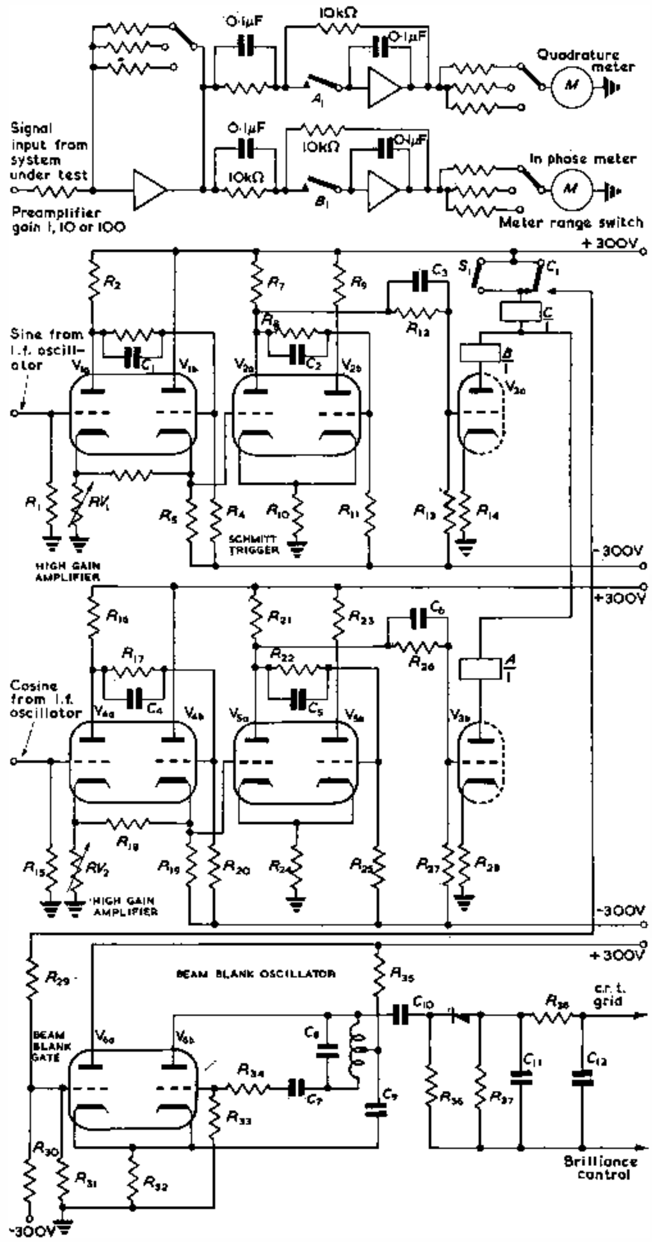


Fig. 9. Phase indicating voltmeter using sampling circuit

input voltages may be handled. Relay A in the 'quadrature' sampling circuit is operated each time the reference voltage passes through zero (i.e. the relay opens when the reference voltages make a positive to negative excursion through zero and closes when a negative to positive excursion is made. Relay B in the 'in phase' sampling circuit operates when the reference voltage reaches a peak, but since it is easier to accurately detect a zero crossing a voltage from the oscillator in quadrature with the reference voltage is used to control this relay.

The signal from the oscillator, which is connected to the input of the system under test, and referred to on

Fig 9 as 'Sine' to distinguish it from the 90° displaced 'Cosine' signal is also connected to the input of the 'quadrature' relay operating circuit.

The signal is amplified by a high gain amplifier V_{1a} and V_{1b} before being applied to the input of a Schmitt trigger circuit V_{2a}, V_{2b}. The variable resistor RV_1 is used to set the voltage at the cathode of V_{1b} (when the input to the relay operating circuit is zero) to the critical triggering voltage of the Schmitt circuit. A very small positive voltage at the input will therefore trigger the Schmitt circuit to the stable state where V_{2a} is conducting and V_{2b} cut off. The anode of V_{2a} is resistance coupled to the relay control valve V_{3a} and when V_{2a} conducts V_{3a} is cut off, de-energizing relay B and causing the contacts to open. A small negative input voltage will return the circuit to the other stable state with V_{2a} cut off, causing relay B to close. It is obvious that if a sinusoidal waveform symmetrical about zero voltage, is connected to the input of the high gain amplifier the relay will operate in the desired fashion. The relay A circuit is similar but this relay operates at the zero crossings of the 'Cosine' output from the oscillator (i.e. the peaks of the reference 'Sine' voltage).

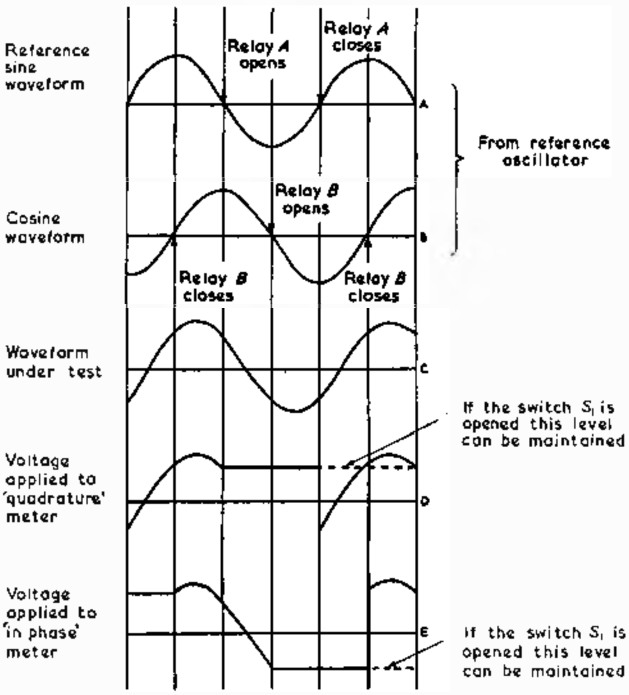


Fig. 10. Waveforms present in the phase indicating voltmeter

The output from the 'in phase' sampling circuit is connected to the X-plate amplifier of a cathode-ray oscilloscope and the output from the 'quadrature' sampling circuit is connected to the Y-plate amplifier. Voltmeters are also connected at the output of each circuit. Thus when both relays are open the spot on the cathode-ray tube is deflected to a point representing the end of the test signal vector. During the time when one or both of the relays are closed the tube must be blanked to avoid displaying a confusing pattern. At low frequencies the blanking must be maintained for a considerable time. At 0·01c/s, for example, the tube is brightened for 25sec and blanked for 75sec. The usual capacitor coupling to the grid (necessary because the grid is −e.h.t.) is not possible because of the large time-constant required and an r.f. oscillator V_{6a}, V_{6b} is used to generate the blanking pulse. Rectification is carried out at e.h.t. potential and a small high voltage capacitor C_{10} couples the r.f. to the rectifier circuit.

The h.t. supply to the relay control valves V_{3a} and V_{3b} is fed through the coil of a third relay, relay C, and the contacts of this relay connect +300V to the relay control valves when energized and to the beam blanking r.f. oscillator circuit when de-energized. When the +300V supply is connected to the beam blanking circuit through resistors R_{29} and R_{30} the valve V_{6b} is cut off because of the large voltage appearing across R_{32} and the r.f. oscillator stops, resulting in spot brightening on the cathode-ray tube. Relay C opens only when both relays A and B are open.

If it is desired to take meter readings of the 'in phase' and 'quadrature' component voltages it is necessary to arrange that when the relays A and B open they will remain open as long as required for the readings. This is achieved

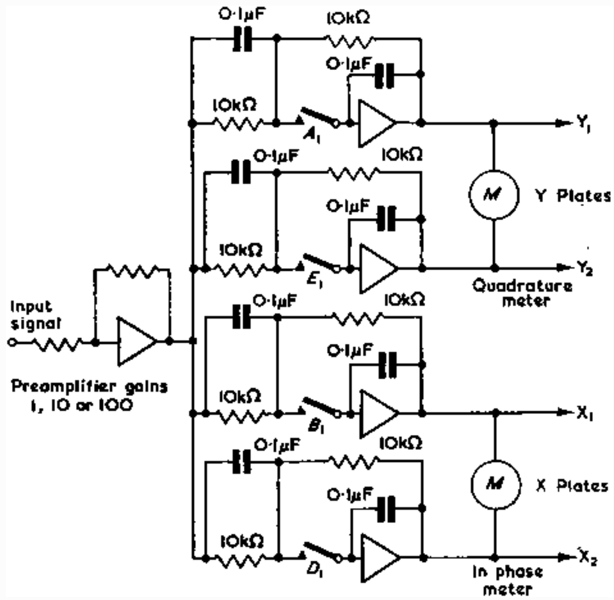


Fig. 11. Phase indicating voltmeter (*Scheme A*) with even harmonic rejection

by connecting a switch S_1 across the contacts of the relay C so that when this relay opens and S_1 has been previously opened the h.t. supply to all three relays is removed and they cannot close again until the h.t. supply is restored by closing S_1. Fig. 10 shows some of the waveforms in the phase indicating voltmeter.

It will be realized that the instrument described does not discriminate against harmonics or d.c. in the waveform under test but merely measures two instantaneous amplitudes of the waveform regardless of its shape. When waveforms other than pure sine waves are to be measured only the amplitude and phase of the fundamental are of importance. A modification to the system shown in Fig. 11 will eliminate d.c. and even harmonics. Two additional sampling circuits using relays D and E are incorporated. The relays A and B operate in the manner already described. Relay E opens 180° (of the reference voltage) after A and samples the waveform 180° displaced from the first sample. If F represents the instantaneous amplitude of the fundamental sampled by relay A and H_0, H_{2n} and H_{2n-1} represents the instantaneous amplitudes of the d.c. component, even harmonics and odd harmonics respectively ($n = 1$, 2, 3, etc.), the voltage sampled by relay A is $F + H_0 + H_{2n} + H_{2n-1}$. The voltage sampled by relay E is $-F + H_0 - H_{2n-1} + H_{2n}$ since at 180° the fundamental changes sign (being displaced by $(2n-1)\pi$) but the sign of the d.c. component and even harmonics (displaced by $2n\pi$) remains the same. If the outputs of the two sampling circuits are subtracted and halved the resulting voltage read on the quadrature meter is $F + H_{2n-1}$ (i.e. the instantaneous amplitude of the fundamental and odd harmonics). A voltmeter connected across the two outputs will read the required voltage difference. The 'in phase' sampling circuits with their associated relays B and D operate in a similar fashion. The relay operating circuit shown in Fig. 9 requires two additional relay control valves similar to V_{3a} and V_{3b} for the relays D and E. These two extra valves have their grids resistance coupled to the anodes of V_{2b} and V_{5b}. The h.t. supply to all four relays is now connected through the coil and one set of contacts of relay C. The switch S_1 must be opened to obtain an oscilloscope display since otherwise with the four relays there is never a time when all four relays are open. Fig. 12 is a multiple exposure of several points displayed on a cathode-ray tube at various spot frequencies. The top display is the response of a simple RC lag circuit showing the familiar semi-circular locus, and the bottom display is the response of two such circuits in cascade. The axes are traced by applying an a.c. signal first to the Y-plates with the X-plates earthed and then to the X-plates with the Y-plates earthed.

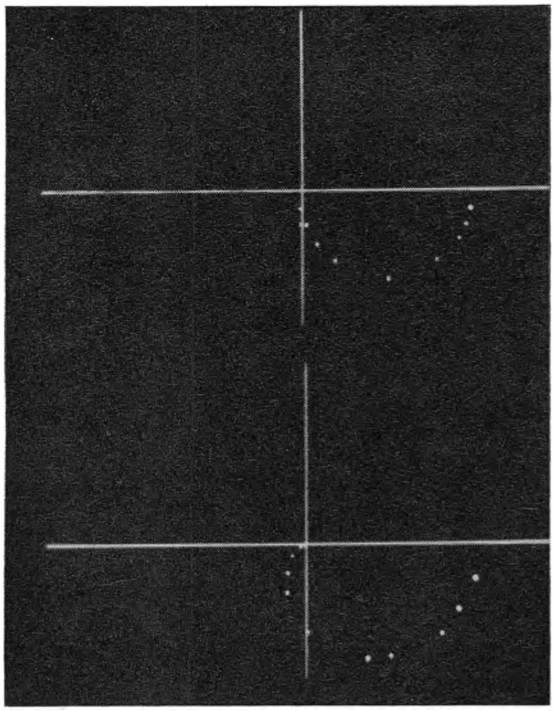


Fig. 12. Multiple exposure of points obtained on a cathode-ray tube
Top—Simple RC lag circuit
Bottom—Two cascade RC lag circuits

The five amplifiers used in the unit are continuously drift corrected d.c. amplifiers[2]. The main d.c. amplifier has a gain of 10 000 and the chopper drift correcting amplifier has a gain of 1 000. The grid referred zero error is less than $50\mu V$.

Scheme B

In general the output voltage from a system under test can be expressed in the Fourier form for a complex periodic waveform

$$V_o = \sum_{n=1}^{n=\infty} A_n \sin\,(n\omega t + \phi_n)$$

where ϕ_n is the phase shift.

If V_o is multiplied by $\sin \omega t$

$$\sin \omega t \,.\, V_o = \tfrac{1}{2}\sum_{n=1}^{n=\infty}\Big\{A_n \cos\,[(n-1)\,\omega t + \phi_n] - A_n \cos\,[(n+1)\,\omega t + \phi_n]$$

This expression consists of a d.c. component (or average value) $= \frac{1}{2} A_1 \cos \phi_1$ (which is half of the 'in phase' component of the fundamental) plus a series of cosine harmonic functions. This process can be carried out electronically by applying the system output voltage V_o and a voltage $\sin \omega t$ from the reference oscillator to the input of a multiplier unit.

The multiplier unit may be one of the many types available for analogue computation. The d.c. component of the product $\sin \omega t \,.\, V_o$ can be measured by connecting a low-pass filter and a moving-coil meter at the output of the multiplier unit. At frequencies under 1c/s, however, it becomes impossible to construct a suitable filter and a more elegant method of finding the average amplitude is to integrate the output of the multiplier unit over a period T where

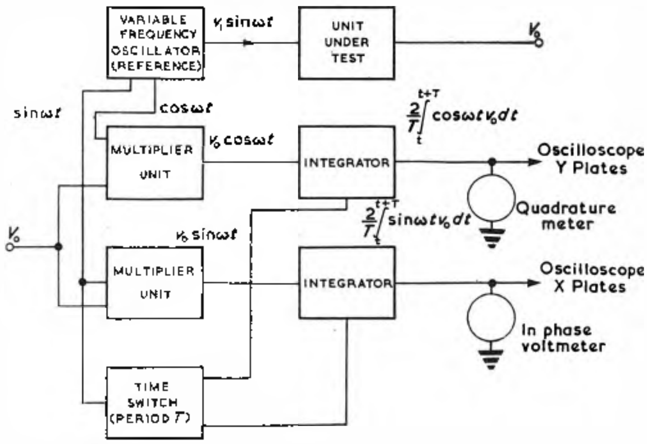


Fig. 13. Phase indicating voltmeter *(Scheme B)*

T is the time period of the reference voltage and divide the result by $T/2$. Thus

$$2/T\int_t^{t+T} \sin \omega t \,.\, V_o\, dt = 1/T \sum_{n=1}^{n=\infty}\int_t^{t+T} A_n \cos\,[(n-1)\omega t + \phi_n] - A_n \cos\,[(n+1)\omega t + \phi_n]\, dt$$

$$= 1/T\sum_{n=2}^{n=\infty}\left\{\frac{A_n \sin\,[(n-1)\omega t + \phi_n]}{(n-1)\omega} - \frac{A_n \sin\,[(n+1)\omega t + \phi_n]}{(n+1)\omega}\right\}_t^{t+T}$$

$$+ \; 1/T\left[\left(A_1 \cos \phi_1)t - \frac{A_1 \sin\,(2\omega t + \phi_1}{2\omega}\right)\right]_t^{t+T}$$

$$= A_1 \cos \phi_1$$

If the integration is stopped after Tsec this 'in-phase component will appear as a d.c. voltage at the output of the integrator and can be displayed on a voltmeter or connected to the X-amplifier of a cathode-ray oscilloscope. A block diagram of the scheme is shown in Fig. 13.

In a similar fashion the 'quadrature' component of the fundamental can be obtained by multiplying V_o by $\cos \omega t$ and integrating to find the average amplitude. The output of the integrator in this case can be connected to the Y-amplifier, of the cathode-ray oscilloscope and with the connexion to the X-amplifier described above a point, representing a point on the Nyquist plot, can be obtained at each frequency.

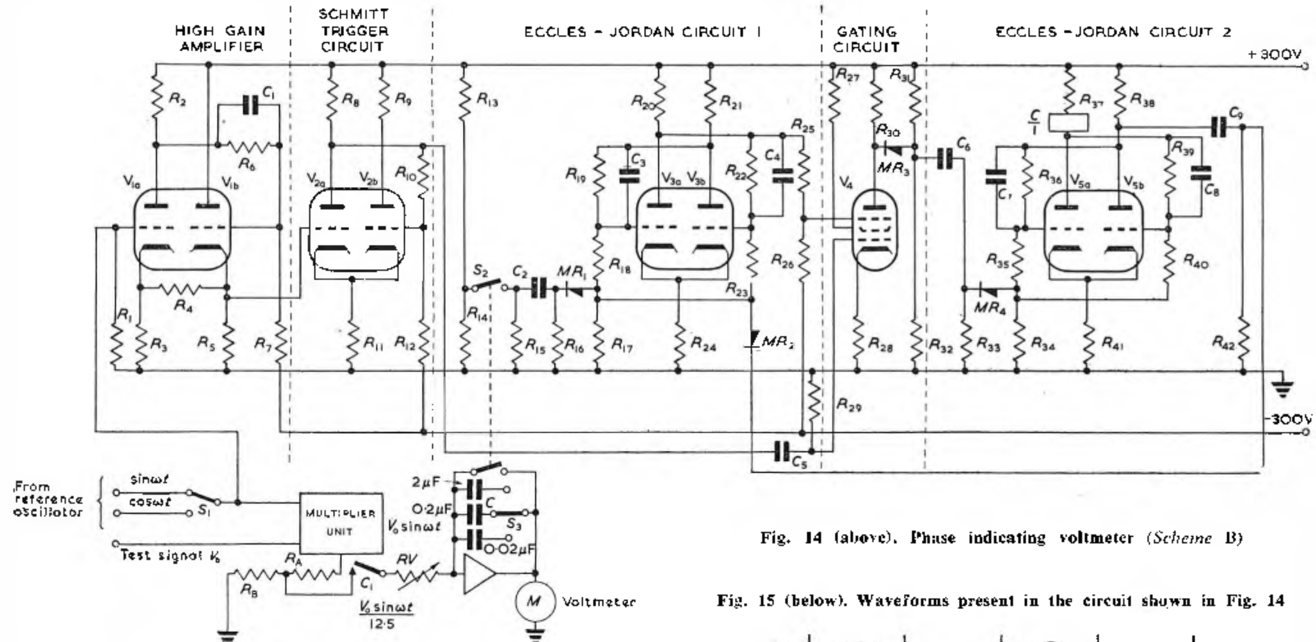
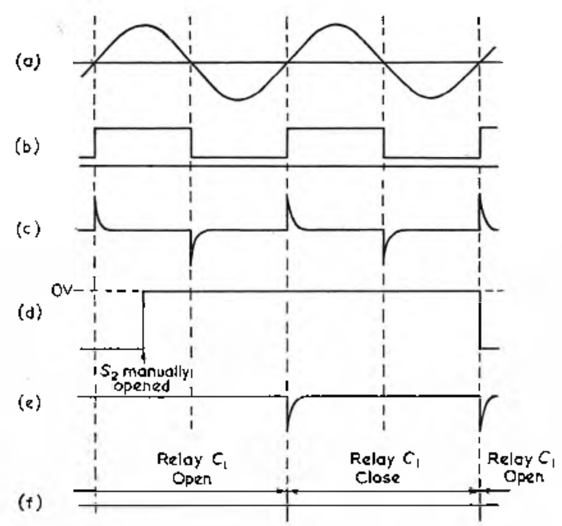


Fig. 14 (above). Phase indicating voltmeter (*Scheme B*)

Fig. 15 (below). Waveforms present in the circuit shown in Fig. 14



A circuit diagram of the phase indicating voltmeter is shown in Fig. 14. To avoid expensive duplication this instrument is designed to measure either of the two components by selecting either a sin ωt or cos ωt voltage from the reference oscillator to apply to the multiplier. This signal is also applied to the relay operating circuit which controls the time of operation of the integrator.

The high gain amplifier and Schmitt trigger produce square waves whose leading and trailing edges are coincident with the zero crossings of the input reference sine wave. The square waves are differentiated by the circuit C_5 and R_{29} producing the waveform shown in Fig. 15(c) which is applied to the control grid of the gated pentode valve V_4. This valve has the suppressor grid held negative, thus cutting the valve off. When S_2 is opened, which is the procedure prior to taking a reading on the phase indicating voltmeter, a negative pulse is applied to the Eccles-Jordan 1 circuit and this circuit is triggered to the other stable state and returns the suppressor grid of V_4 to earth potential. The V_4 suppressor grid waveform is shown in Fig. 15(d). Fig. 15(e) shows the pulses which are passed to the Eccles-Jordan 2 circuit and it will be seen that after S_2 is opened the next positive going pulse at the control grid of V_4 (Fig. 15(c)) is amplified and inverted by V_4 and is passed to V_5. This triggers the Eccles-Jordan 2 circuit to the condition where current flows in the coil of relay C and closes the contact C_1. The second positive going pulse shown in Fig. 15(c) reaches V_5 in the same way and re-opens the relay C. At the same time the negative going pulse which appears at V_{5b} anode is differentiated and fed-back to Eccles-Jordan 1 causing it to revert to its original stable condition and cutting off the gate valve V_4.

The action of the relay operating circuit therefore is to unclamp the integrator and open the gate valve V_4 by manually opening the switch S_2. Then relay C closes and remains closed for one time period of the reference voltage. When it opens at the end of this period the d.c. voltage existing at the output of the integrator is read on a meter and further operations of relay C are prevented (unless S_2 is closed and re-opened) because the gate valve V_4 is cut off.

The multiplier unit used is a quarter square type using selenium diodes in the squaring circuits[3].

The phase indicating voltmeter as described operates with the integration system down to 0·01c/s. Above 5c/s, as already explained, the integrator is switched out of circuit and the meter is connected to the output of the multiplier unit. Under these conditions the instrument will operate up to 5kc/s. With an improved multiplier unit higher frequency operation is obviously possible.

The required output from the integrator is $2/T \int_t^{t+T} \sin \omega t \cdot V_0 dt$ and at the lowest frequency (0·01c/s) the required coefficient of integration is $2/100 = 0{\cdot}02$. The output of the multiplier unit is divided by the low resistance potential divider R_A and R_B to produce a voltage sin ωt $V_0/12{\cdot}5$ at the input to the integrator. The required product of C and R is then 4 and a 2MΩ resistor (RV) and 2μF capacitor (C) are used. The time-constant CR of course requires to be decreased as frequency is increased and this is done by using three decade switches exactly similar to that described for the low frequency oscillator and shown in Fig. 6. Varying RV from 2MΩ to 200kΩ and using a 2μF capacitor covers the frequency range 0·01 to 0·1c/s. Two other capacitors of values 0·2μF and 0·02μF are available on the 'range selector' switch S_3 to cover the ranges 0·1 to 1·0c/s and 1·0 to 10c/s.

Conclusions

The equipment described appears to have several advantages over that now commercially available. In particular, accurate measurements can be carried out at very low frequencies and, since the output of the measuring equipment appears as a d.c. voltage a cathode-ray oscilloscope may be used to obtain a Nyquist plot.

The oscillator has the advantages of a very low d.c. content and the facility for making smooth starts and stops makes the unit attractive for testing delicate mechanisms where 'snatch' must be avoided. The range of both instruments can be extended below 0·01c/s, the limit being placed by the very large time-constants involved. There is much less difficulty at the high frequency end and both pieces of equipment can be made to operate up to at least 10kc/s.

It is obvious that simple modification of the equipment could be carried out so that the amplitude of the oscillator output, and the amplitude of the output voltage from the system under test could be calibrated in decibels. The decibel gain or attenuation of the system could then be given directly, together with the phase for application directly to say a Nichol's chart.

Acknowledgments

The authors wish to thank the Directors of Short Brothers and Harland Ltd. for permission to publish this article. Thanks are also due to those members of the Research Department who gave invaluable assistance in the development of the equipment.

Appendix 1

The prime after the symbols denotes that Laplace transforms are used.

The equation being solved by the circuit in Fig. 2(a) is:

$$(CR)^2 p^2 V_o + V_o = V$$

$V_o' = \dfrac{V}{p[(CR)^2p^2 + 1]}$ if V is a step voltage with the Laplace transform V/p

$$= V\left(1/p - \frac{p}{p^2 + [1/(CR)^2]}\right)$$

$$V_o = V\,(1 - \cos 1/(CR) - t)$$

Output from unit 2 $= -(CR)\,dV_o/dt = -V \sin(t/CR)$

Output from unit 1 $= -(CR)^2\,d^2V_o/dt^2 = V\cos(t/CR)$

Pulsatance $\omega = (1/CR)$

Frequency $f = (1/2\pi CR)$

Appendix 2

The relationship between V_o and V is

$$V'_o = \frac{V'}{(CR)^2\,p^2 + 1}$$

or

$$V_o'/V' = \frac{1}{(CR)^2\,p^2 + 1}$$

For sinusoidal inputs

$$V_o/V = \frac{1}{-(CR)^2\omega^2 + 1}$$

When $\omega = (1/CR)$ the gain is infinite and the circuit can maintain itself in oscillation at this frequency (see Appendix 1). At any other frequency:

$$V_o/V = \frac{1}{-(f/f_o)^2 + 1}$$

where f_o is the frequency of resonance.

Gain to 3rd harmonic (i.e. $(f/f_o) = 3$) is $-\frac{1}{8}$.

Gain to 5th harmonic (i.e. $(f/f_o) = 5$) is $-1/24$.

The gain of each integrator is $1/\omega CR$ which is unity at the resonant frequency, $\frac{1}{3}$ at the third harmonic and $1/5$ at the fifth harmonic.

$\therefore$ The oscillator output (i.e. the output of unit 2) will contain third and fifth harmonics 3 and 5 times, respectively, greater than the output of unit 3.

Appendix 3

Refer to Fig. 16 which shows the basic circuit of the oscillator with amplifier zero errors represented by generators with voltages equal to the grid referred zero errors, connected in series with the input grid.

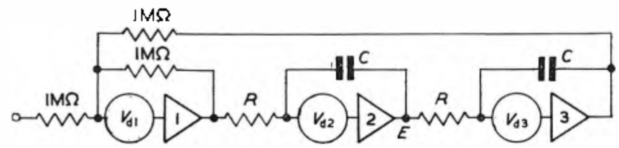


Fig. 16. The basic oscillator circuit showing the effect of amplifier drift

Let E be voltage output from unit 2

E_1 be voltage output from unit 1

E_3 be voltage output from unit 3

Assuming zero input grid current and open loop gain of amplifier

Then $E_1' = E_2' + 3V_{d1}'$

$$E' = -\frac{E_1' + V_{d2}'(1 + pRC)}{pRC}$$

$$E_2' = -\frac{E' + V_{d3}'(1 + pRC)}{pRC}$$

Substituting for E_2' and E_1'

Then

$$E' = V_{d3}'\frac{(1 + pRC)}{1 + p^2R^2C^2} - 3V_{d1}'\frac{pRC}{1 + p^2R^2C^2} + V_{d2}'\frac{pRC(1 + pRC)}{1 + p^2R^2C^2}$$

If zero errors are assumed constant so that $V_d' = (V_d/p)$

Then

$$E' = V_{d3}\frac{(1 + pRC)}{p(1 + p^2R^2C^2)} - 3V_{d1}\frac{RC}{1 + p^2R^2C^2} + V_{d2}\frac{RC(1 + pRC)}{1 + p^2R^2C^2}$$

Thus

$$E(t) = V_{d3}(1 + \sin(t/RC) - \cos(t/RC)) - 3V_{d1}\sin(t/RC) + V_{d2}(\sin(t/RC) + \cos(t/RC))$$

i.e.

$$E(t) = V_{d3} + \sin(t/RC)\,(V_{d3} - 3V_{d1} + V_{d2}) + \cos(t/RC)\,(V_{d2} - V_{d3})$$

The d.c. component is V_{d3}. The second and third terms in the above expression show that an amplitude error and a phase error are introduced but both these effects are small.

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The Electroforming of Waveguide Components

By P. Andrews*, B.Sc.

Certain waveguide components cannot easily be made by normal machining processes and in these cases electroforming is often a useful method. In this article a simple acid-copper electroforming process is described which is suitable for laboratory or small scale production use.

(Voir page 185 pour le résumé en français : Zusammenfassung in deutscher Sprache auf Seite 190)

WHILE most waveguide components are made by normal machine shop processes, such as machining from the solid and fabrication from sheet materials, many components cannot be made easily by these methods. In these circumstances two techniques have proved extremely valuable. They are:

(1) The metal spraying process[1]

(2) Electroforming.

In this article only the latter method will be considered, but it should be pointed out that these two processes are complementary, the former being more convenient where loss is not very important and very difficult shapes are encountered, while the latter is of more use where losses are of paramount importance. In addition closer tolerances can be obtained with electroforming.

When losses are important the material from which the component is made should possess high conductivity. At a frequency of 10kMc/s the skin depth for copper is about 25μin. Thus, if the losses are to be kept within 10 per cent of the theoretical value, the surface roughness should be less than about 5μin. This is readily achieved with electroformed components.

Probably the most important advantage of electroforming and metal spraying is that waveguide components consist of hollow devices with the internal surface dimensions important, and a male former can usually be made to a higher accuracy than the desired finished product.

Reports describing electroforming of waveguide components have usually described the periodic reversal process from a hot cyanide bath. The process described below is simpler and suitable for any laboratory, without any worry from fumes and can also be used for production of components.

The Method

The Acid Copper Solution

The solution used is that given by Canning & Co.[2] and consists of the following:

Pure copper sulphate	32oz or	200g
Aluminium potassium sulphate	2oz or	12g
Pure sulphuric acid	9oz or	56g
	(about 5fl.oz)	(31ml)
Water	to 1 gallon or	1 litre

The copper sulphate (usually in the fine crystal form like fine granulated sugar) and potassium alum are dissolved in warm water and filtered into the plating tank and allowed to cool. Tightly packed glass wool is a suitable filter material; filter papers giving a slow rate of flow. The requisite amount of sulphuric acid is then slowly and carefully poured in as a thin stream, the solution being stirred continuously with a glass rod during the addition. The bath is then made up to working volume with water, and its density checked.

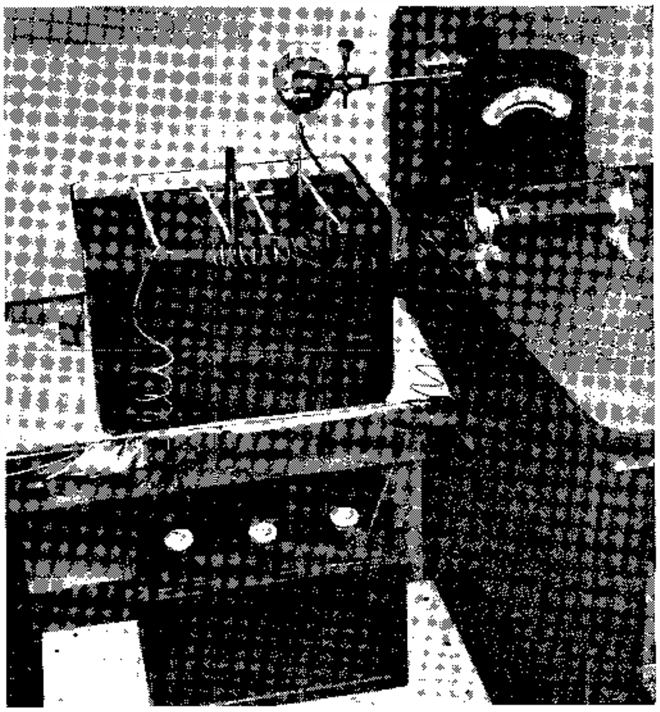

Fig. 1. Experimental plating bath (Polythene cover removed)

Temperature and Electrical Supply

As the bath described was built solely for experimental electroforming of individual items, and as little or no supervision was desired, no attempt was made to plate at

* *Royal Naval Scientific Service.*

high current densities. The bath was, therefore, operated at room temperature which in the buildings concerned was always fairly steady in the region of 60°F.

The electroforming was performed at current densities of the order of $12A/ft^2$ and the interelectrode distance was always made as large as possible, consistent with symmetrical placing of four or more anodes around the mandrel. The interelectrode distance was kept greater than five inches. It is obvious that the interelectrode distance should be as large as practicable so that the electrostatic field distribution can be as uniform and gradual as possible. In this way, clean deposits needing very little machining can be obtained. On occasions when it was desired to reduce the plating time, the current density was increased to about $25A/ft^2$ and very gentle stirring with a small propeller was added.

Circulation of the solution ensures that the copper sulphate, formed during electrolysis by action of the acid on the anodes, is diffused throughout the bath so that the solution remains homogeneous and does not become impoverished in metal at the cathode face. Polarization is thus prevented and a steady rate of deposition maintained.

The electrical energy was supplied by means of 6V car type accumulators. This voltage was dropped and controlled by a rheostat, leaving about 1 to $1\frac{1}{2}$V across the bath.

Rate of Deposition

From the solution used it is usual to assume a deposition rate of 0·0001in for $108A.min/ft^2$. This gives a deposition rate of 0·001in per $1\frac{1}{2}$ hours at $12A/ft^2$. Thus, a component needing $\frac{1}{8}$in of copper deposition requires about 190 hours of plating, i.e. 8 days. It must be remembered, of course, that a component progressively increases its surface area during the electroforming until in 2cm waveguide for instance, the surface area has often increased by 30 per cent before taking into account any nodules and surface irregularities which may have formed. When all these facts have been taken into account, the surface area more than doubles, so that over the eight days the current must be progressively increased. In practice, a graph of approximate surface area increase can be drawn, and the current stepped up each morning to keep the deposition rate approximately constant.

Much higher rates of deposition can be obtained by raising the bath temperature, and by using a cylindrical anode and rotating the mandrel, but this is of more interest for production purposes.

Bath Maintenance

For good quality electroforming, it is essential that the solution should be clean, and of the correct strength. In order to keep the solution clean the bath is covered by Polythene sheeting to eliminate dust. In addition, whenever a new item is to be introduced into the bath, the solution should be filtered to remove any particles which may have got into the solution. These particles, if not removed, help to form centres for the growth of nodules. A more satisfactory procedure is to fit a pump and filter to the bath so that the solution may be continuously filtered. This is highly desirable if many objects are to be made, but not essential for occasional laboratory items.

In addition the composition of the bath should be checked periodically. The copper content of the bath tends to rise with time while the free acid concentration falls. A sample of solution is, therefore, taken every month and titrated against a standard solution of sodium hydroxide to determine the amount of sulphuric acid needed by the bath.

Fig. 1 shows a photograph of the simple bath with Polythene cover removed. A mandrel can be seen suspended in the middle of the bath with four anodes, each about six inches from the mandrel, suspended symmetrically around it. The battery, rheostat and ammeter are also shown, while above the bath can be seen the small motor rotating a small paddle in the solution.

