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Commentary

BY the time this issue appears the Instruments, Electronics and Automation Exhibition at Olympia, London, will be drawing to its close and, while it is obviously impossible at the present moment, to comment on the Exhibition in retrospect, it can hardly have failed to be an unqualified success. Altogether some seven hundred exhibitors, including one hundred and thirty from overseas, will have occupied over 200 000 square feet of exhibition area and will have displayed equipment valued at approximately £20M. It is expected that over 10 000 overseas buyers, engineers and manufacturers will have attended the Exhibition and to ensure this publicity has been conducted throughout the world and special arrangements have been made with the international airlines to provide facilities for overseas visitors.

From the advance information available it is obvious that a vast array of instruments and equipment will have been offered for inspection, covering all facets of the industries concerned. Undoubtedly the visitors' greatest difficulty will have been to make the best use of the time at their disposal, for to locate the items of personal interest in so vast an array is clearly no easy task. To carry out a stand-to-stand inspection, even allowing only five minutes per stand, including the walking time between stands, would occupy just over 58 hours! By attending the Exhibition for the whole of the time it is open this could just about be accomplished—but it is a feat of endurance upon which few would embark and probably none would finish. It is claimed by its organizers that it will be the largest exhibition of its type in the world and while it is gratifying to know that the British instrument and electronic industries can organize such a mammoth show, it may well be that there is some danger of its becoming too large.

It is, of course, no easy problem to decide whether it is better to have one large, all embracing exhibition or whether to stage a number of smaller and more specialized events. There are strong arguments in favour of both arrangements but on balance and providing it does not get too unwieldy and out of hand the IEA type of exhibition probably has the most to commend it, particularly from the point of view of overseas visitors who are more likely to make one four- or five-day visit to this country than a number of shorter visits. There is, perhaps, one proviso to this conclusion and that is that the exhibition should be well catalogued and that the catalogues should be available well before the opening of the exhibition, so that intending visitors can plan their viewing campaign in advance. Commercial exhibitions seldom, if ever, seem to be able to accomplish this, but that it can be done, on a somewhat smaller scale may be, is yearly demonstrated by the Physical Society and the Institute of Physics.

If nothing else the IEA Exhibition will have served to demonstrate the virility of the electronic and instrument industries and this is further exemplified by the Thirty-first Annual Report of the Radio and Electronic Component Manufacturers' Federation which has recently been published. The figures contained in this Report show the steady growth of the industry and testify to the important position which it occupies in the country's economy.

In a diversified industry such as our own it is not possible to produce precise figures but it is estimated that the gross output of the radio and electronic industry rose by 10 per cent in 1963. The total production was some £380M of which £190M, exactly 50 per cent, was accounted for by capital equipment. It should, however, be noted that defence contracts represented something over 40 per cent of the latter figure.

On the all-important export side the figures given are equally encouraging, though a warning note is sounded. During 1963 the total exports of electrical machinery and apparatus, including computers and sound recording and reproducing apparatus were £334M, which made the electrical industry the second largest exporter after the motor vehicle manufacturers. Towards this total radio and electronic apparatus contributed £87·9M, telephone and telegraph apparatus £28·6M and instruments £9·6M. These figures do not, of course, tell the whole story for a great deal of electrical and electronic apparatus is included in other categories of finished products.

While these figures cannot be regarded as anything other than satisfactory there are two points in the R.E.C.M.F. Report which show that there is no room for complacency. The first is that the increase of 7 per cent in exports of radio and electronic products was slightly less than the previous year's rise and 8 per cent for U.K. exports generally in 1963. The second is that imports of radio and electronic products amounted to £41·8M in 1963 which is an increase of 25 per cent on the 1962 total and continues the trend of recent years in which, with one exception, imports have increased at a higher rate than exports.

British visitors to overseas exhibitions will already have seen that the electronic industries of a number of countries have made very rapid strides forward in the last few years, and the fact that 130 overseas exhibitors have taken space at the IEA Exhibition is further proof that competition for the world's markets is becoming increasingly hard as the years go by.

To maintain or improve the position of this country's electronic industry is going to call for an all-out sustained effort at all stages of research, development and production.

An Underwater Acoustic Telephone for Free-Swimming Divers

By B. K. Gazey*, Ph.D. and J. C. Morris*, Ph.D.

A frequency-modulated acoustic carrier telephone system has been developed for the use of free-swimming divers. Operating at a carrier frequency of 120kc/s and transmitting approximately 1W of acoustic power, it has been tested at ranges of up to 500 yards. The system is described briefly and details of the experimental trials are given.

(Voir page 428 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 437)

A SMALL, portable, self-contained underwater communication system for the use of free-swimming divers is a necessity if the diver is to make the utmost use of his time underwater. At present, diver-to-diver communication is almost non-existent, being limited to hand signals for short ranges, and conventional telephone systems embodying cumbersome interconnecting cables for longer ranges. The necessity of using an interconnecting cable completely destroys the advantages of manoeuvrability and freedom of movement afforded to a SCUBA equipped diver (SCUBA is the abbreviated form of Self-Contained Underwater Breathing Apparatus).

The applications of a self-contained underwater telephone are numerous, the most important surely being the provision of continuous supervision of a diver's action, responses and position in the interests of safety, a vital consideration underwater. The system would also enable operations performed by a number of divers simultaneously to be co-ordinated efficiently, which would be invaluable in such operations as underwater site surveying for civil engineering projects, salvage work, prospecting as well as shallow water zoological and geological studies.

Recently, attempts have been made by several independent groups to produce a reliable underwater communication system dispensing entirely with interconnecting cables. On considering the conditions under which such systems must operate it is readily apparent that those based upon electromagnetic radiation can be of little use owing to the severe attenuation imposed by sea water upon most of the electromagnetic spectrum[1]. The only portion of the spectrum which may be of use is the visible light region and it should be possible to produce a communication system using speech-modulated light which would have a useful range in certain favourable clear-water areas. Unfortunately, the turbidity of the sea, in general, and in British waters in particular is such that it would often restrict such a system to ranges of the order of a few feet only, and not infrequently to inches.

Two other possibilities then remain; the first is to employ electrical conduction by setting up electrical conduction paths within the sea at audio frequencies. The second is to use ultrasonic acoustic radiation which is modulated by the speech signal. The first of these methods is limited to short-range applications only, and it would appear that prior to August 1963 only a limited measure of success had been achieved with the 'acoustic link', the name now given to a telephone based upon the transmission of sound through the sea, short ranges of the order of a few tens of feet again being the limiting factor.

Acoustic radiation is a far more attractive proposition for the transmission of information underwater than electromagnetic radiation. It is able to propagate under conditions of extreme turbidity and at low frequencies it is not highly attenuated by absorption in the water. Systems embodying acoustic transmission have the further advantage of being relatively inexpensive to produce. Acoustic communication underwater has a very limited history and efforts in the past have been directed mainly to the telemetry of data[2,3,4,5,6] from simple instruments, in particular depth gauges attached to fishing nets, etc. Most of these have used frequency-modulation techniques to relay their information owing to the inherent superiority of frequency modulation from the point of view of signal-to-noise performance. This signal-to-noise superiority is of considerable importance for this application owing to the high noise level experienced in the sea due to such causes as the passage of the net through the water, the breaking of surface waves, the pounding of shore lines and the scouring of the sea bed.

A Practical Communication System

The system to be described also uses a frequency-modulated carrier signal to take advantage of the signal-to-noise superiority of f.m. It is also used to avoid the necessity of providing an a.g.c. amplifier in the receiver having a dynamic range in excess of 100dB. Using a f.m. system the receiving amplifier need only limit the incoming signal, a requirement which is readily accomplished using a fixed, high gain amplifier.

It is possible that pulse code modulation (p.c.m.) techniques may be of considerable use in underwater communications but so far they have not been investigated by the authors.

The operating frequency of the system must be chosen so that it is high enough to enable a transducer, which inevitably has a high Q factor and therefore a narrow relative bandwidth, to pass the frequency-modulation spectrum of intelligible speech, which in the present case is of the order of 5kc/s when using a modulation index of 1 per cent, and yet low enough to avoid signal attenuation due to absorption losses within the sea. The compromise between the bandwidth requirement, and the avoidance of the attenuation loss places the signal frequency somewhere in the range 80kc/s to 150kc/s and 120kc/s was chosen as the carrier frequency of the prototype system. For most applications the diver would be never more than 200 yards from the parent vessel, so only low powers of less than one watt of acoustic power would be needed during transmission which means that the underwater unit could be made in a very compact form.

The usefulness of the principle of the underwater acoustic link has been demonstrated experimentally using the fully-transistorized portable equipment described below. A block schematic of the underwater units is shown in Fig. 1.

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Description of Prototype System

The Transmitter (Fig. 2)

The basic modulating element consists of an astable multivibrator, the base resistors of which are returned to a different voltage from that of the collector resistors. The modulating signal is amplified and fed via an emitter-follower and decoupling capacitor C_1 to the junction of the base resistors. By this means the modulating signal can any change in the oscillating frequency of the multivibrator resulting from a change in its loading when the power amplifier is switched on. A voltage stabilizer is used to prevent drift in the frequency of oscillation of the multivibrator.

The Receiver (Fig. 3)

This consists of a single transistor amplifier stage tuned to 120kc/s with a bandwidth of 10kc/s followed by a

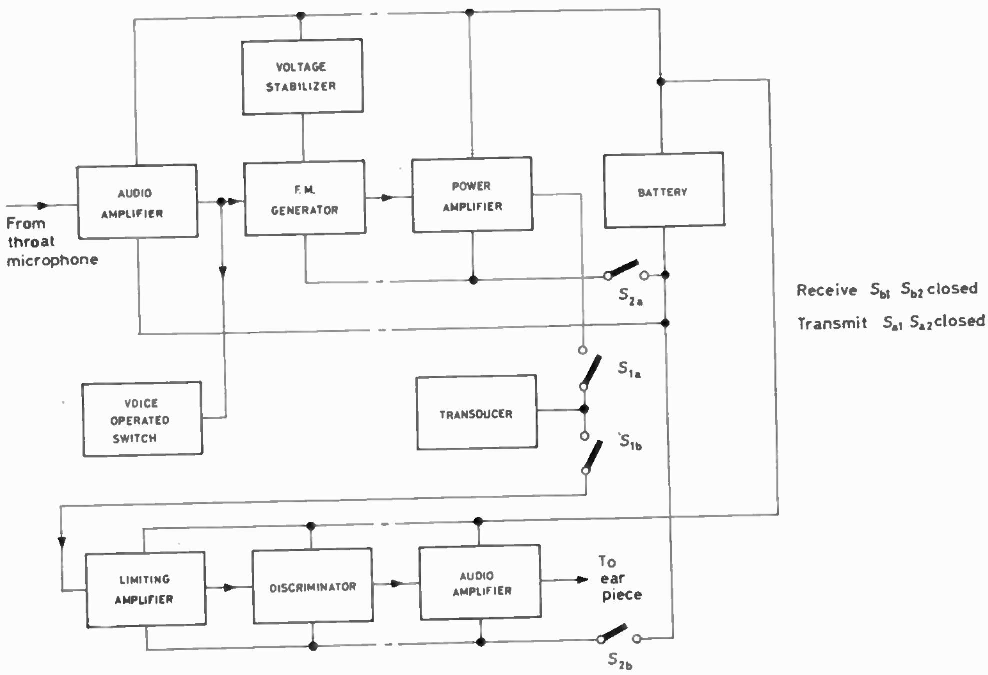


Fig. 1. The prototype system

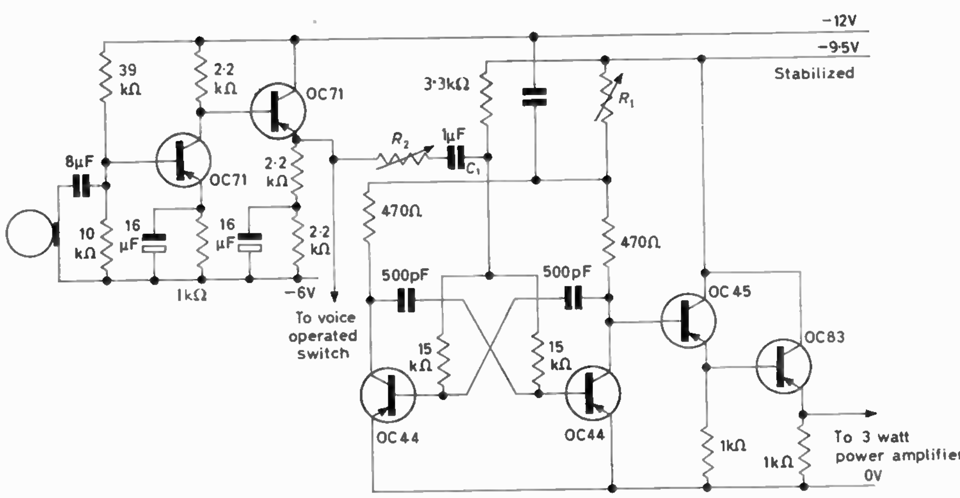


Fig. 2. Frequency modulation unit of transmitter

be made to alter the 'aiming' voltage of the bases of the multivibrator transistors, consequently changing the frequency of oscillation of the multivibrator. The carrier frequency and the modulation index can be adjusted by means of resistors, R_1 and R_2 respectively.

The frequency-modulated carrier output of the multivibrator is fed via a 'super alpha' pair circuit to a class-B push-pull power amplifier giving an output power of 3W. The power transistors used were OC24's mounted directly on the outside casing of the telephone, thereby providing a heat sink. The super alpha pair is required to obviate

three transistor directly-coupled amplifier. The overall receiving amplifier gain is 130dB. This amplifier ensures that the received signal is completely limited and suitable for passing into the simple discriminator which is of the pulse counting type. The audio output of the discriminator is subsequently amplified and fed to the bone-conduction ear pieces via a complementary pair push-pull amplifier giving an audio power of 200mW.

The Voice Operated Switch (Fig. 4)

To relieve the diver of the task of manually switching

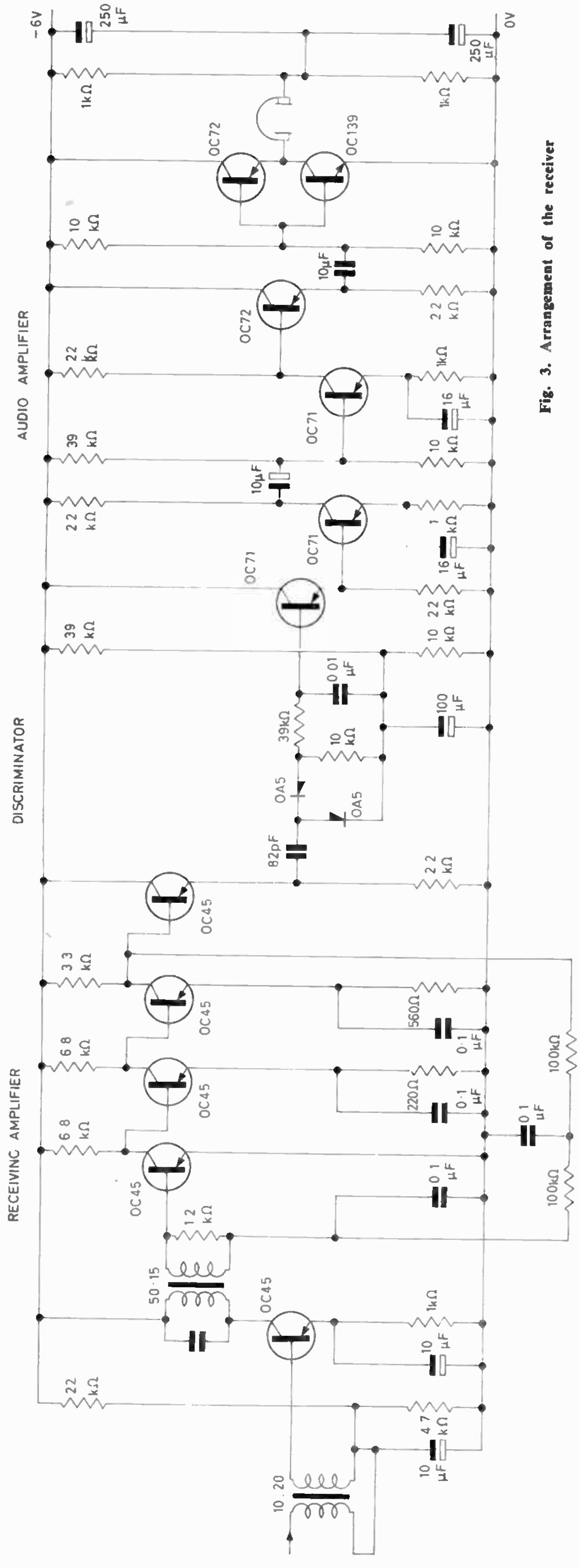
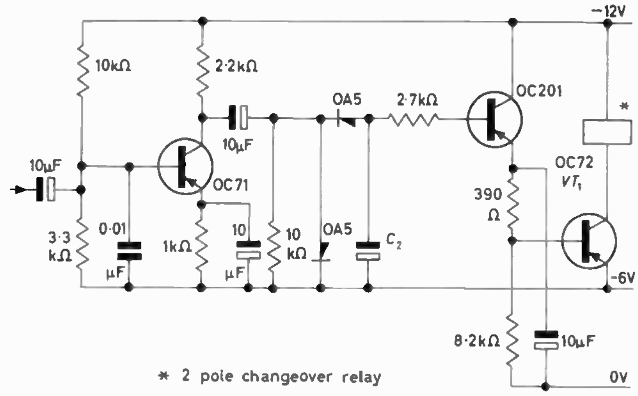


Fig. 3. Arrangement of the receiver



* 2 pole changeover relay

Fig. 4. The voice operated switch

the telephone from receive to transmit, a voice operated switch is provided. The speech signal fed to the multivibrator is also fed to a circuit which produces a d.c. level shift as long as the speech signal is present; this is used to turn on transistor VT_1 of Fig. 4 thereby operating the two-pole changeover relay. Chattering of this relay between the speech impulses of normal conversation is prevented by careful choice of the value of the capacitor C_2; it must not be too large otherwise the beginning of each transmission will be lost. The changeover relay transfers the battery from the receiver to the transmitter and at the same time changes the transducer from the receiver input to the power amplifier.

The arrangement of the electronic circuit is shown in Fig. 5.

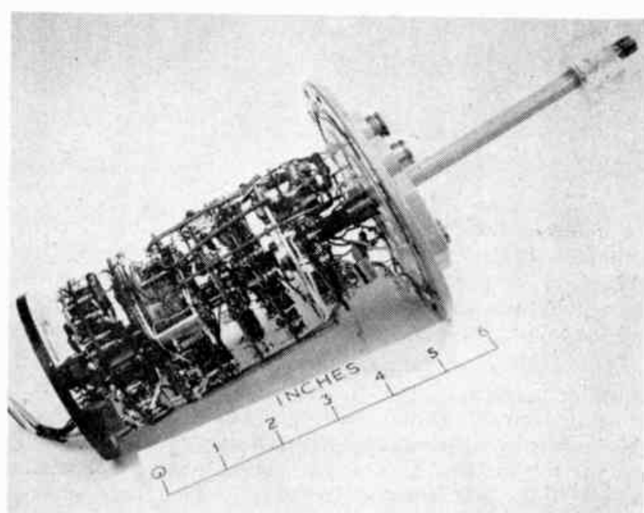
The Power Supplies

The battery pack consists of two 6V handlamp batteries connected in series, the speech signal amplifier and voice-operated switch being permanently connected to one of these. The receiver is operated by the other. During transmission the full 12V is used to operate the power amplifier. During reception the current drain is approximately 100mA and rises to 500mA during transmission. The telephone will, however, be used for transmission for only about 10 per cent of the operational time; consequently a battery life in excess of 25 hours can be expected.

The Transducers

The acoustic carrier-signal transducer consists of a lead-

Fig. 5. Arrangement of electronic circuit



zirconate PZT-5A electrostrictive ceramic tube with a total length of 25mm and a diameter of 12·5mm. It is operated in its circumferential mode, fundamental resonance being at 120kc/s with a bandwidth of 10kc/s. If operated with its axis maintained vertical it is omnidirectional in the horizontal plane and possesses a vertical beamwidth between the half-power directions of 15°. The overall efficiency of the transducer approaches 30 per cent, and consequently an effective acoustic power of approximately 1W is radiated.

Since the divers will in general be situated in mid water an isctropic radiator is not necessary. The small degree of directionality afforded by a cylindrically propagating transducer then helps to increase the maximum range of the system and reduces interfering reflections from the surface and the bottom of the sea.

The transducer element is protected by encapsulation in a silicone rubber having approximately the same acoustic impedance as seawater itself. The transducer is shown in Fig. 6.

The speech signal is obtained using a throat microphone which has been waterproofed and modified to withstand pressures in excess of 75 lb/in^2. The actual problems of speaking under water will be discussed later.

Modified throat microphones were also used as bone conduction earpieces. Underwater their acoustic output couples into the ear far more efficiently than when they are operated in air. The microphone and bone conduction earpiece are shown in Fig. 7.

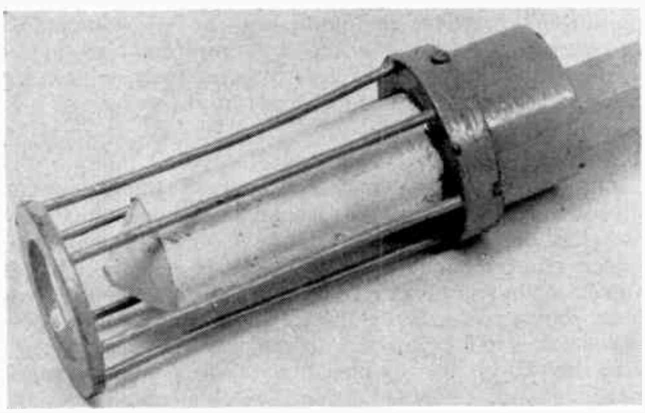
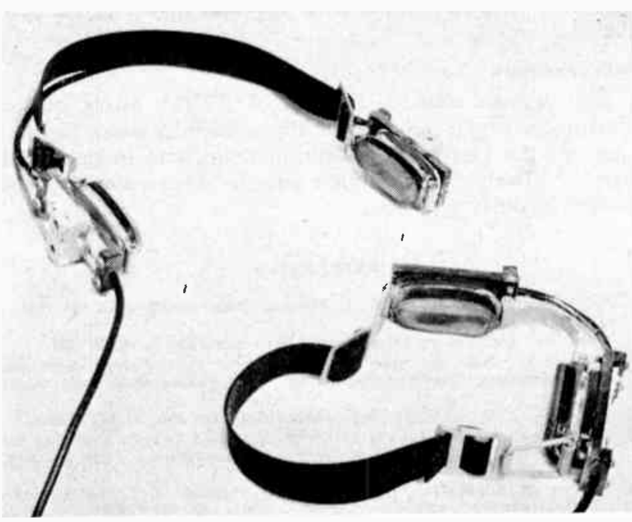


Fig. 6 (above). Acoustic carrier-signal transducer

Fig. 7 (below). Throat microphone and bone-conduction head-set



The Pressure Housing

This consists of a 3½in outside diameter flanged brass tube sealed by two end-plates bolted to the flanges. Matching grooves carrying 'O' rings are provided in the end-plates and flanges to provide water-tight seals. One end-plate carries the on-off switch, the other, the two power transistors and the coaxial sockets connecting the microphone, earpiece and transducer to the main unit. The total length of the telephone is 20in and its weight, complete with batteries and transducer, is 19 lb. The complete unit is shown in Fig. 8.

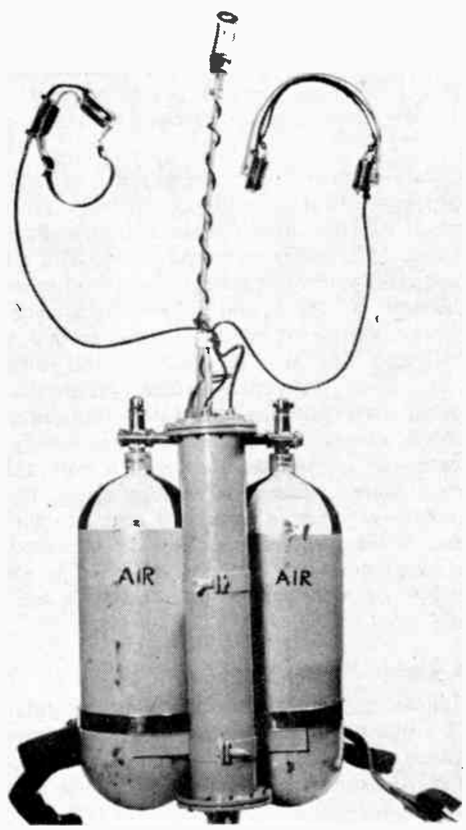
The underwater units and a third surface unit embodying manual transmit/receive switching and a loudspeaker output for the receiver have been constructed and tested. The transducer of the surface unit which is positioned at a depth of 4ft 6in below the surface by means of a float, incorporates a reflector plate to prevent acoustic signals reaching the sea-surface which might otherwise, after reflection, interfere with the direct signals to the diver.