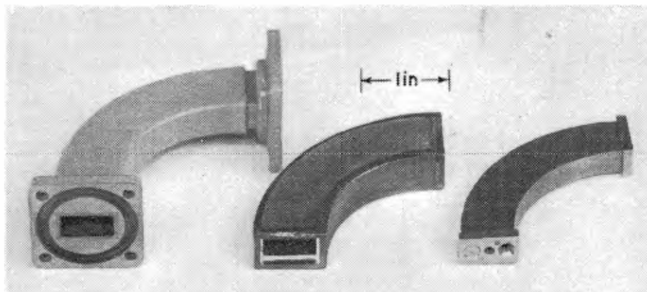

Fig. 2. H-plane waveguide bend and mandrel

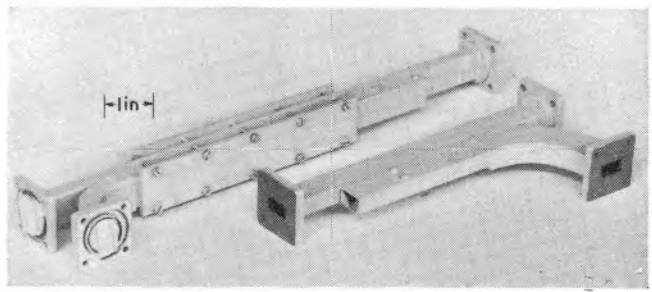

Fig. 3. Directional couplers with electroformed bends

Experience with this type of bath has shown that a certain amount of particle contamination of the bath occurs from impurities in the anodes. It is current practice now, therefore, to completely separate the anodes from the cathode with a filter made up of two sheets of perforated plastic sheeting with glass cloth sandwiched between them. This prevents particles from the anodes reaching the cathode.

Mandrels

The usual material used for mandrels is S80 stainless steel. Several high chromium content steels have been used, the material usually containing about 18 per cent chromium and 8 per cent nickel. The surface is finished to better than 4μin and no taper is needed for extraction although it is an advantage. The copper electroform does not bond to the high chromium content steels; warming and the use of a press being sufficient to remove the mandrel.

Fig. 2 shows a stainless steel mandrel for a 90° H-plane bend in WG18 waveguide (2cm), a bend after removal of the mandrel with the edges cleaned up, and an electroformed bend with flanges fitted and painted. Although the electro deposit is about 1/10in in thickness the outside surface is not excessively rough, and when painted without being machined is not unpleasant in appearance.

Fig. 3 shows directional couplers in WG18 waveguide which incorporate electroformed E-plane and H-plane bends.

Fig. 4 shows two stainless steel mandrels for the rotary vane attenuator shown in Fig. 5. One mandrel is a right circular cylinder, while the other mandrel tapers from a rectangular section to a cylinder of the same diameter. The finished electroform needed two slots, 0·013in wide by 0·015in deep, on opposite diameters to take an attenuating glass vane. These slots were made by electroforming over Bexene inserts which stood proud by the required amount. The use of plastic here helps in the initial throw into the recess by concentrating the electric field. Electroforming into a recess is always difficult, but, by placing the anodes in such a way that the resultant electric field is optimized for the recess, steps can be electroformed satisfactorily at least on a laboratory basis. Fig. 6 shows a mandrel for a stepped transition from one waveguide size to another. Although, unfortunately, this mandrel was made in five pieces instead of one, a satisfactory electroform was made from it and is shown in Fig. 7.

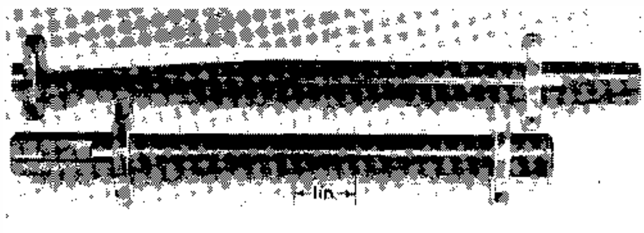

Fig. 4. Mandrels for rotary vane attenuator

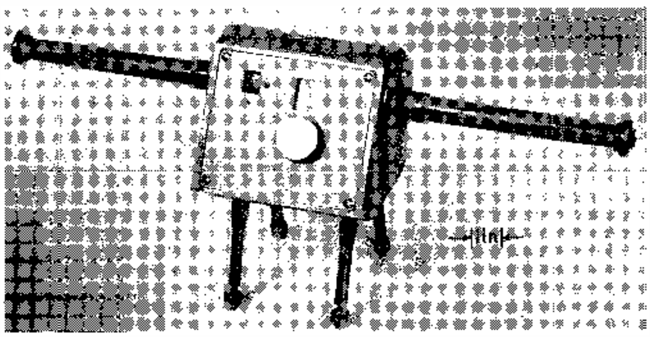

Fig. 5. Rotary vane attenuator

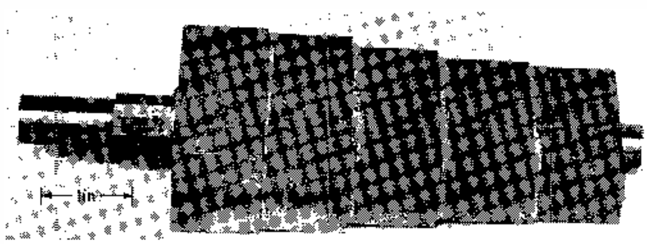

Fig. 6. Mandrel for step transition

Although S80 stainless steel has been the main material for mandrels, since such a mandrel can be used time and time again, disposable Perspex mandrels have also been used, a film of silver first being evaporated on to the Perspex in vacuo to make it conductive.

The Cleaning and Plating

It has already been stated that the bath must be kept spotlessly clean. In addition the mandrel must also be perfectly clean and degreased (e.g. with trichloroethylene) before insertion in the bath. Once the mandrel has been put in the bath it is advisable to plate continuously until finished. A stoppage or removal for inspection may only cause stratification of the deposit.

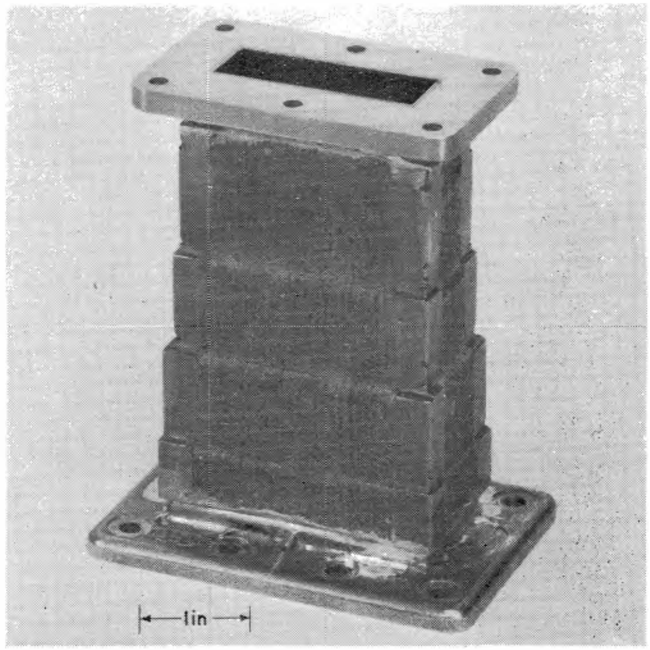

Fig. 7. Electroformed step transition

Conclusions

It has been demonstrated that many waveguide components can be electroformed in a simple acid copper bath. Although the plating speed is only of the order of a thou or so per hour, this is not considered to be a serious disadvantage except for mass production. If care is taken to keep the bath clean and the anodes are well positioned the throwing power is perfectly satisfactory. While the metal only has a hardness of the order of 80 brinell, this has not been found to be a drawback. The most important points to remember are:

(1) Cleanliness, both of mandrel and solution.

(2) Once the mandrel is in the bath the plating should be continuous.

(3) No attempt should be made to hurry the plating by increasing the current unduly.

(4) Whenever the solution has been in use for some while it is advisable to replace it since the concentrations alter with use. All the chemicals concerned are cheap.

Acknowledgments

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A Remotely Tuned Echo Box

The use of high Q resonant cavities in making assessments of the overall performance of pulsed microwave radars is now well established.

In this application the cavity is shock excited by a sample of the transmitter pulse, fed to the cavity via a directional coupler. A typical layout is shown in Fig. 1. If the Q of the cavity is sufficiently high it will continue to 'ring' for an appreciable period after the end of the transmitter pulse. At any given frequency and temperature, and for a fixed magnitude of transmitter pulse sample, the length of 'ring'

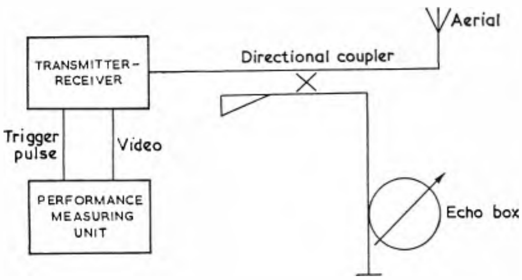


Fig. 1. A typical layout

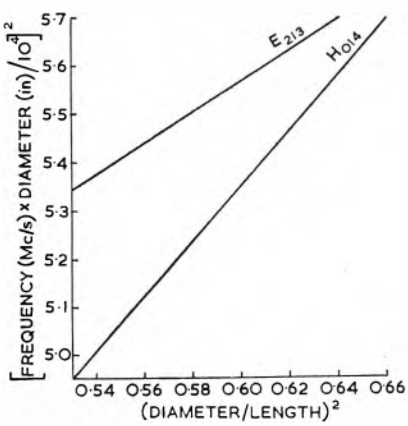


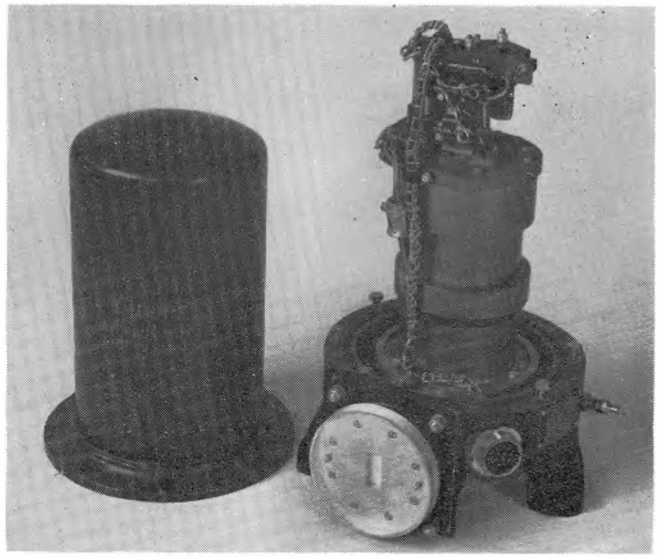
Fig. 2. Mode chart

is proportional to the ratio of peak transmitter power to receiver noise power (i.e. to the overall performance).

Normally the cavity is used with a gated receiver (or performance measuring unit) which measures the signal-to-noise ratio at known periods after the start of the transmitter pulse. From a knowledge of the decrement* of the cavity it is possible to calculate the change in overall performance if the radar to which the cavity is coupled by measuring the day-to-day variations in ring time.

For absolute measurements of the overall performance rather more information about the cavity radar and performance measuring unit is required.

* *8·686 (2π × resonant frequency)/loaded Q factor.*



An echo box for an airborne radar equipment

The illustration above shows an 'echo box' developed by the Applied Electronics Laboratories of the General Electric Co. Ltd. for an airborne radar equipment. It is flown in land and carrier based aircraft achieving near sonic speeds, for which reason it is ruggedly built to withstand the adverse environmental conditions imposed by installation in a high speed aircraft. To avoid deterioration of performance due to the climatic conditions likely to be met anywhere in the world the unit has been sealed and pressurized. Although not hermetically sealed it is capable of maintaining an internal pressure for many months without attention.

This unit is a tuned 'echo box' operating in the H_{014} mode in the X band. It is tunable over 600Mc/s, at a rate of about 150Mc/s/min, and within this range all crossing modes, and all but one interfering mode have been eliminated. The one interfering mode (E_{213}) has a response over 40dB down on the wanted mode. A mode chart is shown in Fig. 2. The working surfaces are copper plated giving an unloaded Q of 50 000. Turning is achieved by a non-contacting plunger remotely controlled and motor driven (in this case by a two-phase 400c/s size 11 servo motor). Limit switches are provided which indicate the ends of the tuning range and which can be used to stop or reverse the servo motor.

So that all units are completely interchangeable a preset, variable attenuator is provided in the waveguide coupling to the 'echo box'. This attenuator is used to standardize all units to give the same ring time on a radar of minimum acceptable overall performance.

A platinum resistance thermometer bulb is embedded in the body of the cavity to indicate the cavity temperature to enable a correction to be applied to the measured ring time when appropriate.

With this particular instrument, used in conjunction with a stable performance measuring unit, measurements of overall performance have been made which were repeatable to within 1dB of the theoretical value.

Acknowledgment is made to the General Electric Co. Ltd, Electronics Division, Coventry, for the information published in the foregoing description.

Measurement of Vibration Amplitudes

By R. A. S. Kay*, B.Sc., A.M.Inst.E.

A technique is described for measurement of the amplitude of vibration produced by vibration generators. Particular reference is made to the calibration of vibration pick-ups. The method may be used within the lower audio-frequency range and is unaffected by variation of waveform. Use is made of stroboscopic equipment in conjunction with mechanical and optical levers.

(Voir page 185 pour le résumé en français:
Zusammenfassung in deutscher Sprache auf Seite 190)

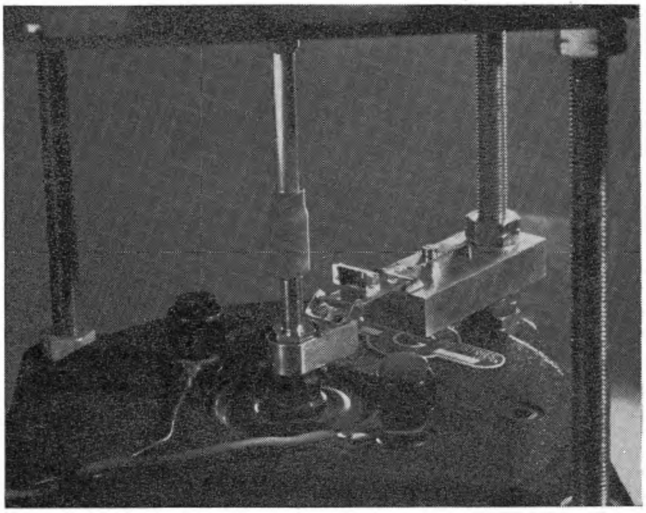


Fig. 1. Arrangement of sensitive strip and mirror on exciter

WHEN a large number of vibration pick-ups had to be calibrated, a comparatively quick and accurate method was required which was both easily reproducible and portable. These requirements were fulfilled in the method described below.

The original apparatus was used in conjunction with an electromagnetic vibration generator. It may be adapted for use with any form of exciter or vibrating mechanism, provided that there is a place on the exciter case or framework to which a clamp may be attached.

When calibrating pick-ups, the seismic types are fixed directly on to the exciter armature, while the non-seismic types are rigidly clamped to the exciter case and a connexion is made between the armature and the sensitive shaft of the pick-up. In the laboratory, there are many applications in which the technique itself may be used as a vibration pick-up.

Instrumentation

A device which has to be clamped on to the exciter is illustrated in Fig. 1. It consists of a rigid metal strip, one end of which is pivoted on a small metal block clamped to the exciter armature. The other end of the strip is attached with a spring-loaded sliding pivot to a second metal block rigidly clamped to the exciter case. A small mirror (surface silvered) is cemented on the strip in such a way that the plane of the mirror is at right-angles to the plane of the strip and to the long side of the strip. As shown in Fig. 1, the mirror is offset to one side of the strip, so that the armature connecting shaft does not interfere with the optical arrangement as described below.

A movement of the armature causes the strip and mirror to rotate. The angle of rotation is measured by arranging a telescope and a large arcuate scale in such a way that the telescope may view a small portion of the scale as reflected by the mirror. This arrangement is sketched in Fig. 2. The telescope is fitted with crosswires so that a reading may be taken off the scale image. As it is undesirable to touch the telescope (for refocusing purposes) during a calibration, the scale is set in position at such a distance that the mirror is at the centre of curvature of the scale.

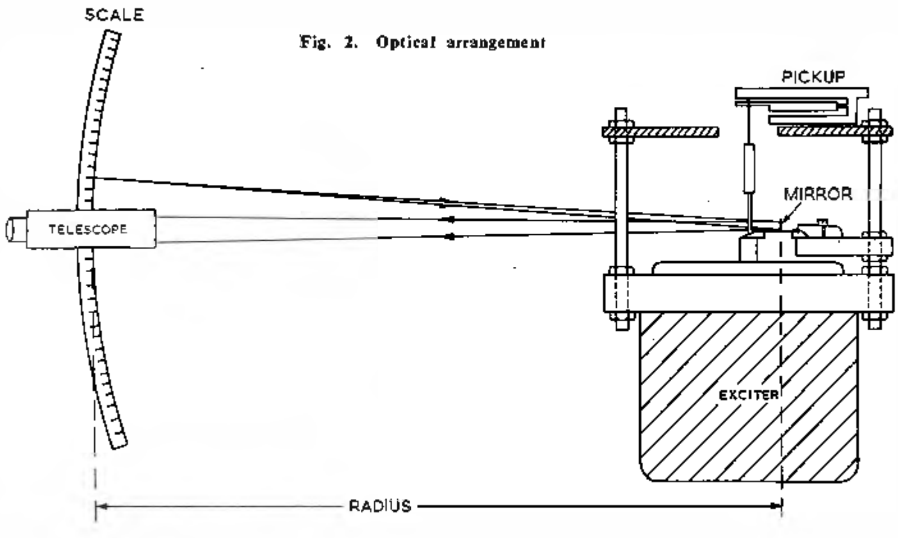


Fig. 2. Optical arrangement

When vibration occurs, the image of the scale appears blurred. Therefore, to enable the scale image to be observed, the scale is illuminated with a stroboscope. When the flashing frequency of the stroboscope is adjusted to be nearly the same as, or a suitable fraction of, the frequency of the armature excitation, the scale image is seen to move up and down. The peak-to-peak amplitude of the vibration may then be determined by observing the reading of the scale at the limit positions of the movement.

Calibration Procedure

Preliminary Calibration

A preliminary calibration is made to determine the relationship between the scale reading and the armature displacement. For this purpose, a micrometer head is clamped to the exciter body in such a way that its spindle is in line with the exciter armature as shown in Fig. 3. The spindle and armature are held in contact by attaching two springs between them.

The apparatus is adjusted so that the metal strip is at right-angles to the direction of motion of the armature, and the telescope is viewing the centre of the scale. The armature is now moved by turning the micrometer head. A total movement of approximately an eighth of an inch is made on each side of the central position in increments of 0·01in. The scale reading is recorded at each of these

* *A. V. Roe & Co. Ltd.*

incremental positions. A graph is then plotted of scale reading against armature deflexion, as shown in Fig. 4.

Calibration of Pick-up

The general arrangement with a non-seismic pick-up in position is shown in Fig. 5. When excitation occurs and the stroboscope is switched on, the rate of movement of the scale image may be altered by adjusting the flashing frequency of the stroboscope. The movement may be slowed down in this manner until the scale readings at each limit

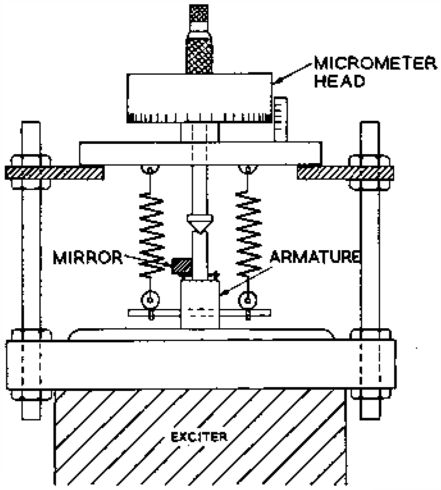


Fig. 3. Static calibration

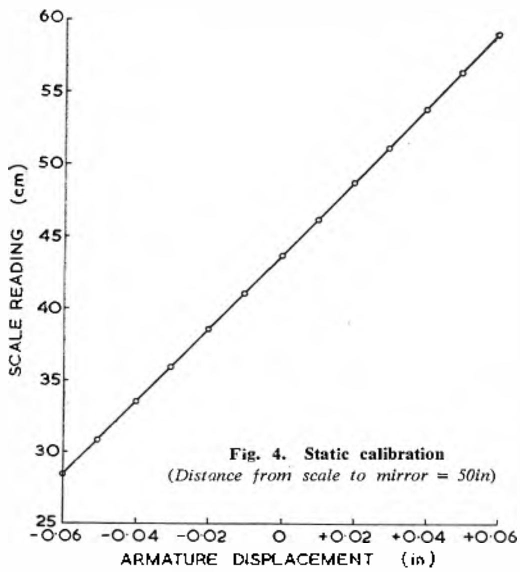


Fig. 4. Static calibration
(Distance from scale to mirror = 50in)

of the motion may be easily observed. The difference of these two readings, when divided by the gradient of the graph line previously plotted, gives the amplitude of the vibration.

The power input to the exciter is adjusted until the amplitude, measured as above, is of a desired magnitude. The output signal of the pick-up may then be recorded.

Accuracy and Sensitivity

Geometrical Error

From the geometry of the system, it is seen that if the armature is given a displacement about the mean position of a magnitude X, then the angular deflexion of the strip is $\theta = \sin^{-1}(X/L)$, where L is the distance between the pivots on the strip. As the mirror is at the centre of curvature of the scale, the scale image reading is directly proportional to the angle of the mirror.

This relationship introduces an error, as it is desired that the scale reading should be proportional to the displacement X. However, as explained below, this error is so small that often it may be neglected.

For small angles, $\sin\theta$ may be written as:

$$\sin\theta = \theta - (\theta^3/3!) \text{ plus small negligible terms.}$$

$\theta^3/3!$ is the error term.

In the case of a large displacement, say $X = \pm 0{\cdot}125$in with a strip of length $L = 1$in, then:

$$\sin\theta = (X/L) = 0{\cdot}125$$

whence $\theta = 0{\cdot}12537$rad.

thus $\theta^3/3! = {\cdot}00032$rad.

Therefore, the error is $\mp 0{\cdot}26$ per cent,

i.e.: $X = \pm 0{\cdot}125\text{in} \mp {\cdot}0003\text{in}$ as measured by the scale.

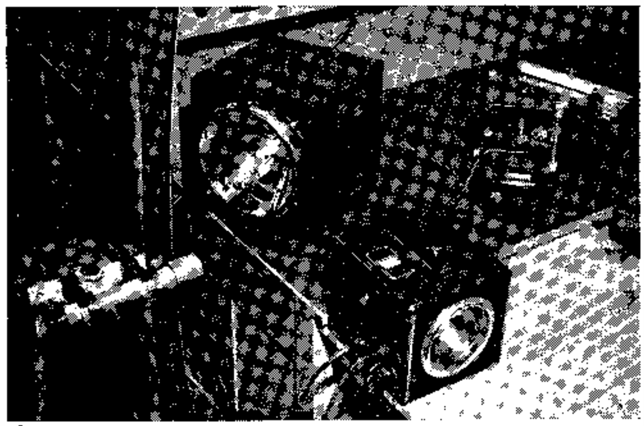


Fig. 5. General arrangement for calibration of pick-up
(For the purpose of this photograph, the exciter has been moved nearer to the scale and telescope)

However, for most calibrations the amplitude required is only of the order of $\pm 0{\cdot}01$in, in which case the error with such a one inch strip is only $\pm 0{\cdot}2 \times 10^{-6}$in. This is outweighed by the observers' error in reading the scale.

Physiological Error

In the system described, it was possible to interpolate visually the scale reading to a tenth of a division. The graph shows that ·001in was represented by a reading of 2·57 from the scale observations. Thus the error incurred when measuring an amplitude is $\pm{\cdot}00005$in. Note: The magnification of the telescope was such that an armature movement of ·00005in could be noticed by the observer. (This corresponds to a strip rotation of ·00005rad.)

Dominant Error

Putting the error term $\theta^3/3! = \pm{\cdot}00005$rad, gives $\theta = \pm 0{\cdot}67$rad, thus $X = \pm 0{\cdot}067$in. at such an amplitude, therefore, both the errors previously described are of similar magnitude. In this case, therefore, the total error is approximately $\pm{\cdot}00005 \times \sqrt{2}\text{in} = \pm{\cdot}00007$in.

Below amplitudes of $\pm 0{\cdot}05$in, the geometrical error becomes small, and so for calibrations using displacements less than this amplitude, the error may be taken as $\pm{\cdot}00005$in.

Other Applications

There will be applications in which the order of amplitudes desired to be measured may vary greatly. In such cases, an optimum set of conditions must be attained among the amplitude range desired, the distance between the pivots on the strip, and the error that can be tolerated.

Acknowledgment

The author wishes to thank Messrs. A. V. Roe & Co., Ltd, for the use of the above photographs and for permission to publish this article.

An Electronic Coder and Decoder for Teleprinter Signals

By J. Das*

The coding and decoding of messages as used in teleprinters have been simulated with electronic circuits. The letter key triggers a 50c/s multivibrator and the output of which is gated by the same key according to the code assigned to the letter. The multivibrator stops after sending the stop pulse on the line. In the decoder, a multivibrator is started by the start pulse and the incoming signal is sampled, selected and identified through a series of channel separator, code selector and counter circuits. Auxiliary binary codes have been assigned to the code pulses for the final identification. Miniature gas-filled triodes have been used in all counting and selector circuits.

(Voir page 185 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 190)

IN printing telegraphy, the transmission of the telegraph signal starts with the operation of a keyboard and ends with the typing of the message on a tape or a page. The intermediate processes involve coding of the transmitted message at the sending end and decoding of the received messages at the receiving end. Since the keyboard and the mechanical typing unit with its typebars cannot be eliminated, it is only possible to incorporate electronic circuits to replace the mechanical devices in the intermediate processes.

Electronic devices, like electronic regenerative repeaters[1,2], are already in use for teleprinter circuits. Electronic repeaters simulate the functions of a mechanical regenerative repeater, but have the added advantages of a better margin of reliability, ease of production and reduced maintenance costs. Similar advantages can also be obtained with a semi-electronic teleprinter. An attempt has been made here to simulate the functions of the coder and the decoder of the mechanical teleprinter with electronic circuits.

With the successful use of pulse code modulated systems[3] and sequential switching circuits[4], the present-day knowledge of coding and decoding is vast. Any suitable method of coding and decoding the message could be adopted, but the basic 5-unit code with start and stop signals has been used in the electronic circuits here so that this instrument can be used in tandem with the existing mechanical teleprinters. However, it is much easier in the electronic circuits to incorporate some of the modern error-correcting codes, than it would be for the mechanical teleprinter.

Principles of Operation

Coding

Basic teleprinter signals consist of a start pulse, five code pulses and a stop pulse. The duration of the first six pulses is 20msec each and that of the stop pulse is usually 30msec. The problem is to generate these pulses electronically, such that the five code pulses are either positive or negative in accordance with the code assigned to the particular letter to be sent. Fig. 1 shows the block schematic of the coder.

If it is arranged to trigger a multivibrator of time period equal to 20msec and then pass the differentiated positive pulses through a chain counter (used as a channel separator), it is easy to obtain at the output individual pulses of 20msec duration. The second to sixth pulses are sent through gates which either open or close, depending upon the code to be sent. The opening of the gates and the triggering of the multivibrator are controlled by the particular letter-key on the keyboard. The seventh pulse from the chain counter stops the multivibrator and releases the key. The start and stop pulses are always sent on the line, and hence are not gated. But the stop pulse excites

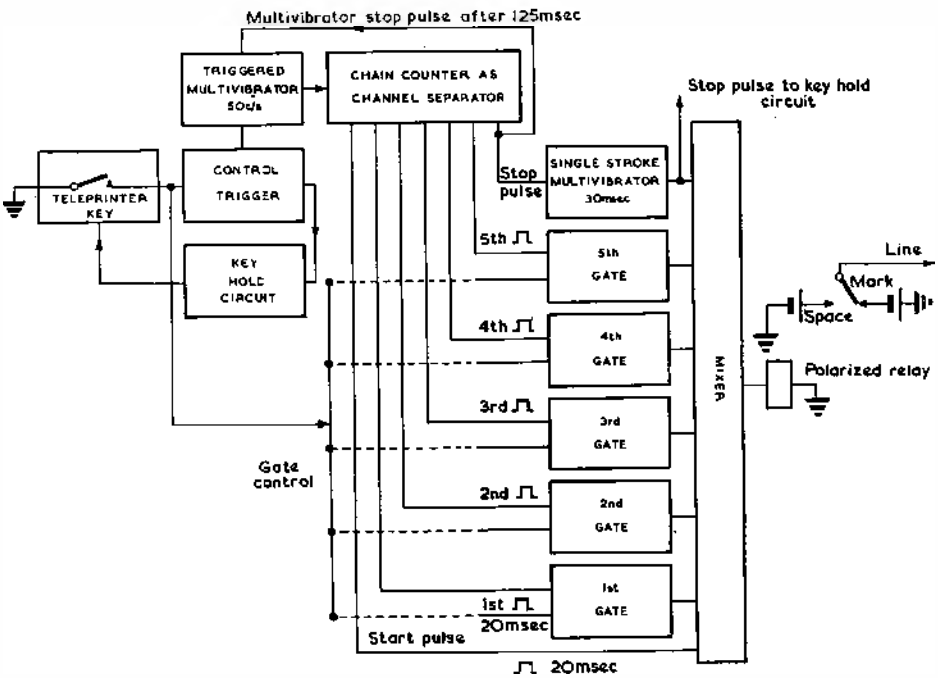


Fig. 1. The coder

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a single shot[1] multivibrator which generates a pulse of the required 30msec duration. The start pulse, gated pulses and the stop pulse are sent through a mixer and the mixer output controls the polarized relay which sends space and mark pulses on the line.

Decoding

The basic idea in decoding the teleprinter signals is to identify the start signal and the respective code signals and to recombine them into the letter symbol sent from the other end. Fig. 2 shows the block schematic of the decoder. Normally the multivibrator remains quiescent during the stop-pulse period (mark), and it is triggered by the start pulse (space). Two outputs are taken from the multivibrator, one lagging the other by 10msec. The leading pulses are sent directly to the channel separator, which produces 20msec pulses corresponding to the time position of the code pulses. The lagging pulses are used

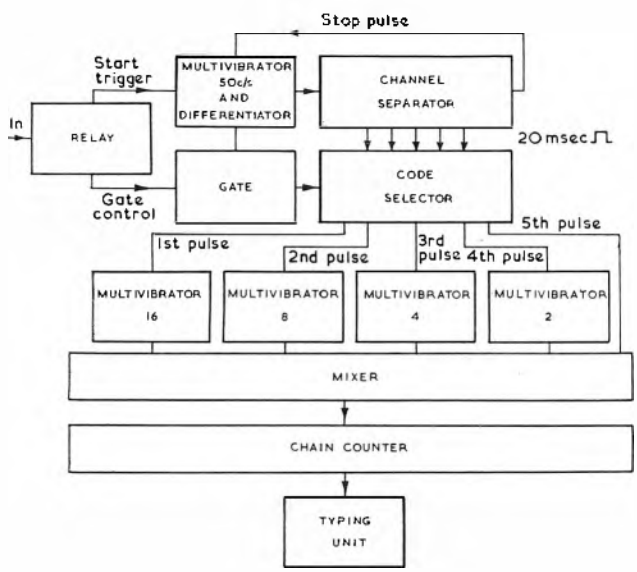


Fig. 2. The decoder

to sample the incoming signal at 20msec intervals. Since the first sampling pulse occurs at 10msec after the leading edge of the start pulse, the decoder is capable of handling the received signal with a maximum of 50 per cent distortion. The code selector now produces an output whenever both the channel pulses and the sampled pulses are present. This provides the information as to whether a particular space-pulse is present in the received message or not. Fig. 3 shows the different pulses produced at different stages.

Recombination of the selected pulses could be done in various ways. Five relays could be assigned the time-positions of the five code pulses. A relay would operate if the particular code pulse is present and would not operate if the code pulse is absent. If the transfer contacts of the five relays are arranged in the form of a tree[5], thirty-two outputs can be obtained to indicate the presence or absence of the thirty-two characters. It is, however, felt that it will be difficult to arrange relays with sufficient contacts to have the required high speed of operation. Alternatively a mechanical decoder could be used as is prevalent in the mechanical teleprinter or Teletype machines.

Electronic decoding has been done here by assigning binary codes[4] to the different code pulses. The first pulse is assigned the number 16 and is made to trigger a multivibrator which produces exactly 16 auxiliary pulses in the output. The second, third, fourth and fifth pulses are assigned the numbers 8, 4, 2, 1 respectively. All these auxiliary pulses are counted and made to give thirty-two distinct outputs. These outputs will excite the respective typebars of the typing unit.

Circuits

Coder

For transmitting the teleprinter signals, a normal type of keyboard is used. Each letter key will control the

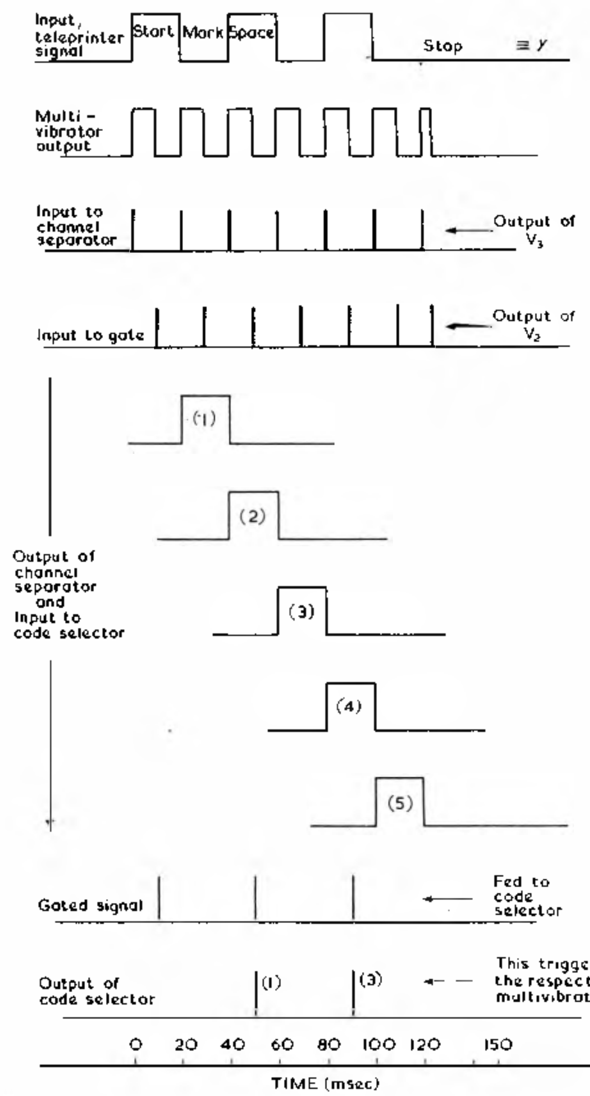


Fig. 3. Sequence of pulses in the decoder

trigger pulse to the multivibrator and the gates which will either open or remain closed depending upon the code to be sent. This can be arranged by having insulated contacts below the key and the pressing of the key will connect the required contacts to earth. Alternatively, the keys can operate five code bars[6], which will either move to operate the contacts or remain stationary as required by the codes of the pressed key. As the key should remain held for the 150msec period, required to transmit the seven pulses, there will be a holding magnet which will operate a locking bar, which in turn will keep the key pressed for the required duration. This arrangement is exactly similar to that used in the modern teleprinters.

The triggered multivibrator circuit is shown in Fig. 4. The letter key controls V_1, which in turn triggers the multivibrator, and operates the holding magnet L via V_3. The differentiated positive pulses are fed to the chain counter. The seventh pulse from the chain counter is fed back to V_2 to stop the multivibrator after producing seven pulses. On completion of the transmission of the 30msec stop-pulse (mark), the magnet L is de-energized. In stopping V_3, allowance for the release time of the magnet L is made.

The chain counter used as a channel-separator is shown in Fig. 5. The output of the multivibrator is fed to the chain counter and 20msec pulses are obtained at the cathodes of V_2, V_3; . . . . V_8. The start pulse is directly fed to the mixer stage and the seventh pulse excites the single shot multivibrator to produce the 30msec stop pulse as shown in Fig. 6(b). All other code pulses are fed to the gates which are controlled by the different letter keys. Fig. 6(a) shows the gate circuit. The grid of the gating tube is either earthed or not, depending upon the code combinations to be sent.

Decoder

The triggered multivibrator in the decoder is similar to that in the coder except that the multivibrator is now controlled by the incoming start pulse and stops automatically after producing the seventh pulse. The multivibrator and its control circuits are shown in Fig. 7. The output from V_3 is fed directly to the chain counter. The output from V_2 is fed to the code-selector via an AND circuit, where it is mixed with the incoming teleprinter signals. These sampled pulses are 10msec behind the leading edge of the incoming signal pulses.

The chain counter circuit, shown in Fig. 8 is used as a channel separator and is similar to that shown in the coder. The only difference is that the last tube in the chain operates a relay X during the period of the stop pulse, and the contact X_1 controls the magnet of the selected typebar. The code selector, shown in Fig. 8, is so arranged that an output is obtained from any of the tubes only when the channel pulse and the gated signal pulse occur simultaneously. This finally indicates the presence or absence of a particular code pulse.

These code pulses are made to trigger the respective multivibrators which generate either 16, 8, 4, 2 or 1 pulses depending upon the code positions they are assigned. The

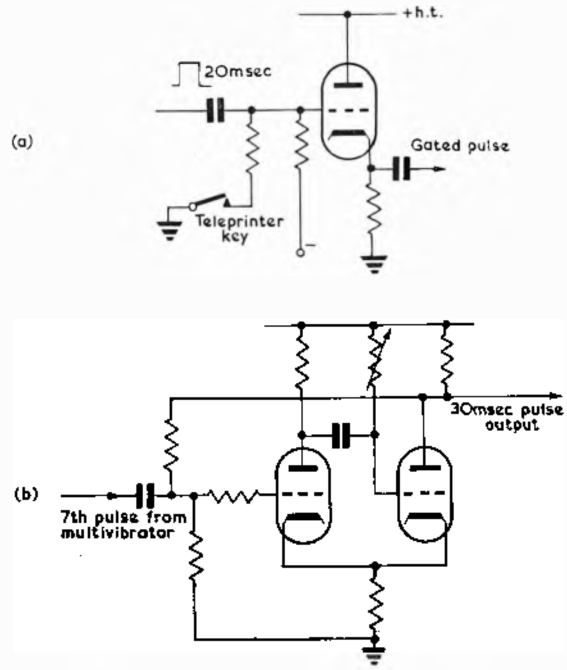


Fig. 6. (a) Gate of coder
(b) 30msec multivibrator of decoder

Fig. 4. Triggered multivibrator of coder

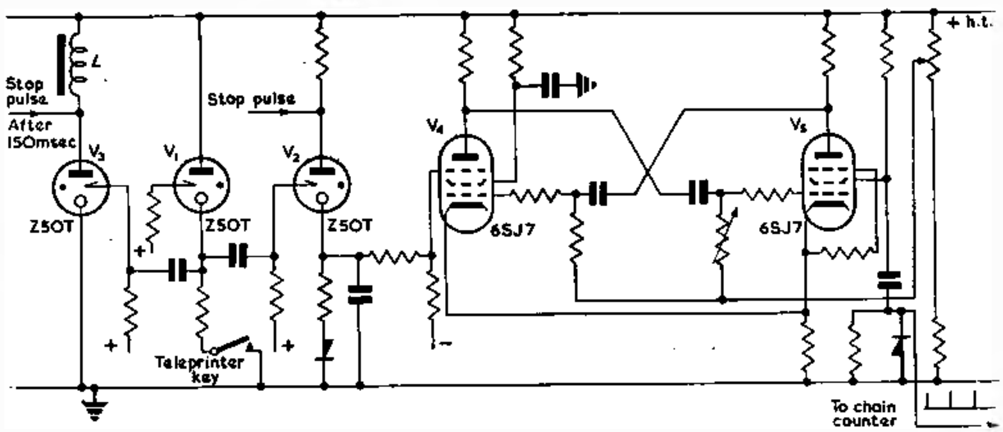
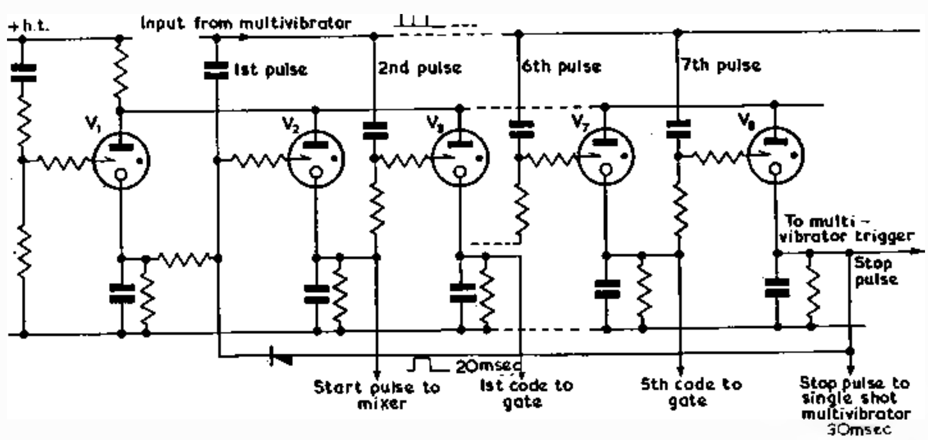


Fig. 5. Channel separator of coder



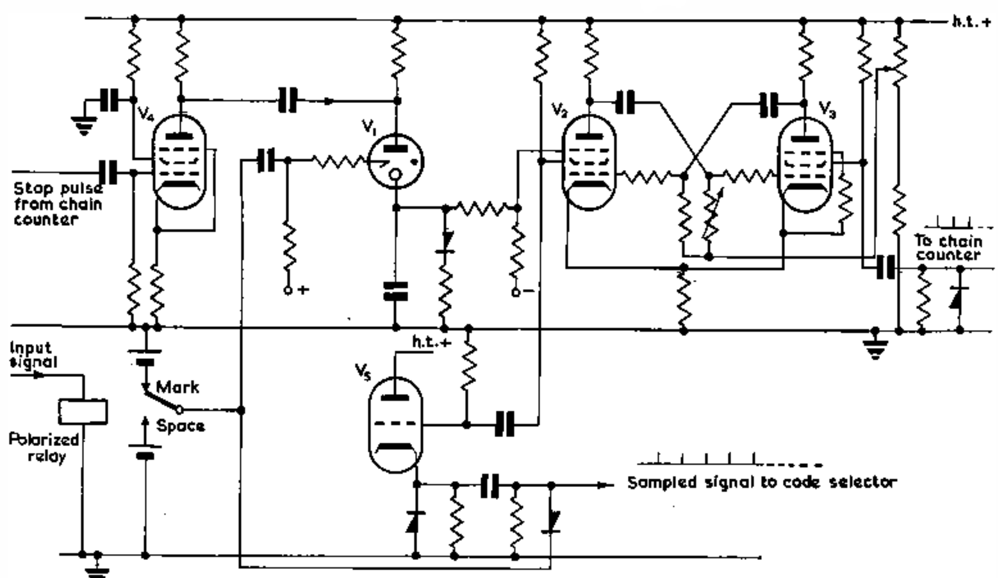


Fig. 7. Triggered multivibrator of decoder

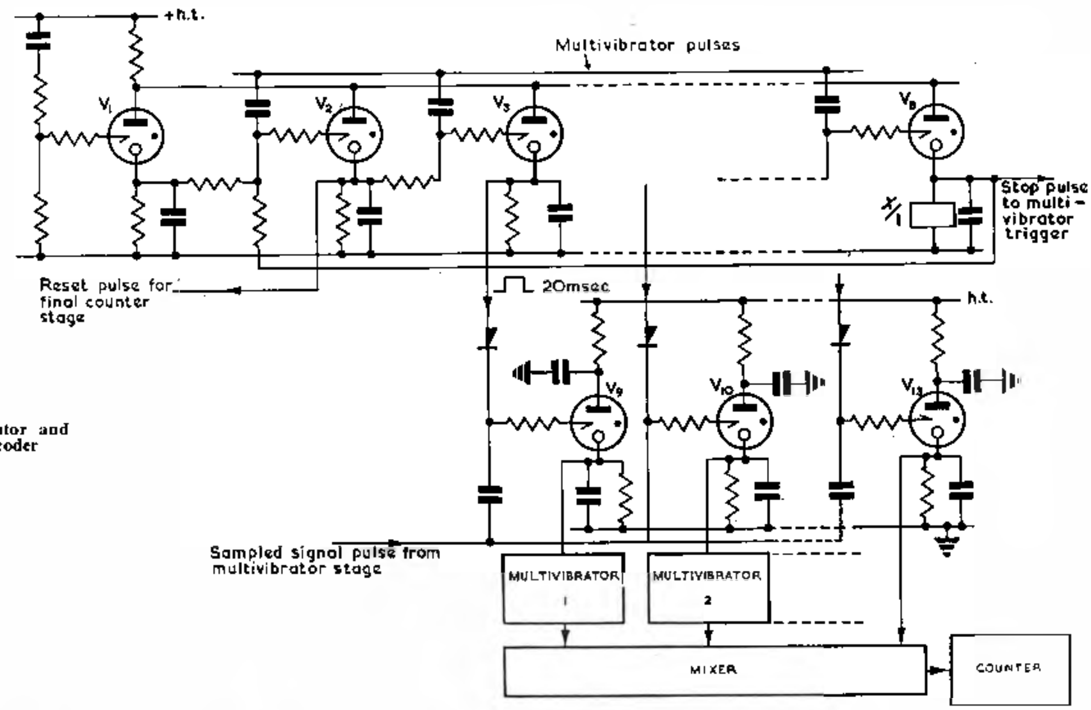


Fig. 8. Channel separator and code selector of decoder

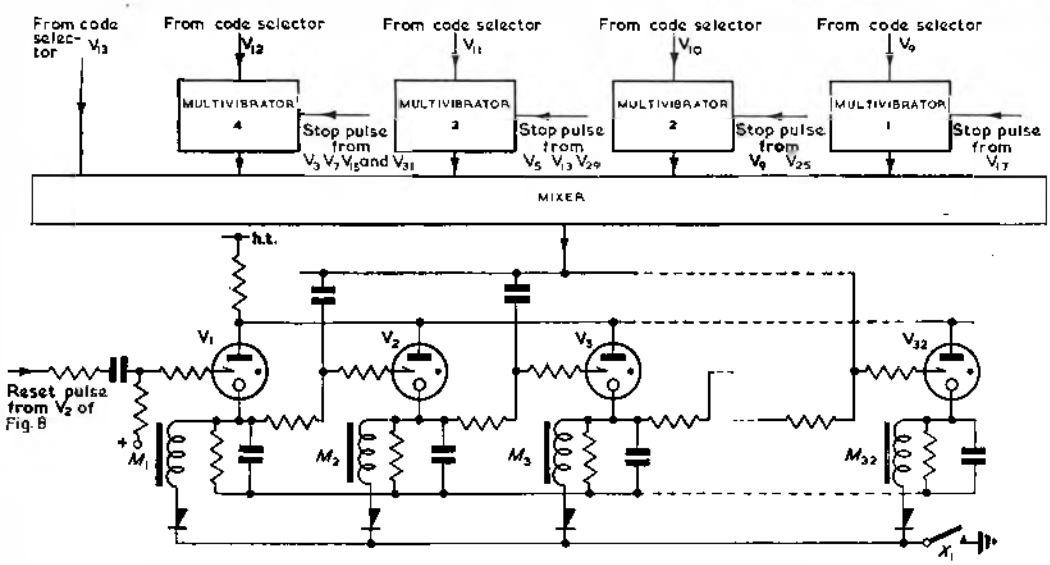


Fig. 9. Final counter circuit

multivibrators are fed with stop pulses from the final counter circuit such that they generate the required number of pulses only. The arrangement is shown in Fig. 9. The multivibrators here need not be so stable and symmetrical as that shown in Fig. 7; and hence, a simpler circuit, as shown in Fig. 10, has been used. The multivibrator outputs are mixed together and fed to the final counter circuit which recognizes the letter to be typed. The selected typebar-magnet is energized by the contact X_1 during the 30msec stop pulse period. Diodes in series with the magnets have been used to prevent the operation of more than one magnet at a time.

Typing Unit

It is the function of the electromagnets in the final counter circuit to operate the typebars during the stop-

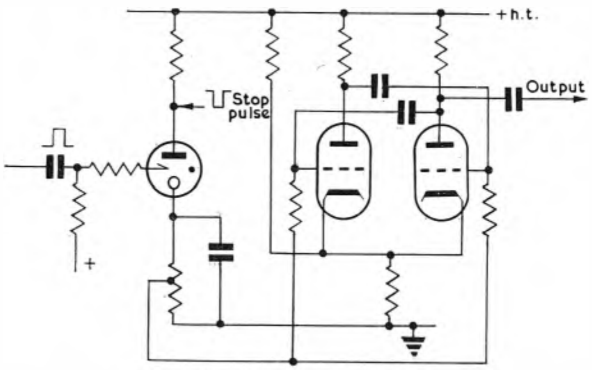


Fig. 10. Triggered multivibrator

pulse period. The typing unit of a lightweight typewriter can be used for the purpose. The keys are replaced by links connected to the armatures of the electromagnets and whenever a particular electromagnet is excited, the link pulls the typebar so that the type carried by it strikes an ink-ribbon against the paper.

Alternatively, the thirty-two magnets can be arranged in concentric rings and the typebars carried on the armatures. It is so arranged that the operation of a magnet actuates the typebar such that the type carried by it strikes an ink-ribbon against a paper tape.

Discussion

In the channel separators, code selectors and starter circuits above, Phillips' trigger tubes type Z50T have been used. This gas-filled triode has very small ionization and deionization times, and hence is capable of the speed of operation required in these circuits. In the final counter circuit, Phillips' type 5823 tubes have been used, as this tube can give sufficient current (maximum peak anode current is 100mA) to energize the typebar magnets. The total number of tubes required for the decoder is fifty-three. A saving in the number of tubes in the final counter can be made by using a two-stage counter utilizing the Ericsson's Dekatron[5] selectors GS10B, as shown in Fig. 11. But the Dekatron selectors are incapable of supplying sufficient current to energize the typebar magnets. Hence auxiliary means to energize the magnets have to be adopted, after the identification of the received symbol is made. Due to the relative costs of the 5823 tubes and the GS10B, it is felt that no appreciable economy can be made by using GS10B counters.

The operating margin of the decoder depends on the stability of the 50c/s multivibrator, triggered by the start pulse. This multivibrator has, therefore, been made elaborate and anode loading has been avoided. Dain[9] has also shown a stable triggered multivibrator for similar use. Using stabilized voltages, a margin of 45 per cent is easily obtained in the prototype instrument, as tested with a mechanical t.d.m.s. (code disk operated with stroboscope).

Special functions like letter-shift, figure-shift, carriage-return, line feed and others can be incorporated in the design of the typing unit. The mechanical design of the typing unit is not yet complete, but it is expected that the ultimate design will follow the line indicated earlier.

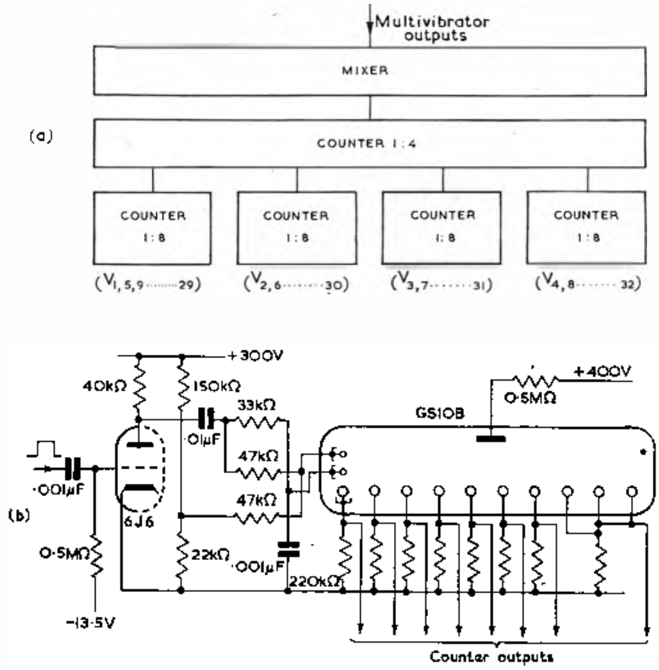


Fig. 11. Two stage Dekatron counter circuit

Since the electronic circuits are used in coding and decoding, it is advantageous to use the known techniques to improve the signal-to-noise ratio, and minimize the interference and distortion in the received signal. A slicer circuit[10] can be used to obtain the above. To avoid the operation of the decoder with noise impulses, a start delay[1] circuit can be incorporated in the trigger of the decoder multivibrator. If it is desired to use the instrument as a non-typing unit, higher speed of operation may be obtained by using pulses of smaller duration.

Acknowledgment

The author wishes to thank Prof. H. Rakshit, D.Sc., F.N.I., for his kind interest in this work.

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A Modern Frequency Shift Telegraph Receiver

By E. J. Allen*

The article describes a radio telegraph receiver which is claimed to represent an entirely new approach to high-grade h.f. radio teleprinter reception. It is designed around current Post Office specifications and the use of a new principle of reception overcomes serious shortcomings inherent in conventional designs under adverse propagation conditions and affords a greatly extended 'good-printing' time.

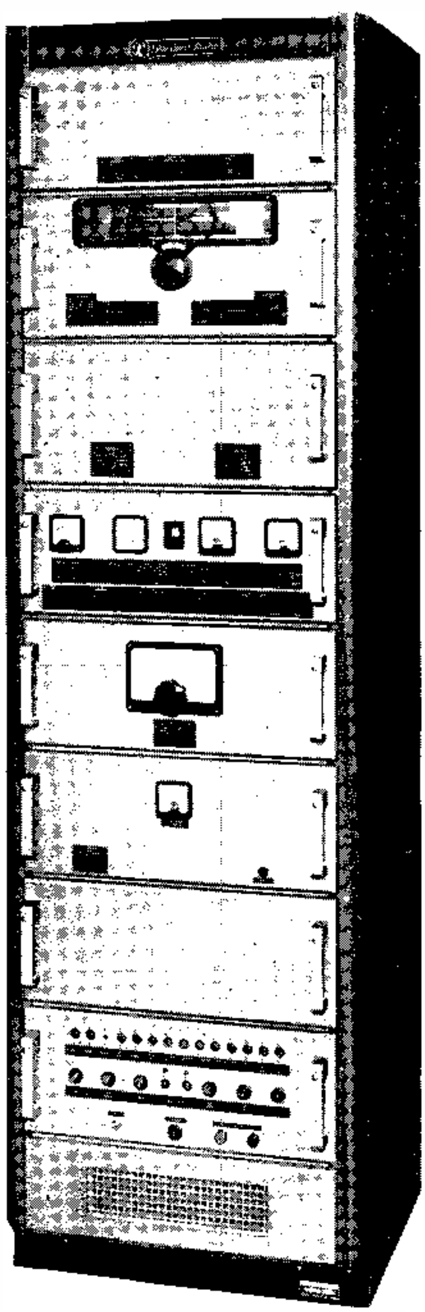
(Voir page 185 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 190)

THE frequency-shift mode of communication was introduced in the latter part of World War 2 as an improved method of handling high-speed telegraphy. It was also the first successful attempt at passing teleprinter traffic over h.f. radio systems. Reception in dual-diversity at that time consisted of two standard communication receivers suitably modified to work from a common oscillator, a diversity combining unit and a telegraph unit, a conception which has continued, basically, to the present day.

In this method, the usual treatment of signals prior to detection is to pass them through a limiter and discriminator to convert them to double-current pulses, and then through a shaper to the teleprinter or other recording instrument. If selective fading is present, it is possible to have, for example, a strong 'mark' signal and almost no 'space' signal. Under such conditions, the limiter will raise the level of the 'space' signal to equal the 'mark' so that the teleprinter will receive a clean 'mark' and a burst of noise, leading to failure of printing.

In the S.T. & C. receiver type RX.5-C the 'mark' and 'space' signals are separated. Since there are two diversity paths there are four signals available, two on 'mark' and two on 'space'. The 'mark' signals are combined in a ratio-squarer which adds them in the ratio of their powers, thus obtaining the best signal-to-noise ratio. The 'space' signals are treated in the same manner. The resulting 'mark' and 'space' signals are then converted to double-current signals and added together. The system will function quite correctly with only one of the four signals present; in fact, both space and frequency diversity operation has been obtained.

This method gives an improvement in signal-to-noise ratio over that obtained, for equal signals, by the usual method of switching to the strongest signal. The automatic frequency control system operates on both 'mark' and 'space' frequencies to ensure the best possible control; and when the receiver is working in four-frequency diplex (F6), it operates on all four frequencies.



The S. T. & C. receiver type RX.5–C

In the standard form of this receiver the cabinet is fully wired for all facilities, but equipped for the reception of frequency shift (F1), on-off telegraphy (A1) and m.c.w. (A2) with crystal control only, and the standard bandwidth of 1kc/s. To cater for variations in individual requirements certain additional facilities can be offered:—

- Variable frequency oscillator.
- Crystal calibrator.
- Four-frequency diplex (F6) including crystal filters for 2kc/s bandwidth.
- Crystal filters for 500c/s bandwidth ('sharp').
- Crystal filters for 6kc/s bandwidth (A3 telephony).
- Auto-transformer unit for 100-130V input, accommodated in the base of the cabinet.

As the strip-unit technique is used, all the facilities offered as optional extras may be incorporated by the user at a later date with the minimum of trouble.

All valves except one are internationally recognized types using B7G, B9A or international octal sockets. The one exception is the EM81 electron ray tuning indicator, employed because there is no suitable international type of U.K. manufacture. Failure of this valve will not affect the working of the equipment.

A triple-superheterodyne circuit is employed with intermediate frequencies at 1·6Mc/s, 100kc/s and 10kc/s, crystal filters being used at 100kc/s. Polar d.c. output is available sufficient to operate two local and one remote teleprinter. Tone output variable between 400 and 3 000c/s is also provided.

Brief Description of Circuits

Two r.f. amplifiers are mounted on one chassis and mechanically ganged to one control to cover the range 2 to 30Mc/s in seven bands with suitable overlap between bands. There is also

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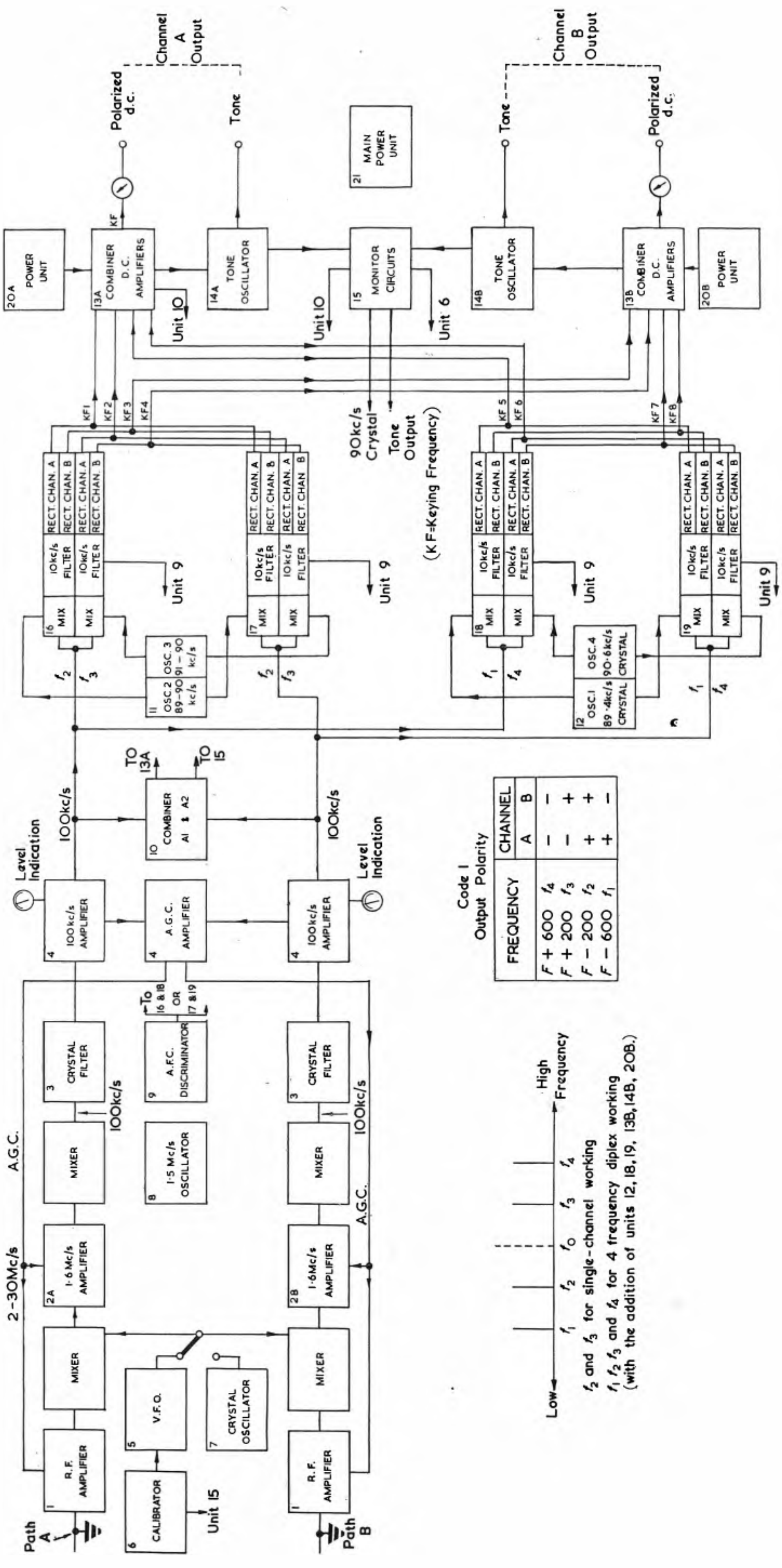

FREQUENCY	CHANNEL A	CHANNEL B
$F+600$ f_4	−	−
$F+200$ f_3	−	+
$F-200$ f_2	+	+
$F-600$ f_1	+	−

Fig. 1. The radio telegraph receiver

a small overlap at 2Mc/s and 30Mc/s to allow these frequencies to be tuned correctly.

The output from these amplifiers is mixed, either with the crystal oscillator fitted as standard, or the variable frequency oscillator, which is an optional and additional facility. The crystal oscillator provides positions for 10 switched crystals. Crystal controlled oscillator or variable frequency oscillator operation is selected by the operator by one switch operation. A crystal calibrator, when fitted, gives 100kc/s and 500kc/s reference points, audio from this unit being fed to the monitor unit.

The resulting outputs are then amplified and converted to 1·6Mc/s with a bandwidth of ±5kc/s. The two diversity outputs are now fed into two crystal filter stages, provision being made for four pairs of filters:—

1kc/s (standard)
500c/s (sharp)
2kc/s (diplex—F6)
6kc/s (telephony—A3)

Such filters as may be fitted are selectable by a switch on the front panel.

The amplified 100kc/s outputs are then rectified and compared on a level basis, the resultant d.c. being fed back as a common negative voltage controlling gain in the r.f. and i.f. amplifiers in both signal paths; the path with the higher level determining the common negative voltage. As r.f. and i.f. amplifiers in both paths have identical gains and are fed from a common bias, the gains of both paths are reduced by the same amount. The level-ratio existing between outputs from each 100kc/s amplifier is therefore the same as the level-ratio between the inputs to the two r.f. amplifiers.

The outputs from the two 100kc/s amplifiers are taken to a combiner unit, the action of which is to combine the two reception paths in the ratio of the squares of their received amplitudes. This method of weighting the levels before combining is superior to that of linear addition, and gives an improvement of 3dB over that of one path only.

F.S.K. (F1) Single-Channel Working

The frequency spacings for F1 and F6 are:—

$$f_1 = f_0 - 600\text{c/s}$$
$$f_2 = f_0 - 200\text{c/s}$$
$$f_3 = f_0 + 200\text{c/s}$$
$$f_4 = f_0 + 600\text{c/s}$$

f_0 being the reference frequency.

For single-channel working, only the frequencies f_2 and f_3 need be considered, the spacing between them representing the shift, and f_3 being usually the 'mark' frequency. The two signals from one diversity path are converted by mixing with two variably tuned oscillators, to 10kc/s, the third i.f. The 10kc/s filters are adjustable in bandwidth to allow for variations in keying speed or shift. Outputs from the filters are then rectified. Exactly similar treatment is given to the signals in the other diversity path. Thus, there are now four d.c. outputs resulting from the two paths.

The two rectified levels identified with f_2 are combined in a ratio-squaring circuit, those for f_3 being treated the same way. The resultant voltages are converted into signals of sign and magnitude corresponding to double-current working, the overall effect being that frequencies f_2 and f_3 from the two diversity paths are each converted to double-current signals, and all four levels at these frequencies contribute to the final output, thus giving dual frequency-diversity combined with dual space-diversity.

A further feature of the design is that, when signalling stops, i.e. during a marking period, a holding voltage of the correct polarity is available at the output terminals of the unit to ensure proper operation for 'start-stop' signalling.

Four-Frequency Diplex (F6) Working

This is obtained by addition of certain units to the equipment trays which are fitted, as standard, to receive them, either before delivery from the factory or later by the user. A pair of crystal filters for the 2kc/s bandwidth is also added to the crystal filter unit.

Crystal oscillators in a convertor unit provide the drive for conversion of f_1 and f_4 to 10kc/s. Crystals normally supplied provide for the frequencies −600c/s and +600c/s about the reference frequency f_0. It so happens, however, that certain systems may not use ±600c/s for diplex working; to cater for this, an additional pair of crystal sockets is wired to a switch in the unit concerned. When such additional crystals are provided to special order, the user may quickly transfer from the normal ±600c/s system to the other without delay.

Automatic Frequency Control

Since all signalling frequencies are converted to 10kc/s, sample levels can be taken and passed through a filter; and because the rate of change of frequency or information-rate is relatively slow, this filter can be restricted in bandwidth to 50c/s with high attenuation outside this band. Unwanted frequency components do not, therefore, appear at the input of the discriminator.

The d.c. output of the discriminator is amplified and applied to a permanent-magnet, low-inertia d.c. motor geared to a variable capacitor. This tunes a stable, free-running oscillator centred on 1·5Mc/s. The discriminator acts as a 10kc/s reference frequency standard, and any departure produces a positive or negative-going voltage which operates the motor in one direction or the other. This ensures that the frequency of the incoming signal, when mixed with 1·5Mc/s from the oscillator, is maintained at 100kc/s.

The system is designed to cater for slow frequency variations up to +5kc/s of the mid-band frequency of the 1·6Mc/s i.f. amplifiers with alarm facilities at ±4kc/s.

Monitoring Facilities

Every endeavour has been made to provide self-checking circuit arrangements in order to facilitate servicing in the field without use of external test apparatus.

The crystal calibrator, when fitted, enables the operator to ascertain that the receiver is functioning satisfactorily over the tuning range. As many major users will have their own station standards, however, this may be redundant, and is therefore an optional item.

Other circuit checks and adjustments are as follows:—

Systematic distortion.
A.F.C. discriminator.
Calibration of shift-oscillators.
100kc/s discriminator.
Radio frequency circuits.
Polar d.c. and tone outputs.
Variable frequency oscillator.

Brief Performance Specification

Frequency Range

2 to 30Mc/s (150 to 10m).

Selectivity (according to filters fitted)

500c/s 'Sharp'.

1kc/s 'Standard'.

2kc/s 'Diplex' (F6).

6kc/s 'Telephony' (A3).

Sensitivity and Error Rate

F.S.K. (F1) 0·125μV in series with 75Ω required at 9·3Mc/s using 500c/s pass-band and 200c/s shift for an error of 1 per 1 000 characters at 50 bauds (1kc/s = 0·175μV).

A1—A2 0·25μV in series with 75Ω required at 9·3Mc/s for an error of 1 per 1 000 characters at 50 bauds (1kc/s = 0·35μV).

Noise Factor

Not exceeding 5dB below 15Mc/s.

Not exceeding 7dB above 15Mc/s.

Image Suppression

Better than 70db from 25-30Mc/s.

Better than 80db below 25Mc/s.

Stability

For a temperature variation of ±20°C about a mean ambient of 25°C with supply voltage variations not exceeding ±5 per cent:

First beating oscillator ±0·005 per cent.

Second beating oscillator ±0·02 per cent.

Frequency shift oscillator ±0·04 per cent.

A.F.C. System

Correction range ±3kc/s.

Residual error 10c/s up to 50 bauds and 20c/s at 200 bauds.

Distortion

Better than 5 per cent up to 200 bauds for partial or complete failure of mark or space signal on f.s.k.

Output

Polar d.c. 50-0-50mA.

Tone 10mW (10dBm) maximum into 600Ω in the range 400 to 3 000c/s.

Shift

200 to 1 200c/s.

Blocking

The unwanted signal must be at least 45dB above the wanted signal 5kc/s off-tune.

Acknowledgments

The development of this receiver has been evolved in consultation with some of the principal operators of radio teleprinter traffic, who have afforded facilities for direct observation of heavy traffic under adverse conditions. Furthermore the entire design concept has been based on the provisions of Post Office Specifications W.6081 'Dual Diversity Frequency Shift Telegraph Receivers'.

Acknowledgment is due to Standard Telephones and Cables Ltd for permission to publish this article.

A Simple Demodulator Circuit for Instrumentation Purposes

By R. Hoodless*, A.M.I.E.E.

Many instrumentation transducers are designed to form two arms of a bridge network, energized by a carrier voltage. The output amplitude and phase of such a bridge is related to the quantity being measured, but requires phase-conscious rectification to provide an analogue voltage.

This article describes a simple circuit which may be used when subsequent amplification is unnecessary.

(Voir page 185 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 190)

MANY transducers employed in instrumentation work are of the differential inductance or resistance type, connected in a bridge circuit energized by an a.c. carrier as shown in Fig. 1.

For many applications, the magnitude of the alternating voltage appearing across the output terminals is large enough to feed an indicator or recorder galvanometer direct after rectification. A half wave rectifier and indicator connected in series across the output terminals does, however, have two drawbacks:

(a) Only the magnitude of the output is available and no indication of phase is possible.

(b) At low output voltages the diode, be it hard valve or semiconductor, behaves as a non-linear element, necessitating special calibration of the indicator.

Further, when semiconductors are employed, this effect is dependent on ambient temperature.

In most applications, it is necessary to have a linear output together with an indication of phase, and it is usual to feed the output into a phase conscious rectifier network such as a Cowan ring demodulator.

Demodulators of this type often demand centre-tapped

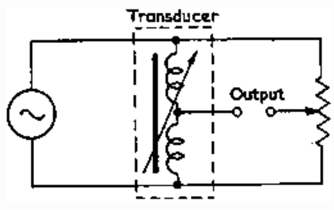

Fig. 1. Bridge connected transducer

transformers and four diodes, and can introduce a loss of signal, necessitating additional amplification.

For many applications this complication and increase in space cannot be tolerated, and in such circumstances, the demodulator circuit shown in Fig. 2 may be employed.