Trials

The acoustic communication system has so far undergone two sets of trials, the first set being conducted under very unfavourable conditions in a reservoir, the other set in the open sea. The propagation conditions pertaining at each of these trials and the results obtained will now be discussed.

Initial tests were performed in a reservoir having a maximum depth of about 25ft. As no SCUBA diver was available, midwater tests were impossible and surface to surface communication with the underwater unit suspended from a boat was investigated. The depth of the transducer of the underwater unit was only 9in, consequently the

Fig. 8. Prototype underwater acoustic telephone mounted upon a set of SCUBA air-bottles



communication path was one of the most difficult possible and the one most likely to produce multiple-path propagation interference. This interference is illustrated by Fig. 9 which shows that waves on the surface of the reservoir produce a large number of surfaces each disposed in such a way as to reflect acoustic energy originating at the sending transducer so that it arrives at the receiving transducer. The length of each of these different signal paths will be different, however, and the signals arriving at the receiver will possess a multitude of phases. The vectorial summation of these individual signals performed by the receiving transducer will therefore produce extra frequency components in the frequency-modulation spectrum of the transmission and so cause interference distortion of the speech signal.

This effect will be most pronounced at short ranges but as the range is increased the phase discrepancies will be reduced and speech intelligibility can be expected to improve. This was found to be true on the initial trials; at ranges of less than 100 yards speech was practically unintelligible but at a range of 500 yards, the maximum

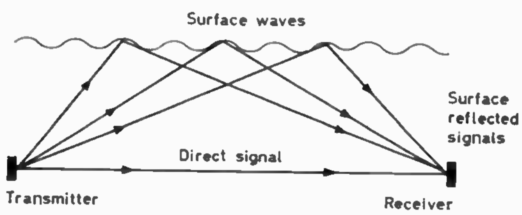


Fig. 9. **Illustrating multiple path propagation of acoustic energy**

attained, it was possible to hold a perfectly intelligible two-way conversation. It must be pointed out that the range limit of 500 yards was imposed by lack of a large enough expanse of water and not by lack of received signal.

The main series of trials was performed at sea off the island of Ibiza in the Mediterranean Sea during the month of August 1963 using the facilities provided by an Underwater Diving Expedition from the University of Birmingham.

Surface-to-surface communication was once again shown to be subject to multiple-path interference. When, however, a SCUBA diver operated the telephone at depths greater than 15ft, two-way conversation, with a high degree of speech intelligibility, between diver and surface became possible both at short and long ranges. The maximum depth and range achieved during this second set of trials were 50ft and 300 yards respectively, and during one test three-way diver-to-diver-to-surface communication was established. One notable and interesting effect occurred when both divers transmitted simultaneously. The two underwater carrier signals both with a nominal frequency of 120kc/s were in fact separated by approximately 1kc/s and these gave rise to a beat note equal to this frequency difference at the receiver. This is to be expected but future systems must be more carefully matched in frequency to prevent loss of intelligence in the event of multiple transmission.

Speech Under Water

The most common and the most popular form of SCUBA equipment employs a separate face-mask and mouthpiece, the latter being clamped firmly between the teeth for the duration of the dive. This clamping precludes any form of articulation underwater.

It has been observed, however, that certain divers are able to utter recognizable sounds underwater if they remove their mouthpiece to do so, the use of a throat microphone would enable these divers to communicate via the acoustic telephone.

For the majority of divers this removal of the mouthpiece would be both unpleasant and ever dangerous, and in any event it would be very time-consuming, so some form of face mask providing speech conditions approaching those experienced normally is required. This requirement is fulfilled by the 'full-face' mask developed by Normalair Ltd, and certain of the helmets associated with constant-volume diving suits. For all the tests carried out with the acoustic telephone a Normalair full-face mask was used which incorporated a secondary mask to prevent carbon dioxide 'build-up'.

At one stage of the development of the system it was thought that the noise generated by the process of breathing and more particularly by the release of air from the air demand-valve of the SCUBA equipment would give rise to signals in the microphone greater in amplitude than the speech signals.

Tests carried out in a swimming bath, however, showed that breathing noise was negligible and that demand-valve and bubble-stream noise produced a signal in the throat microphones of less than 15 per cent of that produced by speech underwater. No premature closing of the voice powered switch by demand-valve noise was therefore experienced.

It was also thought that the demand- and bubble-stream noise would mask the audio output of the bone-conduction earpieces, but in practice this was not found to be so owing to the very good acoustic coupling between the earpiece and the mastoid bone afforded by the water.

Conclusions

Long-distance communication between free-swimming divers is possible using an acoustic telephone link. This fact has been proved conclusively by trials carried out under realistic conditions using a frequency-modulated carrier communicator. The degree of intelligibility has been shown to be acceptable provided the diver is at a reasonable depth below the surface; and provided favourable thermal gradients within the sea are available, ranges of the order of a mile or so should be obtainable with quite a small-sized equipment.

The practical trials also stressed the need for improvement in face mask and associated microphone design to enable a telephone acceptable to most divers to be produced.

Acknowledgments

The authors wish to thank the SCUBA divers of the expedition organized by the Physical Education Department of the University of Birmingham, and in particular Mr. W. Tuxworth, the leader of the expedition, for the diving facilities provided.

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An Electronic Method of Ignition Advance for Automobiles

By A. R. Hayes*

The full load ignition requirements of a particular engine are described by an algebraic equation which, when applied to a proposed basic scheme, indicates the type of circuit needed to control ignition timing electronically. As an illustration a possible circuit is given whose performance compares favourably with the present mechanical system.

(Voir page 428 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 437)

WITH the advent of semiconductors, electronic equipment is being used on an increasing scale in automobiles[1], largely on account of the special properties of semiconductors and their suitability for working directly from low voltages. In some instances the electronic parts form new accessories, for example, ice detectors, automatic parking light controllers, and rectifier circuits; while in others the semiconductor circuits replace the older established techniques, for example, voltage regulators[2], radios, spark generation[3,4] and tachometers[5]. In these latter respects the new parts employing semiconductors have advantages regarding size, accuracy, and no mechanical moving parts, but tend to be more expensive at the moment than the parts they replace.

The part to be described is designed specifically to replace the centrifugal automatic spark advance mechanism of a certain six cylinder engine, although the basic scheme used should be applicable to any engine. Used with an already existing system of induction pick-up and transistor spark generator, the ignition system of an automobile may be made almost entirely electronic, only the spark distribution remaining mechanical.

Automatic Advance

For efficient power generation the spark in the cylinder of an i.c.e. must occur at a particular point in the engine cycle. The exact instant is a function of engine speed and load. The present method of automatically adjusting the spark timing for speed variations is by a system of rotating masses driven mechanically from the crankshaft. For load variations, the load is monitored indirectly by the pressure in the inlet manifold which mechanically adjusts the spark timing via an aneroid capsule. This system has been in use many years and undergone much development, but being mechanical tends to wear and lose accuracy.

The range over which the timing is varied is always in the latter part of the compression stroke just before top dead centre (b.t.d.c.). Usually the timing is measured as an angle of the crank taking top dead centre as 0°, and thus all timing become degrees b.t.d.c. Fig. 1 shows the timing requirements of a certain engine as a function of speed under full load conditions, together with curves giving a 2 per cent power loss. Superimposed are the curves for the centrifugal advance mechanism normally used with this engine.

Curve Equation

The empirical characteristic shown in Fig. 1 may be represented approximately by an equation of the form:

$$\theta = \alpha - \frac{N - b}{aN} \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

where

θ is the advance angle in crank degrees b.t.d.c.,

N is the engine speed in revolutions per minute

and

α, a, b are constants.

Of the three constants one may be arbitrarily chosen, the other two then being obtained by substituting two sets of

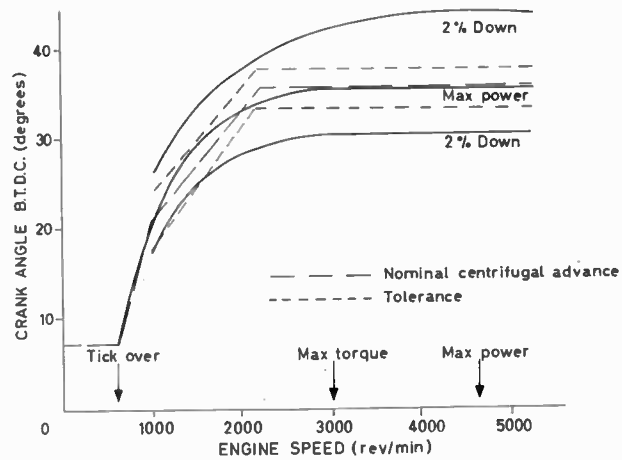

Fig. 1. Optimum ignition characteristic and that given by the mechanical centrifugal system

empirical values into equation (1). Since 1 000 rev/min is near the lowest speed for even torque and 4 000 rev/min is between maximum power and maximum torque, these values of N are suitable for calculating the constants.

Taking values for α of 55°, 70° and 90° yields three sets of values for a and b. Fig. 2 shows the plot of calculated points using equation (1) for these three conditions. It is clear that all fit the empirical curve with about the same degree of accuracy, from which it can be concluded that the value of α is not critical over the range considered.

Basic Circuit

A basic scheme is shown in Fig. 3(a). A pulse is obtained, a fixed number of degrees b.t.d.c. and then retarded to give the required timing. This necessitates a pick-up device to give the pulse, a signal containing speed information, a functional circuit to operate on the speed signal, and a delay circuit triggered by the picked up pulse and controlled by the output from the functional circuit.

Since each cylinder fires once every two crank revolutions, the repetition rate of the picked up pulses is directly proportional to engine speed. A speed signal may be derived by smoothing the pulse train, so removing the

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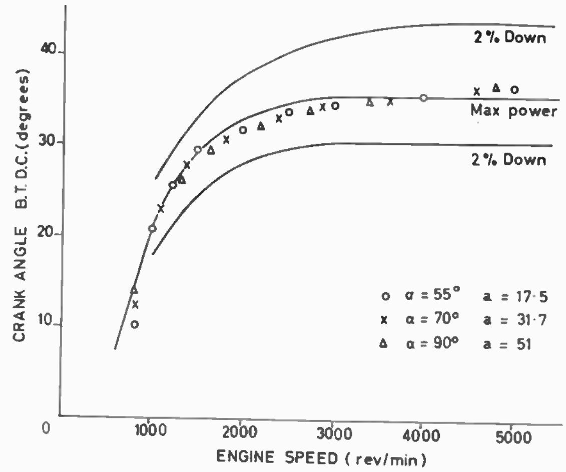


Fig. 2. Comparison between the optimum curve and points calculated from $\theta = \alpha - (aN/(N-b))$ for three arbitrary values of α

need for a separate speed monitor. For long term accuracy it is preferable to shape the pulses before smoothing. This modified scheme is shown in Fig. 3(b) with the trigger for the delay circuit also obtained from the shaper circuit, using it as a pulse amplifier.

Block Characteristics

The necessary transfer characteristics of the separate blocks can be most easily obtained by studying equation (1) rather than the empirical curve. For this purpose equation (1) is transformed from an angle equation to a time equation.

If β° is the pick-up angle b.t.d.c. then the delay circuit must have time delay (t_d) equivalent to $(\beta - \theta)^\circ$. Since 1° of crank angle $\equiv 60/N \,.\, 1/360$ sec, then:

$$t_d = \frac{\beta - \theta}{6N}$$

Substituting for θ and putting $\beta = \alpha$, gives:

$$t_d = \frac{a}{6(N-b)} \quad \dots\dots\dots\dots\dots\dots (2)$$

Equation (2) represents a rectangular hyperbola with asymptotes at $t_d = 0$ and $N = b$ and can be obtained by the following set of simple transfer characteristics.

(a) Smoothing circuit, output proportion to speed

(b) Delay circuit, delay time proportional to reciprocal of control input

(c) Functional circuit, output proportional to input minus a constant

Equations (1) and (2) only apply over a speed range producing useful torque. At tickover and starting speeds the conventional mechanical system produces an advance of 7° b.t.d.c. (Fig. 1) and this was used as a design figure for the electronic circuit. With a constant pick-up angle the circuit delay must be equivalent to $(\beta - 7)^\circ$, a constant, i.e. the delay time—speed curve will again be a rectangular hyperbola but of different product and now having the time delay and speed axes as asymptotes. Such a requirement would increase the complexity of the functional circuit, and on this count a second pick-up unit receiving its pulses 7° b.t.d.c. is felt to be a simpler solution. This second input is fed to the delay circuit in such a way as to terminate the delay only if the timing period attempts to last longer than the equivalent of $(\beta - 7)^\circ$ crank angle. This addition to the basic scheme is included in Fig. 3(b).

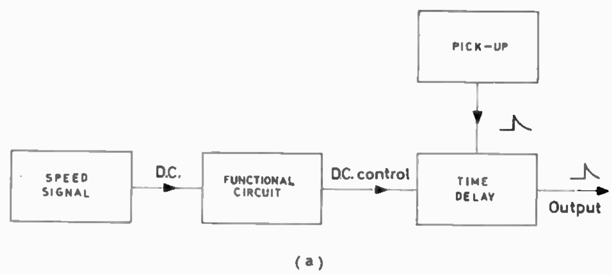
Circuit Description

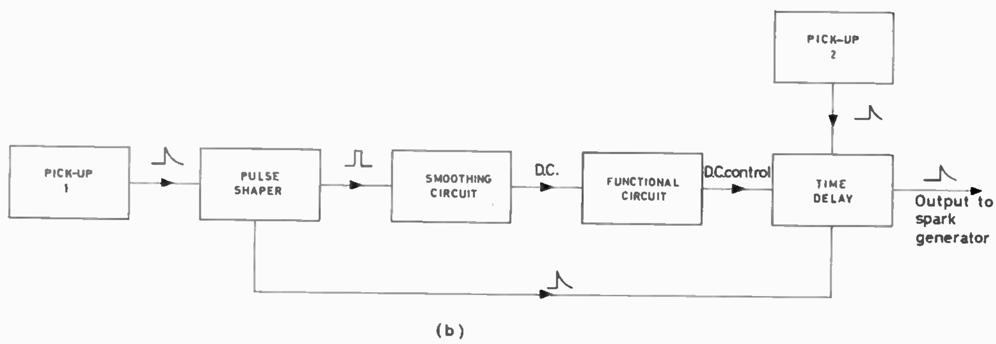
Using the general principles discussed in the preceding section a circuit (Fig. 4) was designed and constructed. The values of components are for a pick-up angle of 55°. R_7 and R_8 are adjusted alternately for correct delay at 1 000 and 4 000 rev/min respectively. The characteristic is shown in Fig. 5.

An induction type pick-up was used as illustrated in Fig. 6(a). A magnetic shunt on the trailing side of each pick-up produced a larger negative impulse. Fig. 6(b) shows the bench top device. It has two pick-up heads to cover the total requirements of the ignition characteristic. For correct simulation of the engine the laboratory pick-up revolved three times faster than the engine to give the same pulse rate, and was one-third the radius to give the same sensitivity. Fig. 6(c) shows the waveform from the pick-up at a crank speed of 1 000 rev/min. The transition about zero occupies 0·1msec of the period equivalent to 2° of crank angle, thus 1° is the upper limit to variation in pick-up angle if only the latter half of the transient is used. In the circuit (Fig. 4) self bias of the transistors VT_3 and VT_6 occurs so that triggering is near the negative peaks and so variation is less than this 1°. With a gap of 1mm each pick-up produced a waveform of 18V peak-to-peak at 1 000 rev/min crank speed on open-circuit.

Since the main concern is with the advance circuit, little effort has been made to design an efficient or practical pick-up system. The sole object of this part was to provide a trigger source to demonstrate the automatic circuit.

Fig. 3. Electronic advance schemes
(a) basic (b) modified for speed monitoring and slow running





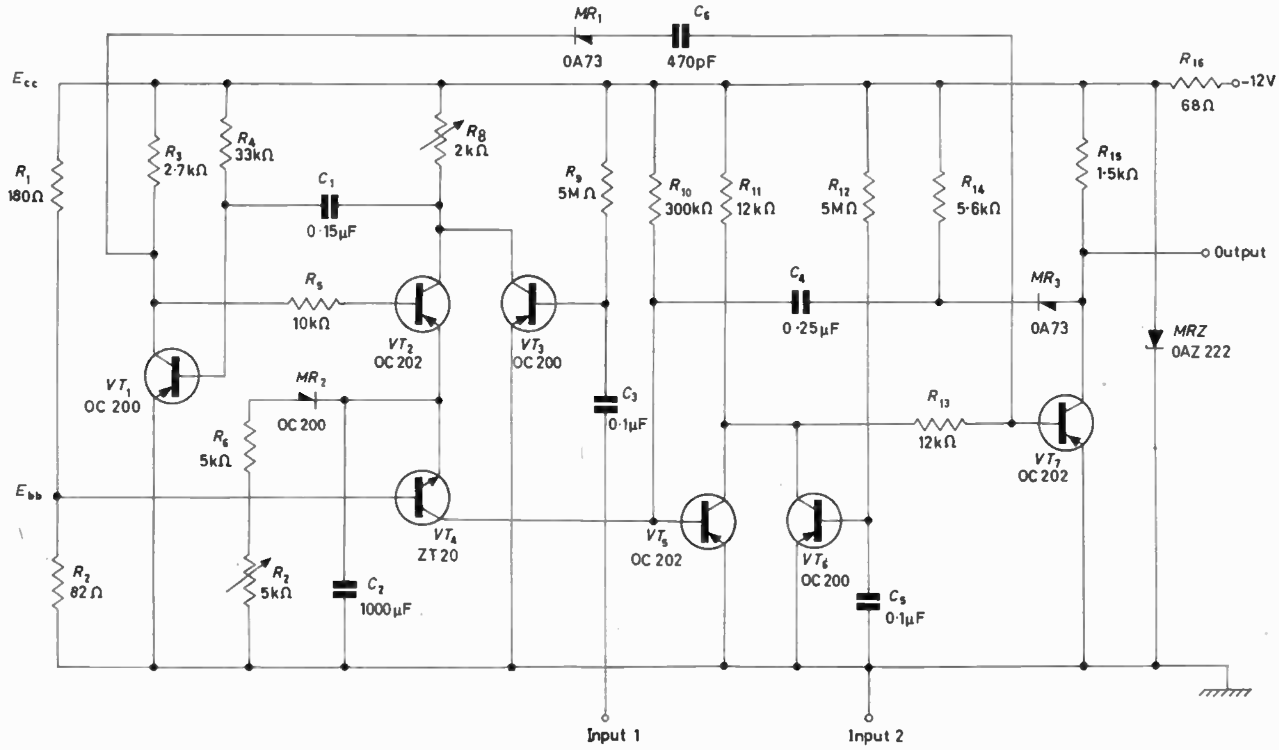


Fig. 4. Practical ignition advance circuit

The pulse shaper is a conventional monostable multivibrator and consists of the transistors VT_1 and VT_2 (Fig. 4) with associated circuits. The output is taken from the emitter of VT_2, the transistor which conducts for a fixed time after each trigger pulse, and smoothed by C_2. The value 1 000μF is a compromise between efficient smoothing and response to speed change. Both VT_1 and VT_2 operate between saturation and cut-off for accuracy and simplicity of circuits. The appendix shows the average emitter current to be:

$$I_{e2(av)} = 0{\cdot}018\ k_2\ NE_{cc}\ (C_1R_4/R_8) \quad \ldots\ldots\ldots\ (3)$$

showing that it is approximately proportional to speed. k_2 is a factor close to unity, dependent on the ratio of base emitter voltages to supply voltage. The average collector current of VT_2,

$$I_{c2(av)} = 0{\cdot}018\ k_1\ NE_{cc}\ (C_1R_4/R_8)$$

is proportional to speed and a meter included as part of R_8, may be used as a tachometer (Fig. 7).

The functional circuit consists of the npn transistor VT_4 and the branch containing R_6, R_7 and MR_2. The base of this transistor is held at a constant potential so that the impedance seen by the emitter of VT_2 is low and has little effect on the operation of the shaping circuit. Making the base negative ensures a reverse biased collector junction. The relationship between $I_{e2(av)}$ and the average collector current of VT_4, $I_{c4(av)}$ is clearly given by:

$$I_{c4(av)} = \alpha_4 \left(I_{e2(av)} - \frac{0{\cdot}313\ .\ E_{cc} + V_{eb4}}{R_{MR2} + R_6 + R_7} \right) \quad \ldots\ldots\ (4)$$

which approximates to the required characteristic, slight error occurring since V_{eb4} is a function of I_{c4}. The addition of MR_2 to the constant current chain gives some temperature compensation for V_{eb4} drift with temperature.

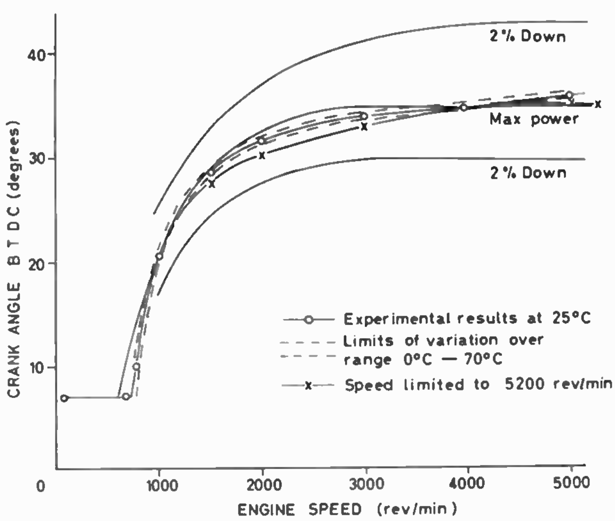
The delay circuit is a modified monostable multivibrator (VT_5, VT_7) in which the recovery of the base of VT_5 after switching is controlled by a current source rather than by the more usual resistor, the source being the collector of VT_4. The circuit is triggered into its quasi-stable state by the negative going edge of the waveform at the collector of VT_1, and switches back after an interval of time dependent upon the current source.

The relationship between $I_{c4(av)}$ and delay time (t_d) is shown in the appendix to be:

$$t_d = \frac{k_3\ .\ C_4\ .\ E_{cc}}{I_{c4(av)}} \quad \ldots\ldots\ldots\ldots\ (5)$$

Combining equations (3), (4) and (5) gives the overall

Fig. 5. Circuit characteristic with temperature drift boundaries



characteristic:

$$t_d = \frac{55{\cdot}6\, k_3 C_4 R_8}{\alpha_4 k_2 C_1 R_4} \cdot \frac{1}{N - (55{\cdot}6\, k_4 R_8 / k_2 E_{cc} C_1 R_4)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

where

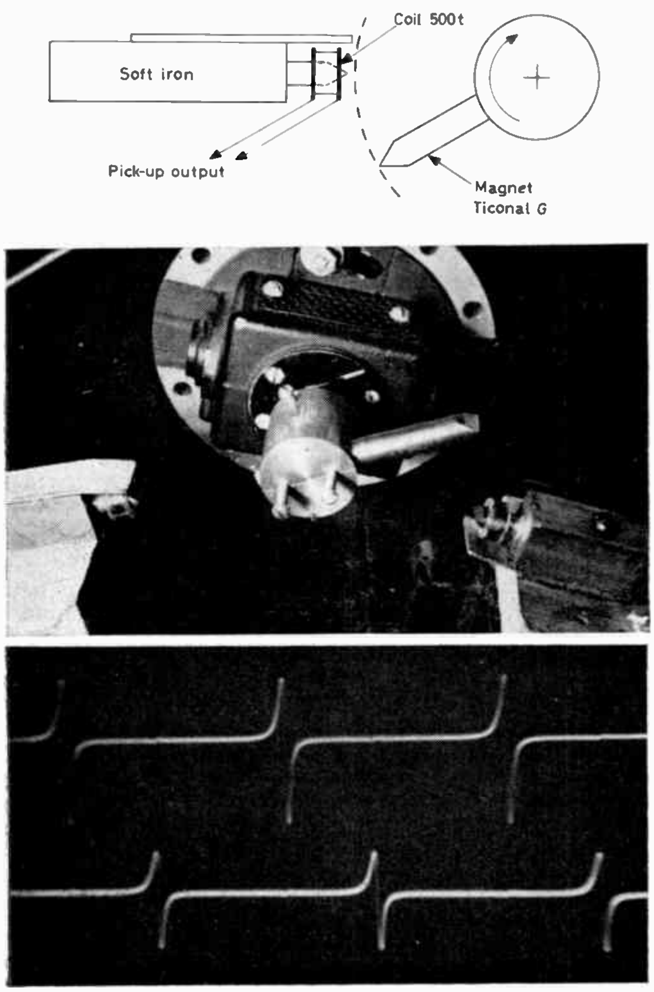
$$k_4 = \frac{0{\cdot}313\, E_{cc} + V_{eb4}}{R_{MR2} + R_6 + R_7}$$

which has the desired hyperbolic characteristic. Output is taken from the collector of VT_7 as a negative edge.