It will be seen that with the bridge in the balanced con-

* *Blackburn & General Aircraft Ltd.*

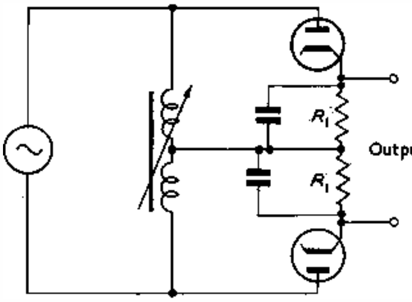

Fig. 2. Demodulator circuit

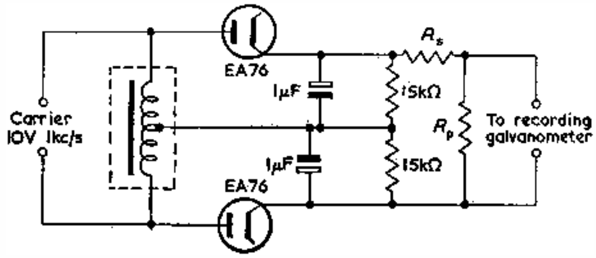

Fig. 3. Circuit of unit for measuring differential air pressures
(R_p and R_s—Attenuator pad to provide optimum damping for following galvanometer)

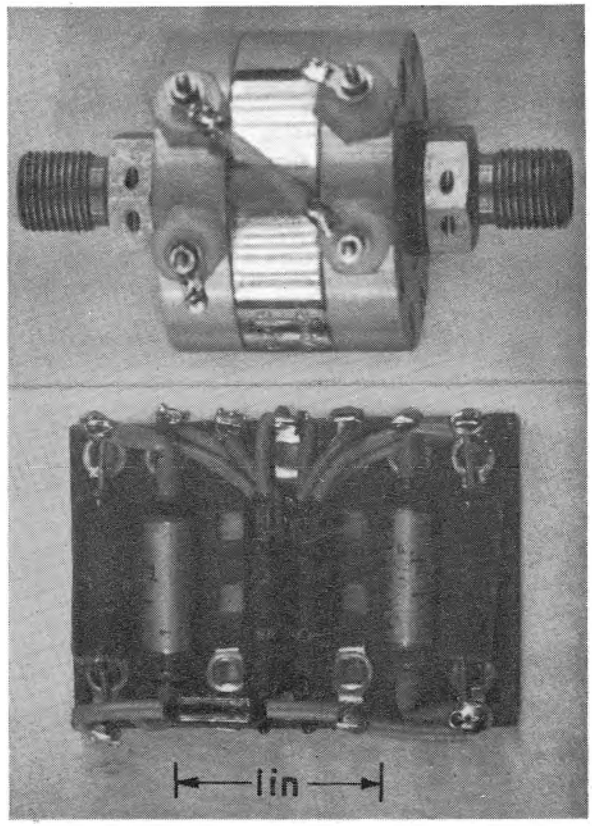

Fig. 4. Construction of equipment for measuring differential air pressures

dition the upper and lower halves are symmetrical, and a half of the carrier voltage is rectified by each diode.

As the carrier voltage is usually of the order of 10 to 20V, the diodes are made to work on the linear part of their characteristics.

The d.c. voltages appearing across the two cathode loads are equal, and at the output terminals their algebraic sum is zero.

When the bridge is unbalanced, the carrier voltage is unequally divided between each half of the demodulator, and as the rectified voltage across each cathode resistor is directly proportional to the a.c. appearing across the associated half of the transducer, the d.c. voltage appearing at the output terminals describes the magnitude and direction of unbalance on the bridge.

It should be realized that the diode loads appear in shunt with each half of the transducer, and as this will reduce its sensitivity, the value of the resistors should be as high as possible consistent with matching into the recording or indicating device.

The degree of filtering of the rectified carrier is dependent on the frequency response of the indicator being used.

Figs. 3 and 4 show a typical aircraft unit for measuring differential air pressures and recording on a galvanometer recorder. The two resistors R_p and R_s are employed to adjust the sensitivity of the transducer and to provide optimum damping for the galvanometer.

The same circuit has been successfully employed in conjunction with an a.c. pick-off to measure aircraft control surface angles on both recorders and moving-coil cockpit instruments, and it is felt that suitably potted, use could be made of this simple circuit in telemetry applications.

Acknowledgment

The author wishes to thank Blackburn and General Aircraft Limited for permission to publish this article.

Television in Automobile Research

To help in studying the behaviour of cars and trucks in motion, Vauxhall Motors' engineers are now using open circuit television at the Vauxhall Test Centre at Chaul End, near the company's Luton and Dunstable factories.

The transmitting licence was the first to be issued by the General Post Office for industrial use in Great Britain.

The camera, mounted on the vehicle close to the component being observed, is connected to a small transmitter inside the body or cab. The aerial is fixed to the roof of the vehicle, and transmits to a receiver aerial on the roof of the nearby Research Laboratory. This is connected to a normal television receiver inside the building, where several people are able to study the picture at one time.

This new 'tool' is being used in a number of ways. Already it has successfully revealed the cause of intermittent localized vibration on some models at certain critical speeds. The engineers expect to get particularly useful results by studying the behaviour in action of springs and shock absorbers, propeller shafts and many other 'hard to see' components.

Vauxhall have used 'closed circuit' television at Chaul End for the past two years. Before that, a ciné camera was the only way of providing pictorial information, but this system involves delays for developing the film, and the possibility of having to re-take if the results are not satisfactory.

The closed circuit television marked a big step forward but because the viewing screen had to be carried in the car or truck being observed, it was impossible for more than two people to study the results at one time. Hence the decision to develop a system with the receiver stationary in the laboratory.

No suitable transmitter was available to suit the specialized needs of this work and the allotted frequency of 750Mc/s, so Vauxhall research department had to build one themselves. The whole unit fits into a case 6in by 14in by 16in, which matches the size of the camera remote control gear.

There is still some picture flutter when the transmitting vehicle is moving fast. This does not preclude accurate observation, however, and Vauxhall are confident they will overcome it within the next few months.

Power for the transmitter and for the lamp that illuminates the 'subject' is provided by a petrol-engine driven generator or rotary convertor carried in the boot of the car.

A Method of Developing Periodic Functions

By J. Pereli

All complex waveforms may be expressed as a series of sinusoidal functions and in the past this type of expression has completely satisfied the engineer. In this article it is shown, however, that the well-known Fourier series is not the only way to develop a periodic function and, for example, a square function can be expressed in triangular or other periodic components as may be convenient.

(Voir page 185 pour le résumé en français:
Zusammenfassung in deutscher Sprache auf Seite 190)

IN the following discussion, it will be demonstrated that the well-known Fourier series is not the only way to develop a periodic function. For example, a square function can be expressed in triangular or other periodic components in addition to the sinusoidal components.

All vibrations are composed of harmonic waves having sinusoidal shapes. When such vibrations are expressed as sinusoidal functions they are easy to operate mathematically, and easy to develop since there are simple formulae for calculating the coefficients of a Fourier series.

In the past the expression of complex waveform as sinusoidal functions has completely satisfied the engineer, and has been sufficient to examine how such waveforms as speech or music are transmitted. The number of components of the Fourier series appearing in the output waveform compared to the input signal is precisely characteristic of the degree of distortion.

Nowadays, however, the need to transmit and test other waveforms, for example square waves, has increased considerably, so that the square wave plays an important part in investigating the performance of transmission equipment. This does not mean that the sine wave is decreasing in importance, but merely that other waveforms are becoming more common.

At present most of the results derived below are primarily of theoretical interest, their eventual practical significance will only become apparent when electronic oscillator circuits can be constructed having vibrations other than sinusoidal. It is important, however, that engineers remain aware of the alternative series.

Fourier's theorem states that each periodic function can be resolved into a series of sine and cosine functions. It will now be shown that any periodic function can be developed into a series of any other periodic function. Before discussing the theorem it is desirable to recapitulate some of the definitions, and to introduce the new one presented in this article.

Function $f(t)$ is called periodic according to time period T (where $T = (2\pi/\omega)$), if

$$f(t) = f(t + T) = f(t + 2T) = \dots f(t + nT) \quad \dots . (1)$$

where n is an integer.

Generally, function $f(t)$ is even if

$$f(t) = f(-t)$$

and odd if

$$f(t) = -f(-t)$$

Examples for even and odd functions respectively are

$$f(t) = \cos \omega t \text{ and } f(t) = \sin \omega t$$

Each function can be produced as a sum of an even and an odd function because

$$f(t) = \frac{f(t) + f(-t)}{2} + \frac{f(t) - f(-t)}{2} = \phi(t) + \psi(t) \quad \dots . (2)$$

where

$\dfrac{f(t) + f(-t)}{2}$ is even because when $-t$ is substituted for t, it becomes

$\dfrac{f(-t) + f(t)}{2}$ which has not changed sign, and

$\dfrac{f(t) - f(-t)}{2}$ is odd because when t is replaced by $-t$

$\dfrac{f(-t) - f(t)}{2} = -\dfrac{f(t) - f(-t)}{2}$, a change of sign.

The exception is when $f(t)$ is originally even, because then the odd component is 0 and when $f(t)$ is originally odd then the even component is 0.

If $f(t)$ is periodic, $\phi(t)$ and $\psi(t)$ are periodic as well.

If $f(t)$ is periodic a Fourier series is available from it, e.g.

$$f(t) = (a_0/2) + a_1 \cos \omega t + a_2 \cos 2\omega t + \dots + b_1 \sin \omega t + b_2 \sin 2\omega t + \dots \dots . (3)$$

and

$$\phi(t) = (a_0/2) + a_1 \cos \omega t + a_2 \cos 2\omega t \dots \dots . (4)$$

and

$$\psi(t) = b_1 \sin \omega t + b_2 \sin 2\omega t \dots \dots . (5)$$

as $\sin(-x) = -\sin x$ and $\cos(-x) = \cos x$.

It can be seen that $f(t)$ can be developed from the sum of the two functions: $\phi(t)$ and $\psi(t)$, one of these even, the other odd. $\phi(t)$ and $\psi(t)$ are developed according to Fourier in such a way that in the odd $\psi(t)$ the coefficients of cosine members are zero (i.e. $a_i = 0$) and in the even $\phi(t)$ sine coefficients are zero (i.e. $b_i = 0$).

If the function $f(t)$ is even or odd one can obtain from it two component functions with a simple displacement of co-ordinates. So it does not alter the generality if one supposes the function to have even and odd components as well.

Definition

Those functions which are fundamentally equal to $f(t)$ but their periods in series $T/2, T/3 \dots T/i \dots$ will be called '$f(t)$ multiplied functions'. These functions can be obtained from function $f(t)$ in the following way:

$$f(t_i) = f(it) \qquad i = 1, 2, 3, \dots \quad \dots . (6)$$

Theorem

If $f(t)$ is periodic according to time period T one can develop from it a series of optional periodic functions which satisfies the following conditions:

$g(t)$ is periodic according to time period T

the functions figuring in the series have even and odd components of $g(t)$ and multiplied functions of these as well.

Proof

Let $g(t)$ have the even component $\phi(t)$ and the odd component $\psi(t)$, and let $\phi(t_i)$, $\psi(t_i)$ respectively be the multiplied functions of $g(t)$.

* *Telephone Works Laboratory, The General Electric Co., Ltd.*

It can be stated that

$$f(t) = c_0 + c_1\phi(t_1) + c_2\phi(t_2) + c_3\phi(t_3) + \dots + d_1\psi(t_1) + d_2\psi(t_2) + d_3\psi(t_3) + \dots \quad \dots\dots (7)$$

Now the functions below can be developed into Fourier series,

$$\phi(t_1),\ \phi(t_2),\ \phi(t_3),\ \dots$$

and

$$\psi(t_1),\ \psi(t_2),\ \psi(t_3),\ \dots$$

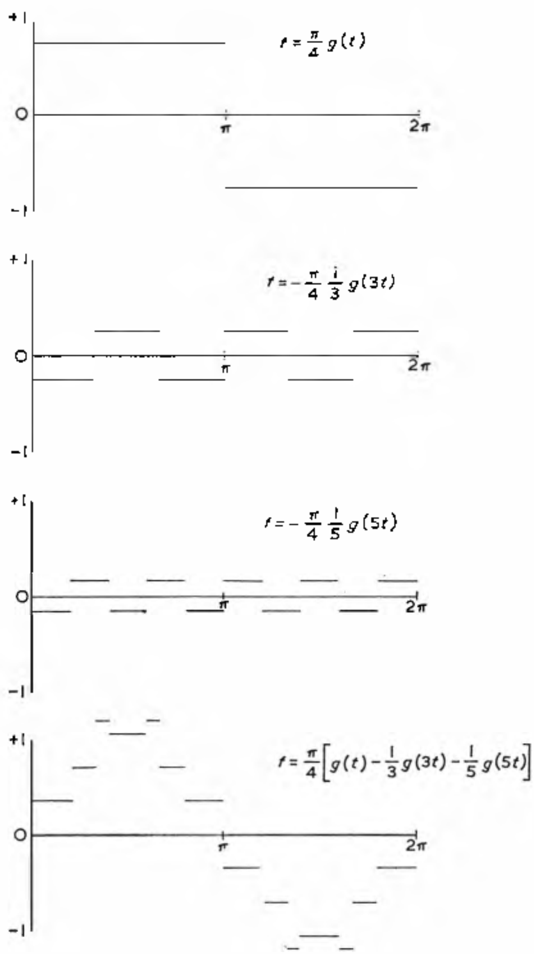

Fig. 1. Development of the example described

and from equation (6) their Fourier series is as follows:

$$\phi(t_i) = (a_0/2) + \sum_{n=1}^{\infty} a_n \cos ni\omega t$$

and

$$\psi(t_i) = \sum_{n=1}^{\infty} b_n \sin ni\omega t \quad \dots\dots\dots\dots\dots (8)$$

One can determine the coefficients a_i and b_i in the normal way of the theorem of Fourier series.

Substituting the right-hand side of the equivalence in equation (7) the following equivalences are obtained:

$$f(t) = c_0 + \sum_{i=1}^{\infty} c_i\,(a_0/2) + \sum_{i=1}^{\infty} c_i \sum_{n=1}^{\infty} a_n \cos ni\omega t + \sum_{i=1}^{\infty} d_i \sum_{n=1}^{\infty} b_n \sin ni\omega t \quad \dots\dots\dots\dots (9)$$

By adding the components of equation (9)

$$f(t) = k_0 + k_1\cos\omega t + k_2\cos 2\omega t + k_3\cos 3\omega t + \dots + l_1\sin\omega t + l_2\sin 2\omega t + l_3\sin 3\omega t + \dots \quad \dots\dots (10)$$

where

$$\left.\begin{array}{ll} k_0 = c_0 + (a_0/2)\sum_{i=1}^{\infty} c_i & l_1 = d_1 b_1 \\ k_1 = c_1 a_1 & l_2 = d_1 b_2 + d_2 b_1 \\ k_2 = c_1 a_2 + c_2 a_1 & l_3 = d_1 b_3 + d_3 b_1 \\ k_3 = c_1 a_3 + c_3 a_1 & l_4 = d_1 b_4 + d_2 b_2 + d_4 b_1 \\ k_4 = c_1 a_4 + c_2 a_2 + c_4 a_1 & \end{array}\right. \quad \dots (11)$$

But equation (10) is identical to the Fourier series of $f(t)$ and the coefficients k_i and l_i can be obtained, therefore, employing the Fourier series. In possession of k_i and l_i and with the aid of equations (11) c_i and d_i can be readily obtained and the above theorem can be, therefore, considered as proved.

EXAMPLE

Let $f(t) = \sin t$ .... (12)

$$g(t) = \left\{\begin{array}{l} 0, \text{ if } t = n\pi,\ n = \text{integer} \\ +1, \text{ if } 0 < t < \pi \\ -1, \text{ if } \pi < t < 2\pi \end{array}\right\} \quad \dots\dots (13)$$

$g(t)$ can be developed in a Fourier series in the following way:

$$g(t) = (4/\pi)\,[\sin t + (1/3)\sin 3t + (1/5)\sin 5t + \dots] \quad \dots\dots\dots\dots (14)$$

and its multiplied functions:

$$g(2t) = (4/\pi)[\sin 2t + (1/3)\sin 6t + (1/5)\sin 10t + \dots]$$
$$g(3t) = (4/\pi)[\sin 3t + (1/3)\sin 9t + (1/5)\sin 15t + \dots]$$

and generally

$$g(it) = (4/\pi)[\sin it + (1/3)\sin 3it + (1/5)\sin 5it + \dots] \quad \dots\dots\dots\dots\dots (15)$$

Although, as discussed previously, the even component of the square function should have been considered, because the function to be developed is odd itself, the coefficients of the even component will be equal to zero.

The development is as below:

$$\begin{aligned} \sin t = {} & c_0 + c_1(4/\pi)\,[\sin t + (1/3)\sin 3t + (1/5)\sin 5t + \dots] \\ & + c_2(4/\pi)[\sin 2t + (1/3)\sin 6t + (1/5)\sin 10t + \dots] \\ & + \dots\dots + \\ & + c_i(4/\pi)\,[\sin it + (1/3)\sin it + (1/5)\sin it + \dots] + \\ & + \dots \quad \dots\dots\dots\dots\dots\dots\dots\dots (16) \end{aligned}$$

$$\sin t = c_0 + \sum_{i=1}^{\infty} c_i(4/\pi)[\sin it + (1/3)\sin 3it + (1/5)\sin 5it + \dots]$$

$$= c_0 + \sum_{n=1}^{\infty}\sum_{i=1}^{\infty} c_i(4/\pi)\,[1/(2n-1)\sin i\,(2n-1)t] \quad \dots\dots (17)$$

From the equality of both sides the c_n components can be obtained:

$$c_0 = c_2 = c_4 = \dots = c_{2n} = \dots = 0,$$

n being a positive integer

$$\left.\begin{array}{ll} (4c_1/\pi) = 1 & c_1 = (\pi/4) \\ (1/3) + c_3\,(4/\pi) = 0 & c_3 = -(\pi/12) \\ (1/5) + c_5\,(4/\pi) = 0 & c_5 = -(\pi/20) \\ (1/7) + c_7\,(4/\pi) = 0 & c_7 = -(\pi/28) \\ (1/9) - (4/12)\,.\,(1/3) + c_9(4/\pi) = 0 & c_9 = 0 \end{array}\right\} \quad (18)$$

etc.

Therefore, the development is as follows:

$$\sin t = (\pi/4)[\,g(t) - (1/3)\,g\,(3t) - (1/5)\,g\,(5t) - (1/7)\,g\,(7t) \dots] \quad \dots\dots\dots\dots (19)$$

The first components and their sum can be seen on Fig. 1.

Four Simultaneous Transmissions from One Aerial

(The BBC V.H.F., F.M. Transmitting Station at Sandale, Cumberland)

By F. D. Bolt*, B.Sc., M.I.E.E.

In August 1958 the BBC extended their v.h.f., f.m. broadcasting service to the Lake District and S.W. Scotland. Four simultaneous transmissions are radiated from a common aerial, each with an effective radiated power of 120kW.

Particular care was taken to prevent 'out-of-band' radiation, and this article describes how such unwanted radiation was reduced to a few microwatts.

(Voir page 185 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 190)

THIS station, which was brought into service by the BBC on 18 August 1958, is, so far as is known, the first v.h.f. broadcasting station in the world to radiate four programmes simultaneously from a single aerial: this article describes some of the technical problems that had to be solved to enable this to be done efficiently, while complying with severe limitations on the level of unwanted inter-modulation products so as to protect other radio services working in adjacent bands.

The effective radiated power on each of the four programmes is 120kW, and, since the coverage of the station extends into South-West Scotland as well as Cumberland and Westmorland, it was necessary to broadcast both the Scottish Home Service and the North of England Home Service in addition to the Light and Third programmes. A single slotted cylindrical aerial is used to radiate all four programmes omni-directionally.

In accordance with BBC practice the transmitter equipment and aerial system are duplicated; normally working in parallel, each part can operate independently of the other, to maintain the service in the event of a fault. This arrangement has been described, for a three frequency station, by Hayes and Page[1]; Sandale is similar, but with the addition of a fourth pair of transmitters radiating on a frequency separated by the standard interval of 2·2Mc/s, i.e.,

Service	*Frequency*	*Transmitter Power*
Light Programme	88·1Mc/s	10kW + 10kW
Third Programme	90·3Mc/s	10kW + 10kW
Scottish Home Programme	92·5Mc/s	10kW + 10kW
North of England Home Programme	94·7Mc/s	10kW + 10kW

A reflected wave set up by a mismatched aerial will arrive again at the aerial, after a second deflexion at the transmitter, with a phase delay determined by the electrical length of the path traversed. When the primary wave is frequency modulated the phase difference between primary and reflected waves will vary; consequently the resultant signal will be amplitude modulated and contain unwanted components.

The electrical length of the main transmission line and filter circuits being fixed by other considerations, this effect must be controlled by limiting the aerial reflection coefficient. Because of this and of the need to limit the maximum peak voltage set up on the transmission lines a maximum value of 10 per cent was decided upon for the aerial reflection coefficient. This is equivalent to a standing wave ratio on the lines of 1·22.

Fig. 1 shows this ratio as measured on each half of the aerial system. The development of the aerial took place in three stages:

(1) A theoretical analysis to determine slot dimensions and the susceptance correction required[2].

(2) Measurements on a prototype to establish the practical design laid down by (1) and to determine the controls required to correct for variations from the 'ideal'.

(3) The application of (1) and (2) to the aerial as installed on the mast.

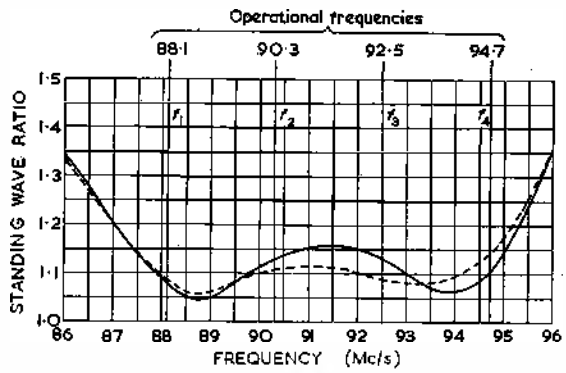

Fig. 1. Aerial impedance

- - - - - - - - - - *Upper 4 stacks*

———————— *Lower 4 stacks*

It was decided early in the design stage that the input impedance of each slot would be adjusted to the required limits and that the distribution feeder system, i.e., the lines paralleling all slots to the main transmission line, would be set up to work into matched resistive loads equal to the mean value of the slot impedance. This allowed the complicated distribution system to be adjusted in the workshop where the variable elements of the transformers could be readily altered. Non-uniformities due to multi-way junction boxes, insulators, and coaxial connectors, etc., were thus easily detected and corrected before installation and so did not confuse the final adjustment of the slot impedance controls. The reflection coefficient of the distribution feeders is less than 2 per cent over the operational frequency band.

Little difficulty is normally experienced with the uniformity of the 51·5Ω 3¼in main coaxial transmission lines, but their electrical lengths must be equal to within ±5°; p.t.f.e. insulation is used throughout, and all conductors are either high-conductivity copper or silver-plated brass. The lines are maintained under a small pressure of carefully dried and filtered air.

It was necessary to limit the power radiated at fre-

* *British Broadcasting Corporation.*

quencies outside the band to an extremely low level (10 to 30μW) in order to avoid risk of interference with mobile radio services using adjacent frequency bands. Such out-of-band frequencies may be produced in the transmitting equipment, or as a result of non-linearity in the resistance of the feeders, or of adjacent metalwork. Particular attention had, therefore, to be paid to the elimination of poor contacts in the fabricated cylindrical surfaces, in the back screens, and in the exposed feed-point connexions. After all adjustments had been made such contacts were cleaned, tightened and painted with zinc-chromate paint.

The form of combining filter employed at Sandale has been described by Beck, Norbury and Storr-Best[3]

In ascending order the frequencies f_1, f_2, f_3, and f_4 are combined as shown in Fig. 2, first f_4 and f_3 in a filter with resonators adjusted for optimum performance on f_3 and f_3 + 3Mc/s.

The combined output is fed into a second circuit adding f_2, the resonators being adjusted on frequencies f_2 and f_3 + 3Mc/s.

Finally a third circuit adds f_1, the resonators being adjusted on frequencies f_1 and f_1 + 3Mc/s.

3Mc/s is chosen as the frequency separation instead of the standard interval of 2·2Mc/s as it gives the optimum cross insertion loss between inputs of the filters over the frequency band, this being determined by the susceptance/frequency curve of the open-ended limb of the resonators, and the maximum permissible peak voltage at the open end. The insertion loss between the two inputs of each combining filter exceeds 50dB.

The filters, when correctly terminated by loads, are 'constant resistance' over a wide band of frequencies and, from the point of view of the power leaking from one transmitter to another, each filter can be considered as a generator with an internal impedance matching the transmitter feeder line. The current voltage set up by this power at the transmitter terminals cannot therefore exceed twice the value which it would set up across a matched load at the same point. It follows that whatever impedance the output circuit of the transmitter presents to the incoming 'leak-through' frequency the cross insertion loss at that frequency cannot drop by more than 6dB.

Out-of-band frequencies of the form $2f_1 - f_2$, $2f_1 - f_3$ etc can be produced in the transmitter output circuits by the leak-through frequency (e.g. f_2) mixing with the second harmonic of the carrier frequency (e.g. $2f_1$), at a level determined by the cross insertion loss (to f_2) of the combining filter and the mixing loss. Out-of-band frequencies of the order of between 60dB and 65dB below carrier level are generated in this way. The best overall performance in this respect is achieved when the level generated within the transmitters is about equal to the level produced by poor contacts on the mast and other conductors in the vicinity of the aerial which has been found to be between −95dB and −110dB. Notch type filters, each attenuating a selected frequency, are therefore inserted in the output feeders from the transmitters to increase the cross insertion loss.

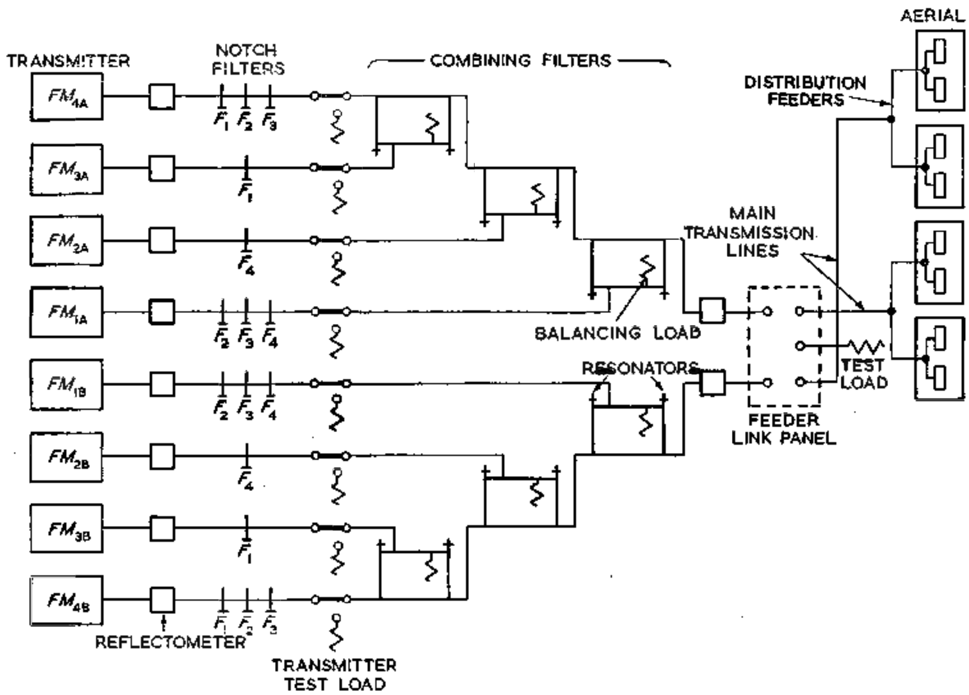

Fig. 2. Arrangement of filters

The full complement of notch filters fitted is:

Transmitter Protected	*Notch Filter Stop Frequency*	*Out-of-Band Frequencies Suppressed*
T_1	f_2, f_3, f_4	f_1 − 2·2; −4·4; −6·6
T_2	f_4	f_1 − 2·2
T_3	f_1	f_4 + 2·2
T_4	f_1, f_2, f_3	f_4 + 2·2; +4·4; +6·6

and the additional loss is between 25 and 30dB.

To obtain the maximum additional attenuation the notch filter must be attached to the transmitter feeder at a point where the apparent impedance looking into the transmitter output circuits is a maximum. This is done by measuring the impedance at a convenient joint in the feeder with the transmitter 'cold' and establishing the position of the maximum by reference to a Smith chart. The point of the attachment is not very critical providing it is not more than ⅛th wavelength from the maximum and this tolerance allows three notch filters to be positioned side by side on the transmitter output feeder to give near-optimum attenuations on three frequencies.

The notch filters are essentially similar to the resonators of the combining filters being tapped quarter wavelength stubs connected in parallel with the feeder line, through 'stalks' to give the required stop- and pass-band characteristics[4]. The level of the out-of-band frequencies finally entering the main transmission lines is thus typically derived as the sum of:

Combining filter cross insertion loss	$\simeq$ 50dB
Notch filter insertion loss	$\simeq$ 28dB
Mixing loss in transmitter	$\simeq$ 12dB
Combining filter 'through' losses to 'out-of-band' frequency	$\simeq$ 6dB
Total	$\simeq$ 96dB

This figure represents an extremely high degree of suppression. The actual level of out-of-band frequencies radiated from the aerial may be slightly greater than the level present in the transmission lines, but should not cause any serious interference with other services receiving weak signals in the adjacent bands. It is important, however, that receivers used by such services in the presence of strong signals in the adjacent broadcasting band, should not themselves produce inter-modulation, and that metalwork near the receiving site should not include poor contacts, and thus re-radiate inter-modulation products derived from the combination of the four frequencies radiated by the BBC station.

No problems associated with the transmission of four frequencies simultaneously arose on the transmitting equipment proper except that the protection circuits became correspondingly more complex. Each transmitter is tripped if the reflection coefficient on its output feeder exceeds 20 per cent and excessive power in the combining filter balancing loads operates a trip bringing off all the associated transmitters.

The four programmes are monitored for faults automatically and where reserve equipment is standing by, this is brought into operation automatically and at the same time an indication of the nature of the fault is given.

Acknowledgments

The author wishes to express his thanks to the Chief Engineer of the BBC for permission to publish the foregoing information.

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A New American Office Computer

A new fully transistorized electronic data processing system has recently been announced by the Radio Corporation of America. It is known as the RCA 501 and expansibility and versatility are among its main features.

An installation can include up to 63 magnetic tape stations under automatic programme control: the high speed magnetic core storage capacity can range from 16 000 characters to 260 000 in steps of 16 000: random access files can be added in increments of 1½ million characters. Similarly, transistorized punch-card input or output, or large-volume printing capacity, can be added to a 501 system whenever it is advantageous to do so. These additions can be made without upsetting routine operations.

Electronic data processing operations can begin with a 501 system of moderate size and cost, avoiding excessive capacity and expense. Then, as the work load increases, or as it is decided to do more tasks electronically, units can be added so that the work potential of the system is in balance with work requirements. This can be accomplished in stages of readily manageable size, and of reasonable cost.

All system operating controls are centralized within a 10in by 12in area in a single streamlined control panel. To start a work routine, the operator pushes a simple combination of buttons which activates the work program. From that point on, the operation is under program control and the system automatically performs the entire task. If desired, however, the operator may manually control the operation of the system and may read out every stage of the execution of a program.

In the 501 tape store variable length recording is used. This means that the amount of tape used is in almost direct proportion to the amount of data. In most other systems a fixed length of tape is allowed for each item in an entry, and this length is used regardless of the actual length of the data. The waste of space and excessive processing time is obvious. To avoid this, some systems resort to special programming; but that is expensive.

Further, in the 501, the space between entries on the tape is very small—only 0·4in—and an important reduction in processing time results. Still further savings arise from the rapidity with which the tapes can be put in motion. The tapes can be read by the computer when they are moving either forward or backward, and major savings in processing time, especially sorting, result from this also.

Reliability of operation is achieved by the extensive use of such techniques as automatic parity checking and dual arithmetic. In addition, the 501 records all data twice on its magnetic tapes, without increasing either the length of tape used, or the processing time.

The computer reads and writes to and from the magnetic tape at 33 000 characters per second. This is a very conservative rate which contributes substantially to the low cost and dependability of the system. It should be noted, however, that because of the efficiency provided by variable length recording, by the short gap between entries, and by the short time required to put the magnetic tapes in motion, the 501 is able to process data at a rate equivalent to that of more conventional machines with a read-write speed of 90 000 characters per second, or even higher. And this is accomplished in the 501 without special programming or additional electronic circuits, and therefore without the high costs ordinarily associated with high speeds.

Time-sharing permits the performance of many kinds of simultaneous operations with large reductions in processing time. Among these are: read-compute, write-compute, read-write.

It is claimed that through the use of advanced circuits and logic the potentialities of magnetic cores have been exploited to the utmost. The high speed magnetic core storage can handle data in either variable or fixed length, and can transfer data at the rate of 4 characters in 15μsec.

An output printer, operating under computer control, will deliver the output of the system, in variable format, at the rate of 600 lines per minute and there may be up to 120 characters per line. Computation can proceed while the paper being printed is advancing.

A paper tape reader will transfer data from punched paper tape to the 501 computer at the rate of 400 characters per second. A monitor printer provides a low-cost auxiliary system output.

The physical design of the 501 computer is of an advanced design. The transistors together with other sub-miniature components are assembled on small plastic wafers, with the components on one side and the necessary printed wiring on the other. A number of these small units (up to 12) are then mounted on a thin plastic board, which also has printed wiring on its reverse side, to form a plug-in assembly which is installed in the system by simply sliding it into position.

Short News Items

The Council of the Institution of Electrical Engineers announces that the name of the Radio and Telecommunication Section of the Institution has been changed to Electronics and Communications Section. The following circumstances provide the background to this decision. In recent years the word 'Electronics' has been broadly used to cover the evolution of new techniques in fields other than communication and, although the basis of this work may well be attributable to those who have hitherto been regarded as engaged in the radio field, the final applications are often developed by other electrical engineers. Moreover, the incorporation of the word 'Electronics' into the name of the Section is intended to emphasize to the profession that the Institution is manifestly the learned society for those properly qualified electrical engineers who regard themselves as 'electronic' engineers. The word 'Radio' no longer appears in the title of the Section, because it is felt that this word, with its modern connotation of certain limited applications, is now insufficiently comprehensive. The continued inclusion within the sphere of the Section of such interests as navigational aid systems and radar is, it is felt, implied in the new title. So far as the omission of the word 'Telecommunication' is concerned, it is considered that the word 'Communications' will be interpreted broadly within the context of electrical engineering, and the change makes for a shorter and, at the same time, a more comprehensive title.

A second course on the Control and Instrumentation of Reactors will be held at the Harwell Reactor School from 7-17 July, and will be open to British and overseas students. The first course held in October last was heavily overbooked and a total of 98 attended. It lasted for five and a half days, but as a result of the experience gained from this course, it was decided to extend the second course to nine days. The course is primarily intended for those who have a direct interest in the control and instrumentation of nuclear reactors, and it will be assumed that participants have some knowledge of the basic principles of these subjects. In addition to the lectures there will be visits to zero energy and high flux research reactors and other relevant parts of the Harwell Establishment. The fee for the course will be 50 guineas, exclusive of accommodation, and application forms, available from the Reactor School, must be returned by 7 May to the Principal, Reactor School, Atomic Energy Research Establishment, Harwell, Didcot, Berkshire. The next course for Senior Technical Executives to be held at the Harwell Reactor School will be from 15-25 June. Full details of this course may also be obtained from the Principal.

The Acoustics Group of the Physical Society is sponsoring two symposia dealing with the problem of noise and vibration. The first, at 2.15 p.m. on 24 March in the Physics Department, Imperial College, London, S.W.7, under the title 'Recent Studies of Noise Problems', will survey recent work on the measurement and effects of noise, with contributions on certain aspects of aircraft and automobile noise. It is open to all without formality. The second is a one-day meeting on 7 April in the Physics Department, Southampton University. Entitled 'New Techniques in the Analysis of Noise and Vibration', it will include contributions from both practical and theoretical aspects on the use of correlation techniques, of digital computers for data processing analysis, and on general applications of statistical communication theory. It is a joint meeting with the Institute of Physics. Further details may be obtained from D. M. A. Mercer, Physics Department, Southampton University.