Slow Running

As long as the delay time is equivalent to less than 48° crank angle the second input is inoperative. At lower speeds, below 750 rev/min. with the components shown, the current from VT_4 is insufficient to fulfil this condition and the delay period is now terminated by the input from the second pick-up via VT_6. The second input has a further advantage, namely the removal of delay response time when the speed changes. Without the second input but with a more complex functional circuit, a large time-constant would be necessary for the smoothing circuit which would slow down the transient speed response. The second input by-passes the shaper and smoothing and at low speeds the operation is essentially the switching over of the delay circuit by input one and the switching back by input two. The delay circuit is then operating in a bi-

Fig. 6. Induction pick-up details
(a) principle (b) model (c) waveform



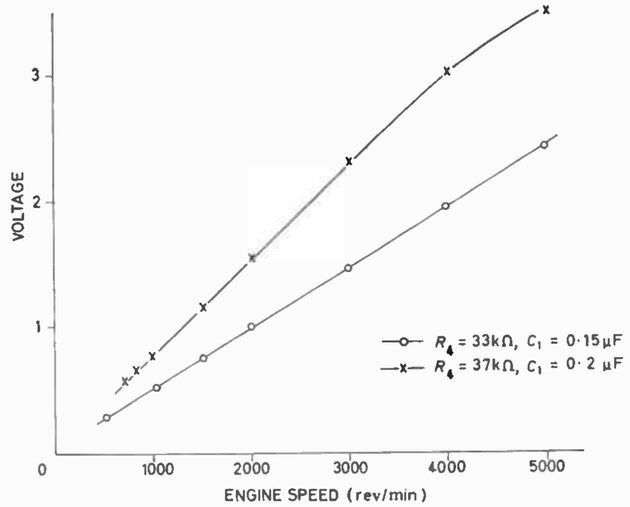


Fig. 7. Voltmeter calibrataion for use as tachometer

stable mode. This involves zero response time for speed changes, so is ideal for starting from rest.

At speeds above 750 rev/min where input 2 is inoperative, response time is finite as speed changes must alter the smoothed output. However, now that the use of input two has removed the need for smoothing at low speeds, the capacitor C_2 may be smaller. With the values shown, the largest time-constant of C_2 is approximately 7·5sec at 650 rev/min and a transient response time of less than 1sec occurs when the speed is changed from 1 000 rev/min to 2 000 rev/min stepwise. In practice such a speed change will occupy a finite time of a few seconds indicating that the response time is negligible. Even with larger C_2 the effect is to give retardation of ignition on acceleration and advance on deceleration, both acceptable to an engine.

The resistor R_{11} is to provide base current at all times to transistor VT_5 to allow it to saturate when conducting. It becomes the sole source of base current at low speeds. Its upper value is limited by the minimum base current required for saturation, while a low value will restrict the lowest speed at which input 2 is effective. In this case $R_{11} = 300\text{k}\Omega$ and the circuit should operate down to 50 rev/min in the bistable mode. However, the pick-up sensitivity limits this to 70 rev/min, quite low enough for starting purposes.

Pick-up Angle Selection

To accommodate all required delays the pick-up angle must be greater than 35°. Fig. 2 shows that the angle is relatively unimportant in approximating to the desired delay-speed characteristic. However, the smaller the angle of pick-up then the larger may be the permitted percentage drift in delay for a given power loss, on account of the band formed by the −2 per cent power curves being of the same width at any one speed irrespective of the pick-up angle. On the other hand a small pick-up angle necessitates large currents to control the delay circuit at high speeds, or the alternative of reducing C_4. This latter course will raise the lower speed at which input two becomes inoperative so making for more difficult starting. Also a small pick-up angle gives poorer correlation at speeds in the region of 600 rev/min. The choice of 55° for pick-up is a compromise of these factors.

Engine Speed Limiting

The circuit inherently possesses a speed limiting property since the circuit will cease to function abruptly as the width of shaped pulses approaches the period between adjacent triggers. With the circuit of Fig. 4 this limit occurs at 7 800rev/min. Alteration of R_4 to 37kΩ and C_1 to 0·2μF produced a reduction in this figure to 5 200 rev/min, the maximum sustained speed quoted for this engine, but decreased the accuracy of the characteristic.

Circuit Stability

Factors liable to introduce drift are voltage and temperature variations.

Inspection of the overall transfer characteristic (equation (6)) indicates dependence on E_{cc} directly and indirectly by way of the factors k_2 and k_3 whose exact values depend on the ratios between various base emitter voltages and E_{cc}. The Zener diode stabilizes this supply in the region of 7V where the temperature coefficient is low.

Measurement of drift in timing with variation in supply voltage at 20°C shows a deviation of less than 0·2° crank angle over the range from 16V down to 10·5V in the speed range 1 000 to 5 000 rev/min, a possible range of voltage from a 6 cell lead-acid battery. At starting speeds there is no deviation, due to inputs one and two being a fixed angular distance apart, and at these speeds the circuit triggers reliably with a supply as low as 3V, enough to accommodate the drop in battery terminal voltage when supplying starter current.

Major causes of drift due to temperature are V_{be} variations in the transistors and values of the resistors and capacitors. All resistors based on equation (6) are high stability types. No special capacitors have been used. Temperature compensation has only been applied to cancel drift of V_{be} in the npn transistor. The boundaries of drift in the overall characteristic due to temperature variations from 0°C to 70°C are shown on Fig. 5. Although engine compartment temperatures may exceed this range, the circuit does not rely on mechanical drive and may be located anywhere in the vehicle.

Conclusions

The empirical ignition advance requirements of a certain internal combustion engine at full load were analysed. It was shown that the ignition advance measured as crank angle is a simple algebraic function of speed over a speed range from fast tickover to full speed. Using this result a possible scheme for performing the requirement electronically was discussed which should be applicable to any engine using spark ignition. As a practical illustration a circuit was constructed for the engine initially considered. Its characteristic compared favourably with the empirical curve, and proved to have low, and acceptable, drift with regard to voltage and temperature variations normally encountered in an automobile.

This type of advance unit, used in conjunction with already available pick-ups and spark generators, will make the ignition system entirely electronic with the exception of the spark distribution. In comparison with the conventional mechanical unit, the electronic circuit is as accurate and is free from oscillation, backlash and variation of timing between cylinders. The initial cost of the unit described may not be competitive, although circuit simplification by the use of unijunction transistors or other switching devices could make it so. From available information[6] on the degradation of transistor properties with time, equivalent to mechanical wear, a unit life of several thousand hours without maintenance can be expected. The electronic circuit has additional features. It governs the engine at a sharply defined speed; the addition of a meter creates a tachometer; and location can be considered separately from engine design.

Finally, the electronic unit allows the possibility of controlling ignition timing by engine parameters unsuited to mechanical control, and perhaps it will eventually form part of a closed control system for optimizing performance.

Appendix

Derivation of Circuit Characteristics

All component numbers refer to Fig. 4.

(a) *Emitter and collector currents of VT_2*

Assuming zero bottoming voltage for VT_2, complete recovery of its collector between pulses, and ignoring the effect of R_8 on time-constant, the conduction period of $VT_{2(cond)}$ is given by:

$$t_{cond} = C_1R_4 \ln\left[\frac{2E_{cc}-E_{bb}-(V_{eb4}+V_{be1(on)})}{E_{cc}-V_{be1(co)}}\right]$$

Putting

$$E_{bb} = \frac{82\,.\,E_{cc}}{82+180}$$

$$t_{cond} = k\,.\,0{\cdot}522\,.\,C_1R_4$$

where k is a factor near unity and dependent on the ratios of V_{eb4}, $V_{be1(on)}$, $V_{be1(co)}$ to E_{cc}.

When VT_2 conducts:

$$I_{c2} = \frac{E_{cc}-E_{bb}-V_{eb4}}{R_8}$$

$$I_{b2} = \frac{E_{cc}-E_{bb}-(V_{eb4}+V_{be2(on)})}{R_3+R_5}$$

and:

$$I_{e2} = I_{c2} + I_{b2}$$

The trigger period, $t_{trig} = (60/N)\,.\,(1/3)$

$$\therefore\ I_{c2(av)} = (t_{cond}/t_{trig})\,.\,I_{c2} = 0{\cdot}018\,k_1\,NE_{cc}\,(C_1R_4/R_8)$$

and:

$$I_{e2(av)} = 0{\cdot}018\,k_2\,NE_{cc}\,(C_1R_4/R_8)$$

where both k_1 and k_2 are near unity. and depend on k, $V_{be2(on)}$, R_3, R_5, R_8.

(b) *Time delay (t_d) control by I_{c4}*

Assume that I_{c4} is constant over one period.

After VT_5 is triggered off its base will recover through a voltage $E_{cc}+V_{be5(co)}-V_{be5(on)}$ in time t_d due to the discharge of C_4 by I_{c4}. VT_5 then switches back to its stable state.

$$\therefore\ t_d = (C_4/I_{c4})\,(E_{cc}+V_{be5(co)}-V_{be5(on)})$$

$$= \frac{k_3C_4\,E_{cc}}{I_{c4}}$$

where

$$k_3 = 1 - \frac{(V_{be5(on)}-V_{be5(co)})}{E_{cc}}$$

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A Differential Nuclear Magnetic Resonance Magnetometer

By D. E. P. Silver*, B.Sc., A.M.I.E.E., A.Inst.P.

An instrument has been designed which enables measurements of magnetic field distribution over large pole surface areas to be rapidly and accurately taken. Although nuclear magnetic resonance is used for the sensing element no frequency measurements are required. The apparatus can also be used with good results for an electromagnet supplied from an unstabilized power source. A differential principle is used in which the field intensities at various points in the pole gap are measured with respect to some arbitrarily fixed point in the gap.

(Voir page 428 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 437)

NUCLEAR magnetic resonance has been widely used for the measurement and control of magnetic fields since 1946 when the researches of two independent university groups in the U.S.A., one at Harvard[1] and the other at Stanford[2], were published.

The physical basis of the method is the absorption of radio frequency energy by nuclei precessing in an external magnetic field. Absorption occurs when the radio frequency is equal to the frequency of precession (v) and the latter is related to the intensity of the external magnetic field (B) by the equation

$$v = \gamma/2\pi \, B \quad \text{.......} \quad (1)$$

where γ is the gyromagnetic ratio for the nucleus.

The most convenient nucleus to use for field measurement is that of hydrogen, i.e. the proton for which $\gamma/2\pi$ has the value $4{\cdot}2578 \times 10^3$ c/oersted. The frequency at which absorption occurs can be detected by the reduction in voltage which results across a parallel-tuned circuit fed from a high impedance source when energy is taken from the circuit. The absorbing nuclei are closely coupled to the circuit by enclosing the sample, e.g. water, in the tuning inductance. A continuous indication of the absorption condition is achieved by superposing a small oscillatory field on the main field. Whenever the field-frequency relationship in equation (1) is satisfied an absorption of energy occurs.

The method is capable of high accuracy with quite simple apparatus in fields of strengths greater than 200 oersted and where the inhomogeneity over the detecting element does not exceed a few tenths of an oersted, but the principle has been extended, by a special technique[3], to the measurement of fields in the range 0·17 to 500 oersted with gradients as high as 200 oersted/cm.

In all instruments using magnetic resonance for field detection the quantity measured is the frequency of electromagnetic oscillations and to ensure accuracy direct measurement by a reliable wavemeter is essential. If the method is used to examine the field strength variations in the pole gap of a large electromagnet the procedure can become tedious as a separate frequency measurement is involved for each point measured. Furthermore, the power supply for the electromagnet must be current stabilized (or, preferably, field stabilized) to a high order if the full capabilities of the resonance method are to be realized. In such a case it is the field distribution which is of interest but the above method of measurement gives the absolute field strength at each point.

The instrument to be described was designed specifically to measure the field uniformity in the pole gap of a 90° sector electromagnet of 1 metre radius to be used for an isotope separator[4]. The initial measurements were to be made at the manufacturer's works where no stabilized current source was available; the field intensity would therefore be subject to variations of the same magnitude as the mains supply i.e. ~1 per cent whereas the measurements to be made were to check that the radial field variations did not exceed 0·1 per cent. A differential method was therefore used in which the field strengths at all points in the pole gap were measured relative to one arbitrarily chosen point in the gap.

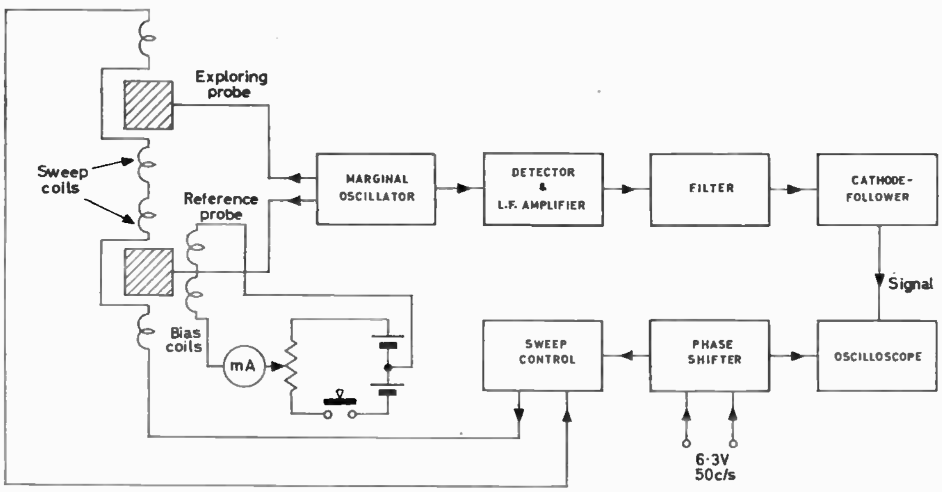

Fig. 1. Arrangement of magnetometer

General Description

A block diagram of the apparatus is shown in Fig. 1. The nuclear resonance detector is similar to the marginal oscillator described by Pound *et al*[5]. (Other circuits e.g. Hopkins' autodyne, are equally suitable. Fig. 2. shows a transistor circuit designed for n.m.r. detection[5].) In this

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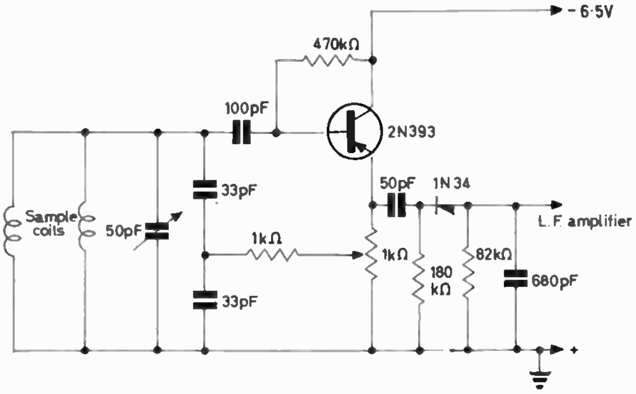


Fig. 2. Transistor n.m.r. detector

case, however, the oscillator feeds two probes whose inductances are in parallel with the single tuning capacitor (Fig. 3); thus the same frequency of oscillation exists at each probe and energy absorption will occur in both simultaneously only if they are in the same magnetic field strength. The material containing the absorbing nuclei most commonly used is water with the addition of paramagnetic ions to reduce the relaxation time. A 1 per cent solution of $MnCl_2$ or $Fe(NO_3)_3$ is suitable. Petroleum jelly (Vaseline) has also been successfully used and has the advantage that it is more easily contained than water.

The small modulating fields for each probe are provided by coils in the Helmholtz configuration enclosing the proton samples. The two identical pairs of coils are connected in series with a variable resistance and supplied from a 6·3V 50c/s source. The amplitudes and phases of the alternating fields at each probe should thus be identical.

In addition to the modulating coils the exploring probe is fitted with another pair of Helmholtz coils through which direct current can be passed in a direction either to augment or reduce the steady field in the vicinity of the sample. By this means the field strength experienced by each probe can be made identical even though the probes may be situated in regions of different external field strength; provided, of course, that the difference does not exceed the maximum which can be produced by the Helmholtz coils. The current producing the incremental field is derived from batteries via an ammeter and switch biased to 'off' to prevent unnecessary current drain. Once the Helmholtz coils are calibrated the meter reading can easily be converted into field strength difference between the probes.

The marginal oscillator is very susceptible to stray alternating magnetic fields which can be difficult to eliminate if an a.c. heater supply is used for the valves. A high-pass filter with cut-off at about 100c/s is therefore included in the low frequency amplifier circuit.

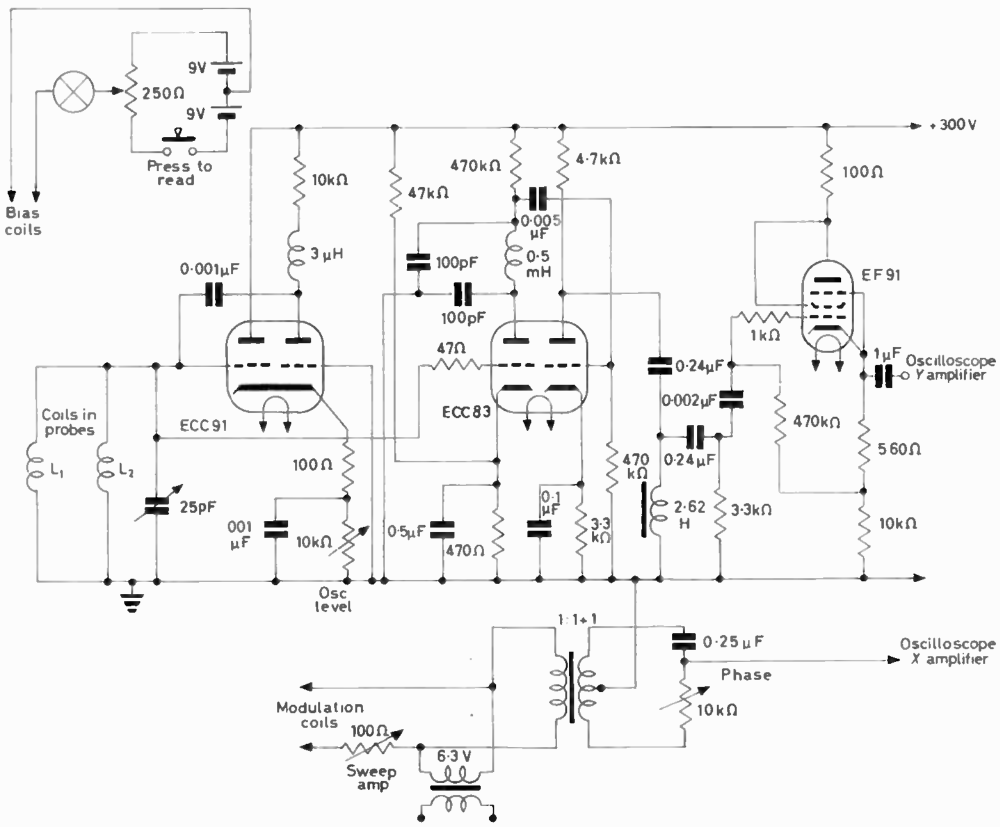
The absorption signals are displayed on an oscilloscope with a 50c/s sinusoidal time-base supplied through a phase shifting network. From Fig. 4 it will readily be appreciated that, unless the time-base is in phase with the modulating fields, each probe will produce two separate signals. Adjustment of the phase will superimpose the signals although perfect registration is usually not obtained owing to slight differences in the signal contours on the forward and return paths of the modulating field. The appearance of the trace for in-phase and out-of-phase conditions with different and identical fields at the probes are shown in Fig. 4.

Design of the Probes and Mounting

The electrical and mechanical design of the probes will depend to a large extent on the nature of the investigation to be made. A brief description of the arrangement used by the author to examine the field homogeneity of the 1 metre radius magnet previously mentioned is given below as a general guide only.

The nominal field strength of interest in this case was about 5 000 oersted which corresponds to a frequency of about 21Mc/s. The sample coils, in conjunction with the connecting cables and tuning capacitor, were designed to resonate at this frequency. To ensure freedom of movement the flexible cable from the oscillator to the reference probe was made about 4ft long and the exploring probe was connected by a 4ft long 1in diameter rigid brass tube to the oscillator unit which in turn was mounted on a

Fig. 3. Complete circuit



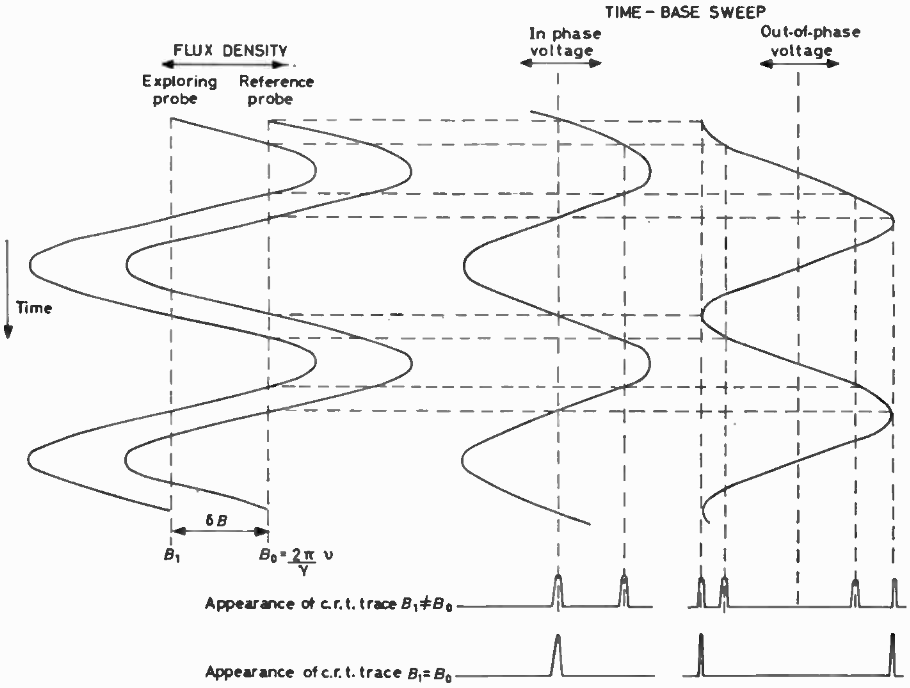


Fig. 4. Phase relationships

$$B = \frac{16\pi NI}{25\sqrt{5}\,a} \quad \ldots\ldots (2)$$

where N is the turns per coil

I „ „ current in amperes

a „ „ mean radius of coil in centimetres.

A current of 0·5A was allowed for a flux density of 15 oersted. The field strength per unit current was found experimentally by the following method.

The probe carrying the d.c. coils was inserted into a steady magnetic field and the oscillator tuned to obtain a resonance signal. With the signal aligned with a predetermined point on the oscilloscope graticule the frequency of the oscillator was measured by wavemeter. The oscillator frequency was then altered slightly, so offsetting the signal which in turn was restored to its original position by passing current through the Helmholtz coils. The magnitude of the current was noted and the new frequency of the oscillator measured. This procedure was repeated for several frequency increments above and below the centre frequency. The increments were expressed in terms of field strength and a graph of coil current against field strength was plotted (Fig. 6).

The modulation coils were wound with the same number of turns as the d.c. coils.

lathe tool slide bolted to a rotating table. Both slide and table were calibrated so that the azimuthal and radial positions of the probe could be accurately located. The centre of rotation of the table was made coincident with the centre of curvature of the magnet. A diagram of the probe head is shown in Fig. 5.

The tuning range of the oscillator was restricted by the capacitance of the cables but as measurements at one nominal field strength only were required this limitation was not troublesome. The probes were constructed so that other heads could be inserted if necessary.

The probes in this case could be made relatively large as the magnet gap was 6cm, but a similar arrangement has been used for checking a 15in radius magnet with a ¼in pole gap.

Calibration of the D.C. Helmholtz Coils

The number of turns on the coils was calculated using the expression

Performance

The half amplitude width of the resonance signal in this apparatus is approximately 0·4 oersted and the uncertainty in setting the signals for coincidence, as judged by obtaining maximum amplitude of the absorption signal, is about 0·1 oersted. At a nominal field strength of 5 000 oersted this represents a discrimination of 1 part in 50 000. The accuracy of a point measurement is less than this as the sensitive area of the sample was about 20mm².