The 5th International Instrument Show, sponsored by B & K Laboratories Ltd, will be held at the International Instrumentation Centre, 4 Tilney Street, Park Lane, from 6-10 April. It will be open each day from 10 a.m. to 7 p.m., except on Monday (opening 11.30 a.m.) and Wednesday (closing 9 p.m.). Products from over 50 factories from 10 countries will be shown and several new instruments and components will be displayed, particularly from overseas. Emphasis will be on new high speed analogue and digital instrumentation, new components such as the Varicap and Halltron, developments in e.h.t. power measurement and frequency analysis, new measuring microphones and ultra-precision magnetic tape data recorders. Applications for tickets should be made to the organizers, either at 4 Tilney Street, London, W.1, or 57 Union Street, London, S.E.1.

The United Kingdom Atomic Energy Authority has decided to make fuller use of microphotography, in order to make atomic information more easily available. The effect of this will be to make all non-secret reports which have been prepared since 1947 readily obtainable. Complete sets are also being presented to a number of other countries and to certain international agencies. In addition to this, the Authority is increasing its facilities for supplying reports in conventional form as they are prepared.

The Radio Industry Council states that a new record was reached for exports of British radio equipment of all kinds in 1958. The provisional value, over £45m, was over £1½m more than that of the previous highest level, 1957, and is nearly four times that for 1948 (£11·9m). The highest proportionate rise was for valves and cathode ray tubes, £5·3m, or £1·4m higher than in 1957, and a new record level. Record levels were also reached in the sound reproducing equipment groups, where the total, £11·3m, represented a rise of £1·4m over 1957 and was more than double the value for 1955 (£5·6m).

The Ministry of Supply has placed a substantial contract with Marconi's Wireless Telegraph Co. for v.h.f. Direction Finders for use at airports and airfields in the United Kingdom. The equipments, which have been ordered on behalf of the Ministry of Transport and Civil Aviation, will provide a total of 24 d.f. channels. The largest installation, with four channels, is for the Southern Air Traffic Control Centre. Dual channel installations are to be provided for the Northern and Scottish Air Traffic Control Centres, and single channels will be installed at other principal airports including Gatwick, Stansted, Blackbushe and Elmdon. London Airport is already equipped with Marconi v.h.f. Direction Finders. The Direction Finders ordered in this contract are type AD.210C, the first of a new and comprehensive series of automatic d.f. equipments, developed by Marconi's to provide in the simplest and least expensive form the direction finding requirements of an airport. Experience gained in d.f. installations in many parts of the world indicated that remote control over long distances is rarely required.

20th Century Electronics Ltd have appointed Mr. P. Holton to take charge of their Photomultiplier Applications Advisory Service. The aim of this service is to provide the customer with the fullest information on the choice of photomultiplier for particular applications and the optimum conditions for their use.

Smiths Aircraft Instruments Ltd and Kelvin & Hughes Ltd, together with Sperry Gyroscope Co. Ltd (Brentford Division), announce an arrangement for collaboration in certain major projects for aircraft control and instrumentation systems covering all aspects of such enterprises. The unique technical resources and facilities of both organizations, specialists in the design of advanced instrumentation and control equipment, are being applied, in the first instance, to the development of a flight control and instrumentation system for new British civil aircraft, in particular the de Havilland 121. Proposals are also in hand for similar systems for future military aircraft.

LETTERS TO THE EDITOR

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

Current 'Creep' in Transistors

DEAR SIR,—In using pnp germanium junction transistors in circuits with poor d.c. stabilization of working point a slow drift in collector current was noticed. It was traced to a progressive increase in I_{co} the collector-base leakage current, even with constant ambient temperature, having a time course of the order of minutes or, in one case, several hours.

The first, and probable explanation, thermal run away, was excluded on account of (a) the small dissipation involved and (b) the very long time over which the increases took place.

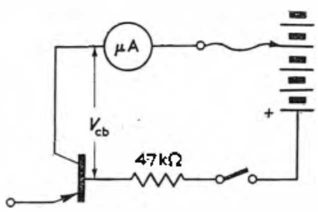


Fig. 1. Simple test circuit

Several transistors of different manufacture were tried in the simple circuit shown (Fig. 1). On switching on, an initial value for I_{co} was obtained. Soon after in several specimens an increase was observed and the change plotted against time (Fig. 2), the rise being approximately exponential. When I_{co} had risen considerably, the circuit was broken for one second, and when remade, I_{co} reverted to about its initial value, and began to rise again, but at

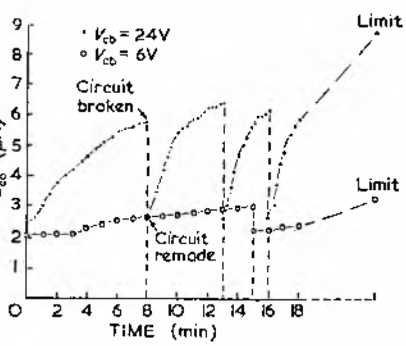


Fig. 2. Current against time showing creep

an increased rate. Again the circuit was broken for one second. The results were similar to that following the first break, except that the rate of increase was even greater.

It was evident that the rates of rise in I_{co} were to some extent dependent on the previous history, and very dependent on the reverse potential applied between collector and base.

The rising characteristic had different initial, intermediate and final rates, i.e. three exponentials were involved, while subsequent rising characteristics, with one-second interruptions, indicated a fourth exponential function.

It would be interesting to hear whether any readers have noticed similar effects, or have any possible explanation of this 'creep'.

Yours faithfully,

R. E. GEORGE,
Physics Department,
Guy's Hospital Medical School,
London, S.E.1.

Circuit for a Reversible Dekatron Counter

DEAR SIR,—Further to the article by Mr. D. L. A. Barber (ELECTRONIC ENGINEERING, Jan. 1959, p. 42) your readers may be interested in the following circuit for a reversible Dekatron counter which was developed by the writer from the circuits described in a previous article ('Transistor Circuits for Use with Gas-Filled Multi-Cathode Counter Valves', J. B. Warman and D. M. Bibb, ELECTRONIC ENGNG., March 1958, p. 136).

Since the circuit requires only three transistors per decade, with two gating transistors for up to 5 stages, it is suggested that it represents a considerable improvement on the circuit described by Mr. Barber.

The basic principles of operation are shown in Fig. 1. Transistors X_1 and X_2 form blocking oscillators with the transformer, and when either S_1 or S_2 is closed, one of the blocking oscillators is triggered by a pulse applied to the input winding. The collector voltages are transformed and applied to the guides of the Dekatron, the initial voltage rise being applied to one, and the overshoot to the other by means of the diodes in the

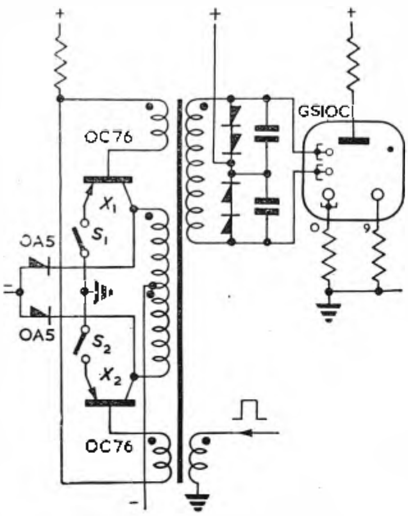
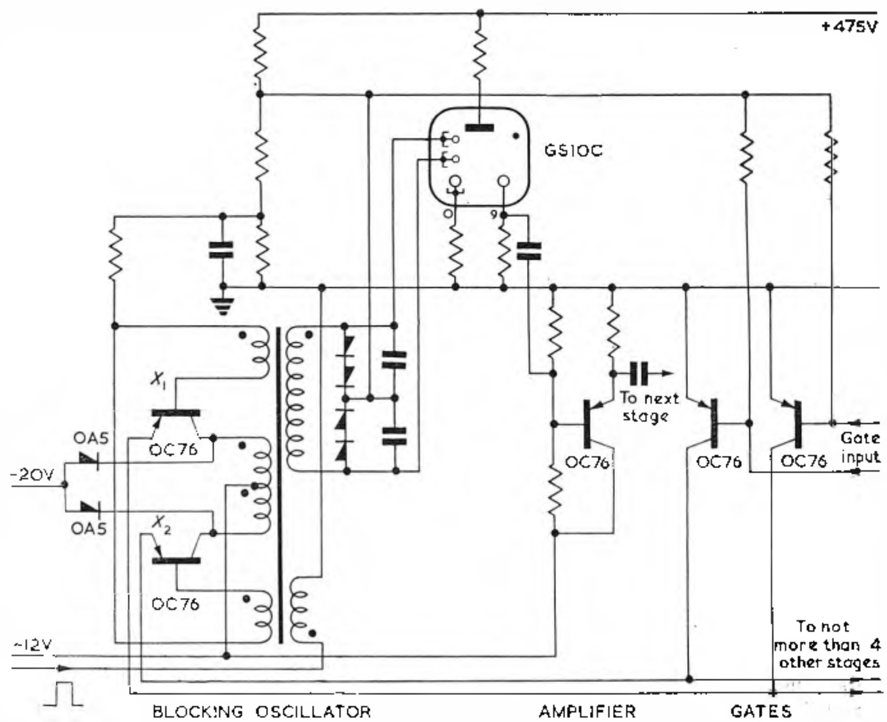


Fig. 1 (above). Basic principle

Fig. 2 (below). Application of principle to a decade counter



secondary winding. The capacitors delay the fall of each pulse to provide the necessary overlap. When S_1 is closed, transistor X_1 is triggered by positive input pulses, and the Dekatron glow rotates in one direction. When S_2 is closed however, negative inputs trigger X_2, and because the primary windings of the transformer are reversed, the initial voltage pulse and overshoot are applied to the guides in reverse sequence, rotating the glow in the opposite direction. Thus for a square input pulse, the Dekatron will count in one direction from the positive edges with S_1 closed, and in the opposite direction from the negative edges with S_2 closed. (The collector diodes limit the overshoot voltage.)

Fig. 2 represents the application of this circuit to a decade counter of several stages. The switches S_1 and S_2 are replaced by two transistor gates, whose states are set by the direction-determining signals. The output signal from the number 9 cathode of the Dekatron is differentiated and fed to the next stage via an emitter-follower.

The necessity for gates for the 'carry' pulses is eliminated because, when set to count forwards, say, the blocking oscillators trigger on negative edges (i.e., when the glow leaves cathode 9), and when set to count backwards, they trigger on the positive edges (i.e., when the glow arrives on cathode 9).

The gating transistors will carry sufficient current to enable them to be common to 5 stages, their input requirements being of the order of 1mA.

The above circuit was developed for its simplicity, and ease of operation. Since no thermionic devices are used, considerable reliabilty is expected.

Yours faithfully,
K. F. Bacon,
Mullard Research Laboratories

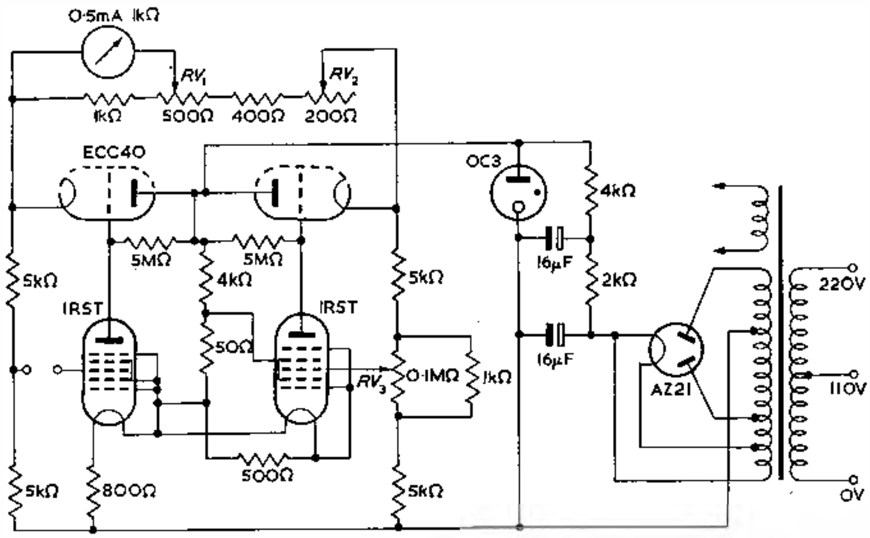


Fig. A. pH meter amplifier

A Feedback Electrometer Amplifier

Dear Sir,—I have read Mr. Allenden's article in the January 1958 issue of Electronic Engineering with great interest, since I dealt with the same problem some years ago. However, the remark in his letter in the October 1958 issue has really aroused my interest as he asks for references to a system which will stabilize a d.c. amplifier by a factor of 30 or higher. May I call your attention to a circuit which I designed for this purpose.

I think it is a general principle that the stability of a symmetrical circuit is orders better than that of the equivalent single-sided one. Cost was an important factor to me, so I did not use an electrometer valve but a battery heated heptode (1R5T) with exceptionally low grid current, which gave a higher gain, so that I saved a voltage amplifier (the cascade stage in Mr. Allenden's design).

The circuit diagram in Fig. A is a copy from the publication[1] in which we gave a complete description of the design and operation of the amplifier. Here I will only point out that one half of the circuit (a conventional Roberts circuit[2], consisting of a stable heated 'electrometer' and a cathode-follower) has already achieved by the high negative feedback a reduction of about 1:10 in the effects of any change in heater current. Since the two symmetrical amplifier valves are heated in series, any change in heater current produces a similar effect on both sides, and therefore only produces a second order change in the output. Roughly speaking the symmetrical circuit improved the stability by a further factor of 10.

The amplifier has been used as a pH meter for several years without the slightest complaint. The zero stability was in fact within 0·01pH (about 0·5mV) using any pair of valves from a random batch of 12.

Yours faithfully,
A. D. Boronkay
Unicam Instruments Ltd,
Cambridge.

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2. Roberts, J. *Rev. Sci. Instrum. 10*, 191 (1939).

The Author Replies:

Dear Sir,—I am indebted to Mr. Boronkay for drawing my attention to a most interesting and original circuit, which would appear to be ideally suited to pH meter applications. The somewhat high grid current (10^{-12}A) limits its use to what may be called 'semi-electrometer' conditions, and the floating input is objectionable for many vacuum physics applications.

Taking up the points in Mr. Boronkay's letter, I would not expect more than one order improvement by use of a balanced circuit with no provision for adjustment or selection.

Negative feedback has no beneficial effect on fluctuations arising at the input—these are simply reduced in the same proportion as the gain itself and hence for cathode-originating drafts one must rely on either the matching of valves, or the stabilization of heater power. I suspect that most of Mr. Boronkay's drift-reduction arises, as in my own amplifier, from stabilization of heater current. This hypothesis would appear to be supported by the fact that his drift figure is some 5 to 6 times better than mine for the same degree of filament power stabilization—this extra factor presumably arises mainly from the use of balanced stages and secondarily from the fact that his input stage gain is 5 times greater than mine, rendering his circuit that much less liable to h.t. line and second-stage effects.

Using the CV2348 with a 5MΩ anode load gives about the same gain as the 1R5 in Mr. Boronkay's input stage, and it is then possible to build the single-ended amplifier using only one valve envelope (a twin triode) for second and third stages, while maintaining the high loop gain (~250) of the published circuit.

One of the points implied in my article and subsequent correspondence is that present stabilization and electrometer valve techniques are such that power supply drift can always be reduced to a level at which uncorrelated (and therefore uncompensatable) residual fluctuations predominate. This being so, the use of a single-ended circuit may well result, in the limit, in better performance: in non-limiting cases, however, balanced stages may allow power supply stability requirements to be relaxed.

Yours faithfully,
D. Allenden
Electronic Services Group,
Associated Electrical Industries Ltd,
Research Laboratory,
Aldermaston.

BOOK REVIEWS

Electrons, Waves and Valves Space Charge Waves and Slow Electromagnetic Waves

By A. H. W. Beck. 396 pp. 50 figs. Demy 8vo. Pergamon Press Ltd. 1958. Price 90s.

THE history of many branches of physics reveals a struggle between the protagonists of a corpuscular theory on the one hand and a wave theory on the other. The study of light is an outstanding example wherein the fortunes of war have swayed to and fro since the time of Newton.

The pattern repeats itself in the evolution of the theory of valves in which individual electrons remain active over several cycles of the radio frequency field. For many years ballistic theories of electron motion proved adequate to describe the behaviour of early klystrons and magnetrons. The advent of the travelling wave tube and the multi-cavity klystron caused the resurrection of dormant theories of space charge waves on "long" electron beams. The take-over was so successful that the ballistic approach has conceded precedence at least for the time being. An important exception arises, however, in the study of the reflex klystron; this the space charge wave theorists apparently have left alone, not, perhaps, without having burnt their fingers.

During recent years the effort expended on the research and development of microwave valves has produced an overwhelming flow of original papers on the subject. To keep well informed requires an almost full time study of the literature or a rapid and intelligent abstracting machine. There is a need therefore for books that are essentially reviews of the subject which maintain both the expert and the teacher up to date in their knowledge. An essential feature of this class of work is that it must contain Stop Press News and therefore, in part at least, it must be written hurriedly and without complete understanding of every detailed result. Moreover to cover the field in a reasonable compass, clarity must occasionally be sacrificed for brevity.

Here then is a book of this calibre on space charge waves in electron beams and their application to the study of many types of microwave valves. The general introduction is followed by a condensed treatment of Maxwell's equations. This leads to a broad description of radio frequency circuits used for propagating slow electromagnetic waves which will interact with space charge waves. The groundwork is completed by a comprehensive account of space charge waves including the multi-mode theory which the author has advanced so successfully. The remainder of the book is devoted to application of the results in evaluating the performance of klystrons, travelling wave tubes, crossed field devices and other special beam type tubes. It concludes with a discussion of noise phenomena and the methods of noise reduction in electron beams.

In his preface the author remarks on the aversion felt by his readers for advanced mathematics. If this is real it is a reflection on the teachers of mathematics. They must realize that they have to sell their wares by indicating the use to which they can be put.

This book should prove invaluable to anyone interested in the modus operandi of microwave valves. It provides several illustrations of the use of mathematics and therefore also merits study by those responsible for the teaching of this subject.

J. DAIN

Principles of Electronics

By H. Buckingham and E. M. Price. 419 pp. 70 figs. Demy 8vo. 2nd edition. Cleaver-Hume Press Ltd. London. 1958. Price 17s. 6d.

A QUICK dip into the book gives the impression of an easily assimilable work within the scope of the title, and a more detailed study not only confirms but emphasizes the excellence of the presentation as a blend of descriptive matter with quantitative theory suitable for all but the specialist. The preface suggests that heavy-current electrical engineers will find it a good grounding in the subject and this too is endorsed.

The scope involves about a quarter of the book on theory with another quarter on common electronic devices; the remaining half is devoted to a wide range of methods and applications. The very short section on electronic devices to measure ionizing radiations is somewhat sketchy, and the illustration of the old gas X-ray tube may mislead: a common thermionic or hot-cathode tube would be more representative.

Two chapters are new in this edition, on magnetic amplifiers and on transistors. The latter is a general survey which is unbiased, if the term may be used for such a device, and might with advantage stress present practice more, as is covered by the statement by one authority that 'npn' type might correctly be taken to mean 'not produced now'. It is of course true that developments in transistors are so rapid that new types and techniques may render much of this obsolete before the rest of the book is outdated.

There are many test questions, and answers are provided for the numerical ones. Terminology and symbols are refreshingly correct to British Standard practice.

E. H. W. BANNER

Electronic Circuits

By E. J. Angelo, Jr. 450 pp. 80 figs. Demy 8vo. McGraw Hill Publishing Co., New York and London. 1958. Price 70s.

THIS book caters for the post Higher National Certificate student, who wishes to rationalize his knowledge of 'lumped' electronic circuits. To this end, throughout the seventeen chapters, valves and transistors are examined side by side. Equivalent circuits are used to establish both the alternating and quiescent conditions in amplifiers and pulse shaping circuits. Rectifier symbols are inserted to show the direction of flow of current under d.c. conditions, and this is particularly useful in the consideration of pulse shaping circuits and their voltage transfer characteristics. On the other hand, great care must be taken in examining the circuits, since these rectifiers may be so biased that they are either conducting all the time or not at all.

The applications of thyratrons as time-base generators, and as controlled rectifiers, are dealt with quite fully; but, as the author states in the preface, 'Nonlinear electronic circuits are treated only in an introductory manner in this book', modulators being dealt with only very briefly. Oscillators, in fact, are represented only by the Wien Bridge and the tuned grid types. The emphasis is always toward amplifiers and circuits used in television waveform generators; but in spite of this there is no description of display tubes, camera tubes, or of the electron optics involved.

A chapter deals with linear circuit analysis, and its application to electronic circuits; and useful points are made in connexion with Thevenin's Theorem and controlled voltage and current sources. In particular a reduction theorem is suggested, which replaces each resistance, reactance and voltage in the controlled circuit by another element in the simplified circuit, multiplied by a factor of $1 + A$, where A is the amplification of the controlled source.

A later section is devoted to the study of transient conditions using linear differential equations. The means of evaluation chosen is the classical method of finding the Particular Integral and Complementary Function, rather than to use the Laplace Transform, although this is introduced and its advantages explained.

The last chapter is on feedback, in which the Nyquist diagrams and pole-zero patterns for amplifiers are discussed.

Throughout the book worked examples in quite new circuit techniques are used as illustrations, and are neatly arranged. References are given at the foot of sections where applicable, and the work is concisely indexed. Examples for the student to work on are given at the end of each chapter. These are most interesting, many of the questions being on the synthesis rather than the analysis of circuits. It is a pity that answers are not provided.

Some of the terms used have a definite transatlantic flavour, for example, 'open-circuit forward voltage transmittance' and 'piece-wise linear analysis'; but this is a book for teachers of the subject, who will find fresh ideas in its pages.

D. J. HENMAN

The Physical Foundation of Biology: An Analytical Study

By Walter M. Elsasser. 219 pp. 20 figs. Demy 8vo. Pergamon Press, 1958. Price 30s.

HERE is yet another recent book whose contents one would not have guessed from its title. For more than half its length it makes practically no connexion with biology, except perhaps by contrast: for it deals with artificial automata, their powers, their limitations, and their engineering requirements. The author's eventual object is to argue that the mechanistic explanation of brain processes is impossible without invoking what he calls 'biotonic processes', fundamentally different from those incorporated in automata. To support his thesis he wants to argue that the information-content of an organism cannot be supplied and maintained by mechanical processes: hence, on the one hand, the extensive if (inevitably) sketchy survey of current computing and communicative techniques, and on the other, the simple and lucid presentation of basic notions in information theory, which fill so much of the book.

This is a difficult argument to follow. The fact that we find 'no evidence of storage, input or output devices' (pp. 151, 138, 143) certainly counts against digital computer-models of the brain; but these have never been strong candidates, and the objection has less force against the self-organizing statistical models which seem more realistic.

The key notion of the information-content of an organism is particularly elusive. How are we to define the conditional *probabilities* which Shannon's theory requires? Granted that individual synoptic contacts are too unstable to store independent items of information (p. 134), is it certain that the hundreds of dendritic ramifications from one neuron could not store at least one bit between them? Elsasser's worry here seems to arise from the noise-intolerance of digital techniques (p. 145) rather than from a balanced assessment of what is informationally necessary. Again, the role of the environment in supplying and maintaining the detailed information-content of a growing organism seems greatly under-valued. If the two were quite alien to one another, the input from the environment might well count as 'noise' for this purpose; but since in fact the structure of organisms has evolved to match many of the demands of their environment, the input is bound to contain a large component which counts as information. Altogether this informational argument is the weakest part of the book, and it seems a pity that so much is made to hang on it.

For it seems not at all implausible, as the author wants to argue, that vital biological information may be carried by molecular configurations too delicate to be observable. It is less clear why such information-storage should be called 'non-mechanical', still less given so mystical-sounding a name as 'biotonic'. It does not seem impossible to imagine artificial contrivances made sensitive in like manner to unobservable molecular processes: and it would then be hard to prevent the engineer from including these in his category of 'mechanism'.

The question that remains open, despite the author's most readable argument, is whether such processes are informationally essential.

D. M. MACKAY

Automatic Process Control

By D. P. Eckman. 368 pp. 100 figs. Demy 8vo. John Wiley & Sons Inc., New York. Chapman & Hall Ltd., London. 1958. Price 72s.

THE author successfully brings together in one volume most of the theory previously limited in text books to basic servomechanisms and applies it to the more complex cases found in process control.

In a rewritten and up-to-date form Professor Eckman has used a limited amount of material from his previous work *Principles of Automatic Process Control*. This book has been written for the more advanced student or practising engineer and requires a good grounding in basic mathematics and thermodynamics to be fully appreciated. Derivation of block diagram techniques is well covered. The usual methods of frequency response analysis and the Stability criteria of Nyquist and Bode receive due attention.

Elementary synthesis of process control elements is also introduced. The analysis and synthesis methods are also applied to measuring elements which is of particular interest to the process control engineer. This work is rather theoretical, however the theory presented is supported by a section on the practical methods of generating control functions, which describes in detail the pneumatic, electric and electronic equipment actually being used in many process industries. The author points out many practical limitations of the theory, unfortunately the difficulties encountered when using frequency response techniques for process plant analysis do not receive attention.

Particular process industries are not considered in detail, the author is attempting, and wisely so, to give a sound basis in fundamentals. The examples quoted are concerned with the measurement and control of such quantities as flow, temperature, pressure and level.

More elaborate cascade control systems and the techniques employed in batch process control are briefly considered. Also briefly mentioned are self optimizing and computer control schemes.

It is extremely difficult to know exactly what to include in a volume of this nature. Perhaps it would have enhanced this book if an introduction to statistical methods as applied to process control had been included. Also analogue techniques, which are currently gaining considerable favour, are only briefly covered.

Many worked examples are included during each chapter and also several problems are provided, complete with the answers. Some useful detailed experiments are described including one on the use of an analogue simulator.

E. F. SNARE

Fourth National Symposium on Vacuum Technology Transactions

Edited by W. G. Matheson. 176 pp. 90 figs. Medium 8vo. Pergamon Press Ltd., New York, Los Angeles, Paris, London. 1958. Price 90s.

THIS book includes papers presented at the National Symposium on Vacuum Technology Transactions held in Boston in October 1957.

These symposia are organized by the American Vacuum Society Inc, the successor to the Committee on Vacuum Techniques, Inc, which was set up in 1953 to sponsor symposia on the subject and to assist in the dissemination of related knowledge.

Papers are included on the fundamental developments of vacuum technology and engineering, new methods and techniques for obtaining high vacuum, instrumentation, controls and other vacuum devices.

ELECTRONIC EQUIPMENT

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

IMPEDANCE COMPARATOR

(Illustrated below)

Dawe Instruments Ltd, 99-101 Uxbridge Road, Ealing, London, W.5

The type 304 impedance comparator is designed for production line testing of resistors, capacitors and inductors.

The circuit incorporates a 1kc/s oscillator which feeds a Wheatstone bridge. The out-of-balance signal due to the

unknown component is, after amplification, applied to a phase sensitive demodulator. The apparatus may be switched to indicate the resistive or reactive components on a large scale meter which is calibrated to display percentage deviation of impedance or difference in phase-angle between the unknown and the standard.

The impedance deviation range is −25 to +35 per cent and the phase-angle deviation range (tan δ) −0·3 to +0·3 both in three ranges. The normal ranges for deviation measurements are: 10Ω to 10MΩ; 50pF to 10μF; 2mH to 100H.

EE 7751 *for further details*

PRECISION SLIDEWIRE POTENTIOMETER

Kelvin & Hughes Ltd, New North Road, Barkingside, Essex

This potentiometer is primarily intended as a computing element for conversion of angular rotation to resistance or voltage with a high degree of linearity and stepless resolution.

By employing the slidewire principle, so that the contact runs continuously on the resistance wire instead of moving from turn to turn, infinite resolution is achieved, and linearity is limited only by the accuracy to which the wire is drawn.

A typical potentiometer has a total value of 450Ω, is rated for 200mA, and is traversed by 180 turns of the spindle. An accuracy to 0·1 per cent of actual reading is obtainable down to 1 per cent of full range; in terms of full-scale reading, the accuracy is to 0·03 per cent.

EE 7752 *for further details*

FINE WIRE FEEDER

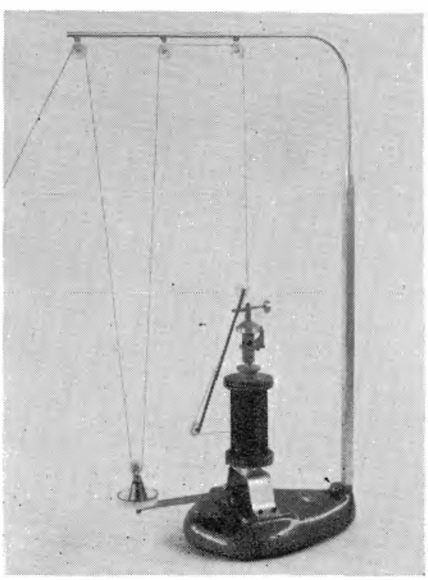
(Illustrated below)

Kinetrol Ltd, Trading Estate, Farnham, Surrey.

The Kinetrol fine wire feeder is for unwinding fine wire at constant tension from a reel, while it is being wound on to instrument bobbins, etc.

The feeder stands 15in (38·1cm) high. It will handle the thinnest copper wire, down to ·0008in (0·02mm) diameter; or nichrome down to ·0006in (0·015mm) diameter. The tension may be adjusted from a minimum of 5g to a maximum of 15g. It will feed 46 to 52 s.w.g. wire at 60in/sec (150cm/sec) and the spring controlled model (not illustrated) will feed thicker wire (42 to 46 s.w.g.) at 20ft/sec (6m/sec).

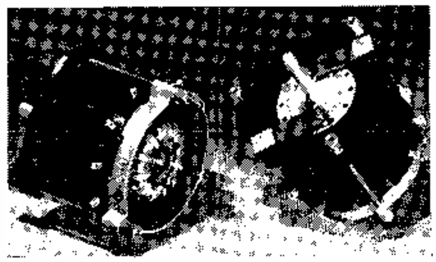
The wire is unwound from its reel by the action of winding it on to the article being manufactured. The reel is stationary on the feeder; and an arm is pulled by the wire, rotating round the reel, to lead it away over a series of pulleys. Between two of these pulleys, mounted on a beam, the wire hangs in a loop, to support an adjustable jockey-weight attached to a jockey pulley. This jockey-weight applies the correct tension to the wire. It is poised over a pan attached to the end of a lever. The lever actuates a brake controlling the spinning of the rotating arm. The slightest slackening in the tension in the wire causes the jockey-weight to settle in the pan, which applies the brake to the rotating arm and restores the tension. As the tension increases the



jockey-weight tends to rise, releasing the brake till the tension is correct again. In an extreme case, if the wire jams on the reel, the jockey-weight can rise several inches without increasing the tension, and gives warning of trouble.

The feeder allows a high winding speed at constant tension, without straining or breaking the wire, where it is wound on to an irregularly shaped object. The only moving part (the rotating arm) is so light, that its inertia will not break the wire.

EE 7753 *for further details*



LOW RESISTANCE INSTRUMENT SWITCH

(Illustrated above)

W. G. Pye & Co. Ltd, Granta Works, Newmarket Road, Cambridge

This instrument switch is of a new design based on two years of fundamental research into problems related to contact resistance such as contact pressure, number of contact points, materials, lubrication, indexing, mechanical wear and contamination.

The overall switch resistance is approximately 0·7mΩ and the variation of contact resistance is less than ±20μΩ. The overall resistance drift during the life of the switch is less than ±50μΩ. Thermal e.m.f. is not more than 0·008μV/°C with uniform change of temperature. Temperature gradient across the switch produces a maximum of 0·025μV/°C.

The switch is totally enclosed and does not require maintenance of any kind. In a life test, 20×10^6 operations were performed, the switch remaining well within the specification.

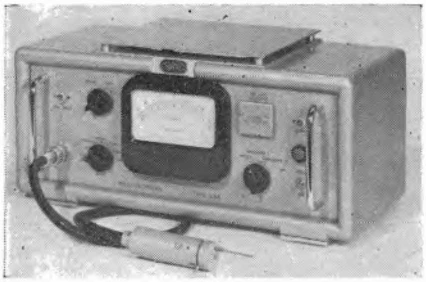
EE 7754 *for further details*

VALVE-MILLIVOLTMETER

(Illustrated above right)

Airmec Ltd, High Wycombe, Buckinghamshire

The valve-millivoltmeter type 264 is a mains operated instrument designed for the measurement of small a.f. or r.f. voltages over a wide range of frequencies. Voltage ranges are covered in 3 to 1 steps from 1mV to 1V, the range being selected from a switch on the



front panel. A rotating turret probe of unusual design is used in which the stray capacitances have been reduced to an absolute minimum. The turret probe is used as a multiplier and provides four positions, × 1, × 0·1 and × 0·01 high impedance, together with a × 1, 75Ω impedance.

The frequency range covered is from 20c/s to 10Mc/s with an accuracy of ±3 per cent up to 3Mc/s; ±5 per cent 30c/s to 6Mc/s and ±7·5 per cent 20c/s to 10Mc/s. A further error of ±2 per cent is introduced when the probe multiplier is used.

As an amplifier, the instrument has an output impedance of 100Ω; the maximum output is 3V into 1kΩ and the frequency response is within ±1dB from 30c/s to 10c/s. The overall gain is 50dB maximum.

EE 7755 *for further details*

INSULATION TESTER

Radiometer, 72 Emdrupvej, Copenhagen, Denmark

This self-contained mains operated megohmmeter, type IM5, provides for accurate resistance measurements from 1MΩ to 10^5MΩ in seven ranges. Five stabilized test voltages of 50, 100, 200, 500V and 1kV are provided and these can be used on all resistance ranges. The type IM5 megohmmeter is designed for measuring insulation resistances of capacitors, transformers, printed circuit boards, cables, etc. The instrument incorporates a guard circuit so that direct measurements of mutual leakage in multi-connector cables or three-terminal capacitors, etc., can be easily made. The instrument is protected against short-circuits in the specimen under test. Before disconnexion of the specimen under test the test voltage is removed and the binding posts are short-circuited. This feature in connexion with a maximal short-circuit current of 4mA makes the instrument absolutely safe.

EE 7756 *for further details*

BAND-PASS CRYSTAL FILTERS

(Illustrated above right)

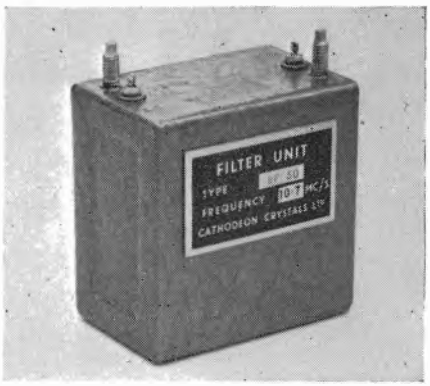
Cathodean Crystals Ltd, Linton, Cambridge.

These miniature i.f. crystal band-pass filters have 80dB attenuation outside the pass-band and are suitable for use in a.m.-f.m. receivers operating in the h.f., v.h.f. and u.h.f. bands.

All filter units are interchangeable with no trimming or padding required; thus, if a set designer requires to change from one channel spacing to another, it is only necessary to insert the corresponding band width filter. The rugged sub-miniature crystal units, together with all other components, are mounted on printed circuit boards and housed in a hermetically sealed brass container.

The miniature units require only 2in by 1 5/16in (51mm by 33·5mm) of chassis space and give substantially flat pass-band characteristics with almost vertical cut-offs. Several bandwidths are available and all possess a minimum attenuation of 80dB. The relatively low insertion loss values render their use between the frequency changer and the i.f. amplifier most suitable and the characteristics entirely eliminate the need for i.f. transformers and permit broad band amplifier design techniques with only a single frequency conversion.

The centre frequency stability of the response curve over a wide temperature range is better than 12 parts in 10^6.



Peak r.f. input voltage is 12V and the phase linearity over most of the pass-band guarantees faithful reproduction for f.m., or pulsed systems. Although the filters are normally terminated for use with valve impedances of 1·6kΩ approximately, impedances giving maximum power transfer in transistorized systems are available.

EE 7757 *for further details*

LEVEL CONTROLLER

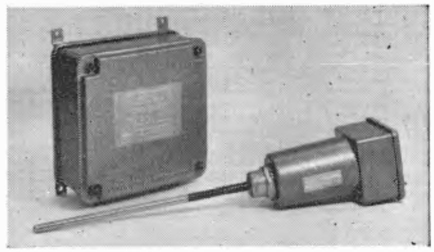
(Illustrated above right)

Lancashire Dynamo Electronic Products Ltd, Rugeley, Staffordshire.

In this new equipment transistor oscillators are used to replace oscillator valves in the detector circuit which registers the change in capacitance at a probe or similar electrode on the approach or recession of a material.

In the transistor oscillator circuit, the external capacitance represented by probe and earth is connected to the tuned circuit of the oscillator.

With the high level probe unit, oscillation occurs when the probe is clear of the material and under these conditions the relay in the control unit is energized. When the material reaches the level of the probe, the change in capacitance causes the oscillation to be reduced and finally cease. The reduced amplitude of oscillation is detected by a further transistor circuit which in turn releases the control relay.



With the low level probe head unit, the system operates in reverse, the relay in the control unit being energized when the probe is completely immersed.

The use of transistors has conferred a number of advantages; for example (1) the entire level detector circuit is housed within the probe head casting; (2) the remote control unit can be mounted any distance away from the probe head unit, with only three interconnecting wires; (3) all wiring external to the remote control unit is at a maximum potential of 12V d.c. to earth; (4) the maximum current which can be drawn in the connecting cables under short circuit conditions is 50mA d.c.

In design, the equipment is integrated with a common form of probe head unit which will accept the various electrode assemblies, these having configurations to suit the application. Maximum ease of maintenance is achieved by the use of printed circuit units, arranged to drop into the diecast exterior casing, a single point contact being automatically made at the probe end of the circuit by means of a spring loaded device forming part of the probe head.

This common probe head unit accepts any of a number of probes designed to cover a maximum variety of industrial applications.

EE 7758 *for further details*

LOW VOLTAGE POWER SUPPLY UNITS

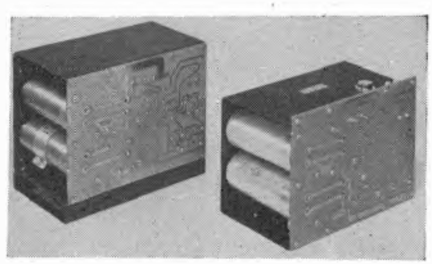
(Illustrated below)

Elliott Bros. (London) Ltd, Century Works, Lewisham, London, S.E.13

The type B.673 power unit employs transistors and comprises a non-linear series stabilizer producing a 50V d.c. supply. Overall regulation is within ±0·5V for a mains input of 210 to 260V a.c. and a load current of 1·5A.

The figure of ±0·5V includes a 0·9V switching waveform caused by the switching action of the non-linear series stabilizer. Output has a temperature coefficient of less than 15mV/°C.

Primarily designed for Post Office equipment, for the operation of relays and solenoids, the unit can be used



wherever a supply voltage variation within ±1 per cent is satisfactory. It will supply any continuous load up to 1·5A and will provide any current within this range regardless of the rate of change of the load.

The type B.672 unit also uses transistors and will produce a 10V d.c. supply at 0 to 1A full load from a normal a.c. mains supply of 215 to 260V or 0 to 750mA from a 200 to 260V mains supply. The overall regulation is better than 35mV and the ripple obtained is less than 1mV peak-to-peak. The output has a temperature coefficient of less than 1mV/°C.

EE 7759 *for further details*

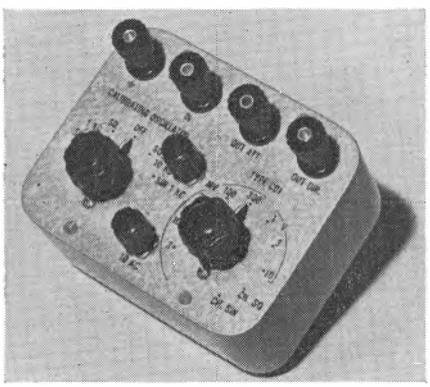
CALIBRATING OSCILLATOR

(Illustrated below)

A/S Danbridge, Frederkssundsvej 60C, Copenhagen, Denmark. Distributed in U.K. by B & K Laboratories Ltd, 4 Tilney Street, London, W.1.

This instrument has been designed primarily for calibrating oscilloscopes, but has numerous uses in the laboratory. A battery-operated transistor circuit is employed, so that a very small and handy instrument is obtained. It supplies output frequencies of 1kc/s and 10kc/s and either square-wave or sine wave outputs are available. The square-wave output is limited by a Zener diode supplying a known amplitude for calibrating purposes. The sine-wave output may be adjusted by comparison with the square-wave and separate check positions on the attenuator switch are provided for this purpose. The output is set separately on each frequency by two potentiometers. The output voltage may be varied by a calibrated step attenuator, and facilities are provided for using the attenuator separately, e.g. for amplifier tests, etc. The output frequencies are sufficiently accurate for time-base calibration, etc. When switching off, the output terminal is connected to a separate terminal to which the test signal may be applied. Thus the instrument may be permanently connected and only switched on when calibrating. A direct high level output is provided, and this may be employed for bridge power supply, etc. In addition, the tuned circuit not in use is isolated from the oscillator circuit and connected to two of the terminals so that it may be used as a filter in external circuits.

EE 7760 *for further details*



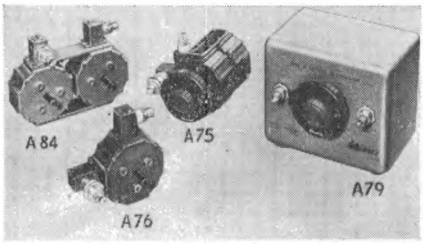
WIDE BAND ATTENUATORS

(Illustrated below)

Advance Components Ltd, Roebuck Road, Hainault, Essex

These ten position attenuators, which are usable from d.c., to v.h.f., consist of either single units or dual units connected in cascade. They normally have an input and output impedance of 75Ω and are designed for use with Plessey Minor coaxial plugs. A 50Ω version, using B.N.C. connectors, will be available upon request. The dual units consist of decade and units attenuators mounted in tandem on the same axis, or side by side with a range of 99dB and 1dB steps.

All these attenuators consist of resistive ladder networks. The resistors are arranged within the cavities of the screening casting so as to maintain the characteristic impedance over a wide frequency range. The characteristic impedance of the network in its cavities is matched to the input and output terminal impedance by means of padding resistors. This



has the advantages of reducing the required overall dimensions of the cavities, and hence the attenuator, and of reducing the effect upon attenuation of a mismatched input and/or output. The effect of internal unavoidable reactances is also minimized.

Considerable care in design has been taken to adequately screen the input portion of the ladder from the output. The back cover is split to prevent circulating currents, the two halves being earthed immediately either side of the split and a screen fitted at the division.

The body casting, cavities and entries are silver plated to reduce losses due to skin effect at very high frequencies. The final finish of the body is lacquered silver plate. The tip of the selector arm and contacts are rhodium plated. The contacts are mounted in polystyrene and indexing is effected separately from the contact itself. The units have a self-lubricating indexing system by which the indexing ball receives lubrication from oil immersed pads at each attenuation position. Both fixed and moving contacts are rhodium plated.

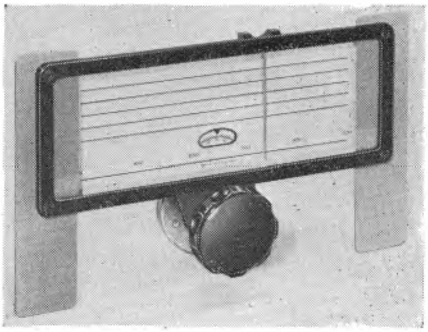
EE 7761 *for further details*

SLOW MOTION DRIVE AND SCALE ASSEMBLY

(Illustrated above right)

Stratton & Co. Ltd, Eddystone Works, Alvechurch Road, Birmingham, 31.

The Eddystone slow motion drive assembly is a high grade unit designed for instrument applications. The



movement is gear driven and flywheel loaded, giving a smooth positive drive, with a reduction ratio of 110 : 1. The pointer has a horizontal travel of 7in. A circular vernier scale, marked over 100 divisions, rotates five times for one traverse of the pointer, and, read with the '100' scale on the dial, provides a total of 500 divisions. The dial has five lines to take calibration markings. A diecast escutcheon, finished glossy black, is supplied and the assembly is complete with Perspex window, knob, fixing screws, and mounting template. It is suitable for mounting on metal or wooden panels up to 7mm thick. Overall external dimensions are 9 3/16in (23·34cm) by 5¾in (14·6cm).

EE 7762 *for further details*

ELECTRONIC MULTI-METER

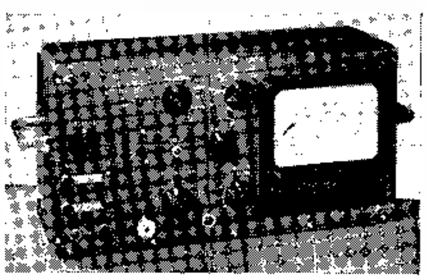
(Illustrated below)

Metrix Instruments Ltd, 54 Victoria Road, Surbiton, Surrey.

It is claimed that with this instrument voltage, current, resistance and other measurements which would normally be possible only with electrometer or vibrating capacitor circuits are made possible by a symmetrical three-terminal circuit using conventional valves. The circuit presents an input impedance of either $10^{14}\Omega$ or zero as required. The output impedance of the circuit is virtually zero and feeds an amplifier and meter with the facility for connecting an external recorder.

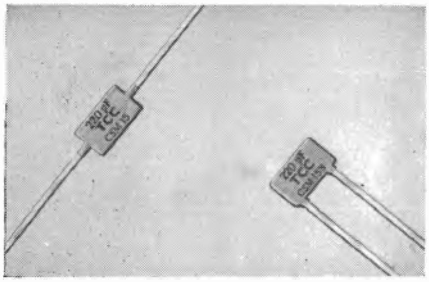
The circuit design is such that an unusual degree of stability is achieved and when a voltage is applied in the 'memory' position (a polystyrene capacitor is switched across the input circuit) the instrument retains the reading for at least twelve hours after disconnecting the source with less than 1 per cent drift.

Small voltage variations can be made with full-scale discrimination regardless of absolute value using an external



capacitor with guard-ring. The capacitor is connected in series with the source and is first charged to the source voltage by short-circuiting the input to the instrument. When the short-circuit is removed the voltage across the instrument is initially zero and records only variations of the source voltage. By using a constant voltage source, the hysteresis losses of capacitors can be measured in a similar manner. The basic ranges of the instrument are: 50mV to 2kV; $0{\cdot}5 \times 10^{-7}$ to 2×10^{-3}A and 1 to $2 \times 10^{10}\Omega$.

EE 7763 *for further details*



MINIATURE SILVERED MICA CAPACITORS

(Illustrated above)

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

These miniature protected silvered mica capacitors are approximately 7/16in by ½in by 3/32in (0·43mm by 0·26mm by 0·1mm) in size. Two types of termination are offered; the type CSM15 with axial terminations for in-line wiring and CSM15s which is side mounting and is thus suitable for incorporation into printed circuit panels, etc. They are available in a capacitance range from 10pF to 220pF and a tolerance range from ±1 per cent to ±20 per cent. The rated working voltage is 350V d.c. and the power factor less than 20×10^{-4} at 1Mc/s.

EE 7764 *for further details*

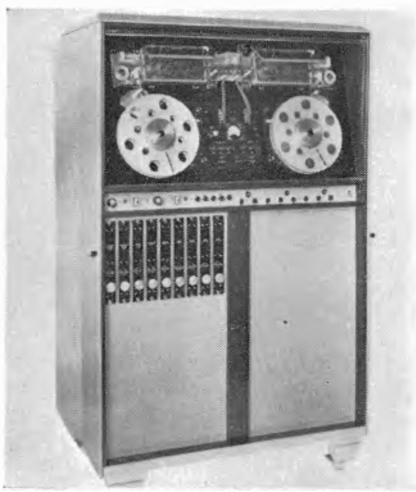
COMPUTER TAPE STORE

(Illustrated above right)

Epsylon Industries Ltd, Faggs Road, Feltham, Middlesex.

This versatile magnetic tape store unit is intended for use with a wide range of computing equipment. All functions of the equipment, including fast spooling and unloading, may be remotely controlled from a remote control panel. The instrument will follow automatic orders to start, stop or reverse up to a rate of 150p/sec. The standard tape speed is 100in/sec (25·4cm/sec) but at a later date the machine may also be supplied to operate at 200in/sec (50·8 cm/sec). At any tape speed the start-stop time in either direction is about 2msec. A patented tape reservoir system eliminates the need for back tension in either direction and the only mass to be accelerated is approximately six inches of free tape. With a 16-channel read-write head and a writing density of 400 bits per track-inch, the capacity of a 3 250ft (248m) tape is over 120 million bits. Two heads may be fitted to give two out-of-phase and interlaced sets of 16 tracks. An erase head is not normally fitted. The straight tape path makes loading or unloading a fast and simple operation. Upon receiving the 'reload' order (remote or push-button control), the machine will fast-spool at 400in/sec (101·6cm/sec) until the tape parts from the take-up spool and it will then stop. The tape reservoirs will be 'emptied' and, upon pressing a push-button, all gates will open, the top covers of the reservoirs will hinge back, and the operator can instantly remove the tape. The spools are fitted with special quick-release push-button hubs. When the machine receives the order to 'spool' it will fast-spool in the required direction until it comes to rest without the tape parting from the spool. In this case the tape reservoirs will remain filled.

The complete equipment is built into a self-contained console which incorporates all electronic control circuits, read-write amplifiers for any desired type of recording, and power supplies. The electronic circuits are built into separate interchangeable plug-in chassis and they comprise 16 'read' amplifiers, 16 'write' amplifiers and the various



machine control units. All chassis are plugged into the front of the console. The equipment is pressurized and force-cooled.

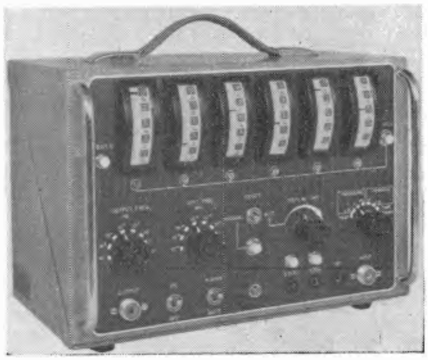
EE 7765 *for further details*

HIGH SPEED COUNTER

(Illustrated above right)

Van Der Heem Ltd, P.O.B. 1060, The Hague, Holland.

This instrument will count up to 999 999 at a maximum counting speed of 1 000 000 per second. An internal variable time-base is provided for frequency measurements and a crystal controlled oscillator for time measurements; time being indicated by counting the number of cycles between start and stop pulses. Frequencies up to 1Mc/s can be measured and time intervals can be obtained in units of 1μsec to 10sec. The counter can therefore be used for many purposes, such as quick and accurate counting of objects, speed measurements, etc. Semiconductor devices (transistors and diodes) and printed circuits are used and the dimensions of the unit are 12in by 9in by 6½in (30cm by 22cm by 16cm). The power supply can be taken from the mains or from a 6V battery; the power consumption amounts to about



10VA from the mains and 3W from a battery.

EE 7766 *for further details*

ELUTION BRIDGE

Griffin & George Ltd, Ealing Road, Alperton, Wembley, Middlesex

The Griffin-Raleigh elution bridge has been designed primarily for monitoring washing processes in transistor production and in the electro-plating industry. A conventional Wheatstone bridge network employing conductivity cells as two of the arms is arranged so that the out-of-balance current may be amplified in a high-gain transistor amplifier.

One of the cells is connected in the influent line to an elution vessel from which the effluent passes through the second cell. On passing the washing fluid through the empty system a deflexion is observed on a moving-coil instrument. The flow is continued until a constant deflexion is obtained whereupon the bridge is balanced to zero deflexion. By this means the effects of temperature variations, carbon dioxide absorption in the bath and difference in cell constants are automatically compensated for. On introducing the work to be washed into the elution vessel a deflexion is again observed and washing is continued until the deflexion falls to zero or to a predetermined low value indicating an acceptable level of chemical cleanliness. One of the cells incorporated in each instrument is of known constant value and the bridge may therefore also be used for the accurate calibration of conductivity cells without the need to use standard solutions. The network is supplied with low-voltage alternating current from an internal source and the amplifier gain may be varied to suit ambient conditions. The bridge is mains operated.

EE 7767 *for further details*

Meetings this Month

THE BRITISH INSTITUTION OF RADIO ENGINEERS

Date: 25 March.
Time: 3 p.m.-5.30 p.m. and 6.30 p.m.-8.30 p.m.
Held at: The London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.
Symposium on Radio Telemetry.

Medical Electronics Group

Date: 19 March. Time: 6.30 p.m.
Venue as above.
Lecture: Instrumentation in Field Physiology.
By: H. Wolff.

South Wales Section

Date: 11 March. Time: 6.30 p.m.
Held at: Cardiff College of Advanced Technology.
Lecture: Applications of Photoelectric Cells.
By: F. A. Benson.

South Western Section

Date: 24 March. Time: 7 p.m.
Held at: The School of Management Studies, Unity Street, Bristol 1.
Lecture: Recent Advances in Travelling Wave Tubes.
By: P. F. C. Burke.

West Midlands Section

Date: 11 March. Time: 7.15 p.m.
Held at: Wolverhampton and Staffordshire College of Technology, Wulfruna Street, Wolverhampton.
Lecture: The Development of High Frequency Tape Recording.
By: P. J. Guy.

Scottish Section

Date: 19 March. Time: 7 p.m.
Held at: The Institution of Engineers and Shipbuilders, 39 Elmbank Crescent, Glasgow.
Lecture: Application of Magnetic Amplifiers to Electrical Switching.
By: J. A. Purdie.
Date: 20 March. Time: 7 p.m.
Held at: The Department of Natural Philosophy, the University, Drummond Street, Edinburgh.
Repeat of above lecture.

North Eastern Section

Date: 11 March. Time: 6 p.m.
Held at: The Institution of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle-upon-Tyne.
Lecture: Microwave Strip-line Circuits for Radar Equipment.
By: K. Foster.

North Western Section

Date: 5 March. Time: 6.30 p.m.
Held at: Reynolds Hall, College of Technology, Sackville Street, Manchester 1.
Lecture: Closed Circuit Television Equipment.
By: R. E. Blyth.

THE BRITISH SOUND RECORDING ASSOCIATION

Date: 20 March. Time: 7.15 p.m.
Held at: The Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2.
Lecture: F. M. Feeder Units.
By: R. S. Roberts.

THE INSTITUTION OF ELECTRICAL ENGINEERS

All London meetings, unless otherwise stated, will be held at the Institution, commencing at 5.30 p.m.

Ordinary Meeting

Date: 5 March.
Lecture: The Reliability and Life of Impregnated Paper Capacitors.
By: J. P. Pitts.

Informal Meeting

Date: 9 March.
Discussion: Need British Standards be Modified to obtain Trade Abroad?
Opened by: T. M. H. Stubbs.

Radio and Telecommunication Section

Date: 18 March.
Lecture: New Amplifying Techniques.
By: C. W. Oatley.
Date: 23 March.
Two meetings.
Lecture: High-Quality Microphones.
By: M. L. Gayford. (In the Lecture Theatre.)
Effects of Argon Content on the Characteristics of Neon-Argon Glow Discharge Reference Tubes.
By: F. A. Benson and P. M. Chalmers. (In the Tea Room.)

Joint Meeting.

Date: 20 March. Time: 6 p.m.
Held at: The Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1. (Joint meeting with the Institutions of Civil and Mechanical Engineers).
Fifth Graham Clark Lecture.
By: Sir Arnold Plant.

Cambridge Radio and Telecommunication Group

Date: 17 March. Time: 8 p.m.
Held at: The Cavendish Laboratory, Free School Lane, Cambridge.
Informal Evening on Reliability of Electronic Components.
Talk by: G. W. A. Dummer.

East Anglian Sub-Centre

Date: 2 March. Time: 8 p.m.
Held at: The Cavendish Laboratory, Cambridge.
Lecture: The Recognition of Moving Vehicles by Electronic Means.
By: T. S. Pick and A. Readman.

North-Eastern Centre

Date: 19 March. Time: 7 p.m.
Held at: The City Hall, Newcastle-on-Tyne.
Faraday Lecture: Automation.
By: H. A. Thomas.

North-Eastern Radio and Measurement Group

Date: 2 March. Time: 6.15 p.m.
Held at: King's College, Newcastle-on-Tyne.
Lecture: High-Quality Microphones.
By: M. L. Gayford.

North Midland Centre

Date: 16 March. Time: 7 p.m.
Held at: The Town Hall, Leeds.
Faraday Lecture: Automation.
By: H. A. Thomas.

Sheffield Sub-Centre

Date: 6 March. Time: 7.30 p.m.
Held at: The City Hall, Sheffield.
Faraday Lecture: Automation.
By: H. A. Thomas.

North Western Centre

Date: 3 March. Time: 6.15 p.m.
Held at: The Engineers' Club, 17 Albert Square, Manchester.
Lecture: Subscriber Trunk Dialling.
By: D. A. Barron.

North-Western Radio and Telecommunication Group

Date: 18 March. Time: 6.15 p.m.
Lecture: Bridging the Atlantic.
By: A. H. Mumford.

North Lancashire Sub-Centre

Date: 11 March. Time: 7.15 p.m.
Held at: North-Western Electricity Board Demonstration Theatre, Friargate, Preston.
Lecture: Computers.
By: R. L. Grimsdale.
Date: 18 March. Time: 7.15 p.m.
Held at: North-Western Electricity Board Demonstration Theatre, Finckle Street, Kendal.
Lecture: British Columbia-Vancouver Island, 138kV Submarine Power-Cable.
By: T. Ingledow, R. M. Fairfield, E. L. Davey, K. S. Brazier and J. N. Gibson.

Northern Ireland Centre

Date: 3 March. Time: 7.30 p.m.
Held at: The Sir William Whitla Hall, Queen's University, Stranmillis Road, Belfast.
Faraday Lecture: Automation.
By: H. A. Thomas.
Date: 10 March. Time: 6.30 p.m.
Held at: The David Keir Building, Queen's University, Belfast.
Lecture: The B.B.C. Sound Broadcasting Service on Very-High Frequencies.
By: E. W. Hayes and H. Page.

South Midland Radio and Measurement Group

Date: 23 March. Time: 6 p.m.
Held at: The James Watt Memorial Institute, Birmingham.
Lecture: The History of B.B.C. Television.
By: R. T. B. Wynn.

Southern Centre

Date: 18 March. Time: 6.30 p.m.
Held at: The Grand Hotel, Bournemouth.
Lecture: The Application of Transistors to Line Communication Equipment.
By: H. T. Prior, D. J. R. Chapman and A. A. M. Whitehead.

Reading District

Date: 16 March. Time: 7.15 p.m.
Held at: The George Hotel, King Street, Reading.
Lecture: Subscriber Trunk Dialling.
By: D. A. Barron.

THE SOCIETY OF INSTRUMENT TECHNOLOGY

Date: 5 March. Time: 6 p.m.
Held at: Manson House, Portland Place, London, W.1.
Symposium on The Use of Data Recorded on Industrial Plant.
Date: 24 March. (Time and place as above.)
Lecture: New Directions in Engineering Psychology.
By: R. Conrad

THE TELEVISION SOCIETY

Date: 3-5 March.
Held at: The Royal Hotel, London, W.C.1.
Annual Exhibition of Television Equipment.
Date: 13 March. Time: 7 p.m.
Held at: The Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, London, W.C.2.
Lecture: Training in Television Servicing.
By: G. C. Barker.

PUBLICATIONS RECEIVED

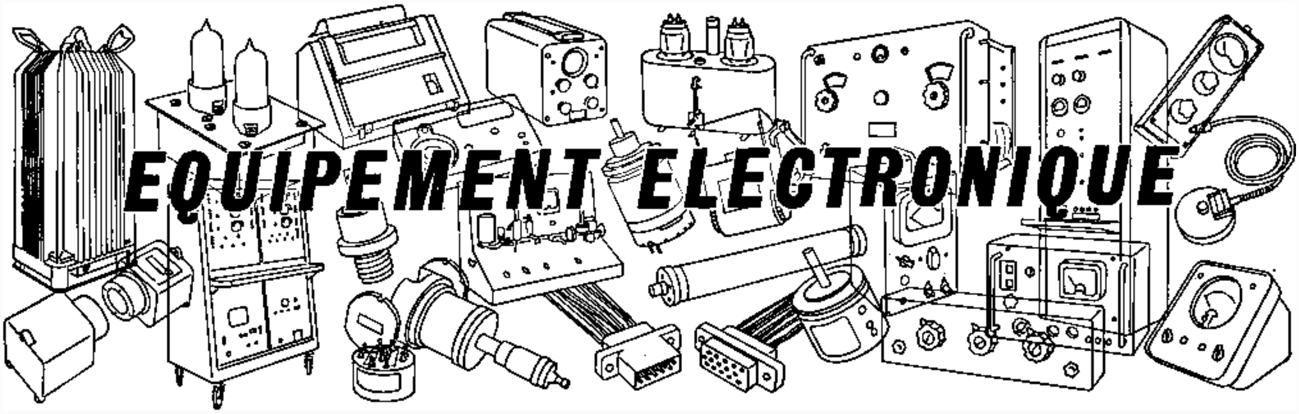
NUCLEAR REACTOR SHIELDING by J. R. Harrison, NUCLEAR REACTOR CONTROL AND INSTRUMENTATION by J. H. Bowen and E. F. O. Masters, and STEAM CYCLES FOR NUCLEAR POWER PLANT by W. R. Wootton are the titles of numbers IV, V and VI in the Nuclear Engineering Monographs series published by the Temple Press Ltd, Bowling Green Lane, London, E.C.1, price 10s. 6d. each. This series of monographs is intended for university and technical college students, research assistants and qualified technicians who require a broad understanding of those topics of nuclear engineering outside their own field of study.

RADIO TUBE VADE-MECUM 1958 14th edition by P. H. Brans has recently been published. The valves are tabulated in numerical and alphabetical order. To avoid thousands of repetitions of types which are really identical, but which have been given special initials by their makers preceding the actual type-number, these initials have been omitted. Symbols and abbreviations have been restricted to a very small number. These are given on a book marker which can be laid out next to the tables. P. H. Brans Ltd, Antwerp. Bailey Bros & Swinfen Ltd, Hyde House, West Central Street, London, W.C.1. Price 32s.

THE PHILIPS PAVILION AT THE 1958 BRUSSELS WORLD FAIR is a book containing five articles which were published in the Philips Technical Review during the Brussels World Fair. It was found that these articles met with enough interest among readers other than regular subscribers to the Philips Technical Review to warrant reprinting them in the present form. The subjects of these articles are, The Architectural Design of Le Corbusier and Xenakis; The Hyperbolic-Paraboloidal Shell and its Mechanical Properties: Model Tests for Proving the Construction of the Pavilion; Construction of the Pavilion in Prestressed Concrete; The 'Electronic Poem' performed in the Pavilion. The book ends with three short articles on Light Effects, Sound Effects and the Electronic Control System. Cleaver-Hume Press Ltd, 31 Wright's Lane, Kensington, London, W.8.

TUBE SEMICONDUCTOR SELECTION GUIDE 1958-1959, compiled by Th. J. Kroes, second edition, has been published by the Philips Technical Library, Eindhoven. It is translated in English, French, German and Spanish and is available in this country through the Cleaver-Hume Press Ltd, 31 Wright's Lane, London, W.8.

DECCA AIR SURVEILLANCE RADAR is a brochure which describes the D.A.S.R.1 long range, terminal surveillance radar operating in the 10cm band. It has been developed especially for civil aviation to meet operational requirements in areas of high traffic density or where jet and turbo-prop aircraft are being operated. This brochure contains a full technical description of the equipment. Decca Radar Ltd, London, S.E.11.



EQUIPEMENT ELECTRONIQUE

Une description basée sur des renseignements fournis par les fabricants de nouveaux organes, accessoires et instruments d'essai. *(Traduction des pages 176 à 179)*

COMPARATEUR D'IMPÉDANCE

(Illustration à la page 176)

Dawe Instruments Ltd, 99-101 Uxbridge Road, Ealing, London. W.5.

Le Comparateur d'impédance Type 304 a été étudié pour le contrôle en cours de fabrication des résistances, condensateurs et inducteurs.

Le circuit comporte un oscillateur de 1 kHz qui alimente un pont Wheatstone. Le signal déséquilibré dû au composant inconnu, est appliqué, après amplification, à un démodulateur à phases sensibles. L'appareil peut être commuté pour indiquer les composants résistifs ou réactifs sur un compteur à grand cadran, étalonné de manière à donner une image du pourcentage de la déviation d'impédance ou de la différence d'angle de phase entre le composant inconnu et le composant-étalon.

La gamme de déviations d'impédance est de −25 à +35% et la gamme de déviations de l'angle de phase (tangente δ) est de −0,3 à +0,3, toutes deux étant échelonnées sur trois graduations. Les gammes normales pour les mesures de déviation sont: 10 Ohms à 10 MOhms; 50 pF à 10 μF; 2 mH à 100 H.

EE 7751 *pour plus amples renseignements*

POTENTIOMÈTRE DE PRÉCISION À CURSEUR

Kelvin & Hughes Ltd, New North Road, Barkingside, Essex.

Ce potentiomètre a été étudié principalement pour servir d'élément calculateur dans la conversion de la rotation angulaire en résistance ou en tension avec un haut degré de linéarité et de résolution directe.

Par l'emploi du principe du curseur, de façon à ce que le contact passe continuellement sur le fil de résistance au lieu de se déplacer de tour en tour, on obtient une résolution illimitée tandis que la linéarité n'est limitée que par la précision avec laquelle le fil est tiré.

Le potentiomètre type a une valeur globale de 450 Ohms, une puissance nominale de 200 mA et il est traversé par 180 tours de broche. Une précision de 0,1% de la lecture effective peut être obtenue jusqu'à 1% de la gamme entière. Pour la lecture sur toute l'échelle, la précision atteint 0,03%.

EE 7752 *pour plus amples renseignements*

BOBINEUR DE FILS MÉTALLIQUES MINCES

(Illustration à la page 176)

Kinetrol Ltd, Trading Estate, Farnham, Surrey.

Le Bobineur de fils métalliques minces KINETROL sert à dérouler à une tension constante le fil métallique fin d'un rouleau tandis qu'on l'enroule sur des bobines d'instruments ou autres.

Le bobineur a 38cm de haut. Il reçoit le fil de cuivre le plus fin, jusqu' à 0,02mm de diamètre, ou le nickel-chrome, jusqu' à 0,015mm de diamètre. La tension peut être réglée d'un minimum de 5g à un maximum de 15g. Il enroule des fils minces dans les jauges les plus communément employées (0,061mm à 0,020 mm) à la vitesse de 150cm/sec, cependant que le modèle à commande par ressort (non reproduit) enroule des fils plus épais (0,102mm à 0,061mm) à la vitesse de 16m/sec.

Le déroulement du fil de son rouleau s'effectue par l'effet de son enroulement sur l'object que l'on construit. Le rouleau reste fixe sur le bobineur tandis qu'un bras tournant autour du rouleau est tiré par le fil et l'entraîne sur une série de poulies. Entre deux de ces poulies, montées sur une traverse, le fil est suspendu en forme de boucle, afin de soutenir un poids tendeur réglable, fixé à une poulie de tension. Ce poids tendeur applique la tension voulue au fil. Il est tenu en équilibre au dessus d'un plateau fixé à l'extrémité d'un levier. Ce dernier actionne un frein qui contrôle le tournoiement du bras tournant. Le moindre relâchement dans la tension du fil provoque la chute du poids dans le plateau, ce qui a pour effet d'appliquer le frein au bras tournant et de rétablir la tension. A mesure que la tension augmente, le poids tendeur tend à s'élever, relâchant le frein jusqu'à ce que la tension soit à nouveau correcte. Dans le cas extrême où le fil se coincerait sur le rouleau, le poids tendeur s'élèverait de plusieurs centimètres sans augmenter la tension et donnerait ainsi un avertissement du défaut.

Le bobineur permet une grande vitesse d'enroulement à une tension constante, sans casser ou forcer le fil, lorsqu'il est enroulé sur un objet de forme irrégulière. La seule partie mobile, c'est à dire le bras tournant, est si légère que son inertie ne peut casser le fil.

EE 7753 *pour plus amples renseignements*

COMMUTATEUR D'APPAREIL DE MESURE À FAIBLE RÉSISTANCE

(Illustration à la page 176)

W. G. Pye & Co. Ltd, Granta Works, Newmarket Road, Cambridge.

Ce commutateur d'appareil de mesure à faible résistance est d'une conception nouvelle basée sur deux années d'études fondamentales des problèmes se rapportant à la résistance de contact, telle que la pression de contact, aux nombre de points de contact, aux matériaux, au graissage, à la division, à l'usure mécanique et à la contamination.

La résistance globale par commutation est d'environ 0,7 mOhms et la variation de la résistance de contact est inférieure à ±20 mOhms. Le glissement de résistance global, pendant la durée du commutateur, est inférieur à ±50 mOhms. La force électromotrice ne dépasse pas 0,008 mV/°C avec un changement uniforme de température. Le gradient de température dans le commutateur produit un maximum de 0,025 mV/°C.

EE 7754 *pour plus amples renseignements*

MILLIVOLTMÈTRE ÉLECTRONIQUE

(Illustration à la page 177)

Airmec Ltd, High Wycombe, Buckinghamshire.

Ce millivoltmètre électronique type 264 est un instrument secteur construit pour les mesures de faibles tensions B.F. et H.F. sur une plage étendue de fréquences. Les gammes de tensions sont couvertes en 3 à 1 plots, de 1 mV à 1 V, le choix de la gamme voulue s'effectuant par un interrupteur sur le panneau avant. L'instrument comporte une sonde à tourelle rotative d'un dessin inédit, dont les capacités parasites one été réduites au strict minimum.

Cette sonde à tourelle est employée comme multiplicateur et comprend quatre positions d'impédance, à savoir X1, X0,1 et X0,01-haute impédance, ainsi que X1.75 Ohms.

La plage de fréquences s'étend de 20 Hz à 10 MHz, avec une précision de ±3% jusqu'à 3 MHz; ±5% de 30 Hz à 6 MHz et ±7,5% de 20 Hz à 10 MHz. Il faut ajouter une marge d'erreur supplémentaire de ±2% lorsqu'on emploie le multiplicateur de la sonde.

En tant qu'amplificateur, le millivoltmètre a une impédance de sortie de 1 000 Ohms; la sortie maximum est de 3 volts dans 1 KOhm et la réponse de fréquence est, avec une marge de ±1 dB, de 30 Hz à 10 Hz. Le gain total est de 50 dB au maximum.

EE 7755 *pour plus amples renseignements*

CONTRÔLEUR D'ISOLEMENT

Radiometer, 72, Emdrupvej, Copenhague, Danemark.

Ce mégohmètre secteur, type IM5, est un appareil complet par lui-même, permettant d'effectuer des mesures précises de résistances, de 1 mégohm à 10^{6} mégohms, dans sept gammes. Il comporte cinq tensions stabilisées d'essai, à savoir 50, 100, 200, 500 volts et 1 kilovolt, pouvant être utilisées sur toutes les gammes de résistance. Il a été étudié pour mesurer les résistances d'isolement de condensateurs, transformateurs, planches de circuits imprimés, câbles, etc. Il comprend un circuit de garde afin qu'on puisse effectuer sans difficulté des mesures directes de fuites mutuelles dans les câbles à plusieurs bornes ou dans les condensateurs à trois bornes. Enfin, il est protégé contre les court-circuits pouvant se produire dans le matériau sous examen. Avant de débrancher ce dernier, la tension d'essai est supprimée et les serre-fils sont court-circuités. Cette particularité de l'appareil écarte tout danger en cas de tension maximale de court-circuit de 4 milliampères.