When used with unstabilized current sources the accuracy of setting for coincidence is reduced owing to

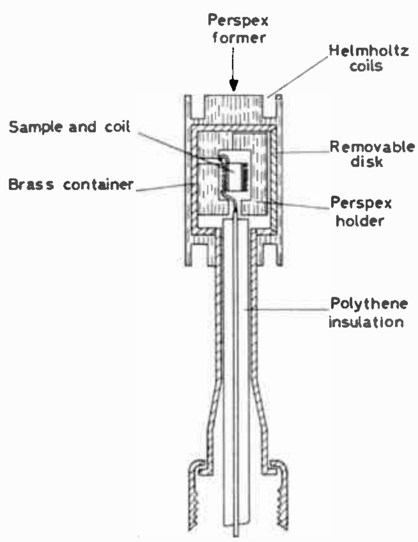
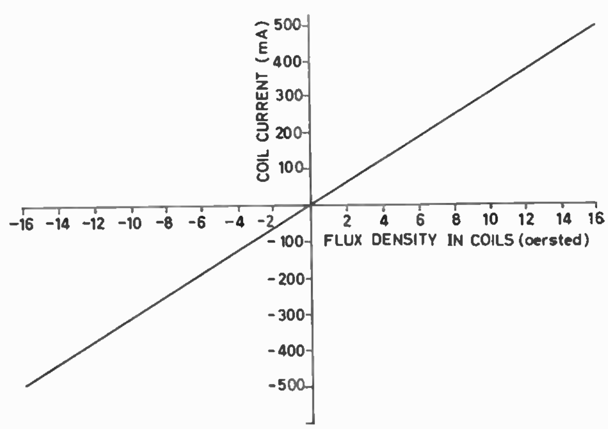


Fig. 5. N.M.R. probe head

Fig. 6. I-B graph for d.c. Helmholtz coils



the erratic movement of the signals. Further errors will be introduced by non-uniform hysteresis effects in the iron of the magnet itself.

The effect of the small incremental field on the main field is negligible. With the two probes in contact i.e. at centres 1¾in apart, no shift in the signal from the reference probe could be detected when the incremental field existing at the exploring probe was 15 oersted. A shift of 0·1 oersted would have been easily detected.

When using the apparatus with the 1m radius magnet several runs, each of 160 points measurements, were made with an average time per run of about 20min.

Conclusion

For field uniformity measurements over large pole areas the apparatus described has distinct advantages over the single probe magnetometer. After calibration of the bias coils no frequency measurements are necessary unless an absolute value of the field strength is required.

Besides simple uniformity measurements the apparatus has been used for investigating,

(a) the effect of shimming the pole pieces.

(b) non-uniform hysteresis effects between various points in the pole gap.

(c) tracking of the field intensities between two magnets connected in series as the current is varied.

Acknowledgements

The author thanks the Director of A.W.R.E. Aldermaston for permission to publish this article on work done while at A.W.R.E. Thanks are also due to Dr. H. W. Wilson for posing the original problem which made the work necessary and for his encouragement to the author in solving it.

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Automatic Gauging Machine

A number of fully automatic electronic gauging machines are currently being installed at the Chelmsford factory of the Hoffmann Manufacturing Co. Ltd. These machines are at present being used to measure the bores and track diameters of ball bearing races immediately after these components have been produced on automatic grinding machines. Should a dimension be outside the specified tolerance, the component is automatically directed into either a 'high' or 'low' reject bin. Should a pre-set number of components be rejected, then the post-gauging machine automatically stops the grinding machine to which it is coupled and a light flashes to warn the operator.

A complete gauging cycle from the reception of the component to its direction into the appropriate output bin takes 8sec. The production cycle time of the machine grinding the bores is 20sec per component.

Operation of the post-gauging machine is electromechanical, although the functions of comparing the measurement made with the pre-set high and low tolerance limits, and the selection of the bin into which the component is to be directed, are performed electronically.

A complete gauging cycle proceeds as follows. As the bearing race is ejected from the grinder it runs down a chute and is stopped before it enters the post-gauging machine by a pneumatically operated stop. Here the component rests for one or more complete grinding cycles to cool down before being inspected. On completion of the next operational cycle, the grinder transmits an electrical signal to the programming unit of the post-gauging machine. This unit comprises a bank of nine cams mounted on a common spindle which is driven at a constant rate by a small synchronous electric motor. At the appropriate times, these cams open and close microswitches, thereby initiating the various machine functions in the correct sequence.

The first of these functions is to release the new cool component from the initial position and allow it to roll down until arrested by a second stop at the gauging station. Then the gauging head is advanced to enter the bore. Two fixed tungsten carbide references disposed at 120° are provided on the gauging head. A third reference location—a stud mounted on a lever—is also provided on the head. When the head is in the fully advanced position, the lever is moved outwards until the gauging stud is brought into contact with the bore.

A variable inductance transducer is connected to the gauging lever. This device in conjunction with its associated electronic circuits, converts the displacement of the lever into an analogue voltage signal, the value of which is displayed on a meter. In addition, this signal is compared with two reference voltages representing the high and low tolerance limits of the diameter being gauged. As a result of this comparison, an electrical control signal is generated if the part is outside the permitted tolerance and this signal operates traps which direct the component into the appropriate reject bin.

Consistent and repeatable gauge readings are obtained within a tolerance of 0·00003in.

A count is kept within the machine of the number of consecutive components rejected. A control switch is provided for the operator to set the number that may be rejected before the post-gauging machine automatically stops the grinder. In practice the post-gauging machine operates as a comparator. It is set up with the aid of master reference components. High and low tolerance limits are also manually set by means of adjustment controls.

The machine can be selected to operate on one of four sensitivity ranges. Full scale deflexion of the meter needle produced by a 50V d.c. signal can represent 0·0006in, 0·002in, 0·006in, or 0·012in.

A Long Range Paging System

A pocket-size personal radio for paging selected personnel who may be up to thirty miles from the transmitter has been developed by Flight Refuelling Ltd. The radio is designed for use with transmitters operating in the mobile v.h.f. radio band, and consists of a receiver and a tone generator.

The receiver, which weighs one pound, is housed in a plastic case measuring 7in by 3in by 1¼in, and is carried by a shoulder strap which incorporates a quarter-wave aerial. Alternatively a rod aerial or car aerial can be used. The receiver remains at 'standby' until a tone of the correct frequency is received. This tone is then amplified as a loud warning note.

The tone generator is housed in a standard torch casing. To operate the receiver, the generator is switched on and held near the transmitter's microphone.

The paging receiver currently in production has a frequency range of 71·5Mc/s to 88Mc/s. Selectivity approximates G.P.O. requirements, and second channel rejection is greater than 60dB.

When at 'standby' the receiver's tone output is switched off while the remaining circuits are continuously switched on and off. This gives very good battery life. Upon receiving a transmitted tone, all the receiver's circuits are switched on by transistor switches.

The receiver then amplifies the tone as a warning note until transmission of the tone ceases, whereupon the receiver automatically returns to the 'standby' state. Alternatively, the receiver can remain on after tone transmission ceases, and a verbal message can then be broadcast from the transmitter. The receiver is then manually switched to 'standby'.

The receiver is equipped with a tone selector unit which can be tuned to any one of three frequencies, thus enabling selective paging to be carried out.

An Analogue Computer Application in Operations Research

By D. Longley*

The analogue computer is now firmly established as a tool for the control engineer, its flexibility and ease of programming provides a theoretical—cum—experimental approach for the solution of a host of dynamic problems and at the same time it enables the engineer to gain a real insight into the behaviour of the system under study. These techniques may also be extended into the science of operations research where the computer may be used both as a simulator of management control problems and as a fast, flexible 'hill-climbing' device. This article is concerned with the latter application of the analogue computer and examples of the solution of linear and non-linear programming problems are described.

(Voir page 429 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 438)

IN engineering education a great deal of emphasis is placed on the analysis of problems with unique solutions, examination candidates expect to be provided with sufficient information to develop a number of equations exactly equal to the number of unknowns of the problem. In practice, however, the engineer often has a certain freedom of manoeuvre and the real problem lies in the selection of the 'best' of several alternatives. In this case the information given to the engineer does not specify a point in vectorial space but rather a multi-dimensional volume—bounded by the specifications of the system—that must be explored to determine the co-ordinates of a point that maximizes some performance criterion.

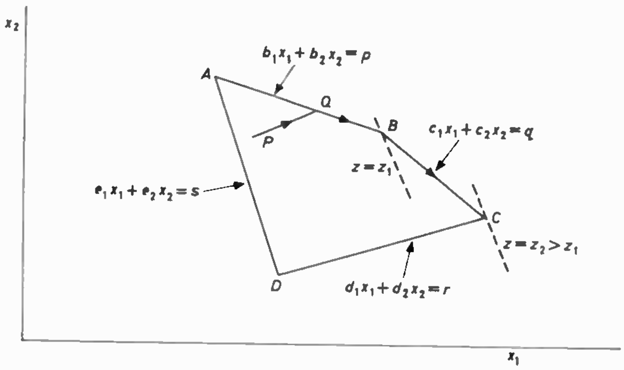

Fig. 1. Simple two dimensional problem

This situation arises in many management and industrial problems although the freedom of manoeuvre is often far greater and the consequences of not selecting the optimum solution may be more costly.

A simple two-dimensional problem may be illustrated graphically (Fig. 1). The constraints to the system may take the form of inequalities

$$b_1x_1 + b_2x_2 \leqslant p \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$c_1x_1 + c_2x_2 \leqslant q \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$d_1x_1 + d_2x_2 \geqslant r \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$e_1x_1 + f_2x_2 \geqslant s \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

where b, c, d, e, p, q, r and s are constants.

It is required to determine the co-ordinates $x_{1'}$, $x_{2'}$ subject to the above constraints, that maximize the function:—

$$Z = a_1x_1 + a_2x_2$$

The system constraints specify an area $ABCD$ in which the solution must lie. A search may be initiated at any point within this area and should commence along the line of greatest slope in z.

$$\text{i.e. } \dot{x}_1 = \alpha(\partial z/\partial x_1) = \alpha a_1$$

$$\dot{x}_2 = \alpha(\partial z/\partial x_2) = \alpha a_2$$

Thus in Fig. 1 the exploration begins at point P and moves in the direction PQ until the search point encounters the boundary AB. Further exploration in this direction is forbidden and the search must continue along the line of maximum permisible slope QB. At B the direction of search is changed once more and at C the point corresponding to maximum z is attained. Thus the co-ordinates of C represent the solution of the problem.

The search may be simulated on an analogue computer where voltages proportional to $\partial z/\partial x_1$ and $\partial z/\partial x_2$ are each injected into integrator circuits so that their outputs represent the co-ordinates of the search point. These voltages are fed into summing units with limiters to detect any trespass over boundary constraints, e.g. an error voltage ϵ_1 is generated such that

$$\epsilon_1 = k\,[b_1x_1 + b_2x_2 - p]$$

$$\text{for } b_1x_1 + b_2x_2 - p \geqslant 0$$

$$= 0$$

$$\text{for } b_1x_1 + b_2x_2 - p \leqslant 0 \quad \ldots\ldots\ldots\ldots \quad (5)$$

where $k \gg 1$.

When such an error signal arises it must be used to modify the velocity of the search voltages, e.g. signals $b_1\epsilon_2$ and $b_2\epsilon_1$ are fed back to the respective integrators in order to reduce the component of the search velocity—orthogonal to the boundary—to zero.

When steady-state conditions are attained the integrator outputs represent the co-ordinates of the point of maximum z. The mechanism of the constraint simulation requires the presence of an error signal so that steady-state voltages representing x_1' and x_2' will lie outside the area $ABCD$ but this error may be reduced to a negligible value by using a sufficiently high error feedback gain (k).

Solution of a Transportation Problem

One of the commonest applications of linear programming is the transportation problem. Here a manager is required to arrange the flow of goods from a number of warehouses to the firm's customers. The system constraints arise from the customer demands and the availability of goods at each warehouse, the function to be minimized is the total transport cost. A simple four by four matrix was

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TABLE 1

DESTINATION / SOURCE	BIRMINGHAM	LIVERPOOL	BRISTOL	GLASGOW	AVAIL. TONS
London	12	20	15	32	20
Belfast	24	12	22	17	190
Bolton	9	4	15	14	240
Dover	15	30	23	42	70
Demand (Tons)	120	240	60	70	

studied on a 60 amplifier analogue computer. The cost matrix, warehouse availabilities and customer demands are illustrated in Table 1.

Using the following nomenclature:

x_{ij} tonnage transported from warehouse i to customer j
c_{ij} cost per ton for the route warehouse i to customer j
A_i total tonnage available at warehouse i
D_j tonnage demand for customer j

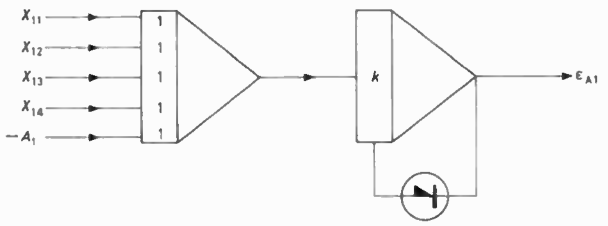


Fig. 2. Availability constraints

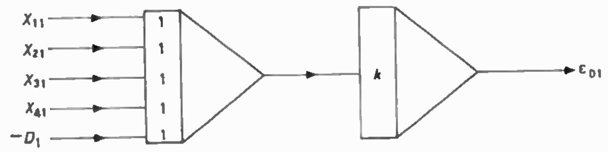


Fig. 3. Demand constraints

The constraints of the system are:

$$A_i \geqslant \sum_{j=1}^{4} x_{ij} \qquad i = 1 \text{ to } 4 \ldots\ldots\ldots (6)$$

$$D_j = \sum_{i=1}^{4} x_{ij} \qquad j = 1 \text{ to } 4 \ldots\ldots\ldots (7)$$

Also:

$$x_{ij} \geqslant 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

$$Z = \sum_{i=1}^{4} \sum_{j=1}^{4} c_{ij} x_{ij} \ldots\ldots\ldots\ldots (9)$$

The four availability constraints require four error signals $\epsilon_{A(i)}$ and these may be generated by configurations of the form illustrated in Fig. 2.

The four demand constraints require an equality between the terms on both sides of equation (7) and thus no limiter circuit is required in the error detecting amplifier (Fig. 3).

The route loadings x_{ij} appear as the output of sixteen integrators, the velocities $\dot{x}_{ij}$—within the constraints—are proportional to the cost per ton, but since a point of minimum z is required the search must be conducted down the line of greatest slope [i.e. $\dot{x}_{ij} = -\alpha(\partial z/\partial x_{ij}) = -\alpha c_{ij}$].

These velocities must also be notified by the appropriate demand and availability error voltages (Fig. 4). The integrator output must also be limited to permit only positive values of x_{ij}.

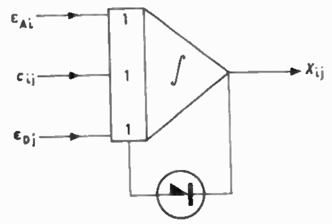


Fig. 4. Demand and availability error voltages

The results obtained from this study are listed in Table 2 and are compared with those obtained by a digital computer programme.

Solution of a Non-Linear Programming Problem

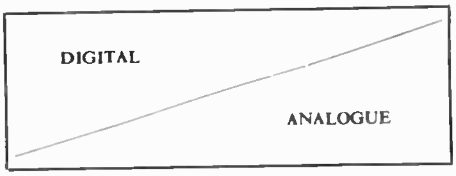
In the transportation problem the gradient of the cost function was constant but the analogue computer technique may be extended into non-linear programming problems.

In the manufacture of a range of products the manager aims at maximizing the total profit, the profit for each item is probably not a linear function of the production level and the choice of these levels will be restricted by labour difficulties, raw material scarcities, stock level considerations etc.

As an example of such a problem a simple case involving four commodities, with profit-production level curves as illustrated in Fig. 5, was studied. The items use a

TABLE 2

	LONDON	BIRMINGHAM	LIVERPOOL	BRISTOL	GLASGOW	SUPPLIED
LONDON	150 / 150	0 / 1	0 / 1	20 / 17	0 / 1	170 / 170
BELFAST	0 / 0	0 / 1	50 / 48	40 / 42	70 / 69	160 / 160
BOLTON	0 / 0	50 / 43	190 / 193	0 / 2	0 / 1	240 / 239
DOVER	0 / 0	70 / 73	0 / 0	0 / 0	0 / 0	70 / 73
DEMAND	150 / 150	120 / 118	240 / 242	60 / 61	70 / 71	



scarce raw material and although the labour force may be deployed on any of the four production lines it is a policy of the firm to arrange the production schedule so that the force is always fully employed. A third constraint arises from the requirement that the stock level of each item should remain within two specified limits. The following nomenclature will be used throughout this section:

P_i Production level of item i

P_{Ri} Profit accruing from production level

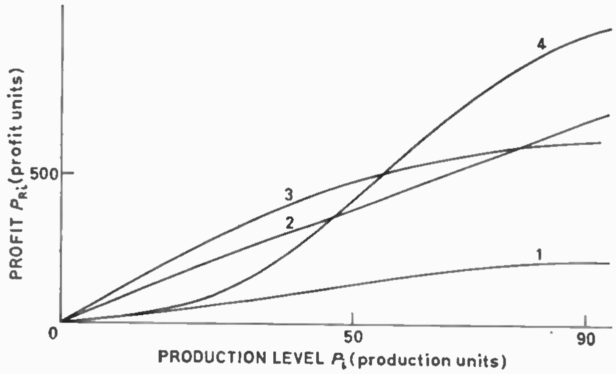


Fig. 5. Profit-production curves

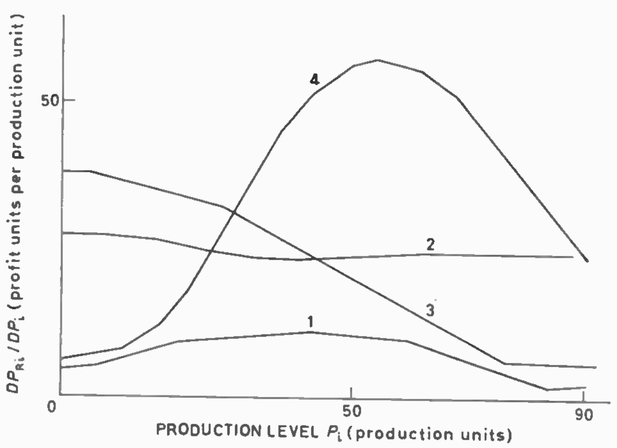


Fig. 6. Profit per unit against production level

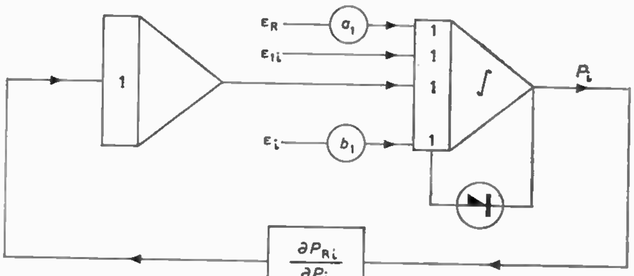


Fig. 7. Arrangement of function generators

a_i Raw material consumption rate per unit production of item i

b_i Labour force required per unit production rate of item i

I_{Li}, I_{Hi} Minimum and maximum permissible stock levels of item i

I_{oi} Present stock level of item i

α_i Forecasted demand of item i over future period T

R, L Total available raw material rate and labour force respectively.

The constraints to the system may be expressed:

$$P_i \geqslant 0 \quad \ldots\ldots\ldots\ldots \quad (10)$$

$$R \geqslant \sum_{i=1}^{4} a_i P_i \quad \ldots\ldots\ldots\ldots \quad (11)$$

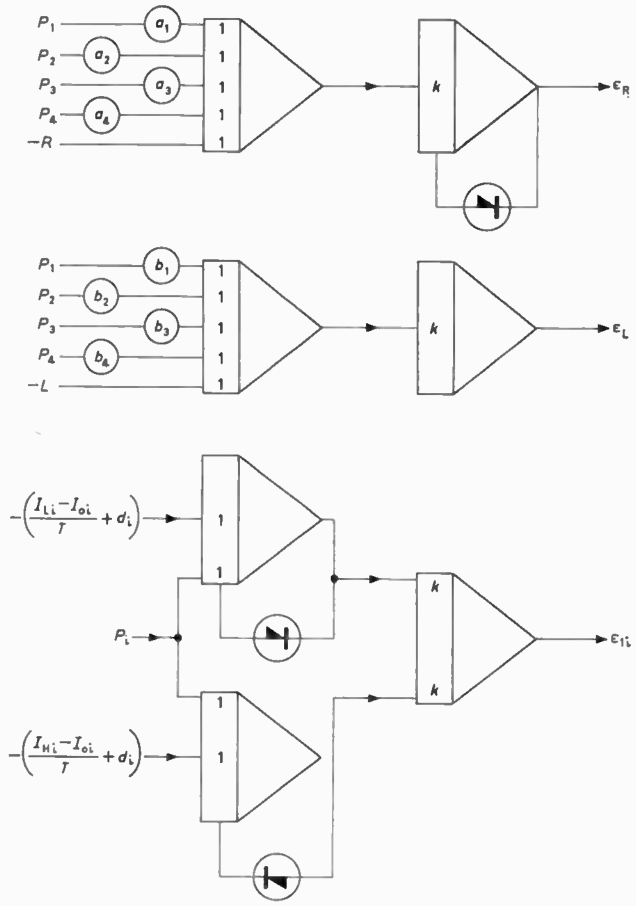


Fig. 8. Production of raw material, labour force and inventory error signals

$$L = \sum_{i=1}^{4} b_i P_i \quad \ldots\ldots\ldots\ldots \quad (12)$$

$$I_{Li} \leqslant (P_i - \alpha_i)T + I_{oi} \leqslant I_{Hi} \quad \ldots\ldots \quad (13)$$

$$i = 1 \text{ to } 4 \quad \ldots\ldots\ldots\ldots \quad (14)$$

The object of the analysis is to determine the four production levels P_i that satisfy the above constraints and maximize the total profit (P_R) where:

$$P_R = \sum_{i=1}^{4} P_{Ri}\ (P_i)$$

During the search—within the constraints—the rate of change of production levels $\dot{P}_i$ are functions of the levels themselves (Fig. 6) since

$$\dot{P}_i = \alpha \partial P_{Ri} / \partial P_i$$

The curves illustrated in Fig. 6 were set up on four function generators and the velocities $\dot{P}_i$ were obtained by feeding back the voltages representing P_i through the appropriate function generator to the integrator input (Fig. 7).

The raw material, labour force and inventory error signals were produced by the configurations illustrated in Fig. 8.

This example provided an excellent illustration of the versatility of the analogue computer technique.

The parameters of the problem could be varied at will and a real insight into the nature of the problem was obtained by studying the effect of each constraint in turn —this was achieved by simply removing the other error voltages.

When the labour and inventory constraints were removed an interesting example of a false maximum was detected. When the search was commenced with initial values $P_1 - P_4 = 0$ a stationary point with a comparatively low value of P_4 was obtained. This arose because the raw material error signal came into operation before the high-slope portion of the $P_{R4} - P_4$ was attained, thus it appeared to be more profitable to divert the raw material from item 4 on to the production of commodities 2 and 4. A search, however, commencing with a high initial value of P_4 resulted in a second stationary point corresponding to a higher value of total profit.

Conclusion

The transportation illustrated both the advantages and the shortcomings of the analogue computer techniques in the solution of linear programming problems. Considerable 'patching' effort was involved in the simulation of a four by four matrix and thirty-two operational amplifiers were required. On the other hand all the system parameters could be varied at will and thus the effect (say) of increasing the availability of a particular warehouse—on the overall cost—could be obtained by simply adjusting a coefficient potentiometer.

This analogue computer technique may be extended to a variety of non-linear programming problems and the flexibility and ease of programming compare favourably with digital computer methods. Moreover the operation of the computer provides a valuable insight into the nature of the optimum-seeking problem and thus opens up the possibility of extending analogue computer techniques into the field of management education.

Acknowledgments

The author is indebted to Dr. H. L. Haslegrave, Principal of Loughborough College of Technology, for permission to publish this article and to Dr. Buckingham for the provision of research facilities in the Department of Electrical Engineering, Loughborough College of Technology.

A Transistorized Marine Radar

A new marine radar, the 'Raymarc', employing solid-state circuits throughout in the display and invertor units, is announced by The Marconi International Marine Co. Ltd. The introduction of the new radar follows successful operational sea trials of a prototype installation on board a British coastal vessel, where, with the co-operation of the owners, the new equipment has for some time been undergoing comparative testing alongside another Marconi marine radar of an earlier design.

The first pre-production installation has been fitted on board the Marconi Marine demonstration vessel *Elettra III*, now on a tour of Northern European ports. The new 'Raymarc' will be demonstrated to British shipping interests when *Elettra III* returns to England.

The 'Raymarc', introduced to meet the needs of owners not wishing to install the more sophisticated 'Hermes' or the stabilized-screen 'Argus', is in no sense limited to small craft. With a 12in diameter cathode-ray tube, it is designed to comply in full with the Ministry of Transport specification, and in some respects exceeds its requirements. Peak transmitted power is 20kW which, giving ranges in the production models up to 36 miles, renders the 'Raymarc' suitable for deep-sea use on large vessels, either as a primary or secondary radar, while coupled automatic switching of pulse lengths, pulse repetition frequencies, and receiver bandwidths combines good long range performance with all the fine discrimination at shorter ranges which has always been a feature of higher-priced Marconi Marine radars.

A high degree of compactness, allied with component accessibility, has been attained in all four units of the 'Raymarc'. The display unit is only 19in in width, including the side handles; and 16in in depth. 24in long—or high—it can be mounted on bulkhead, deckhead, or chart table or fitted on a pedestal. The principal display controls are mounted round the circumference of the 12in p.p.i.—push-buttons for range and range ring selection, heading marker, compass stabilization and selection of ship's head up or relative presentation; and shaped knob controls for brilliance, tune, bearing cursor, gain, clutter, alignment, and scale illumination. These control knobs differ slightly in shape and size for easy identification by touch.

Ranges available on the pre-production model fitted on *Elettra III* are ¾, 1½, 3, 6, 12 and 24 miles, while the first production models will have an additional range of 36 miles. Range rings are set for ¼, ¼, ½, 1, 2, 4 and 4 mile intervals. The 'Raymarc' can be installed with compass stabilization in conjunction with a suitable repeating compass. Bearing accuracy is better than 1 degree.

Facilities are incorporated for monitoring the power output and receiver performance. An 'echo box' is built into the aerial driving unit for this purpose.

The use of transistors, with their longer life and cooler running conditions, eliminates breakdowns caused by valve failure, but ease of maintenance must always be a major factor in the physical design of radar equipment, and considerable attention has been paid to this in the 'Raymarc'. The cabinet of the display unit is built so that both side panels, carrying most of the sub-assemblies, open out on hinges for maximum accessibility. The side panels, complete with the sub-assemblies, may be removed completely by unplugging the connexions; and the assemblies themselves are easily and quickly removed from the panels for servicing or complete replacement. The display unit front panel, complete with its controls, can also be removed with similar ease, giving at the same time full access to the cathode-ray tube.

The 'Raymarc' transmitter unit is also very compact, approximately 17in by 17in by 8in, weight 47 lb, and can therefore be bulkhead mounted without being too obtrusive. All units are readily accessible immediately behind the front panel and can be removed with ease if necessary. Pulse lengths and pulse repetition frequencies are automatically switched when changing range at the display unit, a pulse length of 0·06μsec at a repetition frequency of 2kp/s being employed up to the 3-mile range, while longer ranges use 0·6μsec at 1kp/s. The solid-state invertor is in a unit of dimensions and finish similar to those of the transmitter unit to maintain the symmetry and appearance of the installation.

The 'Raymarc' will operate from a variety of power sources, battery or mains—24, 32, 110 or 220V d.c., or 115 or 230V a.c. An adaptor unit, mounted inside the invertor unit casing, is used when deriving power from the higher voltage d.c. or a.c. mains. The power consumption is only 400W.

A 4ft 6in slotted waveguide aerial is employed, gear-driven at not less than 20 rev/min, in wind speeds up to 80 knots. The slotted waveguide is enclosed in a glass fibre envelope, and the aerial has a horizontal beamwidth of less than 1·8° and a vertical beamwidth of nominally 20°, both measured at half power points.

Digital Computer Analysis of the Tunnel Diode Relaxation Oscillator

By A. L. Riemenschneider* and C. W. Cox†

The purpose of this article is to show a digital computer method for obtaining the solution to the tunnel diode relaxation oscillator. Equations for analysing the tunnel diode relaxation oscillator in the phase plane using Lienard's construction are selected. These equations are used to develop computer programs which accurately yield the oscillator output response directly from the complete diode characteristic and circuit parameters of a second order system. The method faithfully reproduces response waveforms with an accuracy limited only by the accuracy with which the characteristics of the non-linear element is known and is easily within the limits of normal component drift.

(Voir page 429 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 438)

THE non-linear second order system, such as the one represented by the tunnel diode oscillator, is usually solved by phase plane analysis methods using either the method of isoclines or Lienard's construction[1]. Phase plane analysis, however, is a graphical method and tends to become very tedious and time-consuming when accurate results are required. In this article, a computer method involving phase plane analysis and Lienard's construction is used to accurately and quickly predict the output voltage response of the tunnel diode relaxation oscillator directly from the diode characteristic and the circuit parameters.

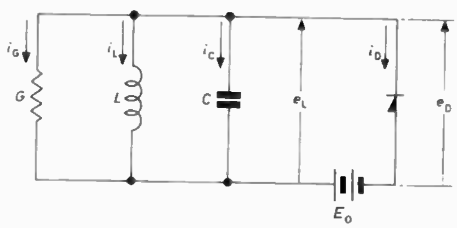


Fig. 1. Tunnel diode oscillator

Phase Plane Analysis

Consider the oscillator circuit shown in Fig. 1. The nodal equation is

$$i_L + i_C + i_G + i_D = 0 \quad \ldots\ldots\ldots\ldots (1)$$

where i_D is the diode current of Fig. 2 and may be represented by

$$i_D = i_D(e_D) \quad \ldots\ldots\ldots\ldots (2)$$

The voltage across the parallel circuit elements may be represented by

$$e_L = L(di_L/dt) \quad \ldots\ldots\ldots\ldots (3)$$

If the diode is biased at (E_o, I_o), the inductance carries the entire d.c. portion of i_D and allows no d.c. component in e_L. Thus the inductance current, i_L of Fig. 1, may be written as

$$i_L = i - I_o \quad \ldots\ldots\ldots\ldots (4)$$

where i is the variational component of current and I_o is the d.c. bias current. Also, from Fig. 2 the diode current of equation (2) may be rewritten in the form

$$i_D = i_D(E_o + e_L) \quad \ldots\ldots\ldots\ldots (5)$$
$$= i_1(e_L) + I_o$$

Equation (1) may now be written as

$$i + LC\,(d^2i/dt^2) + LG\,(di/dt) + i_1(e_L) = 0 \quad \ldots\ldots (6)$$

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† *South Dakota School of Mines and Technology.*

The function $i_1(e_L)$ which appears in equation (6) is the tunnel diode characteristic shown in Fig. 2 with the axes translated to the operating point (E_o, I_o). Since the voltage and current axes of the diode characteristic are dimen-

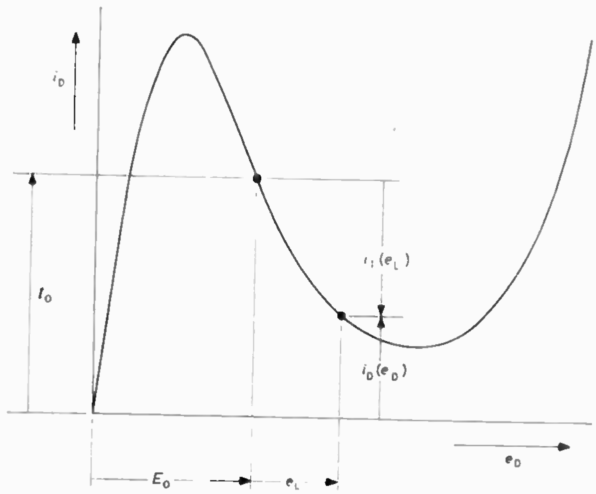

Fig. 2. Tunnel diode characteristic

sionally independent, Lienard's construction in its simplest form, which demands that the dependent variable and its derivative be plotted in the phase plane with the same scale factor, cannot be used in the phase plane solution of equation (6), for stretching one axis and not the other will destroy the angular relationships. The voltage and current axis of the diode characteristic can, however, be made dimensionally dependent by a method following that of Le Corbeiller[2]. Thus, normalizing the time variable to obtain the dimensionless time variable

$$\tau = t/\sqrt{(LC)} \quad \ldots\ldots\ldots\ldots (7)$$

and defining the derivatives with respect to the new variable as

$$di/d\tau = i', \; d^2i/d\tau^2 = i'' \quad \ldots\ldots\ldots\ldots (8)$$

makes it possible to write equation (6) in the form

$$i'' + i_a(i') + i = 0 \quad \ldots\ldots\ldots\ldots (9)$$

where

$$i_a(i') = G\sqrt{(L/C)}i' + i_1[\sqrt{(L/C)}i'] \quad \ldots\ldots (10)$$

Using equation (9), the slope of the phase trajectory at any point in the phase plane is given by

$$\lambda = i''/i' = \frac{-[i_a(i') + i]}{i'} \quad \ldots\ldots\ldots\ldots (11)$$

The auxiliary curve, which is used in Lienard's construction to obtain the phase trajectories, may now be found by equating the numerator of equation (11) to zero. Thus, the auxiliary curve is

$$i = -i_a(i') \quad \ldots\ldots\ldots\ldots\ldots \quad (12)$$

Application of Lienard's construction using equation (12) will yield the phase trajectory and limit cycle[1,3] for any initial disturbance in the oscillator. This phase trajectory and limit cycle represent the phase plane solution of the oscillator system, equation (9), with time τ as a parameter. The time variations $i(\tau)$ and $i'(\tau)$ may be obtained by determination of the time markers on the phase trajectory.

In order to time-mark the phase trajectory, suppose the trajectory is plotted in the i, $1/i'$ plane rather than the i, i' plane. A portion of the trajectory might then appear as shown in Fig. 3. For a very small increment covering the time between t_{n-1} and t_n, it can be shown[1] that

$$\tau_n = \tau_{n-1} + \Delta i(1/i'_m) \quad \ldots\ldots\ldots\ldots \quad (13)$$

where $1/i'_m$ is the mean value of $1/i'$ for the interval τ_{n-1} to τ_n.

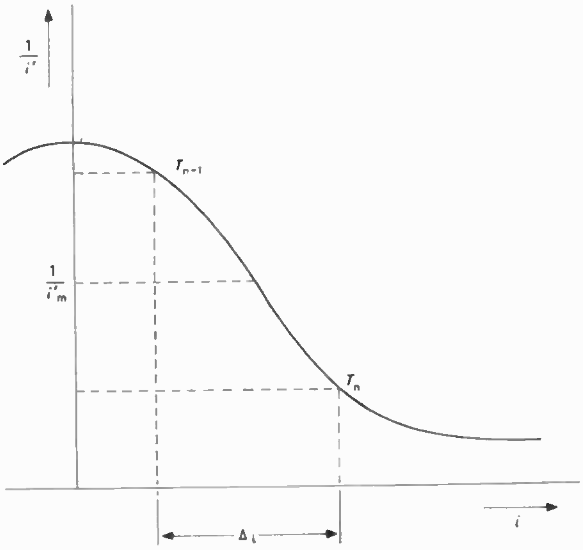

Fig. 3. Time marking phase trajectory

Equation (13) time-marks the phase trajectory in terms of the parameter τ. The solutions $i = i(\tau)$ and $i' = i'(\tau)$ may then be readily determined. The output voltage response is determined by applying equations (3), (4) and (7) to each point of the $i'(\tau)$ solution.

Computer Analysis

Since the phase plane analysis method of analysing non-linear systems such as the tunnel diode oscillator is a long graphical process, most of the analysis methods used to date have been developed using piecewise linear techniques or other approximations. However, the approximate methods sacrifice the accuracy of phase plane analysis for ease of analysis afforded by these methods. Therefore, the computer programs written for the IBM 1620 data processing system, given in the appendix, have been developed to analyse the tunnel diode oscillator by computer techniques using the phase plane analysis given above.

To obtain the limit cycle the computer, using the phase plane analysis program (see Appendix 1), accepts points from the diode characteristic, the circuit parameters G, L and C, the bias point (E_o, I_o), and the initial current i. The computer then translates the axis of the characteristic curve to the bias point and calculates the auxiliary curve from equation (12). Once the auxiliary curve has been calculated, the phase trajectory slope of equation (11) is found at the initial current point 1 of Fig. 4.

The computer then calculates the next point on the phase trajectory by moving along the trajectory slope to the next value of i'. This process continues until the trajectory reaches point 2. At this time, the computer halts to accept a new initial current near point 2. The process of calculating the phase trajectory then continues as before until point 3 is reached where the computer again halts. One complete cycle of the phase trajectory has now been found, and point 3 serves as the initial current for the next cycle. The complete process is repeated until each cycle of the phase trajectory is the same as the last within a specified tolerance. The limit cycle has then been determined. The computer may now be made to punch a set of data cards to be used by the time-mark program (see Appendix 2). The data cards are punched in two decks, one for the first half of the limit cycle and one for the second half.

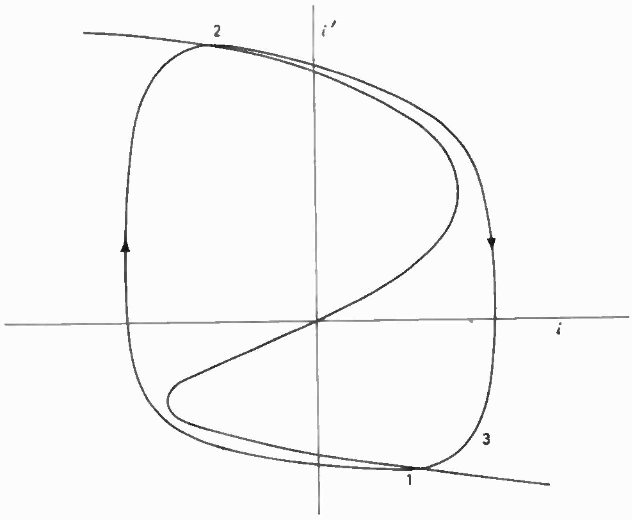

Fig. 4. Phase plane

The time-mark program is used to time-mark the limit cycle obtained by the phase plane program and then compute the output voltage of the tunnel diode oscillator as a function of time. Using the time-mark program, the computer first accepts the values of inductance, capacitance and the initial τ. The first data card deck punched by the phase plane program is then read into the computer. All values of τ are then calculated using equation (13). The values of time and voltage are calculated from equations (3), (4) and (7) and the results are printed out on the computer typewriter. The computer will then wait for a new value of τ, which will be the last value of time calculated multiplied by $1/\sqrt{(LC)}$, to be entered. The second deck of data cards punched by the phase plane program are then read into the computer and the remaining values of voltage and time are computed. The output response of the tunnel diode oscillator has thus been obtained.

Sample Problem

In order to illustrate the accuracy obtained by this computer analysis method, the oscillator of Fig. 1 was first analysed on the computer using a 5mA tunnel diode biased near the centre of the negative resistance region, an inductance of 10mH, a capacitance of 0·01μF and a conductance of 10^{-3}mho. Following the computer analysis, an oscillator was constructed and its output response

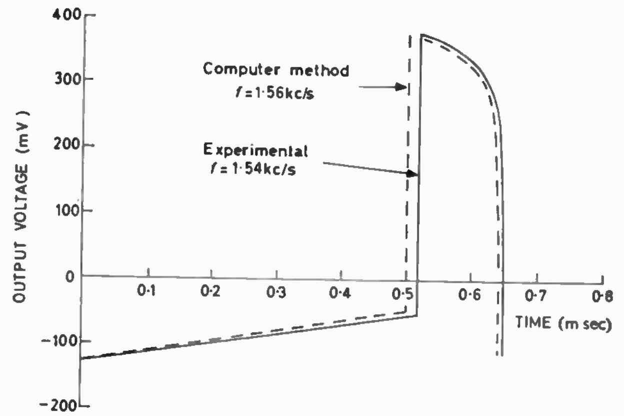

Fig. 5. 5mA tunnel diode oscillator response

compared to the response obtained from the computer. The results of this comparison are shown in Fig. 5.

The differences between the experimental and computer results lie primarily in the widths of the positive and negative pulses. These are only slight differences and affect the overall frequency by only 20 out of 1 560c/s, for an error of 1·3 per cent, an accuracy well within the normal drift range of the components used.

Conclusion

Although the phase plane analysis and computer programs developed in this article are for the analysis of the tunnel diode oscillator, the same techniques used here could easily be extended to the analysis of many other non-linear second order systems. To analyse such problems by conventional non-linear techniques will entail considerable time, unless a 'ball-park' solution is sufficient. However, application of computer analysis techniques should give accurate results as well as a considerable saving of time.

Acknowledgment

The authors wish to express their appreciation to Professor W. L. Reuter of the South Dakota School of Mines and Technology for his valuable assistance and suggestions in the programming of the computer for this problem.

Appendix

(1) Phase Plane Analysis Program

```
      DIMENSION Y(200), X(200), XI(200)
    1 FORMAT (15HENTER G, L, AND C)
    2 FORMAT (/34HENTER YO, XO, AND INITIAL CUR-
      RENT XI)
    3 FORMAT (I4)
    4 FORMAT (E14·7, E15·7)
    5 FORMAT (E14·7)
    6 PAUSE
      PRINT 1
      ACCEPT 5, G, B, C
    7 READ 3, N
      IF (SENSE SWITCH 2) 30, 31
   30 DO 32 I =1, N
      M = N − I + 1
   32 READ 4, Y(M), X(M)
      GO TO 33
   31 DO 8 I = 1, N
    8 READ 4, Y(I), X(I)
   33 PRINT 2
      ACCEPT 5, YO, XO, XI(1)
      DO 9 I = 1, N
      X(I) = X(I) − XO
      Y(I) = Y(I) − YO
      X(I) = (X(I) + (G*Y(I)))
    9 Y(I) = SQRT(C/B)*Y(I)
      DO 17 I = 1, N
      J = I + 1
      IF (Y(I)) 10, 16, 10
   10 S1 = −((X(I) + XI(I))/Y(I))
      IF (SENSE SWITCH 3) 12, 13
   11 FORMAT (E14·7, E17·7, E17·7, E17·7)
   12 PRINT 11, S1, Y(I), X(I), XI(I)
   13 XI(J) = (XI(I) + ((Y(J) − Y(I))/S1))
      IF (Y(1)) 34, 35, 35
   34 IF (Y(J)) 17, 16, 14
   14 IF (S1) 24, 24, 17
   35 IF (Y(J)) 36, 16, 17
   36 IF (S1) 24, 24, 17
   16 XI(J) = XI(I)
   17 CONTINUE
   18 FORMAT (/28H      VOLTAGE      CURRENT)
   20 FORMAT (E14·7, E18·7)
   23 FORMAT (/2HI = I4)
   24 PRINT 23, I
      PRINT 18
      DO 25 K =1, I
   25 PRINT 20, Y(K), XI (K)
      IF (SENSE SWITCH 2) 28, 40
   28 PUNCH 3, I
      DO 29 K = 1, I
   29 PUNCH 4, Y(K), XI(K)
   40 PAUSE
      IF (SENSE SWITCH 1) 7, 6
      END
```

Inputs

The inputs to the phase plane analysis program and the formats are as follows

G, L, and *C*	*G, L,* and *C* are the conductance, inductance and capacitance values of the oscillator respectively and are entered from the typewriter using the format (*E*14·7). Each constant must be entered separately.
N	*N* is the number of points to be entered from the diode characteristic and is entered on a card in the format (*I*4).
Y(I) and *X(I)*	*Y(I)* and *X(I)* are the points of the diode characteristic and are entered on cards. Each card must have one *Y* and one *X* in that order. The format is *E*14·7, *E*15·7.
Y_o, X_o, and *XI*	Y_o, X_o is the translation point and *XI* is the initial starting current of the trajectory. All values are entered from the typewriter one at a time using the format *E*14·7.

The operation is explained under phase plane analysis in the body of this article. However, the values of the initial current are very critical due to the possibility of crossing the auxiliary curve before the trajectory can clear the peaks of the curve. Thus, sense switch 3 may be turned on to monitor the auxiliary and trajectory curve points until a satisfactory value of initial current is found. The initial currents should be picked so that the trajectory just clears the peaks of the auxiliary curve without crossing it. When an unsuccessful value of initial current is used, push reset and insert and enter 4908524 to reinitiate the program.

Switch Settings

The sense switches perform the following functions:

Sense Switch 1 ON—re-initializes to point of card data entry.
OFF—re-initializes to beginning of the program.

Sense Switch 2 ON—causes program to start at *N* and index to 1.
OFF—causes program to index 1 to *N*.

Sense Switch 3 ON—monitors the calculation of the trajectory by printing slope, $Y(I)$, $X(I)$, and $XI(I)$ at each point.

OFF—does not monitor calculation of the trajectory.

(2) TIME MARKING PROGRAM

```
      DIMENSION Y(200), X(200), T(200)
    1 FORMAT (I4)
    2 FORMAT (E14·7, E15·7)
    3 FORMAT (E14·7)
    4 FORMAT (13HENTER L, AND C)
    5 FORMAT (/10HENTER T(1))
    6 PAUSE
      PRINT 4
      ACCEPT 3, B, C
    7 PRINT 5
      ACCEPT 3, T(1)
      READ 1, N
      DO 8 I = 7, N
    8 READ 2, Y(I), X(I)
      M = N - 1
      DO 9 I = 1, M
      J = I + 1
    9 T(J) = (T(I) + (2·0*((X(J) - X(I))/(Y(J) + Y(I)))))
      DO 10 I = 1, N
      T(I) = (SQRT(B*C)*T(I))
   10 Y(I) = (SQRT(B/C)*Y(I))
   11 FORMAT (/27H     VOLTAGE     TIME)
   12 FORMAT (E14·7, E18·7)
      PRINT 11
      DO 13 I = 1, N
   13 PRINT 12, Y(I), T(I)
      IF (SENSE SWITCH 1) 7, 6
      END
```

Inputs

The inputs to the time marking program and the formats are as follows:

L, C and $T(I)$	L and C are the inductance and capacitance values of the oscillator. $T(I)$ is the initial value of time. These three constants are entered separately from the typewriter in the format $E14{\cdot}7$.
N	N is the number of points to be entered from each data card deck punched by the phase plane program and is entered on a card in the format $I4$.
$Y(I)$ and $X(I)$	$Y(I)$ and $X(I)$ are the points of the limit cycle which have been punched on cards by the phase plane program. Each card contains one $X(I)$, $Y(I)$ point in the format $E14{\cdot}7$, $E15{\cdot}7$.

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An Automatic Continuous Weighing Equipment

There is a growing need in the chemical, processing and bulk materials-handling sections of industry for a reliable and accurate automatic continuous weighing system. There are in existence several electromechanical systems capable of performing this function but they have disadvantages associated with the mechanical parts employed. In order to overcome these disadvantages the Erith Works of G.E.C. (Engineering) Ltd has developed and patented an electronic control unit which does away with the need for mechanical components and which is suitable for use with continuous weighing systems of up to 1 500 ton/h capacity. Such equipment in conjunction with a belt-weigher and a vibrating feeder can therefore be employed to control, for example, blending and proportioning plants in steelworks, coalhandling plants in power stations and quarry installations. The Company has already supplied several of these equipments for use in the United Kingdom and overseas.

Since the G.E.C. electronic control unit employs thyristors (silicon controlled rectifiers) it possesses the following advantages over electromechanical systems: it is instantaneous in operation; it is compact; it requires a lower signal for operation; and there is little or no hunting or overshoot.

Principle of Operation

There are three main components of an automatic continuous weighing system, namely the weighing equipment, the control unit and the feeder. An advantage of the G.E.C. thyristor control unit is that it can be employed with any of the various types of belt-weighing equipment commercially available. These usually take the form of a load cell or a transducer which senses the weight of material on the belt and a tacho-generator for measuring the speed of the belt. The signals from these devices are multiplied together electronically, the resulting signal being proportional to the instantaneous rate of material flow.

A signal proportional to the desired feed rate is produced at the set point station which is continuously compared with the instantaneous feed-rate signal in an electronic three-term controller. The output signal from this controller is modified in accordance with the deviation from the desired feed rate, and is fed to the G.E.C. thyristor control unit which automatically regulates the vibrating feeder output to the belt.

Where close limits are not required and the belt speed is reasonably constant, the tacho-generator can be dispensed with to provide a somewhat simpler installation.

Thyristor Control Unit

The basic control unit is completely self-contained and is totally enclosed in a heavy-gauge pressed-steel case suitable for either floor, panel or wall mounting. It consists of a number of electronic sub-assemblies, the maintenance of which is simplified by the use of plug-in printed circuits. The design is such that it operates from the same a.c. supply as the vibrator on the feeder.

Surge-suppression circuits are included together with manual-resetting current-overload protection. Further protection is provided by using very liberally-rated components.

When the unit is used in conjunction with an automatic weighing system the output from the three-term electronic controller is used to control the firing angle of the thyristor. Thus if the actual feed-rate tends to rise above the set level, the firing of the thyristor is retarded so that it occurs later in the half-cycle than the point corresponding to the desired feed-rate and less power is supplied to the vibrating feeder. This results in a reduction in the quantity of material fed on to the belt until equilibrium conditions are re-established.

Similarly, if the feed tends to fall below the set level then the firing of the thyristor is advanced so that more power is supplied to the vibrating feeder.

Sherwen Electromagnetic Feeder

G.E.C. manufactures a wide range of vibrating feeders with capacities of up to 1 500 ton/h, depending on the type of material being handled. A feeder consists essentially of a trough for conveying the material and a vibrator unit, one part carrying the core and the other the armature of an electromagnet. The two assemblies are linked together either by a system of leaf springs and coil springs or by a system of rubber in shear.

The springing system and the two masses are arranged so that the natural frequency of vibration of the complete machine is the same as the frequency of the power supply. Thus, for a small power consumption, a condition of resonance is created resulting in a relatively large amplitude of vibration.