EE 7756 *pour plus amples renseignements*

FILTRES PASSE-BANDE PIÉZOÉLECTRIQUES

(Illustration à la page 177)

Cathodean Crystals Ltd, Linton, Cambridge

Ces filtres passe-bande piézoélectriques miniature de moyenne fréquence ont une atténuation de 80 dB hors de la bande passante et peuvent être employés dans des récepteurs à modulation d'amplitude/modulation de fréquence pour bandes de hautes fréquences et d'hyperfréquences.

Toutes les cellules de filtrage sont interchangeables sans qu'il soit besoin de réglage ou de rechargement. Ainsi, si un constructeur de récepteurs veut changer de canal, il lui suffira d'intercaler le filtre de la largeur de bande correspondante. Ces robustes cellules de filtrage subminiature, ainsi que tous les autres accessoires, sont fixés sur des planches de circuits imprimés et logés dans un coffret de cuivre hermétiquement clos.

Ces filtres miniature n'exigent que 51 × 33,5mm d'espace de châssis et ils ont des caractéristiques passe-bande sensiblement plates avec des chutes d'atténuation quasi verticales. Plusieurs largeurs de bande peuvent être obtenues et elles ont toutes une atténuation minimum de 80dB. Les valeurs de pertes par insertion relativement basses rendent l'usage de ces filtres particuliérement approprié entre le changeur de fréquence et l'amplificateur de moyenne fréquence. De même, leurs caractéristiques évitent complètement l'emploi de transformateurs de moyenne fréquence et permettent la construction d'amplificateurs à large bande avec changement d'une seule fréquence.

La stabilité de fréquence nominale de la courbe de fréquences dans des températures très variées dépasse 12 parties sur 10^{6}. La tension d'entrée haute fréquence de crête est de 12 Volts et la linéarité de phase sur presque toute la bande passante garantit la fidélité de la reproduction dans les systèmes à impulsions ou à modulation de fréquence. Quoique les filtres soient normalement construits pour être employés avec des impédances de lampe d'environ 1,6kΩ, des filtres résistance-capacité assurant une puissance de transfert maximum dans les systèmes transistorisés sont fournis sur demande.

EE 7757 *pour plus amples renseignements*

CONTRÔLEUR DE NIVEAU

(Illustration à la page 177)

Lancashire Dynamo Electronic Products Ltd, Rugeley, Staffordshire.

Ce nouvel appareil fait usage d'oscillateurs à transistors remplaçant les valves d'oscillateurs dans le circuit de détection. Ce dernier enregistre le changement de capacité par une sonde ou une électrode analogue en s'approchant ou en s'éloigant d'un matériau.

Dans le circuit d'oscillateurs à transistors, la capacité extérieure représentée par la sonde et la masse, est reliée au circuit accordé de l'oscillateur.

Avec la sonde de niveau élevé, l'oscillation se produit lorsque la sonde est éloignée du matériau et dans ces conditions le relais de l'ensemble de contrôle est excité. Lorsque le matériau atteint le niveau de la sonde, le changement de capacité provoque une diminution d'oscillations et finalement l'arrêt total de toute oscillation. La diminution d'amplitude des oscillations est détectée par un autre circuit à transistors qui, à son tour, déclanche le relais de contrôle.

Avec la sonde de bas niveau, le système fonctionne dans le sens inverse, le relais de l'ensemble étant excité lorsque la sonde est complètement immergée.

L'emploi de transistors présente les avantages suivants:

Tout le circuit de détection de niveau est logé à l'intérieur du moulage de la tête de la sonde.

L'ensemble de contrôle à distance peut être monté à n'importe quelle distance de la tête de la sonde, avec trois fils d'interconnexion seulement.

Tout le câblage à l'extérieur de l'ensemble de contrôle a un potentiel maximum de 12V c.c. par rapport à la terre.

Le courant maximum pouvant être attiré dans les câbles de connexion, dans des conditions de court-circuit, est de 50mA c.c.

L'appareil englobe un ensemble commun à tête de sondage qui peut recevoir les différents assemblages d'électrodes, dont la forme varie selon les applications. L'entretien est des plus aisés grâce à l'emploi d'ensembles à circuits imprimés construits de manière à pouvoir entrer dans l'enveloppe moulée extérieure, un simple contact s'effectuant automatiquement à l'extrémité du circuit où se trouve la sonde, au moyen d'un dispositif à ressort faisant partie de la tête de sondage.

Cette sonde commune peut recevoir n'importe laquelle des différentes sondes conçues en vue de la plus grande variété possible d'applications industrielles.

EE 7758 *pour plus amples renseignements*

BLOC D'ALIMENTATION DE BASSE TENSION

(Illustration à la page 177)

Elliott Bros (London) Ltd, Century Works, Lewisham, London, S.E.13.

Le bloc d'alimentation type B673 emploie des transistors et comprend un stabilisateur en série non-linéaire produisant une alimentation de 50 volts c.c. Le réglage global ne dépasse pas ±0,5 volts pour une tension d'alimentation secteur de 210 à 260 volts c.a. et un courant de charge de 1,5 A. Le chiffre de ±0,5 volts comprend une forme d'onde de commutation causée par l'effet d'interruption du stabilisateur en série non-linéaire. La puissance de sortie a un coefficient de température de moins de 15 mV/°C.

Quoique principalement étudié pour l'appareillage postal, pour l'actionnement de relais et de solénoïdes, cet appareil peut être utilisé en tout lieu où une variation de la tension d'alimentation de ±1% est satisfaisante. Il fournira n'importe quelle charge continue jusqu'à 1,5 A et n'importe quel courant dans cette gamme, quel que soit le taux de changement de la charge.

Le modèle B672 est également à transistors et produit un courant continu de 10 volts, entre 0 et 1 A pleine charge, d'une alimentation secteur normale de 215 à 260 volts c.a. ou, entre 0 et 750 mA, d'une alimentation secteur de 200 à 260 volts. Le réglage global est supérieur à 35 mV et l'ondulation obtenue est inférieure à 1 mV de crête à crête. La puissance de sortie a un coefficient de température inférieur à 1 mV/°C.

EE 7759 *pour plus amples renseignements*

OSCILLATEUR D'ÉTALONNAGE

(Illustration à la page 178)

A/S Danbridge, Frederkssundsvej 60C, Copenhague, Danemark. Distributeurs en Grande Bretagne: B. & K. Laboratories Ltd, 4 Tilney Street, London, W.1.

Cet instrument a été étudié principalement pour les oscilloscopes d'étalonnage, mais il trouve également de multiples emplois au laboratoire. Il est muni d'un circuit à transistors fonctionnant sur pile, ce qui réduit ses dimensions à celles d'un tout petit appareil, des plus maniables. Ses fréquences de sortie sont de 1 et de 10 kHz, et il produit des sorties d'ondes carrées ou sinusoïdales. La sortie d'ondes carrées est limitée par une diode Zener, fournissant une amplitude connue en vue de l'étalonnage. La sortie d'ondes sinusoïdales peut être ajustée en la comparant avec la sortie d'ondes carrées, l'interrupteur d'affaiblissement étant pourvu à cet effet de positions de vérification à part. La sortie est réglée séparément sur chaque fréquence par deux potentiomètres. La tension de sortie peut être modifiée par un atténuateur à plots étalonné. Ce dernier peut également être employé à d'autres usages tels que, par exemple, les essais d'amplificateurs, etc. Les fréquences de sortie sont suffisamment précises pour l'étalonnage de bases de temps, etc. Lorsqu'on éteint l'appareil, la borne de sortie demeure reliée à une borne à part à laquelle on peut appliquer le signal d'essai. Ainsi l'appareil reste constamment branché et il n'est allumé que pour l'étalonnage. Il est pourvu d'une sortie directe de niveau élevé qui peut être employée pour l'alimentation d'un pont, etc. Enfin, le circuit accordé hors d'usage est isolé du circuit oscillant et relié à deux des bornes de façon à servir de filtre dans les circuits extérieurs.

EE 7760 *pour plus amples renseignements*

ATTÉNUATEUR À LARGE BANDE

(Illustration à la page 178)

Advance Components Ltd, Roebuck Road, Hainault, Essex.

Cet atténuateur à dix positions, pouvant être employé sur courant continu jusqu'aux hyperfréquences, se compose soit d'un élément soit de deux éléments reliés en cascade. Son impédance normale d'entrée et de sortie est de 75 Ohms et il a été conçu pour être employé avec les prises coaxiales Plessey Minor. Un modèle à 50 Ohms, employant des bornes B.N.C., est fourni sur demande. L'appareil à deux éléments comprend un atténuateur de décades et un atténuateur d'unités, montés en tandem sur le même axe ou côte à côte, ayant une gamme de 99 dB, en plots d'un décibel.

Tous ces atténuateurs comportent des réseaux résistifs à échelle. Les résistances sont disposées à l'intérieur des cavités du moulage blindé afin de maintenir l'impédance caractéristique sur une plage de fréquences étendue. L'impédance caractéristique du réseau dans ses cavités est accordée avec l'impédance d'entrée et de sortie aux bornes au moyen de résistances d'équilibrage. Les avantages de cet équilibrage sont multiples: il permet de réduire les dimensions hors tout des cavités et, par conséquent, celles de l'atténuateur également; en outre, l'effet sur l'atténuation de toute désadaptation d'entrée ou de sortie se trouve réduit, de même que l'effet de réactances intérieures inévitables.

Un soin tout particulier a été apporté dans la construction de cet atténuateur afin de séparer comme il convient le côté d'entrée de l'échelle de celui de sortie. Le couvercle arrière est divisé en deux parties de façon à empêcher les courants de circulation, les deux parties étant directement à la terre sur chaque côté de la fente de division et cette dernière portant un écran.

Le blindage, les cavités et les entrées sont argentés afin de reduire les pertes dues à l'effet Kelvin aux très hautes fréquences. Le corps de l'appareil est bordé de vernis argenté tandis que l'extrémité du bras du sélecteur et les contacts sont rhodiés. Les contacts sont montés sur polystyrène et le déclenchement s'effectue indépendamment à partir du contact même. Les éléments sont pourvus d'un système de déclenchement à auto-graissage par lequel la bille de déclenchement est graissée à chaque position d'atténuation par des tampons trempés de lubrifiant. Tant les contacts fixes que les contacts mobiles sont rhodiés.

EE 7761 *pour plus amples renseignements*

ENSEMBLE D'ENTRAÎNEMENT À ACTION LENTE

(Illustration à la page 178)

Stratton & Co. Ltd, Eddystone Works, Alvechurch Road, Birmingham 31.

L'ensemble d'entraînement à action lente Eddystone est un matériel de haute qualité étudié en vue des applications à l'instrumentation. Son mécanisme est actionné par engrenages et volant, donnant une transmission douce, avec démultiplication de 110 : 1. L'aiguille du cadran effectue une course horizontale de 17,5 cm. Une échelle circulaire vernier, graduée en 100 divisions, parcourt cinq tours pour une course de l'aiguille et lorsqu'elle est lue conjointement avec l'échelle '100' du cadran, elle donne un total de 500 divisions. Le cadran comporte cinq lignes portant les repères d'étalonnage. Livré avec écusson coulé en coquille et peint en noir brillant, l'appareil est complet avec fenêtre en plexiglass, bouton, vis de fixage et gabarit de montage. Il peut être fixé sur panneaux de métal ou de bois ayant jusqu'à 7 mm d'épaisseur. Ses dimensions extérieures hors tout sont de 23,3 × 14,6 cm.

EE 7762 *pour plus amples renseignements*

POLYMÈTRE ÉLECTRONIQUE

(Illustration à la page 178)

Metrix Instruments Ltd, 54 Victoria Road, Surbiton, Surrey.

Les fabricants de cet appareil affirment que, grâce à un circuit symétrique à trois bornes utilisant des tubes ordinaires, il est capable d'effectuer des mesures de tension, de courant, de résistance, ainsi que d'autres mesures qui, normalement, ne seraient possibles qu'avec un électromètre ou des circuits de condensateurs vibrants. Le circuit de ce polymètre a une impédance d'entrée de 10^{-4} ohms ou de zéro, selon les besoins. L'impédance de sortie du circuit est virtuellement zéro et elle alimente un amplificateur et un compteur qui peuvent être reliés, s'il y a lieu, à un enregistreur extérieur.

Le dessin du circuit est tel qu'il assure un degré exceptionnel de stabilité et lorsqu'on applique une tension à la position 'mémoire' (un condensateur en polystyrène étant branché à travers le circuit d'entrée), l'instrument garde son indication pendant au moins douze heures après le débranchement de la source, avec un glissement de moins de 1%.

De légères variations de voltage peuvent être effectuées avec une discrimination totale, quelle que soit la valeur absolue, en utilisant un condensateur extérieur avec anneau de garde. Le condensateur est relié en série à la source et il est, en premier lieu, chargé à la tension de la source en court-circuitant l'entrée de l'appareil. Lorsque le court-circuit est supprimé, la tension qui parcourt l'appareil est de zéro au début et n'accuse que les variations de la tension de source. En employant une source de tension constante, on peut mesurer de façon analogue les pertes par hystérésis des condensateurs. Les gammes de base de l'appareil sont: 50 mV à 2 kV; 0,5 × 10^{-7} à 2 × 10^{-3} A et 1 à 2 × 10^{10} ohms.

EE 7763 *pour plus amples renseignements*

CONDENSATEURS MINIATURE AU MICA ARGENTÉ

(Illustration à la page 179)

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

Ces condensateurs miniature à revêtement de mica argenté, mesurent environ 0,43 mm × 0,26 mm × 0,1 mm. Ils s'obtiennent en deux modèles, soit le type CS M15, avec extrémités axiales pour montage en ligne, et le type CS M15S, pouvant être monté latéralement et se prêtant donc à l'installation dans des panneaux de circuits imprimés, etc. Les deux modèles sont prévus pour une gamme de capacités de 10 à 200 pF et une marge de tolérance de ±1% à ±20%. La tension de service nominale est de 350 volts c.c. et le facteur de puissance est inférieur à 20 × 10^{-4} à 1 MHz.

EE 7764 *pour plus amples renseignements*

ENREGISTREUR À BANDE MAGNÉTIQUE POUR CALCULATEURS ÉLECTRONIQUES

(Illustration à la page 179)

Epsylon Industries Ltd, Faggs Road, Feltham, Middlesex.

Cet enregistreur à bande magnétique est un matériel destiné à l'usage avec une gamme étendue de calculatrices électroniques. Toutes les fonctions de cet appareil, y compris le bobinage rapide et le déroulement, peuvent être contrôlées à distance, à partir d'un panneau de télécommande. L'appareil suivra automatiquement les ordres de marche, d'arrêt ou de marche arrière, et ce jusqu'à un rythme de 150 opérations par seconde. La vitesse d'avance actuelle de la bande magnétique est de 25,4 cm/sec., mais les modèles futurs de l'appareil seront également prévus pour une vitesse d'avance de 50,8 cm/sec.

A n'importe quelle vitesse de la bande, la durée d'arrêt-marche dans chaque sens, est d'environ 2 microsecondes. Un système breveté de réservoir à bande magnétique rend superflue la contre-tension dans chaque sens, de sorte que la seule masse devant être accélérée est une bande libre d'environ 15 cm de long. Grâce à une tête de lecture-écriture à seize canaux et une densité d'écriture de 400 chiffres binaires par 2,5 cm de piste, la capacité d'une bande de 248 m est de plus de 120 millions de chiffres binaires. Deux têtes peuvent être fixées à l'appareil afin de produire deux groupes, entrelacés et déphasés, de seize pistes. Une tête d'effacement n'est pas ordinairement prévue. Le parcours droit de la bande fait de l'enroulement et du déroulement une opération simple et rapide.

Lorsque l'appareil reçoit l'ordre de 'recharger' (télécommandé ou par bouton-poussoir), il effectue un bobinage accéléré, à la vitesse de 101,6 cm/sec. et il ne s'arrête que quand la bande se détache de la bobine enrouleuse. Les réservoirs à bande sont alors 'vidés' et, sur pression d'un bouton, toutes les vannes s'ouvrent, les couvercles supérieurs des réservoirs se rabattent en arrière et l'opérateur peut immédiatement retirer la bande. Les bobines sont munies de boutons-poussoirs spéciaux à déclanchement rapide. Lorsque l'appareil reçoit l'ordre de 'bobiner', il effectue un bobinage accéléré dans la direction voulue, jusqu'à ce qu'il s'arrête, sans que la bande ne se détache de la bobine à ce moment-là. Dans ce dernier cas, les réservoirs à bandes restent remplis.

L'ensemble de l'appareillage est incorporé dans une console autonome comportant tous les circuits de contrôle électronique, les amplificateurs de lecture-écriture pour tous genres d'enregistrements et les blocs d'alimentation. Les circuits électroniques sont englobés dans des châssis à prises interchangeables. Ils comprennent 16 amplificateurs de 'lecture', 16 amplificateurs 'd'écriture', ainsi que les divers éléments de contrôle de l'équipement. Tous les châssis sont branchés sur la partie avant de la console. Enfin, l'équipement est pressurisé et refroidi par circulation d'air forcé.

EE 7765 *plus pour amples renseignements*

COMPTEUR À ACTION RAPIDE

(*Illustration à la page 179*)

Van der Heem Ltd. P.O.B. 1060, La Haye, Pays-Bas.

Cet appareil peut compter jusqu'à 999 999 à une vitesse de comptage maximum de 1 000 000 par seconde. Une base de temps variable est incorporée à l'appareil pour les mesures de fréquences, ainsi qu'un oscillateur à contrôle piézo-électrique pour les mesures de temps. Ce dernier est indiqué par le nombre de cycles comptés par les impulsions d'amorçage et d'arrêt. On peut mesurer des fréquences allant jusqu'à 1 MHz et obtenir des intervalles de temps en unités de 1 microseconde à 10 secondes. Le compteur peut donc être employé à des fins diverses, telles que le dénombrement d'objets, les mesures de vitesse, etc. Il comprend des dispositifs semiconducteurs (transistors et diodes) et des circuits imprimés. Ses dimensions sont de 30 × 22 × 16 cm et il fonctionne sur secteur ou sur pile de 6 volts. Sa consommation électrique est d'environ 10 volts-ampères sur secteur et 3 watts sur pile.

EE 7766 *pour plus amples renseignements*

PONT CONTRÔLEUR DE LAVAGE

Griffin & George Ltd, Ealing Road, Alperton, Wembley, Middlesex.

Le Pont contrôleur de lavage Griffin-Raleigh a été étudié principalement pour le contrôle des procédés de lavage dans la production des transistors et l'électroplastie. L'appareil se compose d'un réseau en pont courant Wheatstone, dont les cellules de conductivité tiennent lieu de deux bras, de façon à ce que le courant déréglé puisse être amplifié par un amplificateur à transistors de grande amplification.

L'une des cellules est reliée, dans la ligne d'entrée, à un réservoir de décantation d'où l'écoulement passe dans une seconde cellule. Lors du passage du liquide de lavage à travers le système vide, on observe une déviation sur un instrument à bobine mobile. L'écoulement continue jusqu'à ce qu'une déviation constante soit obtenue, sur quoi le pont est équilibré à une déviation zéro. Par ce moyen, les effets de variations de température, l'absorption de gaz carbonique par le bain et les différences de constantes de cellules sont automatiquement compensées. Lorsque les pièces devant être lavées sont introduites dans le récipient de lavage, on observe à nouveau une déviation et le lavage se poursuit jusqu'à ce que la déviation tombe à zéro ou à une faible valeur prédéterminée, indiquant un niveau admissible de pureté chimique. L'une des cellules comprises dans chaque instrument est d'une valeur constante connue et le pont peut donc être employé également pour l'étalonnage précis des cellules de conductivité, sans qu'il soit besoin d'employer des solutions classiques. Le réseau est alimenté, par une source intérieure, en courant alternatif de faible tension, et le gain de l'amplificateur peut être ajusté aux conditions ambiantes. Le pont fonctionne sur secteur.

EE 7767 *pour plus amples renseignements*

Résumés des Principaux Articles

L'enregistrement et la juxtaposition des formes d'ondes. par R. J. D. Reeves.

Résumé de l'article aux pages 130 à 137

Le matériel pour l'analyse des circuits appliqués est manifestement incomplet par suite de l'absence d'enregistreurs d'oscillogrammes. L'observation, la mesure et l'enregistrement sont les trois étapes de l'analyse systématique; néanmoins, l'enregistrement n'a pas progressé au delà de la simple photographie de la trace. C'est un processus laborieux et l'enregistrement que l'on obtient est insuffisant car les dimensions ne représentent rien.

Avant l'avènement du tube à rayons cathodiques, il était d'usage d'enregistrer les formes d'ondes se répétant au moyen d'un strobographe qui relevait la forme dónde avec un commutateur quasi synchrone. L'équivalent électronique de ce procédé permet aux instruments à lecture directe de remplacer la combinaison tube cathodique-appareil photographique, en introduisant un nouveau degré d'excellence dans la présentation. En maintenant les niveaux de courant continu, les enregistrements peuvent être superposés pour la juxtaposition fidèle des formes d'ondes et la synthèse des familles et des réseaux.

La première partie de l'article examine divers aspects de la strobographie tandis que la seconde décrit un nouvel instrument à usages multiples.

Un détecteur de résonance nucléaire pour la mesure des champs magnétiques. par G. C. Lowe.

Résumé de l'article aux pages 138 à 140

Cet article traite d'un simple circuit à réaction appliquant le phénomène de la résonance magnétique nucléaire pour la mesure des champs magnétiques dans une gamme étendue. Ces mesures ne comportent qu'un minimum de remise au point des éléments du circuit et leur degré de précision est d'au moins 0,01%.

Un nouveau système de sondage pour cartes perforées ou feuilles métalliques minces continues. par S. Morleigh.

Résumé de l'article aux pages 140 à 141

Les méthodes classiques pour fournir les données d'entrée aux calculateurs binaires font généralement usage d'éléments mécaniques ou électriques pour "sonder" les données. Ces dernières se présentent habituellement sous la forme de perforations effectuées en certains points, correspondant aux rangées et aux colonnes de l'organe d'entrée. Ces méthodes sont non seulement compliquées et coûteuses mais elles présentent aussi d'autres désavantages tout en étant d'un fonctionnement relativement lent.

Cet article décrit un nouveau dispositif basé sur une méthode de "sondage" capacitif, qui permet de représenter n'importe quelle carte perforée sous la forme des deux bras distincts, soit C_1 et C_2, d'un modèle courant de pont de capacités. Ainsi la position de n'importe quelle carte perforée peut être aisément identifiée par certains potentiels de sortie correspondant aux valeurs de ces capacités. Des applications supplémentaires de ce dispositif pourraient conduire au remplacement éventuel de certaines installations actuelles de cartes perforées par des bandes ou des feuilles de métal mince continues.

Mesures de phase et d'amplitude aux basses fréquences. par R. J. A. Paul et M. H. McFadden.

Résumé de l'article aux pages 142 à 149

Les auteurs décrivent un générateur basse fréquence et un phasemètre. La gamme de fréquences des deux appareils peut être étendue jusqu'au dessous de 0,01 Hz et au dessus de 10 kHz. L'application principale des appareils combinés est l'essai des systèmes de contrôle de réaction, dans des conditions de circuit ouvert ou fermé.

Les auteurs exposent à grands traits deux méthodes de mesure de phases, basées essentiellement sur l'emploi d'amplificateurs de calcul analogique. Ils indiquent le principe de leur fonctionnement et donnent quelques chiffres de résultats obtenus.

Le façonnage électrolytique des pièces de guides d'ondes. par P. Andrews.

Résumé de l'article aux pages 150 à 152

Certaines pièces de guides d'ondes ne peuvent être fabriquées facilement par les procédés ordinaires d'usinage et en pareil cas l'électroplastie constitue souvent une méthode fort utile. Cet article décrit un procédé simple d'électroplastie cuivre-acide se prêtant à l'usage des laboratoires ou à la production sur une échelle réduite.

L'étalonnage des amplitudes de vibrations. par R. A. S. Kay.

Résumé de l'article aux pages 154 à 155

L'auteur décrit une méthode pour mesurer l'amplitude des vibrations produites par les générateurs de vibrations. Il aborde, en particulier, le problème de l'étalonnage des capteurs de vibrations. La méthode en question peut être appliquée dans la gamme des fréquences acoustiques et elle n'est pas affectée par les variations de formes d'ondes. On emploie à cet effet un appareil stroboscopique joint à des leviers mécaniques et optiques.

Un modulateur-décrypteur électronique pour signaux de téléimprimeur. par J. Das.

Résumé de l'article aux pages 156 à 160

Le chiffrement et le déchiffrement de messages, tels que ceux employés dans les téléimprimeurs, ont pu être effectués également au moyen de circuits électroniques. La touche d'une lettre actionne un multivibrateur de 50 Hz dont la tension de sortie est contrôlée par la même touche, selon le code assigné à la lettre. Le multivibrateur s'arrête après avoid émis l'impulsion d'arrêt vers la ligne. Dans le décrypteur, le multivibrateur est mis en marche par l'impulsion d'allumage et le signal capté est relevé et identifié par une série de circuits séparateurs de bande, sélecteurs de code et compteurs. Des codes binaires auxiliaires ont été assignés aux impulsions de code pour l'identification finale et des triodes à gaz miniature ont été employées dans tous les circuits sélecteurs et compteurs.

Un récepteur télégraphique moderne à variation de fréquence. par E. J. Allen.

Résumé de l'article aux pages 161 à 164

Cet article décrit un récepteur radiotélégraphique qui constituerait un procédé entièrement nouveau de réception haute fréquence de haute qualité par radiotéléimprimeur. Il se conforme aux spécifications actuelles des services postaux britanniques, tout en appliquant un nouveau principe de réception permettant de pallier aux imperfections inhérentes aux appareils conventionnels dans des conditions de mauvaise propagation et donnant une durée de "bonne impression" considérablement accrue.

Un circuit simple de démodulation pour instruments scientifiques. par R. Hoodless.

Résumé de l'article aux pages 164 à 165

De nombreux transducteurs pour instruments scientifiques sont fabriqués de manière à former deux bras d'un réseau en pont, excités par une tension porteuse. L'amplitude et la phase de la puissance de sortie de ce pont dépendent de la quantité mesurée, mais nécessitent un redressement de phase apparentée afin d'assurer une tension analogue.

Cet article décrit un circuit simple pouvant être utilisé lorsque l'amplification subséquente n'est plus nécessaire.

Une méthode pour développer les fonctions périodiques. par J. Pereli.

Résumé de l'article aux pages 166 à 167

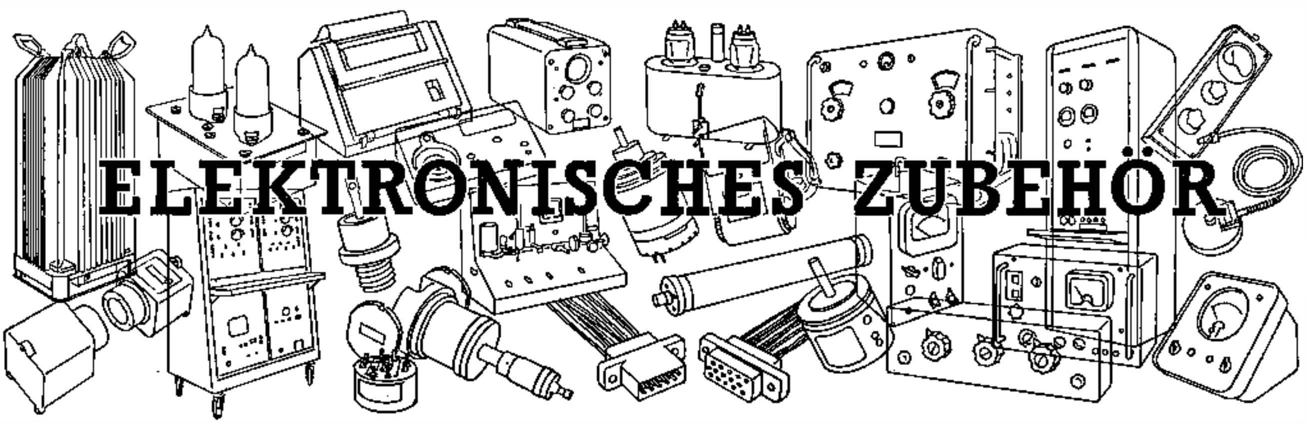
Toute forme d'onde complexe peut être exprimée par une série de fonctions sinusoïdales, expression qui, dans le passé, satisfaisait pleinement l'ingénieur. Cet article démontre, cependant, que la célèbre série de Fourier n'est pas la seule façon de développer une fonction périodique et que, par exemple, une fonction carrée peut être exprimée soit par des composantes triangulaires soit par d'autres composantes périodiques.

Quatre émissions simultanées d' une même antenne. par F. D. Bolt.

Résumé de l'article aux pages 168 à 170

En août 1958, la B.B.C. a étendu ses services d'émission pour hyperfréquences et modulation de fréquence à la Région des Lacs Anglais et au sud-ouest de l'Ecosse. Quatre émissions simultanées sont diffusées d'une même antenne, chacune d'elles ayant une puissance émise effective de 120 kW.

Des précautions toutes particulières ont été prises pour empêcher le rayonnement "hors bande" de se produire et cet article décrit la façon dont ce rayonnement indésirable a été réduit à quelques microwatts.



ELEKTRONISCHES ZUBEHÖR

Beschreibungen, zusammengestellt auf Grund von Mitteilungen aus Herstellerkreisen von neuen Bestandteilen, Zubehöreinrichtungen und Prüfgeräten. *(Ubersetzung der Seiten 176 bis 179)*

IMPEDANZKOMPARATOR

(Abbildungen auf Seite 176)

Dawe Instruments Ltd., 99-101 Uxbridge Road, Ealing, London, W.5

Der Impedanzkomparator Typ 304 ist zum Prüfen von Betriebsleitungen von Widerständen, Kondensatoren und Induktoren entworfen.

Die Schaltung umfasst einen 1 kHz Oszillator, der eine Wheatstonesche Brücke speist. Das unsymmetrische Signal, das durch den unbekannten Bestandteil verursacht wird, wird nach Verstärkung an einen phasenempfindlichen Demodulator gelegt. Das Gerät lässt sich zum Anzeigen der widerstandsfähigen oder reaktiven Bestandteile auf einem mit einer grossen Skala versehenen Meter schalten, der für die bildliche Darstellung der Impedanzabweichung oder des Phasenwinkelunterschieds zwischen der unbekannten Grösse und dem Normwert geeicht ist.

De Bereich der Impedanzabweichung liegt zwischen -25 und -35%, und der Bereich der Phasenwinkelabweichung (tan δ) zwischen $-0{,}3$ und $+0{,}3$, beide in drei Bereichen. Die Normalbereiche für Abweichungsmessungen sind: 10 ohm bis 10 Mohm; 50 pF bis 10 μF; 2 mH bis 100 H.

EE 7751 *für weitere Einzelheiten*

PRÄZISIONS-GLEITDRAHTPOTENTIOMETER

Kelvin & Hughes Ltd., New North Road, Barkingside, Essex

Dieses Potentiometer ist in der Hauptsache als Rechenelement zur Umwandlung von Winkeldrehung in Widerstand oder Spannung mit einem hohen Grad von Linearität und stufenloser Auflösung bestimmt.

Durch Verwendung des Gleitdrahtprinzips, so dass der Kontakt kontinuierlich auf dem Widerstandsdraht läuft anstatt sich von Wendel zu Wendel zu bewegen, wird eine unendliche Auflösung erzielt, und die Linearität wird lediglich durch die Genauigkeit begrenzt, auf welche der Draht gezogen ist.

Ein typischer Potentiometer hat einen Gesamtwert von 450 Ohm, eine Nennleistung von 200 mA, und wird durch 180 Drehungen der Spindel bewegt. Eine Genauigkeit von 0.1% der tatsächlichen Ablesung bis zu 1% des vollen Bereichs lässt sich erzielen; in Werten der Vollmasstabablesung ausgedrückt, beträgt die Genauigkeit 0,03%.

EE 7752 *für weitere Einzelheiten*

FEINDRAHT-ZUBRINGGERÄT

(Abbildungen auf Seite 176)

Kinetrol Ltd, Trading Estate, Farnham, Surrey

Das 'Kinetrol' Feindraht-Zubringgerät dient zum Abwickeln von Feindraht bei konstanter Spannung von einer Rolle, während er zu gleicher Zeit auf Instrumentspulen u.s.w. aufgewunden wird.

Das Zubringgerät hat eine Standhöhe von 381 mm. Es kann den dünnsten Kupferdraht bis zu einer Mindestsärke von 0,02 mmϕ, oder Ni-Chrom bis zu einer Mindeststärke von 0,015 mm bewältigen. Die Spannung ist von einem Mindestzug von 5 g bis zu einem Höchstzug von 15 g einstellbar. Die Wickelgeschwindigkeit für Draht der S.W.G.—Stärken 46-52 beträgt 1 500 mm/Sek., und das federgeregelte Modell (hier nicht abgebildet) ist für stärkere Drähte (S.W.G. 42-46) bei einer Wickelgeschwindigkeit von 6 000/Sek. eingerichtet.

Der Draht wird durch dasselbe Arbeitsspiel von seiner Rolle abgewickelt, mittels dessen er auf den zu fertigenden Artikel aufgewunden wird. Die Rolle befindet sich ortsfest auf dem Zubringgerät; und der Draht zieht einen Arm kreisförmig um die Rolle, und wird von ihm über eine Anordnung von Leitrollen weggeführt. Zwischen zweien dieser auf einer Trägerstrange angebrachten Leitrollen hängt der Draht an einer Schlinge und trägt ein an einer Spannrolle befestigtes Spanngewicht. Dieses Spanngewicht vermittelt dem Draht die richtige Spannung. Es ruht über einer am Ende eines Hebels befestigten Schale. Der Hebel betätigt eine Bremsvorrichtung, mittels derer die Geschwindigkeit des kreisenden Arms geregelt wird. Das geringste Nachlassen der Drahtspannung bewirkt das Herabsinken des Spanngewichts in die Schale, wodurch die Bremsvorrichtung für den sich drehenden Arm betätigt und die Spannung wieder hergestellt wird. In dem Masse, in dem sich die Spannung erhöht, bewegt sich das Spanngewicht in die Höhe und macht die Bremsvorrichtung frei, bis die richtige Spannung wieder hergestellt ist. Falls sich der Draht ausnahmsweise an der Rolle festklemmt, so bewegt sich das Spanngewicht um mehrere Zentimeter nach oben, ohne die Spannung zu verstärken, und gibt auf diese Weise eine Warnung.

Das Zubringgerät gestattet eine hohe Wickelgeschwindigkeit bei konstanter Spannung, ohne den Draht zu zerren oder zu zerreissen, wenn er um unregelmässig geformte Gegenstände gewunden wird. Der einzige bewegliche Teil, (der Dreharm) ist so leicht, dass sein Eigengewicht den Draht nicht zerreissen kann.

EE 7753 *für weitere Einzelheiten*

GERÄTESCHALTER MIT NIEDEREM WIDERSTAND

(Abbildungen auf Seite 176)

W. G. Pye & Co. Ltd., Granta Works, Newmarket Road, Cambridge

Dieser Geräteschalter ist eine neue Entwicklung, gestützt auf zweijährige grundsätzliche Forschungsarbeiten über mit Kontaktwiderstand zusammenhängende Probleme wie Kontaktdruck, Anzahl der Kontaktpunkte, Werkstoffe, Schmierung, Schaltung, mechanische Abnützung und Verunreinigung.

Der Gesamt-Schalterwiderstand beträgt etwa 0,7 mΩ und die Schwankung des Kontaktwiderstands ist weniger als $\pm$ 20 $\mu\Omega$. Die Gesamtwiderstandsverschiebung während der Standzeit des Schalters beträgt weniger als $\pm$ 50 $\mu\Omega$. Die Thermospannung beträgt nicht mehr als 0,008 μV/°C mit gleichmässigen Temperaturwechsel. Das Temperaturgefälle über dem Querschnitt des Schalters erzeugt einen Höchstwert von 0,025 μV/°C.

Der Schalter ist vollständig umschlossen und erfordert keinerlei Wartung. Während einer Standzeitprüfung wurden 20×10^6 Betriebsvorgänge ausgeführt, wobei der Schalter sich gut innerhalb der Spezifikation hielt.