A Low Frequency Random Step Generator

By B. R. Wilkins*

This article describes a circuit which generates a random sequence of discrete output values, the probability of any particular output value being adjustable. The circuit is arranged in such a way that neither the output values themselves nor the probabilities of their occurrence depend on the properties of the noise source.

Experimental observations are included to show that the expected output probability distributions are in fact obtained from a practical generator.

(Voir page 429 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 438)

THE problem of generating any kind of low frequency random signal is complicated by the fact that primary noise sources produce little or no low frequency components. The problem of obtaining low frequency random signals from high frequency ones has been overcome in various ways, such as heterodyning with a local oscillator[1], switching a narrow band signal with a square wave[2], clipping a large amplitude signal with diodes[3], and peak rectification of a narrow band signal[4]. Each of these methods relies on the production of cross-modulation products at all frequencies from zero upwards by means of a non-linear operation, the wanted products being separated by a low-pass filter.

Continuous random signals have also been produced by using a random step generator[5], and in this case the statistical properties of the signal were measured automatically and used to control the generator so as to produce a signal with a specified power spectrum, independent of variations in the primary noise circuit. The need for a random step generator has also risen in connexion with analogue computer simulation work[6], and the circuit to be described has been designed specifically for this purpose. It produces an output whose statistical properties are not dependent on the noise source but are specified by a number of resistors which can be adjusted to give any one of a wide range of probability distributions.

Description of Circuit

Fig. 1 shows a block diagram of the circuit and Fig. 2 shows the waveforms obtained at significant points in the circuit. Wide band noise obtained from a thyratron (Fig. 2(a)) is converted by a Schmitt trigger circuit into a train of pulses of constant amplitude but random width and occurring at random intervals (Fig. 2(b)). These pulses are then applied to a Dekatron selector tube so that the glow rests on each cathode in turn for a random length of time. By connecting each cathode to the summing junction of a d.c. amplifier through an appropriate resistor the random staircase waveform shown in Fig. 2(c) is obtained at the output of the amplifier. This waveform is then sampled by means of a diode switch driven by a multivibrator, and the sampled voltage is retained in the holding circuit during the sampling interval. The multivibrator also clamps the Schmitt trigger circuit during the sampling time. Fig. 2(d) shows the multivibrator waveform and Fig. 2(e) the resulting output waveform. It should be noticed that the time scale for Figs. 2(d) and (e) is different from that for Figs. 2(a), (b) and (c). In fact, the sampling frequency is about one hundredth of the mean repetition frequency of the random pulse train.

The output of the generator in this form is thus a stepped function, whose value changes at regular intervals (the sampling times) and whose value between sampling times is constant at one of ten predetermined discrete values. Provided the sampling interval is long compared with the average interval between the Schmitt pulses, then the probability that the output should take any particular one of its available values is the same for each value.

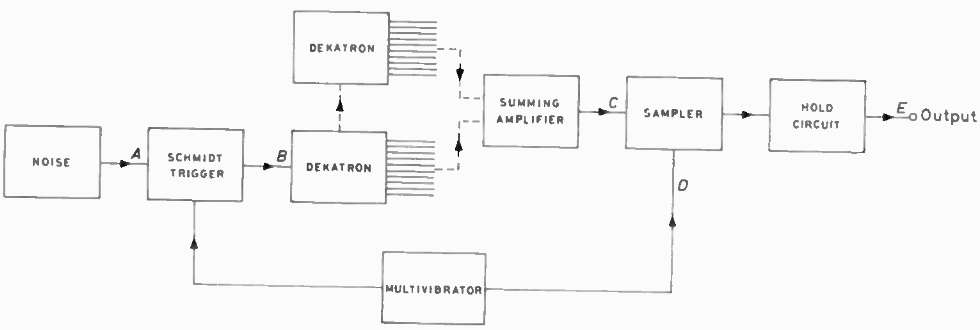
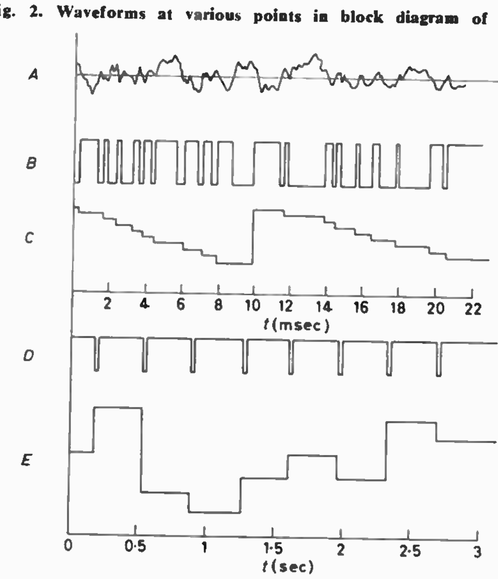


Fig. 1. General arrangement of the generator

Fig. 2. Waveforms at various points in block diagram of Fig. 1



* *University College, London.*

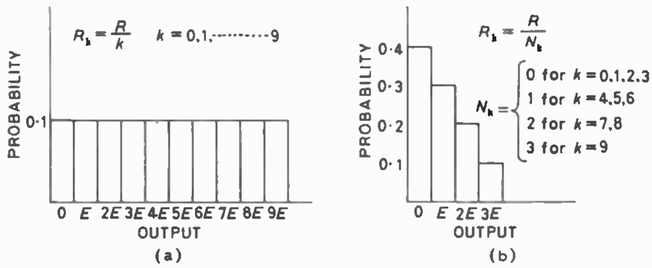


Fig. 3. Variation of output probability distribution for single Dekatron

(a) Rectangular distribution

(b) Skew distribution $(E = -(R_f/R) \cdot V)$

Results obtained from a practical generator of this type are summarized in Table 1. Taking an expected total for each position of 180, corresponding to a rectangular distribution, it is found that:

$$\chi^2 = 9{\cdot}1$$

With nine degrees of freedom, $p\,(\chi^2 \geqslant 9{\cdot}1) \simeq 0{\cdot}4$, so that it may safely be concluded that the generator does select each of its possible outputs with equal probability.

The possibility of manipulating the probability distribution of the final output comes about because one is free to make any choice that seems convenient for the resistors connected between the Dekatron cathodes and the summing junction of the output amplifier. Fig. 2(c), for example, was drawn on the assumption that the resistors had the values

$$R_k = R/k\ (k = 0, 1, 2 \ldots . 9)$$

Where R_k is the resistor connected from cathode k. If

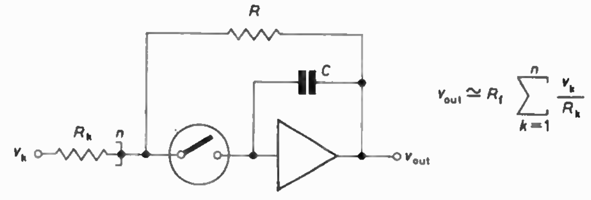


Fig. 4. Combined summing, sampling and holding circuit

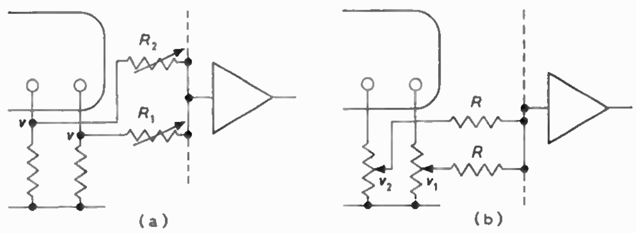


Fig. 5. Alternative ways of adjusting output

the voltage appearing at any cathode when the glow invests it is V and the feedback resistor is R_f then the output voltage will take one of the values:

$$-k \,.\, (R_f/R) .\, V = kE\ (k = 0, 1, 2 \ldots . 9)$$

where

$$E = -(R_f/R) \,.\, V$$

with a constant probability for each particular value of 0·1. This gives the rectangular distribution shown in Fig. 3(a).

If, however, the resistors are given the values:

$$R_k = R/N_k$$

$$\text{where } N_k = \begin{cases} 0 \text{ for } 0 \leqslant k \leqslant 3 \\ 1 \text{ for } 4 \leqslant k \leqslant 6 \\ 2 \text{ for } 7 \leqslant k \leqslant 8 \\ 3 \text{ for } k = 9 \end{cases}$$

then the positive skew distribution shown in Fig. 3(b) is obtained. The important thing to observe about this is that the distribution is determined entirely by the resistor values, and is completely independent of the characteristics of the noise producing circuit.

With the circuit as it stands, there are only ten possible outputs to manipulate, and this restricts the amount of possible variation in the distribution function. However, if a further Dekatron is added, driven from one of the cathodes of the first Dekatron, as indicated by the dotted part of the block diagram of Fig. 1, then there is a total of 100 possible outputs, or by using 12-way Dekatrons this could be increased to 144. This extension reduces the maximum permissible sampling rate, because the sampling interval must now be long compared with the average interval between driving pulses for the second Dekatron, and this is clearly 10 (or 12) times the interval for the first Dekatron. For the particular application for which this generator was wanted, a sampling interval of the order of 300msec was required, and using a 10kp/s selector in the first position and a 4kp/s selector in the

TABLE 1

Dekatron Position	0	1	2	3	4	5	6	7	8	9	Total
Number of Samples in that position	188	178	193	162	176	176	161	179	181	206	1800

$\chi^2 = 9{\cdot}1\ p(\chi^2 \geqslant 9{\cdot}1) \simeq 0{\cdot}4\ (f = 9)$

TABLE 2

FIRST DEKATRON	SECOND DEKATRON										
	0	1	2	3	4	5	6	7	8	9	Total
0	23	32	25	19	27	30	20	26	28	18	248
1	20	30	20	17	27	25	26	20	28	29	242
2	26	25	19	27	25	33	22	25	16	25	243
3	20	29	28	25	26	19	30	19	17	19	232
4	31	23	21	26	22	26	15	22	29	20	235
5	28	26	20	16	17	25	18	24	25	15	214
6	17	17	18	17	18	29	29	20	18	25	208
7	29	20	23	22	20	14	26	22	25	20	221
8	28	16	27	25	25	21	18	16	28	21	225
9	26	31	18	20	18	21	20	29	28	21	232
Total	248	249	219	214	225	243	224	223	242	213	2300

$\chi^2 = 92{\cdot}3\ p(\chi^2 \geqslant 92{\cdot}3) \simeq 0{\cdot}5\ (f = 99)$

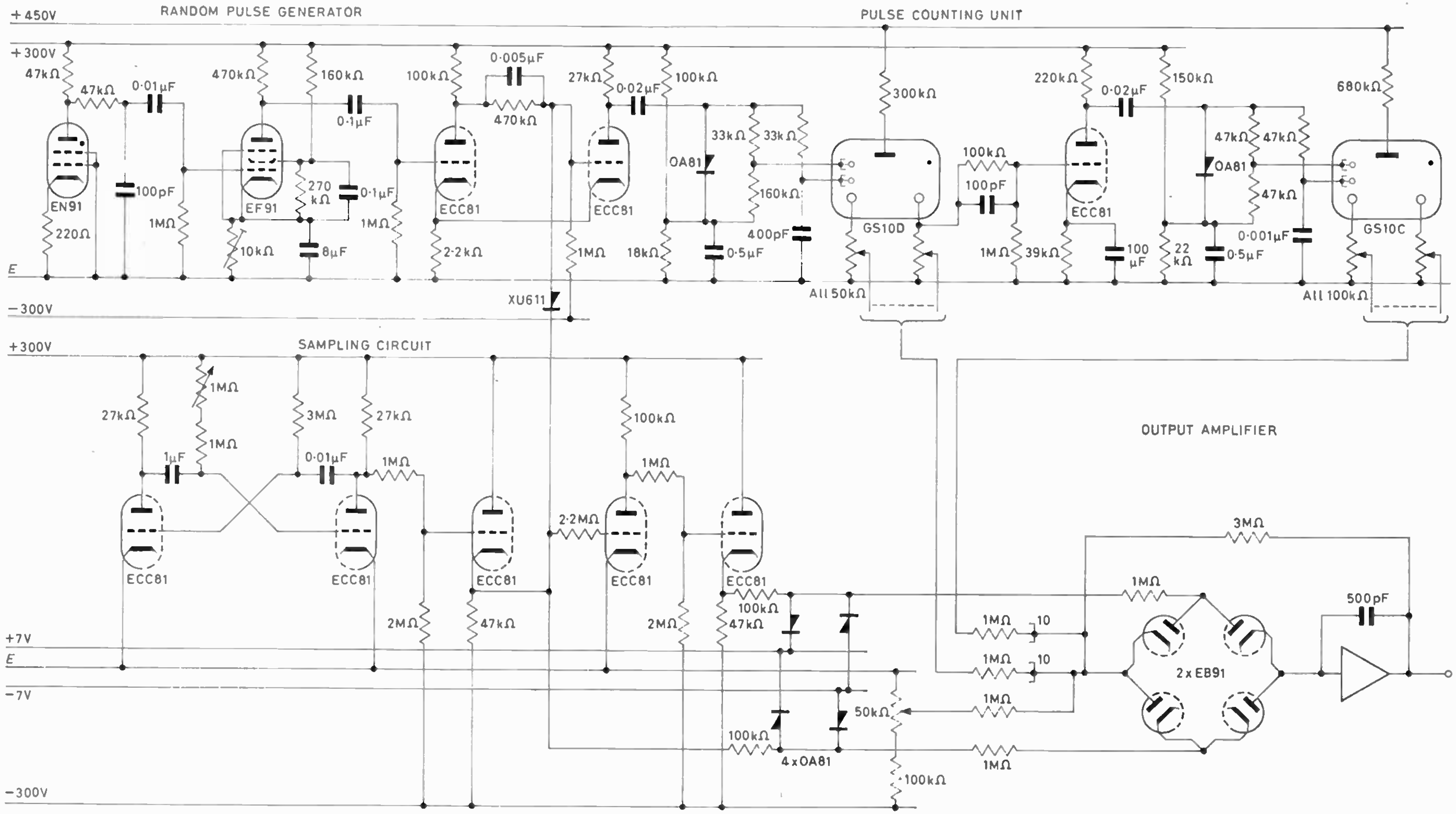


Fig. 6 (above). Complete circuit diagram

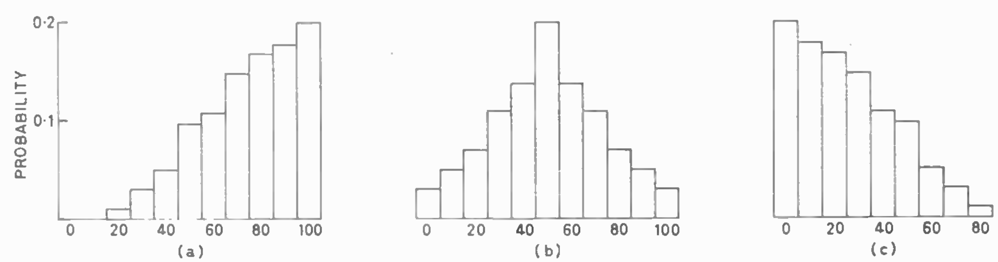


Fig. 7 (left). Histograms for two Dekatron circuit

TABLE 3

OUTPUT VOLTAGE		1st DEKATRON 0	10	20	30	40	50	2nd DEKATRON 0	10	20	30	40	50
No. of Dekatrons	A	1	1	1	1	2	4	0	0	1	2	2	5
Posns. giving	B	3	2	2	1	1	1	1	1	1	2	2	3
each voltage	C	4	2	1	1	1	1	5	2	2	1	0	0

TOTAL OUTPUT VOLTAGE		0	10	20	30	40	50	60	70	80	90	100
No. of combinations of Dekatrons Posns. giving each voltage = % probability of each voltage	A	0	0	1	3	5	10	11	15	17	18	20
	B	3	5	7	11	14	20	14	11	7	5	3
	C	20	18	17	15	11	10	5	3	1	0	0

second position it was found possible to operate at a mean input rate of about 8kp/s, so that the mean interval between driving pulses at the second Dekatron was about 1·2msec. The speed restriction need never be serious, in fact, because hot-cathode selector tubes are now made which operate up to 1Mc/s.

Results obtained from a two Dekatron generator are shown in Table 2. For a uniform distribution there should be 23 samples of each combination, and calculating on this basis yields $\chi^2 = 92{\cdot}3$. With 99 degrees of freedom, it is found that $p(\chi^2 \geqslant 92{\cdot}3) \simeq 0{\cdot}5$, which again suggests that the departure from uniformity is not significant.

Modifications to the Basic Circuit

The system shown in Fig. 1 can be very usefully condensed by making use of a single circuit to combine the functions of the summing amplifier, sampler and sample holder. This circuit, due to Glucharoff[7] is shown in Fig. 4. The switch shown enclosed in a circle is the sampling switch which is closed while sampling and open between sampling periods. It can be shown that when the switch is closed, the output voltage approaches exponentially the value:

$$v_o \simeq -R_f \sum_{k=1}^{n} (v_k/R_k) \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

with a time-constant $\tau = CR_f$.

When the switch is open, the output value is maintained with an accuracy dependent on the characteristics of the amplifier and capacitor. These limitations are fully discussed by Glucharoff[7]: in the present application the holding requirements are very modest, and can easily be met with quite a simple amplifier in conjunction with a special low-leakage capacitor.

A second modification to the basic circuit is in the way of modifying the effect of the Dekatron cathode voltage on the output. Equation (1) shows that the value of v_o can be adjusted either by varying R_k while keeping v_k constant, as shown in Fig. 5(a), or by varying v_k and keeping R_k constant. This second scheme, shown in Fig. 5(b), is preferable, mainly because it permits the complete permissible range of variation of output voltage to be covered with a single potentiometer.

Both of these modifications are incorporated into Fig. 6, which shows the complete circuit diagram of the generator.

Table 3 and Fig. 7 show ways of producing three non-rectangular probability distributions. Although the range of possible distributions is not completely unrestricted, many others are producible by suitable manipulations of the Dekatron outputs.

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SEACOM—Stage 1

The first stage of the South-East Asia Commonwealth telephone cable system (SEACOM) is to be laid in the China Sea during the next six months. Three cableships will lay some 2 000 nautical miles of cable linking Hong Kong, Jesselton (Sabah) and Singapore—operations which must be completed before the monsoon season starts in November. After extensive testing, the link will be opened for public service about the beginning of February, 1965.

SEACOM is being planned and developed in stages and the second stage will complete the system to Australia: This will join Singapore and Hong Kong to COMPAC (Commonwealth Pacific Telephone Cable) which was opened by H.M. The Queen six months ago, and to CANTAT (the Canada/United Kingdom link which has given the public excellent service since December 1962).

SEACOM is the joint undertaking of five countries—Australia, Canada, Malaysia, New Zealand and Britain—and is managed by a committee representative of the five partners. Mr. G. Searle, Deputy Director General of the New Zealand Post Office is the Convenor.

SEACOM, like COMPAC and CANTAT, will have a capacity of 80 telephone channels, with stable circuits for all types of telecommunications.

The cable and deep sea repeaters have been manufactured in the United Kingdom using materials from Australia, Canada, New Zealand and Britain and land based equipment has been obtained from Australia, Canada and Britain. The cable route distances are Jesselton/Singapore 860 nautical miles, Jesselton/Hong Kong 1 050 nautical miles.

Two British firms have received substantial orders for cable and equipment.

Submarine Cables Ltd (a company owned jointly by A.E.I. and BICC) has received orders totalling £2¼M for approximately 1 400 nautical miles of submarine telephone cable and 25 submersible repeaters. These orders represent about two-thirds of the cable and one-quarter of the repeaters required for the first stage of the system.

Standard Telephones & Cables Ltd has received orders worth about £2¼M. The equipment to be supplied covers the routes linking Hong Kong, Jesselton (Sabah) and Singapore. It includes 710 nautical miles of armoured shallow-water cable and unarmoured deep-sea cable of British Post Office type, 70 undersea repeaters (amplifiers) and 10 undersea equalizer units. STC demountable housings are being used on all undersea equalizers. The latest STC transductor-controlled power-feeding equipment is also included in the present orders.

These orders were placed by Cable & Wireless Ltd on its own behalf and as agents for the Overseas Telecommunications Commission (Australia), the Canadian Overseas Telecommunication Corporation, the Telecommunications Department of the Government of Malaysia and the New Zealand Post Office.

Amplitude Distortion in Non-Linear Networks with Particular Reference to Carrier Transmission Systems

By W. Dougharty*

The amplitude relationships between various distortion products are discussed and expressed in a convenient form by means of charts. The distortion to be expected from valves is also considered and various schemes which have been suggested for reducing distortion are noted.

(Voir page 429 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 438)

ALL active network elements at present in use (valves, transistors etc.) are essentially non-linear devices. From this it follows that all amplifiers making use of these elements will distort to a greater or less degree, and it is the business of the design engineer to ensure that the overall distortion in a particular amplifier is within the permitted limits.

When the amplifier is one of a chain of r.f. repeaters handling several separate signals at once, the linearity requirements are particularly exacting because the distortions produced by the individual units are normally additive.

How Distortion Arises

In any practical amplifier, the output, besides containing an amplified replica of the input signal, will contain undesired signals as a direct result of the non-linear relationship between output and input.

The frequencies at which such signals appear include those which are harmonically related to frequencies in the original signal, and others formed by mutually adding or subtracting the original frequencies and their multiples. As a further result of the same output-input relationship other forms of distortion may occur. Signal 'crush' and modulation distortion may be present and modulation may also be transferred from one carrier to another (cross-modulation).

Now it follows from the mathematics of the case that if one knows exactly how the output is related to the input one has sufficient information to calculate the amounts of all forms of distortion. Alternatively, and this is usually more practicable, once the levels of some distortion products have been found the levels of others can be calculated[1]. A direct and straightforward way in which to investigate theoretically the relationships between these products is by the use of power series.

The Power Series

In order to express the non-linear relationship existing between output and input in any network the a.c. output y is assumed to be related to the a.c. input x by the expression:

$$y = \alpha x + \beta x^2 + \gamma x^3 + \delta x^4 + \ldots\ldots$$

which is applicable so long as y is a single valued function of x. If in this expression the input x is assumed to be a composite signal consisting of several frequencies f_A, f_B, f_C, etc., then the output y will be found in general to consist of:

(1) The original frequencies, f_A, f_B, f_C, etc.
(2) Second order products, $2f_A, (f_A \pm f_B)$ etc.
(3) Third order products, $3f_A, (2f_A \pm f_B), (f_A \pm f_B \pm f_C)$ etc.
(4) Fourth order products, $4f_A, (3f_A \pm f_B), (2f_A \pm 2f_B), (2f_A, \pm f_B \pm f_C)$ etc.

and so on, although it is almost always true that in a well designed network of low distortion the fourth and higher order products will be negligible in comparison with the second and third. Some of the products listed above under

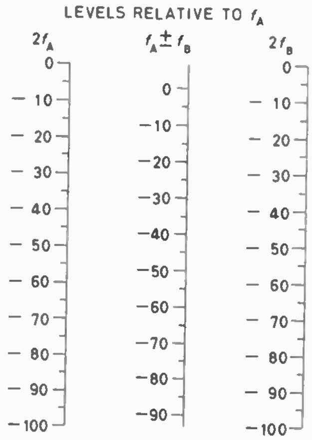
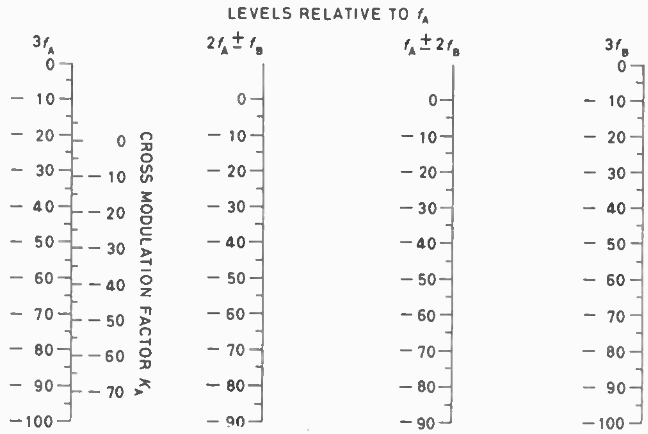


Fig. 1 (left). 2nd order distortion with two signals of frequency f_A and f_B

Fig. 2 (below). 3rd order distortion with two signals of frequency f_A and f_B



odd order distortion are also responsible for cross-modulation, crush, modulation rise and modulation distortion[2].

It is readily shown mathematically[1,2] that a fixed relationship exists between the amplitudes of all products of a given order, and charts are given here (Figs. 1 to 6) by means of which the amplitudes of distortion products of 2nd, 3rd or 4th order can be found, given the relative amplitudes of (up to) three input frequencies and the amplitude of any one distortion product of the appropriate order.

These charts are designed to be used as follows. One of the signals (f_A) is used as a reference and the amplitudes of the other signals and the spurious products are stated relative to the level of f_A. (No account is taken in the charts of bandwidth limitations anywhere in the network. In practice, bandwidth limitation may occur and make it difficult to measure, for example, a third harmonic directly, but this difficulty can sometimes be overcome by measuring the network response at the frequency concerned. It should also be noted that the fact that a harmonic of a given order falls outside the band, does not

* *Rediffusion Research Ltd.*

affect the level of a combination product of that order which falls in the band).

If the relative input level of another signal (f_B) is known, and the relative output of one of the distortion products of the 2nd, 3rd or 4th order, then the appropriate chart gives simply and quickly the relative amplitudes of all other distortion products of that order.

If one is dealing with three frequencies then it is necessary to take the arithmetic mean level in decibels of f_B and f_C relative to f_A: $\dfrac{(f_B + f_C)}{2}$

and use this figure instead of the 'level of f_B' used previously.

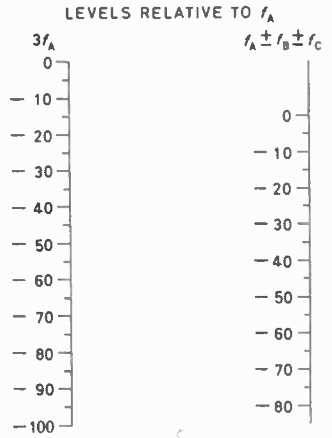
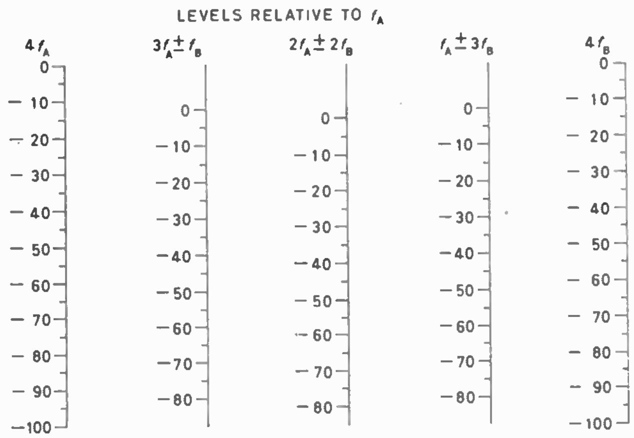


Fig. 3 (left). 3rd order distortion with three signals of frequency f_A, f_B and f_C

Note: replace level of f_B on cursor with level $\frac{f_B + f_C}{2}$

Fig. 4 (below). 4th order distortion with two signals of frequency f_A and f_B



To use the charts the cursor (Fig. 6) must be copied on tracing paper so that it can be placed on the charts in accordance with the instruction on the cursor.

Two quantities define the position of the cursor. The position of the centre is determined by the known level of one of the distortion products and the angle of the cursor is determined by the relative levels of the input signals. The levels of the other distortion products are then read off along the diameter.

Two examples illustrating the use of the charts are given in the Appendix.

Cross-Modulation

It may be useful here to give a definition of cross-modulation factor (K).

Two modulated signals are assumed, an interfering signal A and a wanted signal B, the depth of modulation being assumed the same for both. Due to third order distortion modulation from A will be impressed on B. The cross-modulation factor is then defined as:

$$K = 20 \log \frac{\text{unwanted modulation on B (per cent)}}{\text{wanted modulation on } B \text{ (per cent)}} \text{ (dB)}$$

Now K may be measured in two ways.

If sine wave modulation is used, and the modulation is assumed bi-directional, (i.e. the carrier varies above and below its unmodulated level) then the reference value for harmonic measurement is the unmodulated level of the interfering signal and K will be 21·6dB greater than the third harmonic thus measured (or calculated if outside the band). This is the usual method of measuring and gives a value of K which is called here K_A.

On the other hand, if square wave modulation is used and the modulation is assumed uni-directional (i.e. the carrier varies from its unmodulated level in the downward direction only), then the reference value for harmonic

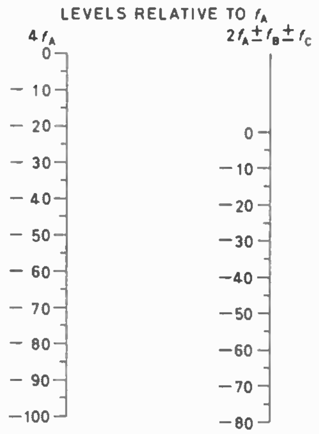
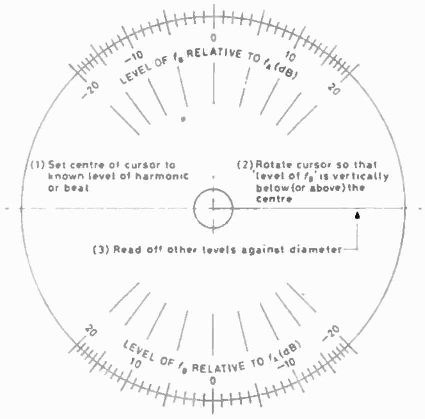


Fig. 5 (left). 4th order distortion with three signals of frequency f_A, f_B and f_C

Note: replace level of f_B on cursor with level $\frac{f_B + f_C}{2}$

Fig. 6. (below). Cursor for use with Figs. 1 to 5



measurement is the unmodulated or maximum level of the interfering signal and K will be 15·6dB greater than the third harmonic. This method has certain practical advantages; the value of K so determined is here called K_B.

Scales for both K_A and K_B are given in Fig. 7 and cross-modulation can be read off on either scale as required.

It should be noted that with both the above methods the modulation voltages measured should be peak-to-peak rather than r.m.s.

Crush

A quantity which is of value in defining the performance of an amplifier in a carrier transmission system is 'crush'.

Crush (or signal crush) is defined as the ratio of the gain at small signal levels where distortion is negligible to that at some specified higher output level. Expressed another way, it is the ratio of the estimated output were the device perfectly linear to the actual output with non-linearity present. It is usually measured in decibels.

Fig. 7 also shows the relationship between third harmonic and crush at a particular frequency, assuming other odd order harmonics are negligible.

As regards the effects known as modulation rise and modulation distortion, which refer to the action of non-linearity in altering the depth of and distorting the modulation, the reader is referred to the extended treatment given by Deketh[2].

Addition of Distortion

If several distorting units are connected in tandem, the overall distortion voltage will be the vector sum of the individual contributions from the various units. This is what one might expect, and it has in fact been confirmed experimentally for repeaters in tandem[3,4].

If the individual contributions are in phase, then the distortion currents will add in the load and the total distortion will rise by 6dB each time the number of distorting units is doubled. On the other hand if alternate contributions are approximately in anti-phase then the overall distortion for a number of units will not differ very much from that due to one alone.

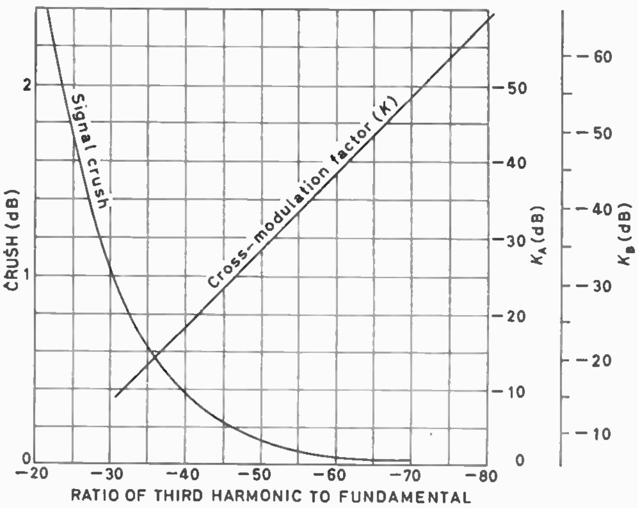


Fig. 7. Cross-modulation

In practice, where even-order distortion is concerned and where the mechanism of distortion is the same in all the units, the distortion introduced by any one unit will in general either add to or subtract from that introduced by a subsequent unit, but it is not normally possible to say which will happen.

In such a case it is reasonable to assume that the effect of doubling the number of distorting units will be to increase the overall distortion by an amount somewhere between 0 and 6dB, i.e. probably about 3dB. This is sometimes referred to as a 'power addition' law, although the conception of adding powers does not seem to be appropriate when considering components having the same frequency and when mutual neutralization is possible.

With third order distortion, including the third-order effect of cross-modulation*, so long as the distortion products are produced in the same way in the various units, distortion will always be additive and will generally increase by approximately 6dB each time the number of units is doubled.

It will also be clear from a consideration of the composite waveform, that with several units in tandem, poleing may be of use in reducing even-order products but will have little or no effect in reducing odd-order products.

To sum up, a rough 3dB increase (each time the number of distorting units is doubled) is appropriate for even-order distortion while a 6dB law is more appropriate for odd-order distortion.

However, it must be remembered that relative phase changes between components may occur as they travel between or through repeaters, and these have not been considered. From which it follows that neither 'law' will in practice be very exact.

Distortion Introduced by Pentodes and Triodes

The distortion produced in a pentode can be expressed in terms of the ratio i_p/i_a where i_p is the peak current swing (i.e. half the peak-to-peak swing in the case of a symmetrical wave) and i_a is the standing anode current, assuming the valve to be biased approximately to the mid-point of its $i_a - v_g$ characteristic.

If $i_p/i_a = 1$ the ratio of second harmonic to fundamental (d_2) is about −19dB and does not vary much with the type of valve. But the ratio of third harmonic to fundamental (d_3) varies considerably with the design of valve[5]. It might, for instance, be about −30dB with a sharp cut-off pentode and would be considerably less with a variable-mu valve.

If i_p/i_a is reduced by x dB, then d_2 is reduced by x dB, d_3 by $2x$ dB, and generally d_n by $(n-1)x$ dB. If i_p/i_a is greater than unity there will be an unpredictable increase in distortion.

Push-pull operation of valves, as is well known, reduces even-order distortion, but leaves odd-order terms unaffected. The reduction of d_2 by this means is about 20dB with careful circuit design and random valves. With matched valves and operating conditions this figure can be increased but it is probably unsafe to rely on any figure better than this in practice.

The use of a moderate amount of feedback will reduce d_2 by the feedback factor but will not necessarily have the same effect on d_3 and higher order distortion terms for reasons which are discussed below.

Distortion in a triode amplifier is normally less than that in a pentode owing to the inherent voltage feedback from the anode which will vary with the design of the particular stage. Apart from this there is no essential difference between the behaviour of triodes and pentodes as regards distortion.

Distortion Reduction by Feedback

It is well known that linearity can be improved by the use of feedback, but it is sometimes implicitly assumed that all distortion products will be reduced equally by this means. This assumption is sufficiently accurate so long as the original distortion is small, or the amount of feedback large. But under certain conditions it can readily be shown that the second order term only is reduced by the feedback factor and that higher order distortion terms will be affected in different ways and may even be increased[6].

In simple terms this effect is brought about by the feedback voltage itself being distorted in its passage through the amplifier and by the production of combination frequencies between it and the original signal.

It is a mistake therefore to regard feedback as a cure for all the ills of distortion, however large; it is better thought of as a means of considerably improving apparatus in which the distortion is already small.

Schemes for Reducing Distortion

When feedback is applied in the normal way to an amplifier (or other device) with the object of reducing distortion, it is usually found that the gain is reduced as well. This is often undesirable, and schemes have been

* *It is probable that 'multiple' cross-modulation, where more than two carriers are concerned, will add up differently.*

suggested whereby distortion is reduced with no corresponding reduction of gain; this price for linearity being paid in some other way.

For instance, Macdonald[7,8] with his 'active-error feedback' feeds back only the unwanted distortion. The overall gain for the 'wanted' portion of the output signal is therefore maintained except in so far as the network may be loaded with the additional circuits required for the scheme.

A block diagram of Macdonald's arrangement is given in Fig. 8.

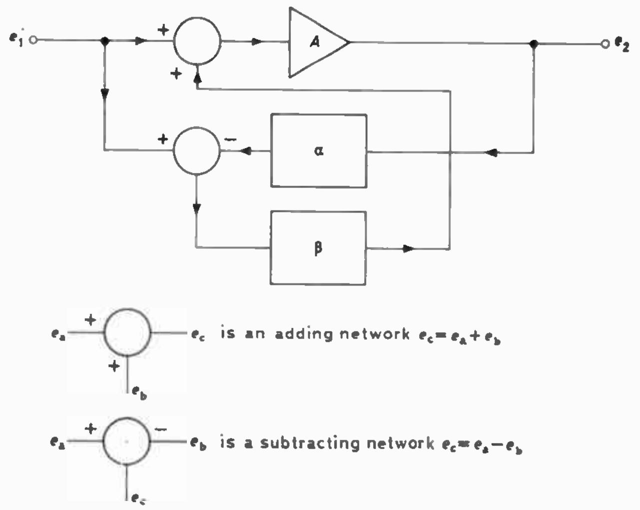


Fig. 8. Macdonald's feedback scheme

A is an amplifier of voltage gain A. α, β are feedback networks which modify the injected voltages by the factors α and β

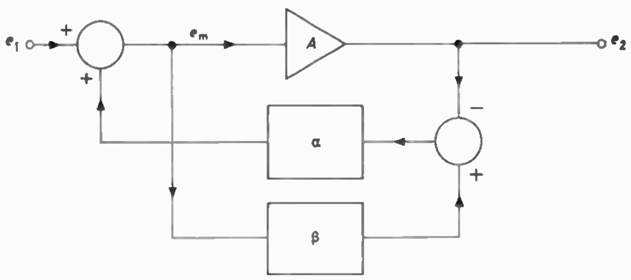


Fig. 9. Guanellas' feedback scheme

Murray[9] has devised a push-pull audio output stage in which one half of the push-pull stage is fed with the input signal and the other half is fed via a high gain amplifier with a signal derived from the difference between output and input voltages. He claims very low distortion with no loss of gain at a cost of one high gain amplifying stage in the feedback circuit.

Guanella[8,10] in a very ingenious scheme succeeds in reducing all distortion to zero without affecting the overall gain. A block diagram of his scheme is given in Fig. 9.

Another approach by Holbrook[11] is to introduce a non-linear passive network designed to produce 'complementary' distortion, with the object of cancelling that already there. A possible difficulty would seem to be that of maintaining cancellation over a range of operating levels and for long periods of time.

The additional circuits required for schemes such as the above is tolerable at audio frequencies and they can be made to work. At radio frequencies the added complexity is an embarrassment and it is usually best to counteract distortion by other means. These include push-pull stages, overall feedback and feedback applied round individual stages. Valves of very high g_m which are now available are particularly useful here, as large amounts of feedback can be applied without reducing the effective g_m to too low a value.

Appendix

The Use of the Charts Figs. 1 to 5

Example 1

Assume that two frequencies f_A and f_B are applied to a distorting network, the level of f_B being 8dB below that of f_A, and assume that output level of the product $f_A - f_B$ is 25dB below the output of f_A. It is required to find the output levels of the frequencies $2f_A$ and $2f_B$, (relative to f_A).

First place the centre of the cursor in the figure -25 in the column headed $f_A \pm f_B$ of Fig. 1.

Secondly rotate the cursor about its centre so that the figure -8 on the circumference comes on the vertical line of the column concerned (i.e. that headed $f_A + f_B$).

Then the levels of $2f_A$ and $2f_B$ are given by the intersection of the cursor diameter with columns headed $2f_A$ and $2f_B$ respectively; i.e. the levels are -23 and -39dB.

Example 2

Assume three frequencies f_A, f_B and f_C of relative levels 0, -6 and -14dB are applied to a network of which the third harmonic $3f_A$ is known to be 17dB below the fundamental. What is the level of the third-order product $f_A - f_B + f_C$? (Note that the levels of the products $f_A \pm f_B \pm f_C$ are all equal).

First place the centre of the cursor on the figure -17 of the column headed $3f_A$ of Fig. 3.

Secondly, evaluate the mean level of f_B and f_C i.e. $-(6+14)/2 = -10$dB and rotate the cursor so that -10 comes on the vertical line of the $3f_A$ column.

Then the level of $f_A - f_B + f_C$ is given by the intersection of the cursor diameter with the $f_A \pm f_B \pm f_C$ column, i.e. it is -22dB.

Conclusion

By means of the charts it is possible to express the simpler combination frequencies due to distortion in terms of a plain harmonic of 2nd, 3rd or 4th order. It is possible to design for a given amount of second harmonic, but it is not usually possible without prior measurement to do so for the third or higher orders. Feedback is a powerful and well tried means of reducing all forms of distortion provided they are initially sufficiently small.

Acknowledgments

Thanks are due to Mr. R. I. Kinross and to members of his staff at Rediffusion Research Ltd for many helpful suggestions, and to the Directors of that company for permission to publish this article.

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Matrix Analysis of the Colpitts' Oscillator

By G. Zelinger*, M.I.E.R.E., Sen.Member I.E.E.E.

The basic design problems of Colpitts' oscillators will be examined and solved by means of matrix analysis. Practical oscillator circuits are considered which utilize either transistors or valves as the active element. It is shown that the complete oscillatory system can be synthesized from an active and passive two-port, each in turn described by an admittance matrix. Design equations will be derived for the oscillating frequency and conditions of oscillation in terms of the fundamental circuit parameters. In conclusion it will be shown how mathematical simplifications may be introduced which will still yield meaningful results for the purpose of engineering approximations.

(Voir page 429 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 438)

IT is well known that an oscillatory system can be represented by a pair of suitably interconnected active and passive two-ports. Oscillators are generally classified according to the mode of these interconnexions[1,2]. Some of the most useful types such as the Colpitts and Hartley may be reduced to a network model of parallel connected active and passive two-ports. In the linear mode of operation, matrix methods are admirably suited to the analysis and study of such systems[1,3,4,5].

There are several good examples in the published literature which deal with the various aspects of oscillator design[6-9]. This article will be devoted to an attempt of comprehensive matrix analysis of the Y type Colpitts' oscillator. Typical transistor and valve of oscillator circuits will be studied. The basic circuits will be broken down into linear models which considerably simplify subsequent analytical work. Mathematically, these models are then described by the admittance matrix of the constituent two-ports. A consistent step by step reasoning will be followed in deriving the frequency of oscillations and conditions of oscillations in terms of the pertinent circuit parameters.

The Oscillatory Circuits, General

If d.c. biasing sources are ignored, the grounded anode or cathode-follower Colpitts' oscillator is of the configuration as shown in Fig. 1. It is convenient to include the grid resistance R_g, which may be a physical element and part of the bias circuit or represent the input conductance of the valve at sufficiently high frequencies. The cathode resistor R_K is generally associated with the external load and as such it may also absorb the resistive losses of the inductance L.

The transistor oscillator of the grounded emitter variety is shown in Fig. 2. There again the d.c. biasing is ignored. Both of these fundamental circuits may be generalized with the block diagram shown in Fig. 3.

By definition, the equilibrium equation which describes these parallel connected two-ports:

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = [Y] \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} \quad \ldots\ldots (1)$$

where:

$$[Y] = [Y]_A + [Y]_B \ldots\ldots\ldots\ldots (2)$$

The symbols $[Y]_A$ and $[Y]_B$ stand for the admittance parameter matrices of the active and passive two-ports respectively. These parameter matrices will be obtained from the original circuit configurations in Fig. 1 and 2 by utilizing some basic principles of matrix algebra[1,3].

* *De Havilland Aircraft of Canada Ltd.*

The Grounded Anode Colpitts' Oscillator

Admittance Matrix of the Active Two-Port

The high input and low output impedance of the cathode-follower is the characteristic feature of this circuit.

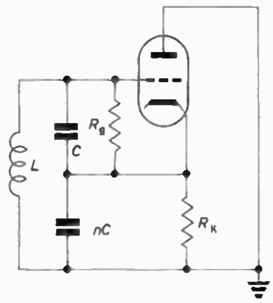

Fig. 1. The grounded anode Colpitts' oscillator

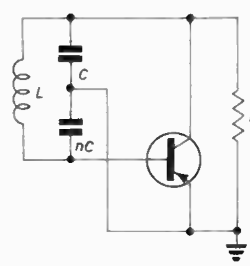

Fig. 2. The grounded emitter Colpitts' oscillator

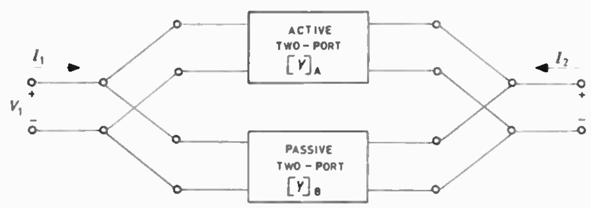

Fig. 3. Arrangement of the Colpitts' oscillators

The admittance matrix of the resistive model will be obtained from the floating admittance matrix. It is convenient to lump together the physical inter-electrode capacitances with the passive external feedback circuit. With this reservation, the floating triode and corresponding resistive model are represented in Figs. 4(a) and 4(b).

where the symbols have the usual meanings:

g_m = mutual conductance

g_{ak} = anode to cathode conductance

g_{gk} = grid to cathode conductance

From Fig. 4(b), the floating admittance matrix may be written down by inspection:

$$[Y]_{TRIODE} = \begin{array}{c|ccc|c} & V_1 & V_2 & V_3 & \\ \hline I_1 & g_{gk} & 0 & -g_{gk} & G \\ I_2 & g_m & g_{ak} & -g_m - g_{ak} & A \\ I_3 & -g_{gk} - g_m & -g_{ak} & g_m + g_{ak} + g_{gk} & K \\ \hline & G & A & K & \end{array} \quad \ldots . (3)$$

From this 3 by 3 floating admittance matrix the two-port parameters may be obtained for any of the three possible grounded electrode configurations. For the purpose of this study the grounded anode operating mode is of interest. The appropriate two-port parameter matrix is obtained by collapsing the second row and second column, leaving a 2 by 2 matrix:

$$[Y]_A = \begin{bmatrix} g_{gk} & -g_{gk} \\ -g_m - g_{gk} & g_m + g_{gk} + g_{ak} \end{bmatrix} \quad \ldots\ldots (4)$$

From this matrix, the resistive model of the grounded

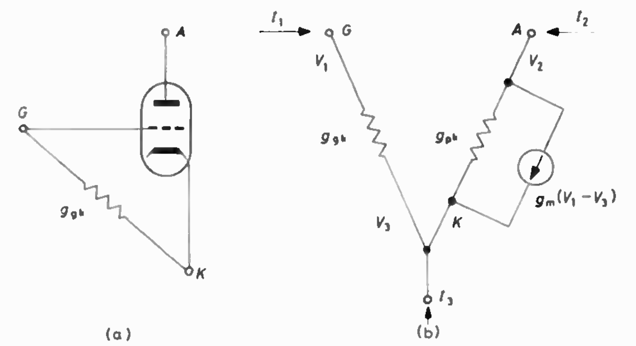

Fig. 4(a). The floating triode
(b). Linear resistive model of the floating triode

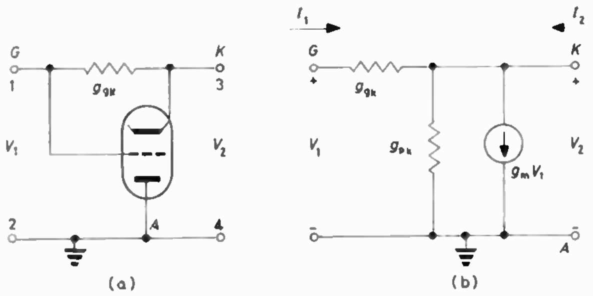

Fig. 5(a). Grounded anode connexion of the triode
(b). Linear resistive model of the grounded anode triode

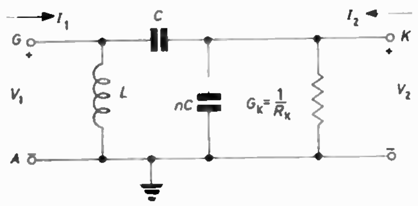

Fig. 6. Network model of the feedback circuit

anode amplifier configuration can be synthesized and terminal conditions re-defined as shown in Figs. 5(a) and 5(b).

Admittance Matrix of the External Feedback Two-Port

Reverting to Fig. 1, it is possible to redraw the passive circuit made up from L, C, nC and R_K in the form of a π network as shown in Fig. 6.

This network model can be described mathematically by the admittance parameter matrix.

From Fig. 6 by inspection:

$$[Y]_B = \begin{bmatrix} (1/pL) + pC & -pC \\ -pC & pC + pnC + G_K \end{bmatrix} \quad \ldots\ldots\ldots\ldots (5)$$

Synthesis of the Oscillating System

It is now quite feasible to synthesize the complete oscillating system from the constituent active and passive two-ports. This is done simply by inserting into the block diagram in Fig. 3, the appropriate linear models from Figs. 5 and 6. The resulting oscillatory system is shown in Figs. 7(a) or 7(b).