EE 7754 *für weitere Einzelheiten*

RÖHREN-MILLIVOLTMESSER

(Abbildungen auf Seite 177)

Airmec Ltd., High Wycombe, Buckinghamshire

Der Röhren-Millivoltmesser Typ 264 ist ein für das Messen von kleinen Ton- oder Hochfrequenzspannungen innerhalb eines weiten Frequenzbereichs entworfenes Netzgerät. Die Spannungsbereiche erstrecken sich in je 3 Stufen von 1 mV bis 1 V, wobei der jeweilige Bereich mittels eines Schalters am Vorderschaltbrett gewählt wird. Ein drehbarer Sondenkopf ungewöhnlicher Konstruktion wird verwendet, in welchem die Streukapazitanzen auf ein absolutes Mindestmass herabgesetzt sind. Der Sondenkopf wird als Vervielfacher verwendet und ergibt vier Stellungen, $\times$ 1, $\times$ 0,1 und $\times$ 0,01 Hochimpedanz, zusammen mit einer × 1, 75 Ω Impedanz.

Der beherrschte Frequenzbereich liegt zwischen 20 Hz und 10 MHz mit einer Genauigkeit von ± 3% bis zu 3 MHz; ± 5% bei 30 Hz bis 6 MHz und ± 7,5% bei 20 Hz bis 10 MHz. Ein zuzüglicher Fehler von ± 2% wird eingeführt, wenn der Sondenvervielfacher verwendet wird.

Als Verstärker hat das Gerät eine Ausgangsimpedanz von 100Ω. Die Höchstausgangsleistung beträgt 3V in 1 k-Ohm und die Frequenzwiedergabe liegt innerhalb ± 1 dB von 30 H bis 10 Hz. Die Gesamtverstärkung beträgt 50 dB als Höchstgrenze.

EE 7755 *für weitere Einzelheiten*

ISOLIERUNGSPRÜFGERÄT

Radiometer, 72, Emdrupvej, Kopenhagen, Dänemark

Dieses in sich abgeschlossene Netz-Megohmmeter, Typ IM5, ergibt genaue Widerstandsmessungen von 1 MΩ bis zu 10^8 MΩ in sieben Bereichen. Fünf stabilisierte Prüfspannungen von 50, 100, 500 V und 1 kV sind vorgesehen und dieselben können in allen Widerstandsbereichen zur Verwendung kommen. Das Megohmmeter Typ IM5 ist zum Messen von Isolierungswiderständen von Kondensatoren, Transformatoren, gedruckten Schaltungsplatinen, Kabeln u.s.w. entworfen. Das Gerät umfasst eine Schutzschaltung, so dass Messungen von Betriebsstromverlusten in Mehrfachverbindungskabeln oder Dreiklemmen-Kondensatoren u.s.w. mit Leichtigkeit vorgenommen werden können. Das Gerät ist gegen das Auftreten von Kurzschluss im Prüfling geschützt. Vor Abnahme des Prüflings wird die Prüfspannung beseitigt und die Klemmschrauben werden kurzgeschaltet. Diese Anordnung in Verbindung mit einem Höchstkurzschlusstrom von 4 mA gewährleistet für das Gerät absolute Betriebssicherheit.

EE 7756 *für weitere Einzelheiten*

BANDPASS-KRISTALLFILTER

(Abbildungen auf Seite 177)

Cathodean Crystals Ltd, Linton, Cambridge

Diese ZF-Miniaturbandpass-Kristallfilter besitzen eine 80dB Dämpfung ausserhalb des Passbands und sind zum Betrieb in amplituden-frequenzmodulierten Empfängern in den Hoch-, Höchst- und UHF-Bändern geeignet.

Alle Filteraggregate sind auswechselbar, ohne dass Trimmer-und Abgleichsvorrichtungen erforderlich sind, so dass, falls ein Gerätekonstrukteur die Abmessungen der Kanalabstände zu ändern hat, es lediglich erforderlich ist, das die entsprechende Bandreite aufweisende Filter einzusetzen. Das feste Subminaturkristallaggregat ist zusammen mit allen anderen Bestandteilen auf gedruckten Schaltungsbrettern angebracht, und in einem hermetisch verschlossenen Messingbehälter untergebracht.

Die Miniaturaggregate benötigen einen Chassisraum von lediglich 51 × 33,5 mm. und ergeben in der Hauptsache flache Passband-Kennlinien mit beinahe senkrechten Sperrlinien. Verschiedene Bandbreiten stehen zur Verfügung, alle mit einer Mindestdämpfung von 80dB. Dank ihrer verhältnismässig niederen Dämpfungswerte sind sie besonders gut zum Einsatz zwischen Frequenzmodulator und ZF-Verstärker geeignet, und die Kennlinien schliessen die Notwendigkeit für Zwischenfrequenzwandler aus und gestatten Breitband-Verstärkerkonstruktionen mit lediglich einer einzigen Frequenzumwandlung.

Die Mittenfrequenzstabilität der Empfindlichkeitskurve innerhalb eines weiten Temperaturbereichs ist besser als 12 Teile in 10^6. Die Spitzeneingangsspannung für die Radiofrequenz beträgt 12 V, und die Phasenlinearität über den grössten Teil des Passbands gewährleistet getreue Wiedergabe für frequenzmodulierte oder pulsierte Systeme. Obwohl die Filter normalerweise zum Betrieb mit Röhrenimpedanzwerten von annähernd 1,6Ω endgeschaltet sind, stehen Impedanzwerte für Höchstkraftübertragung in transistorisierten Systemen zur Verfügung.

EE 7757 *für weitere Einzelheiten*

PEGELPRÜFGERÄT

(Abbildungen auf Seite 177)

Lancashire Dynamo Electronic Products Ltd, Rugeley, Staffordshire

In diesem neuartigen Gerät werden Transistor-Oszillatoren dazu verwendet, Oszillatorenröhren in der Detektorschaltung zu ersetzen, die Kapazitanzschwankungen in einer Sonde oder ähnlichen Elektrode bei der Annäherung oder Entfernung eines Werkstoffs anzeigt.

In der Transistor-Oszillatorenschaltung wird die mittels Sonde und Erde wiedergegebene Aussenkapazitanz mit der abgestimmten Schaltung des Oszillators verbunden.

In dem Hochpegel-Sondenkopfaggregat treten Oszillationen auf, wenn sich zwischen Sonde und Werkstoff ein freier Raum befindet, und unter diesen Bedingungen wird das Relais in dem Prüfgerät betätigt. Wenn der Werkstoff die Höhe der Sonde erreicht, bewirkt die Kapazitanzveränderung eine Verminderung und schliesslich den Stillstand der Oszillation. Die verminderte Oszillationsamplitude wird mittels einer weiteren Transistorschaltung gleichgerichtet, wodurch wiederum das Prüfrelais betätigt wird.

In dem Niederpegel-Sondenkopfaggregat wirkt das System in umgekehrter Weise, wobei das Relais im Prüfaggregat betätigt wird, sobald die Sonde vollkommen untergetaucht ist.

Die Verwendung von Transistoren hat eine Reihe von Vorteilen gezeitigt; zum Beispiel (1) die gesamte Pegeldetektorschaltung ist innerhalb des Kopfgusstücks der Sonde untergebracht; (2) das Fernsteuerungsaggregat kann in jeder beliebigen Entfernung von dem Sondenkopfaggregat, mit lediglich 3 Verbindungsleitungen, angebracht werden; (3) alle Schaltungen ausserhalb des Fernsteuerungsaggregats befinden sich in einem Höchstpotential von 12 V Gleichspannung zur Erdung; (4) Der Höchststromwert, der den Verbindungskabeln unter Kurzschlussbedingungen entnommen werden kann, beträgt 50 mA Gleichstrom.

In dieser Ausführung ist das Gerät in ein Sondenkopfaggregat gewöhnlicher Form eingebaut, das die verschiedenen Elektrodenmontagen aufnehmen kann, die ihrerseits mit dem Gerät entsprechenden Profilen versehen sind. Ein Höchstmass an Wartungsverminderung wird durch Verwendung von gedruckten Schaltungsaggregaten erzielt, die zum Einschieben in das Gesenkgussaussengehäuse eingerichtet sind, wobei mittels einer federbelasteten Vorrichtung, die einen Teil des Sondenkopfs bildet, automatisch ein Einpunktkontakt am Sondenende der Schaltung hergestellt wird.

Dieses gewöhnliche Sondenkopfaggregat nimmt jede beliebige Sondenart auf, die für ein Höchstmass der vielfältigsten industriellen Verwendungszwecke entworfen wurden.

EE 7758 *für weitere Einzelheiten*

NIEDERSPANNUNGS-KRAFT-QUELLENAGGREGATE

(Abbildungen auf Seite 177)

Elliott Bros. (London) Ltd., Century Works, Lewisham

Das Kraftquellenaggregat B.673 verwendet Transistoren und umfasst einen nichtlinearen Serienstabilisator, der einen 50 V Speisegleichstrom erzeugt. Die Gesamtregulierung liegt innerhalb von ± 0.5 V für einen Netzeingang von 210 bis 260 V Wechselstrom und einen Laststrom von 1,5 Amp.

Der Wert ± 0,5 V umfasst eine 0,9 V Schaltwellenform, die durch die Schaltwirkung des nichtlinearen Serienstabilisators verursacht wird. Der Ausgang hat einen Temperaturkoeffizient von weniger als 15 mV/°C.

Das Gerät, das in erster Linie für die Postbehörden, und zwar zum Betrieb von Relais und Solenoiden entworfen wurde, kann überall da eingesetzt werden, wo eine Speisespannungsschwankung innerhalb von ± 1% ausreichend ist. Es liefert jede kontinuierliche Last bis zu 1,5 A und ergibt jeden beliebigen Strom innerhalb dieses Bereichs ohne Rücksicht auf die Änderungsgeschwindigkeit der Last.

Der Typ B.672 verwendet ebenfalls Transistoren und liefert einen 10 V Speisegleichstrom bei 0 bis 1 Amp. Vollast von einer normalen Wechselstromnetzquelle von 215 bis 260 V oder 0 bis 750 mA von einer 200 bis 260 V Netzstromquelle. Die Gesamtregulierung ist besser also 35 mV, und die erzielte Welligkeit weniger als 1 mV Spitze zu Spitze. Der Ausgang hat einen Temperaturkoeffizient von weniger als 1 mV/°C

EE 7759 *für weitere Einzelheiten*

EICHUNGSOSZILLATOR

(Abbildungen auf Seite 178)

A/S Danbridge, Frederkssundvej 60c, Kopenhagen, Dänemark. Vertrieb in Grossbritannien durch B & K Laboratories Ltd., 4 Tilney Street, London, W.1

Dieses Gerät wurde in der Hauptsache für Eichungsoszillographen entworfen, aber hat jedoch zahlreiche Verwendungsmöglichkeiten im Laboratorium. Eine Transistorschaltung mit Batterieantrieb wird verwendet, so dass ein sehr kleines und handliches Gerät erzielt wird. Es ergibt Ausgangsfrequenzen von 1 kHz und 10 kHz und es lassen sich sowohl Quadratwellen- als auch Sinuswellenausgänge erzielen. Der Quadratwellenausgang ist durch eine Zener-Diode begrenzt, die eine bekannte Amplitude für Eichungszwecke liefert. Der Sinuswellenausgang lässt sich durch Vergleichsanstellungen mit der Quadratwelle regeln, und für diesen Zweck sind Prüfstellungen auf dem Dämpferschalter vorgesehen. Der Ausgang wird getrennt auf jeder Frequenz vermittels zweier Potentiometer eingestellt. Die Ausgangsspannung lässt sich durch einen geeichten Stufendämpfer regeln, und Vorrichtungen zur getrennten Verwendung des Dämpfers, z.B. für Verstärkerprüfungen u.s.w., sind vorhanden. Die Ausgangsfrequenzen sind von ausreichender Genauigkeit für Zeitbasis-Eichung, u.s.w. Beim Ausschalten wird die Ausgangsklemme mit einer getrennten Klemme verbunden, an welche das Prüfsignal angelegt werden kann. Auf diese Weise lässt sich das Gerät dauernd anschliessen und muss lediglich für den Eichungsvorgang eingeschaltet werden. Ein direkter hoher Ausgangspegel ist vorgesehen, und derselbe kann für Brückennetzanschluss, u.s.w. verwendet werden. Darüber hinaus ist die sich nicht in Betrieb befindliche abgeglichene Schaltung von der Oszillograph-Schaltung isoliert und mit zwei der Klemmen verbunden, so dass sie als Filter in externen Schaltungen verwendet werden kann.

EE 7760 *für weitere Einzelheiten*

BREITBANDDÄMPFER

(*Abbildungen auf Seite 178*)

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

Dieser Zehnstellendämpfer, mit Anwendungsmöglichkeiten von Gleichstrom bis zu Höchstfrequenzen, besteht entweder aus Einzel-oder in Kaskadenanordnung geschalteten Doppelaggregaten. Sie besitzen gewöhnlich eine Eingangs- und Ausgangsimpedanz von 75 Ω und sind für die Verwendung mit Plessey Minor Koaxialsteckern entworfen. Eine 50 Ω Ausführung, unter Verwendung von B.N.C—Verbindungen, kann auf Wunsch geliefert werden. Die Doppelaggregate bestehen aus Dekaden- und Einheitsdämpfern, die entweder in Tandemanordnung auf derselben Achse oder nebeneinander montiert sind, mit einem Bereich von 99 dB in Stufen von 1 dB.

Alle diese Dämpfer bestehen aus Widerstandsleiternetzen. Die Widerstände sind in den Aussparungen des Abschirmgusstücks angeordnet, um den charakteristischen Wellenwiderstand innerhalb eines ausgedehnten Frequenzbereichs aufrechtzuerhalten. Der charakteristische Wellenwiderstand wird vermittels von Paddingwiderständen der Eingangs- und Ausgangsleitungsimpedanz angeglichen. Dies hat den Vorteil, die erforderlichen Gesamtabmessungen der Aussparungen, und dadurch den Dämpfer, zu verringern, und die Wirkung eines unangeglichenen Eingangs oder Ausgangs auf die Dämpfung zu verringern. Die Wirkung invermeidlicher innerer Blindwiderstände wird gleichfalls herabgesetzt.

Bei der Konstruktion wurde weitgehendst dafür Sorge getragen, die Eingangsabteilung der Leiter hinreichend vom Ausgang abzuschirmen. Die Rückplatte ist geschlitzt, um Umlaufströme zu verhindern, wobei die beiden Hälften unmittelbar an jeder Seite des Schlitzes geerdet sind und an der Teilung eine Abschirmvorrichtung angebracht ist.

Der Gusskörper, die Aussparungen und Eingangsöffnungen sind versilbert, um die bei Höchstfrequenzen auftretende Oberflächenwirkung zu vermindern. Der Aussenanstrich des Körpers besteht aus einem Überzug aus Silberlack. Die Spitze des Wählerarms und die Kontakte sind mit einem Rhodiumüberzug versehen. Die Kontakte sind in Polystyrol gefasst und das Schalten wird getrennt vom eigentlichen Kontakt bewirkt. Die Aggregate besitzen ein selbstschmierendes Schaltsystem, wobei der Schaltball seine Schmierung in jeder Dämpfungsstellung von in Öl getauchten Bäuschen empfängt. Sowohl die fest angebrachten als auch die beweglichen Kontakte sind mit einem Rhodiumüberzug versehen.

EE 7761 *für weitere Einzelheiten*

UNTERSETZUNGSGETRIEBE- UND SKALEN-AGGREGAT

(*Abbildungen auf Seite 178*)

Stratton & Co. Ltd., Eddystone Works, Alvechurch Road, Birmingham 31

Das Eddystone Untersetzungsgeriebe-Aggregat ist eine erstklassige für Geräteverwendung entworfene Bausteineinheit. Die Bewegung erfolgt durch Zahnradantrieb und Schwungrad, wodurch ein gleichmässiger zwangsläufiger Antrieb mit einem Untersetzungsverhältnis von 110:1 erzielt wird. Der Zeiger hat eine waagrechte Bahn von 178 mm. Eine kreisförmige Noniusskala, in 100—Unterteilung, befolgt eine fünfmalige Drehung pro Zeigerdurchlauf, und ergibt zusammen mit der '100'—Skala eine Gesamtanzahl von 500 Unterteilungen. Das Ziffernblatt hat fünf Zeilen zum Aufnehmen von Eichungsmarkierungen. Eine Schlossplatte aus Spritzguss mit schwarzen Glanzüberzug wird mitgeliefert, und das Aggregat ist komplett mit Perspex-Fenster, Knopf, Klemmschrauben, und Montageschablone. Das Gerät ist zur Montage auf Metall-oder Holzplatten bis zu einer Stärke von 7 mm. geeignet. Die Gesamtaussenabmessungen betragen 23,34 × 14,6 cm.

EE 7762 *für weitere Einzelheiten*

ELEKTRONISCHES VIELFACH-MESSGERAT

(*Abbildungen auf Seite 178*)

Metrix Instruments Ltd., 54 Victoria Road, Surbiton, Surrey

Dieses Gerät kann für sich in Anspruch nehmen, Spannungs-, Strom-, Widerstands- und andere normalerweise nur vermittels Elektrometern oder Schwingkondensatorschaltungen mögliche Messungen zu ermöglichen, und zwar mittels einer symmetrischen Dreiklemmen-Schaltung unter Verwendung von hergebrachten Röhren. Die Schaltung gibt eine Eingangsimpedanz von entweder 10^{14} Ω oder Null, wie erforderlich. Die Ausgangsimpedanz der Schaltung ist so gut als null und speist einen Verstärker und ein Messer mit einer Zusatzvorrichtung zum Anschliessen eines externen Schreibers.

Die Schaltungsanordnung ist so entworfen, dass ein ungewöhnlich hoher Grad von Stabilität erreicht wird, und wenn eine Spannung in der 'Gedächtnis'-Stellung angelegt wird, (ein Polystyrol-Kondensator ist über die Eingangsschaltung geschaltet), so behält das Gerät die Ablesung auf eine Zeitdauer von mindestens 12 Stunden nach Abschalten von der Quelle mit einer Trift von weniger als 1%.

Geringe Spannungsschwankungen können ohne Rücksicht auf den Absolutwert mit Volldiskrimination unter Verwendung eines externen Kondensators mit Schutzring hergestellt werden. Der Kondensator ist in Serienschaltung mit der Quelle verbunden und wird zunächst auf die Quellenspannung geladen, und zwar durch Kurzschliessen des Eingangs zum Gerät. Wenn der Kurzschluss weggenommen wird, ist die Spannung über dem Gerät anfänglich null und registriert lediglich Schwankungen der Quellenspannung. Durch Verwendung einer konstanten Spannungsquelle lassen sich die Hystereseverluste von Kondensatoren in gleicher Weise messen. Die Grundbereiche des Geräts sind: 50 mV bis 2 kV; 0,5 × 10^{-7} bis 2 × 10^{-3} A und 1 bis 2 × 10^{19}Ω.

EE 7763 *für weitere Einzelheiten*

VERSILBERTE MINIATUR-MIKAKONDENSATOREN

(*Abbildungen auf Seite 179*)

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

Diese mit einem Silberschutzüberzug versehenen Miniatur-Mikakondensatoren haben eine ungefähre Grösse von 0,43 × 0,26 × 0,1 mm. Zwei Anschlusstypen sind erhältlich; der Typ CSM15 mit Axialanschlüssen zum Hintereinanderschalten, und CSM15s mit Seitenanschluss, der dadurch zum Einbau in gedruckte Schaltungsplatinen u.s.w. geeignet ist. Sie sind in einem Kapazitanzbereich von 10 pF bis 220 pF verfügbar, mit einem Toleranzbereich von ± 1% bis ± 20%. Die Betriebs-Nennspannung beträgt 350 V Gleichstrom und der Kraftfaktor ist weniger als 20 × 10^{-4} bei 1 MHz.

EE 7764 *für weitere Einzelheiten*

MAGNETBAND-SPEICHER FÜR RECHENMASCHINEN

(*Abbildungen auf Seite 179*)

Epsylon Industries Ltd., Faggs Road, Feltham, Middlesex

Dieses vielseitige Magnetband-Speicheraggregat ist zur Verwendung mit einer ausgedehnten Reihe von Rechengeräten bestimmt. Alle Betriebsvorgänge des Geräts, einschliesslich des Schnellaufspulens und Auswechselns Können von einem Fernsteuerungsschaltbrett aus ferngesteuert werden. Das Gerät befolgt automatische Anweisungen für Start, Stop und Umkehr mit einer Geschwindigkeit von bis zu 150 Impulsen/Sek. Die Standard-Bandgeschwindigkeit beträgt 25,4 cm/Sek., aber späterhin wird die Maschine zum Betrieb mit einer Geschwindigkeit von 50,8 cm/Sek. erhältlich sein. Bei jeder beliebigen Bandgeschwindigkeit beträgt die Start-Stoppzeit in beiden Richtungen ungefähr 2 m/Sek. Ein patentiertes Bandbehältersystem macht die Notwendigkeit für Rückwärtsspannung nach beiden Richtungen überflüssig, und der einzige Bandabschnitt, der einer Beschleunigung ausgesetzt werden muss, ist von ungefähr 152 mm. freier Länge. Mit einem 16-Kanal—Ablese-Schreibkopf und einer Schreibdichte von 400 Bits pro Spurzoll (25,4 mm), beträgt die Kapazität eines 248 m Bands über 120 Millionen Bits. Zwei Köpfe können montiert werden, die zwei phasenverschobene und verflochtene Sätze von 16 Spuren ergeben. Ein Löschkopf gehört nicht zur Normalausrüstung. Die gerade Bandbahn macht das Ein- und Ausspannen zu einem raschen und einfachen Vorgang. Auf Erhalt der 'Wiedereinspann'—Anweisung (Fern- oder Druckknopfsteuerung) nimmt die Maschine die Schnellaufspulung vor, und zwar mit einer Geschwindigkeit von 101,6 cm/Sek, bis das Band aus der Aufnahmespule ausläuft, woraufhin das Gerät stillsteht. Die Bandbehälter 'leeren' sich, und, auf Betätigung eines Druckknopfs gehen alle Tore auf, die oberen Abdeckungen der der Behälter schwingen in Scharnieren zurück, und der Bedienungsmann kann das Band in Sekundenschnelle abheben. Die Spulen sind mit besonderen Schnell-auslöse-Druckknopfnaben ausgestattet. Wenn die Maschine die Anweisung 'Aufspulen' empfängt, nimmt sie die Schnellaufspulung in der erforderlichen Richtung vor, bis sie zum Stillstand kommt, ohne dass das Band aus der Spule ausläuft. In diesem Fall bleiben die Bandbehälter gefüllt.

Das komplette Gerät ist in eine in sich abgeschlossene Konsole eingebaut, die alle elektronischen Steuerschaltungen, Ablese-Schreibverstärker für jede gewünschte Art der Registrierung, und die Kraftaggregate enthält. Die elektronischen Schaltungen sind in getrennte auswechselbare Einsteckchassis eingebaut und umfassen 16 'Ablese'—Verstärker, 16 'Schreib'—Verstärker und die verschiedenen Maschinen Steuereinheiten. Alle Chassis werden an der Vorderseite der Konsole eingesteckt. Das Gerät ist druckausgeglichen und druckgekühlt.

EE 7765 *für weitere Einzelheiten*

SCHNELLZÄHLER

(*Abbildungen auf Seite 179*)

Van Der Heem Ltd., P.O.B. 1060, The Hague, Holland

Dieses Gerät nimmt Zählungen bis zu 999 999 bei einer Höchstzählgeschwindigkeit von 1 000 000 pro Sekunde vor. Eine interne regelbare Zeitbasis ist für Frequenzmessungen und ein kristallgesteuerter Oszillator für Zeitmessungen vorgesehen; die Zeit wird durch Zählung der Anzahl der Perioden zwischen Start- und Stopimpulsen ermittelt. Frequenzen bis zu 1 MHz können gemessen werden und Zeitabstände lassen sich in Einheiten von 1 μSek. bis 10 Sek. ermitteln. Der Zähler kann deshalb für viele Zwecke verwendet werden, wie z.B. dem raschen und genauen Zählen von Gegenständen, Geschwindigkeitsmessungen, u.s.w. Halbleitervorrichtungen (Transistoren und Dioden) und gedruckte Schaltungen kommen zur Verwendung und die Abmessungen des Aggregats sind 30 × 22 × 16 cm. Der Betriebsstrom kann vom Netz oder einer 6 V Batterie entnommen werden; der Kraftverbrauch beträgt ungefähr 10 VA bei Netzanschluss und 3 W bei Batteriebetrieb.

EE 7766 *für weitere Einzelheiten*

ELUTIONSBRÜCKE

Griffin & George Ltd., Ealing Road, Alperton, Wembley, Middlesex

Die Griffin-Raleigh Elutionsbrücke wurde haptsächlich zum Überwachen von Waschverfahren in der Transistorfertigung und der Galvanisierungsindustrie entwickelt. Ein hergebrachtes Wheatstone'sche Brückennetz unter Verwendung von leitfähigen Zellen als zwei der Arm wird so angeordnet, dass der unsymmetrische Strom in einem hochgradigen Transistorverstärker verstärkt wird.

Eine der Zellen ist in der Zuflussleitung mit einem Waschgefäss verbunden, von welchem die ausströmende Flüssigkeit durch die zweite Zelle fliesst. Während des Durchflusses der Waschflüssigkeit durch das leere System wird an einem Drehspulengerät eine Ablenkung registriert. Der Durchfluss wird fortgesetzt, bis eine beständige Ablenkung erzielt wird, worauf die Brücke auf Nullanschlag abgeglichen wird. Auf diese Weise werden die Wirkungen von Temperaturschwankungen, Kohlensäureabsorption im Bad und der Unterschied in den Zellerkonstanten automatisch ausgeglichen. Beim Einbringen der zu waschenden Masse in das Elutionsgefäss wird wiederum eine Ablenkung registriert, und das Waschen wird fortgesetzt, bis die Ablenkung auf null oder einen vorbestimmten niederen Wert zurückgeht, der den erwünschten chemischen Reinlichkeitsgrad anzeigt. Eine der in jedem Gerät eingebauten Zellen besitzt einen bekannten konstanten Wert, und die Brücke kann deshalb ebenfalls für die genaue Eichung leitfähiger Zellen benützt werden, ohne die Notwendigkeit, Standardlösungen zu verwenden. Das Netzsystem wird von einer internen Quelle mit Niederspannungs-Wechselstrom beliefert, und der Verstärkergrad kann zur Anpassung an Raumbedingungen geregelt werden. Die Brücke hat Netzantrieb.

EE 7767 *für weitere Einzelheiten*

Zusammenfassungen der Hauptartikel

Das Registrieren und Zusammenstellen von Wellenformen von R. J. D. Reeves

Zusammenfassung des Artikels auf Seite 130-137

Beim Gerätebau für angewandte Schaltkreisanalyse ist die Abwesenheit von Registriervorrichtungen für Oszillogramme ein fühlbarer Mangel. Das Beobachten, Messen und Registrieren sind die drei Stufen zu einer systematischen Analyse, und dennoch hat sich die letztere noch nicht weiter als bis zu dem einfachen Begriff des Fotographierens der Leuchtspur entwickelt. Als Verfahren ist dies umständlich, und als Wiedergabe unzureichend, da die Abmessungen keinerlei Bedeutung haben.

Vor dem Erscheinen der Kathodenstrahlröhre wurden in der Praxis periodische Wellenformen mittels eines Strobografs festgehalten, der das Auslesen der Wellenform mit Hilfe eines nahezu synchronen Kommutators vornahm. Das elektronische Äquivalent dieses Verfahrens ermöglicht die Verwendung von direktschreibenden Geräten an Stelle der Kathodenstrahl- Oszillografs- und Kamerakombination und erbringt eine neue Verfeinerungsstufe für die Darstellung. Durch Aufrechterhaltung der Gleichstrompegel lassen sich Aufzeichnungen an Stelle der wirklichen Zusammenstellung von Wellenformen und der Synthese von Familiengruppen- und Netzwerken einsetzen.

Im ersten Teil dieses Artikels werden verschiedene Gesichtspunkte der Strobographie besprochen, und im zweiten Teil wird ein neues Gerät für Allgemeinzwecke beschrieben.

Ein zur Messung von magnetischen Feldern geeigneter Kernresonanzdetektor von G. C. Lowe

Zusammenfassung des Artikels auf Seite 138-140

Eine einfache Rückkopplungsschaltung wird hier beschrieben, die das Phänomen der magnetischen Kernresonanz zum Messen von magnetischen Feldern über einen weiten Bereich mit einem Mindestmass von Neujustierung der Schaltkreiselemente auf eine Genauigkeit von mindestens 0,01% verwendet.

Ein neues Bestimmungssystem für Lochkarten oder kontinuierliche gelochte Folien Von S. Morleigh

Zusammenfassung des Artikels auf Seite 140-141

Bei den herkömmlichen Methoden des Einbringens von Eingangsinformation in Digitalrechenwerke kommen entweder mechanische oder elektrische Elemente zum Bestimmen der Information zur Verwendung. Dieselbe wird gewöhnlich in Form von Löchern wiedergegeben, die an bestimmten Stellen, die den Reihen und Spalten der Eingangsträger entsprechen, angebracht werden. Abgesehen davon, dass diese Methoden kompliziert und kostspielig sind, sind sie mit weiteren Nachteilen behaftet, und im Betrieb verhältnismässig langsam.

Eine Beschreibung eines alternativen Systems wird hier gegeben, das eine kapazitive Bestimmungsmethode verwendet, mittels derer jede beliebige Spalte einer Lochkarte in Form von 2 bestimmten Abzweigungen, wie z.B. C_1 und C_2, einer einfachen Kapazitanzbrücke wiedergegeben werden. Von da aus kann die Stellung jeder einzelnen Lochung schnellstens vermittels besonderer Ausgangspotentiale, die den Werten dieser Kondensatoren entsprechen, bestimmt werden. Weitere Anwendungen dieses Geräts können möglicherweise zum Ersatz einiger bestehenden Lochkarteninstallationen durch kontinuierliches Band oder Folie führen.

Phasen- und Amplitudenmessung bei Niederfrequenzen von R. J. A. Paul and M. H. McFadden

Zusammenfassung des Artikels auf Seite 142-149

Eine Beschreibung eines NF-Oszillators und Phasenmessgeräts wird hier gegeben. Der Frequenzbereich beider Geräte lässt eine untere und obere Ausdehnung auf unter 0,01 Hz und über 10 kHz zu. Die Hauptanwendung des kombinierten Geräts besteht im Prüfen von Rückkopplungssteuerungssystemen unter offenen und geschlossenen Schleifenbedingungen. Zwei Methoden der Phasenmessung werden umrissen, die in der Hauptsache auf die Verwendung von Analogrechenverstärkern gegründet sind. Das theoretische Prinzip der Wirkungsweise wird wiedergegeben, und einige Leistungswerte sind eingeschlossen.

Das Elektroformen von Hohlleiterbestandteilen von P. Andrews

Zusammenfassung des Artikels auf Seite 150-152

Bestimmte Hohlleiterbestandteile lassen sich nicht sehr leicht mittels gewöhnlicher Fertigungsverfahren anfertigen, und in diesen Fällen bildet das Elektroformen oft eine geeignete Methode. In diesem Artikel wird ein einfaches Säure-Kupfer—Verfahren für Elektroformen beschrieben, das zum Einsatz in Laboratorien oder für Fertigung in kleinerem Masstabe geeignet ist.

Eichung von Schwingungsamplituden von R. A. S. Kay

Zusammenfassung des Artikels auf Seite 154-155

Eine Technik für das Messen von mittels Schwingungserzeugern hervorgerufenen Schwingungsamplituden wird hier beschrieben. Besonderer Bezug wird auf die Eichung von Schwingungstonabnehmern genommen. Die Methode lässt sich innerhalb des unteren Tonfrequenzbereichs verwenden und bleibt unbeeinträchtigt von Abweichungen in der Wellenform. Stroboskische Geräte in Verbindung mit mechanischen und optischen Hebeln kommen zur Verwendung.

Ein elektronisches Verschlüsselungs—und Entschlüsselungsgerät für Fernschreibersignale Von J. Das

Zusammenfassung des Artikels auf Seite 156-160

Das Verschlüsseln und Entschlüsseln von Nachrichtenübermittlungen, wie sie in Fernschreibern zur Verwendung kommen, wurde vermittels elektronischer Schaltungen nachgebildet. Die Buchstabentaste löst einen 50 Hz Multivibrator aus, dessen Ausgangsleistung durch dieselbe Taste gemäss dem dem Buchstaben zugeordneten Schlüssel gesperrt wird. Der Multivibrator kommt nach Aussendung des Stop-Impulses zu der Leitung zum Stillstand. Im Entschlüssler wird der Multivibrator durch den Start-Impuls betätigt, und das eintreffende Signal wird mittels einer Reihe von Kanalscheider-, Schlüsselwähl- und Zählschaltungen sortiert, gewählt und entschlüsselt. Zur endgültigen Entschlüsselung wurden den Code-Impulsen binäre Hilfsschlüssel zugeordnet. In allen Zähl- und Wählschaltungen kommen gasgefüllte Miniaturtrioden zur Verwendung.

Ein moderner Frequenzverschiebungs-Telegrafenempfänger von E. J. Allen

Zusammenfassung des Artikels auf Seite 161-164

Der Artikel beschreibt einen Radio-Telegrafenempfänger, der für sich in Anspruch nehmen kann einen gänzlich neuen Weg zu erstklassigem HF-Radiofernschreibe-Empfang zu beschreiten. Er ist allgemein gesehen gemäss den derzeitigen Postspezifikationen entworfen, und die Verwendung eines neuartigen Empfangsprinzips schaltet die beträchtlichen Mängel aus, mit denen herkömmliche Konstruktionen unter ungünstigen Ausbreitungsbedingungen behaftet sind, und vermittelt eine beträchtlich ausgedehnte Periode des 'guten Druckens'.

Eine einfache Demodulationsschaltung für Zwecke der Gerätekonstruktion von R. Hoodless

Zusammenfassung des Artikels auf Seite 164-165

Viele Geräteumsetzer sind so entworfen, dass sie zwei Arme einer Brückennetzschaltung bilden, die durch eine Trägerspannung betätigt wird. Die Ausgangsamplitude- und Phase einer solchen Brücke ist von dem zu messenden Mengenwert abhängig, bedarf jedoch einer phasenbezogenen Gleichrichtung zum Liefern einer analogen Spannung.

Dieser Artikel beschreibt eine einfache Schaltung, die zur Verwendung kommen kann wenn nachherige Verstärkung unnötig ist.

Eine Methode für das Entwickeln von periodischen Funktionen von J. Pereli

Zusammenfassung des Artikels auf Seite 166-167

Alle komplexen Wellenformen lassen sich in Form einer Reihe von sinusförmigen Funktionen ausdrücken, und in der Vergangenheit war diese Art der Formelfassung ausreichend für den Ingenieur. In diesem Artikel wird jedoch ausgeführt, dass die bekannte Fourier-Reihe nicht die einzige Art darstellt, eine periodische Funktion zu entwickeln, und eine quadratische Funktion z.B. kann in Form einer Dreiecks- oder anderen periodischen Komponente, ganz nach Bedarf, ausgedrückt werden.

Vier gleichzeitige Strahlungen von einer Sendeantenne der UHF/FM—BBC Sender, Sandale, Cumberland von F. D. Bolt

Zusammenfassung des Artikels auf Seite 168-170

Im August 1958 dehnte die BBC ihren UHF/FM—Sendedienst auf den Lake District (Seenbezirk) und Südwestschottland aus. Vier gleichzeitige Sendungen werden von einer gemeinsamen Sendeantenne abgestrahlt, jede mit einer wirksamen Strahlungsleistung von 120 kW.

Besondere Sorgfalt wurde darauf verwendet, 'bandverschobene' Abstrahlung zu verhindern, und dieser Artikel beschreibt, wie eine derartige unerwünschte Abstrahlung auf einige wenige Mikrowatt reduziert wurde.