The new compound linear model in Fig. 7(b), is mathematically completely described by the sum of the admittance matrices (4) and (5) as the 'building blocks'. There-

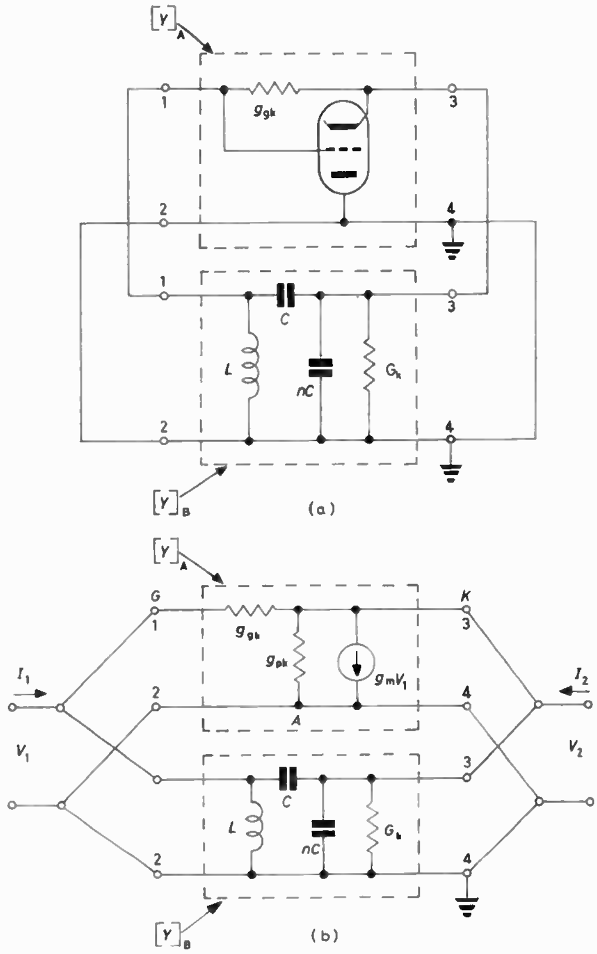

Fig. 7(a). Oscillator circuit redrawn as parallel connected active and passive two-ports
(b). Linear model of the oscillating system

fore the matrix of the oscillating system:

$$[Y]_{osc} = [Y]_A + [Y]_B \quad \ldots\ldots\ldots\ldots (6)$$

$$[Y]_{osc} = \begin{bmatrix} \overbrace{g_{gk} + (1/pL) + pC}^{Y_{11}} & \overbrace{-g_{gk} - pC}^{Y_{12}} \\ \underbrace{-g_m - g_{gk} - pC}_{Y_{21}} & \underbrace{g_m + g_{gk} + g_{ak} + G_K + pC + pnC}_{Y_{22}} \end{bmatrix} \quad \ldots\ldots\ldots\ldots (7)$$

By definition, in an oscillating system the excitation function is zero. Therefore the equilibrium equation (1) for $I_1 = I_2 = 0$ simplifies to:

$$\begin{bmatrix} 0 \\ 0 \end{bmatrix} = [Y] \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} \quad \ldots\ldots\ldots\ldots (8)$$

The nontrivial solution of equation (8) requires that the determinant of the $[Y]$ matrix is zero. Hence for the condition of oscillation:

$$[Y] = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

From equation (7):

$$[Y]_{osc} = \begin{bmatrix} \overbrace{g_{gk}+(1/pL)+pC}^{Y_{11}} & \overbrace{-g_{gk} - pC}^{Y_{12}} \\ \underbrace{-g_m - g_{gk} - pC}_{Y_{21}} & \underbrace{g_m + (g_{gk}+g_{ak}+G_K)+pC\,(n+1)}_{Y_{22}} \end{bmatrix} = 0 \quad \ldots\ldots\ldots\ldots \quad (10)$$

The Y_{22} of equation (10) can be written in a more compact form by putting:

$$(g_{gk} + g_{ak} + G_K) = G_S \quad \ldots\ldots\ldots\ldots \quad (11)$$

where G_S = the sum of the passive conductance parameters. Hence, when using identity (11) the matrix (10) may be put into slightly more compact form:

$$[Y]_{osc} = \begin{bmatrix} g_{gk}+(1/pL)+pC & -g_{gk} - pC \\ -g_m - g_{gk} - pC & g_m + G_S + pC(n+1) \end{bmatrix} = 0 \quad \ldots\ldots\ldots\ldots \quad (12)$$

The difference of the cross products will yield the determinant of this matrix:

$$|Y| = (g_{gk}+(1/pL)+pC)\,\{g_m+G_s+pC\,(n+1)\} - (g_m + g_{gk} + pC)\,(g_{gk} + pC) = 0 \quad \ldots\ldots \quad (13)$$

Expanding the products:

$$|Y| = g_m g_{gk}+(1/pL)\,g_m+pCg_m+G_s g_{gk}+(1/pL)\,G_s+pCG_s + npC\,g_{gk}+pCg_{gk}+(C/L)\,(n+1)+np^2C^2+p^2C^2 - g_m g_{gk}-g_{gk}^2-g_{gk}\,pC-g_m pC-g_{gk}pC-p^2C^2 = 0 \quad \ldots\ldots\ldots\ldots \quad (14)$$

After cancellation of identical terms with opposing algebraic signs, equation (14) may now be re-arranged:

$$|Y| = g_m\,(1/pL) + G_s g_{gk} + G_s\,(1/pL) + G_s pC + npC\,g_{gk} + (C/L)\,(n + 1) + np^2C^2 - g_{gk}^2 - pCg_{gk} = 0 \quad \ldots\ldots\ldots\ldots \quad (15)$$

Substitute now $j\omega = p$ and separate the real and imaginary terms.

From the theory of complex numbers, the real and imaginary parts will be separately also equal to zero.

Hence, the real part of equation (15):

$$|Y|_{REAL} = g_{gk}(G_s - g_{gk})+(C/L)\,(n+1)-n\omega^2C^2 = 0 \quad \ldots\ldots \quad (16)$$

Similarly the imaginary part of equation (15):

$$|Y|_{IMAGINARY} = 1/j\omega L\,(g_m+G_s)+j\omega C\,\{G_s+g_{gk}(n-1)\} = 0 \quad \ldots\ldots\ldots\ldots \quad (17)$$

Now, by definition, equation (16) will give the frequency of oscillations and equation (17) defines the criterion of oscillations.

The Frequency of Oscillations

Reverting to equation (16) by transposition:

$$n\omega^2C^2 = C/L\,(n+1)+G_s g_{gk}-g_{gk}^2 \quad \ldots\ldots \quad (18)$$

$$\omega^2 = \frac{n+1}{LCn} + g_{gk}\frac{(G - g_{gk})}{C^2n} \quad \ldots\ldots\ldots \quad (19)$$

$$\omega = \sqrt{\left[\frac{n+1}{LCn} + \frac{g_{gk}(G_s - g_{gk})}{C^2n}\right]} \quad \ldots\ldots \quad (20)$$

Equation (20) is an exact expression. From equation (11) note the identity:

$$G_s \equiv (g_{gk} + g_{ak} + G_k)$$

In practical oscillator circuits the second term in equation (20) is a negligible quantity. Therefore for the purpose of engineering approximations, equation (20) reduces to:

$$\omega \simeq \sqrt{\left(\frac{n+1}{LCn}\right)} \quad \ldots\ldots\ldots\ldots \quad (21)$$

The Conditions of Oscillations

Reverting to equation (17) and multiplying through by $j\omega C$:

$$C/L\,(g_m+G_s)-\omega^2C^2\,\{G_s+g_{gk}\,(n-1)\} = 0 \quad \ldots\ldots \quad (22)$$

By transposition:

$$(g_m+G_s) = \omega^2LC\,\{G_s+g_{gk}\,(n-1)\} \quad \ldots\ldots \quad (23)$$

$$\omega^2LC = \frac{g_m + G_s}{G_s + g_{gk}\,(n - 1)} \quad \ldots\ldots\ldots\ldots \quad (24)$$

From equation (21) by squaring and transposition:

$$\omega^2LC = \frac{n+1}{n} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (25)$$

Now equations (24) and (25) can be equated:

$$\frac{n+1}{n} = \frac{g_m + G_s}{G_s + ng_{gk} - g_{gk}} \quad \ldots\ldots\ldots\ldots \quad (26)$$

By cross multiplication:

$$G_s+nG_s+ng_{gk}+n^2g_{gk}-g_{kg}-ng_{gk} = ng_m+nG_s \quad \ldots\ldots \quad (27)$$

Re-arrange terms and cancel where applicable:

$$n^2g_{gk} - ng_m + (G_s - g_{gk}) = 0 \quad \ldots\ldots\ldots\ldots \quad (28)$$

Solve this quadratic for n by the standard form:

$$n_1, n_2 = \frac{-b \pm \sqrt{(b^2 - 4ac)}}{2a} \quad \ldots\ldots\ldots\ldots \quad (29)$$

where $a = g_{gk}$

$b = -g_m$

$c = G_s - g_{gk} = G_k + g_{ak}$

$$n_1, n_2 = \frac{g_m \pm \sqrt{[g_m^2-4g_{gk}\,(G_k+g_{ak})]}}{2g_{gk}} \quad \ldots\ldots\ldots\ldots \quad (30)$$

For a physical oscillatory circuit this expression can be again considerably simplified, since in general $g_{gk} \ll G_s$. If such conditions hold, equation (22) reduces to:

$$C/L\,(g_m + G_s) = \omega^2C^2G_s \quad \ldots\ldots\ldots\ldots \quad (31)$$

$$\omega^2CL = \frac{g_m + G_s}{G_s} \quad \ldots\ldots\ldots\ldots\ldots \quad (32)$$

Substituting into equation (32) equation (25) for the term ω^2CL:

$$\frac{1+n}{n} = \frac{g_m + G_s}{G_s} \quad \ldots\ldots\ldots\ldots\ldots \quad (33)$$

$$1/n = \frac{g_m + G_s}{G_s} - 1 \quad \ldots\ldots\ldots\ldots \quad (34)$$

$$1/n = \frac{g_m + G_s - G_s}{G_s} \quad \ldots\ldots\ldots\ldots \quad (35)$$

by inversion from equation (35):

$$n = G_s/G_m \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (36)$$

Substituting finally equation (11) for G_s into equation (36):

$$n = \frac{g_{gk} + g_{ak} + G_k}{g_m} \quad \ldots\ldots\ldots\ldots \quad (37)$$

It is evident from equation (37) that for sustained oscillations the limiting value of transconductance:

$$g_m \geqslant \frac{g_{gk} + g_{ak} + G_k}{n} \quad \ldots\ldots\ldots\ldots \quad (38)$$

The Grounded Emitter Colpitts' Oscillator

The Admittance Matrix of the Common Emitter Transistor in Terms of Hybrid Parameters

It is convenient to use the readily available hybrid parameters of the transistor and then express the admittance matrix of the active two-port in terms of the h parameters. Here again the resistive and forward parameters are of interest. The reverse and reactive components will be combined with the external passive feedback network.

The grounded emitter connected transistor and the corresponding resistive model is shown in Figs 8(a) and 8(b).

The equilibrium equations for the unilateral resistive model shown in Fig. 8(b) are defined as:

$$V_1 = h_{11}I_1 + 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (39)$$

$$I_2 = h_{21}I_1 + h_{22}V_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (40)$$

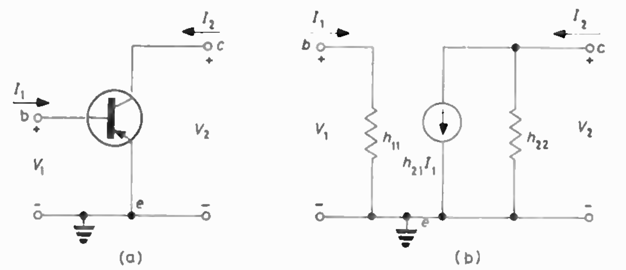

Fig. 8(a). The grounded emitter transistor
(b). Linear resistive model of the grounded emitter transistor if $h_{12} = 0$

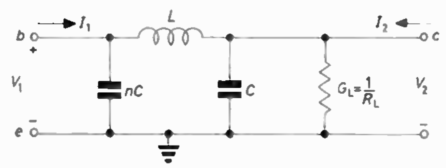

Fig. 9. π network equivalent of the feedback network

By simple algebraic manipulation the Y parameters can be obtained.

From equation (39) by transposition:

$$I_1 = (1/h_{11})\, V_1 + 0 \quad \ldots\ldots\ldots\ldots \quad (41)$$

Substituting equation (41) into equation (40) for I_1:

$$I_2 = (h_{21}/h_{11})\, V_1 + h_{22}\, V_2 \quad \ldots\ldots\ldots\ldots \quad (42)$$

Now from equations (41) and (42) the Y matrix of the transistor may be formed in terms of the h parameters:

$$[Y]_{\text{TRANSISTOR}} = \begin{bmatrix} 1/h_{11} & 0 \\ h_{21}/h_{11} & h_{22} \end{bmatrix} \ldots\ldots\ldots \quad (43)$$

Admittance Matrix of the External Feedback Two-Port

Reverting to Fig. 2, the physical circuit of the oscillator, it is easy to see that the elements L, C, nC and R_L may be redrawn as a π network shown in Fig. 9.

With reference to this network model, it will be assumed that the capacitors nC and C absorb the input and output capacitances of the transistor. The admittance matrix of the two-port model in Fig. 9 may be written down by inspection:

$$[Y]_{\text{NETWORK}} = \begin{bmatrix} npC+(1/PL) & -1/pL \\ -(1/pL) & G_L+pC+(1/pL) \end{bmatrix}$$

$$\ldots\ldots\ldots\ldots \quad (44)$$

Synthesis of the Oscillating System

By a process similar to the preceding thermionic valve example, the oscillating system will be synthesized by the parallel connexion of active and passive two-ports. The circuit configuration so obtained is shown in Fig. 10. An appropriate linear model may be drawn as in Fig. 11. Here again, mathematically, the oscillating system is completely described by the sum of the admittance matrices of the constituent two-ports.

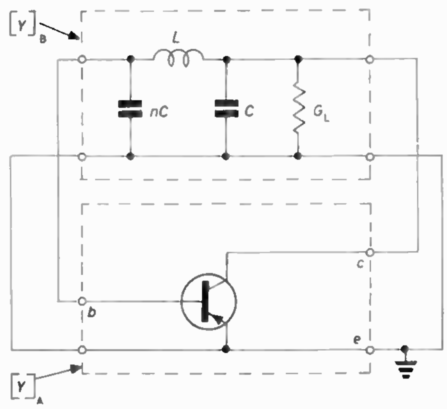

Fig. 10. The transistor grounded emitter Colpitts' oscillator

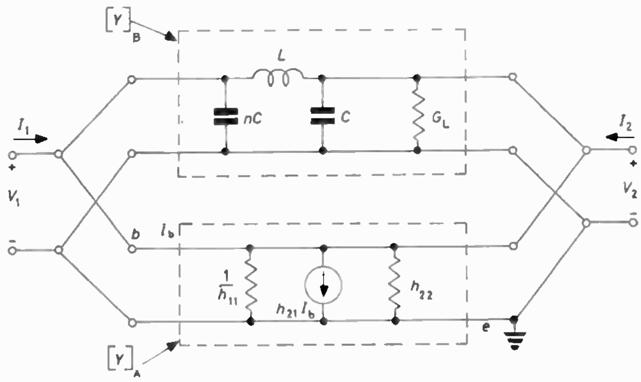

Fig. 11. Linear model of the transistor Colpitts' oscillator

Hence, adding equation (43) to equation (44):

$$[Y]_{\text{OSCILLATOR(CE)}} = \begin{bmatrix} npC+(1/pL)+(1/h_{11}) & -(1/pL) \\ -(1/pL)+(h_{21}/h_{11}) & pC+(1/pL)+G_L+h_{22} \end{bmatrix}$$

$$\ldots\ldots\ldots\ldots \quad (45)$$

It is convenient to put in the Y_{22} term: $G_o \equiv G_L + h_{22}$. That is combine the load conductance with the transistor output conductance. With this slight simplification the admittance matrix (45) may be rewritten:

$$[Y]_{\text{OSCILLATOR(CE)}} = \begin{bmatrix} \overbrace{npC+(1/pL)+(1/h_{11})}^{Y_{11}} & \overbrace{-(1/pL)}^{Y_{12}} \\ \underbrace{-(1/pL)+(h_{21}/h_{11})}_{Y_{21}} & \underbrace{G_o+(1/pL)+pC}_{Y_{22}} \end{bmatrix}$$

$$\ldots\ldots \quad (46)$$

By definition, for the condition of oscillations the determinant of the system matrix (46) must be equated to zero.

Thus from matrix (46):

$$|Y| = (npC+(1/pL)+(1/h_{11}))\ (G_o+pC+(1/pL)) - ((1/p^2L^2)-(h_{21}/h_{11}pL)) = 0 \quad (47)$$

Expanding the products:

$$|Y| = G_o npC+G_o(1/pL)+G_o(1/h_{11}) + np^2C^2+(C/L) + pC(1/h_{11}) + n(C/L) + (1/p^2L^2) + (1/h_{11}pL) - (1/p^2L^2) + (h_{21}/h_{11}pL) = 0 \quad (48)$$

Re-arranging equation (48) and cancelling identical terms with opposing algebraic signs:

$$|Y| = np^2C^2+(C/L)(n+1)+(G_o/h_{11})+pC((1/h_{11})+nG_o)+ 1/pL(G_o + (1/h_{11}) + (h_{21}/h_{11})) = 0 \quad (49)$$

Put $p = j\omega$ and then equate the real and imaginary parts of equation (49) separately to zero.

$$|Y|_{REAL} = -n\omega^2C^2 + (C/L)(n+1)+(G_o/h_{11}) = 0 \quad (50)$$

$$|Y|_{IMAGINARY} = j\omega C((1/h_{11}) + nG_o) + (1/j\omega L)(G_o + (1/h_{11}) + (h_{21}/h_{11})) = 0 \quad (51)$$

THE FREQUENCY OF OSCILLATIONS

Using equation (50) by transposition:

$$n\omega^2C^2 = (C/L)(n+1) + (G_o/h_{11}) \quad (52)$$

$$\omega^2 = \frac{n+1}{LCn} + \frac{G_o}{h_{11}nC^2} \quad (53)$$

$$\omega = \sqrt{\left(\frac{n+1}{LCn} + \frac{G_o}{h_{11}nC^2}\right)} \quad (54)$$

For a physical transistor oscillator the second term in equation (54) is generally negligible. Therefore for the purpose of engineering approximations, equation (54) reduces to:

$$\omega = \sqrt{\left(\frac{n+1}{LCn}\right)} \quad (55)$$

THE CONDITIONS OF OSCILLATION

Reverting to equation (51) and multiplying it through by $j\omega C$:

$$|Y|_{IMAGINARY} = -\omega^2C^2((1/h_{11}) + nG_o) + (C/L)(G_o + (1/h_{11}) + (h_{21}/h_{11})) = 0 \quad (56)$$

By transposition:

$$\omega^2LC = \frac{(G_o + (1/h_{11}) + (h_{21}/h_{11}))}{(1/h_{11}) + nG_o} \quad (57)$$

From equation (55):

$$\omega^2LC = \frac{n+1}{n} \quad (58)$$

Substituting now equation (58) for ω^2LC into equation (57):

$$\frac{n+1}{n} = \frac{(G_o + (1/h_{11}) + (h_{21}/h_{11}))}{(1/h_{11}) + nG_o} \quad (59)$$

Multiply through the numerator and denominator of the right-hand part by h_{11}:

$$\frac{n+1}{n} = \frac{h_{11}G_o + 1 + h_{21}}{1 + h_{11}nG_o} \quad (60)$$

Cross multiply:

$$(n+1)(1 + h_{11}nG_o) = nh_{11}G_o + n + nh_{21} \quad (61)$$

$$n+1+n^2h_{11}G_o+h_{11}nG_o = nh_{11}G_o+n+nh_{21} \quad (62)$$

Cancel similar terms and re-arrange equation (62):

$$n^2h_{11}G_o - nh_{21} + 1 = 0 \quad (63)$$

Solve equation (63) for n by the quadratic formula:

$$n_1, n_2 = \frac{-b \pm \sqrt{(b^2 - 4ac)}}{2a} \quad (64)$$

where

$$a = h_{11}G_o$$
$$b = -h_{21}$$
$$c = 1$$

$$n_1, n_2 = \frac{h_{21} \pm \sqrt{(h_{21}^2 - 4h_{11}G_o)}}{2h_{11}G_o} \quad (65)$$

Note that only positive values of n will yield a meaningful solution. The physical grounded emitter oscillators, generally $h_{21}^2 \gg 4h_{11}G_o$.

Consequently, for the purpose of engineering design, equation (65) simplifies to:

$$n = \frac{h_{21} + h_{21}}{2h_{11}G_o} = \frac{h_{21}}{h_{11}G_o} \quad (66)$$

By definitions:

$$h_{21} \equiv \beta = \text{Forward current gain}$$
$$G_o \equiv h_{22} + G_L = h_{22} + (1/R_L)$$

Therefore when substituting these identities into equation (66) the limiting value of n:

$$n = \frac{\beta}{h_{11}(h_{22} + (1/R_L))} \quad (67)$$

It is evident from equation (67) that for sustained oscillations the limiting magnitude of β:

$$\beta \geqq nh_{11}(h_{22} + (1/R_L)) \quad (68)$$

Conclusion

The Colpitts' oscillator has been studied with generalized matrix algebra. Typical valve and transistor oscillatory systems have been reduced to parallel connected active and passive two-ports. The frequency and the conditions of oscillations have been obtained in terms of electrical parameters which are suitable for circuit design.

Acknowledgment

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Tunable Filter for Low Frequencies Using Operational Amplifiers

By H. Sutcliffe*, M.A., M.I.E.E.

The design of tunable narrow band filters for frequencies down to 0·1c/s, using active elements and RC networks, is complicated by the requirements of trimming and ganging. A principle is described whereby the difficulties are overcome and a method is given for obtaining a 'constant Q' filter equivalent to a critically coupled pair. The design of the associated operational amplifiers, using transistors, forms a substantial part of the article. Details are given of a filter suitable for the frequency range 1 to 1 000c/s.

(Voir page 429 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 438)

THE audio range of frequency is well served with instruments of all types, including tunable filters as parts of wave analysers, and it is not suggested that the circuit described here is likely to supplant existing audio techniques. The circuit is suitable rather for the lower range of frequencies, 0·1c/s to 1kc/s, associated with mechanical vibrations, flicker noise and the response of control systems to random fluctuations[1,2,3].

The design of the tunable filter evolved from the following considerations. At these low frequencies it is essential to use active components associated with resistance-capacitance networks[4]. Transistors are preferred to valves for the active components in view of the greater economy in power consumption, but the variability of transistor characteristics is so great that the operation of the active sections of the circuit must be rendered precise by a large amount of feedback. The low frequencies of operation, combined with the decision to use transistors, restricts the circuit inter-connexions to those of the directly connected type, since conventional *CR* coupling circuits would call for impracticably large capacitors. The frequency response will be determined by *CR* time-constants, and these will inevitably call for components large in volume yet nevertheless precisely adjustable. The variation or adjustment of large capacitors is not practicable, so the requirements of ganging and trimming, and the use of the same engraved scale with change of frequency range, must be satisfied by simple pre-set adjustment of resistors only. A useful feature claimed for the circuit is that capacitors of precise value are not necessary.

It was also considered desirable that the frequency and bandwidth controls should be continuously variable, the gain should be independent of frequency setting, and the amplitude-frequency response should be as square as possible. This latter requirement is adequately met by the equivalent of a pair of critically coupled resonant circuits.

All these points were considered and the conclusion was reached that a suitable design would consist of a number of operational amplifiers inter-connected by capacitors and resistors. Several types of inter-connexion were considered and the most promising of these was chosen for a detailed study. This particular circuit arrangement, and some features of a practical instrument embodying the circuit principles, are described in the following sections.

Basic Circuit

Although in fact the ganging, trimming and range-changing requirements dominated the choice of basic circuit, the basic arrangement will be described in the first place with the assumption that all the components are perfect. Thus it will be assumed that capacitances labelled C and resistances labelled R in the figures are identical, and that the operational amplifiers have infinite p.d. and current amplification.

It is convenient to consider first the circuit shown in Fig. 1, which will be called a single tuned circuit. If capacitor C_d was absent the circuit would oscillate, because

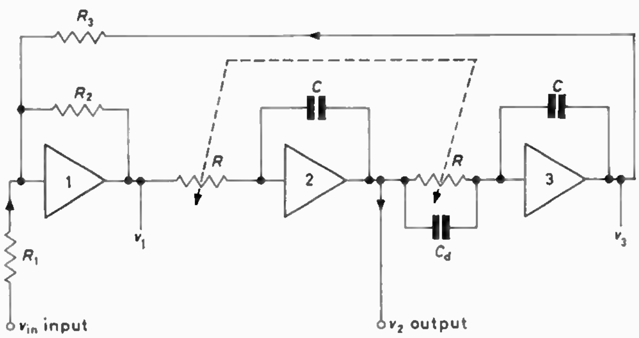

Fig. 1. Single tuned circuit

If $R_1 = R_2 = R_3$, the phasor response is:

$$V_2/V_{in} = \frac{Q}{1 + jQ(\omega/\omega_0 - \omega_0/\omega)} \quad \text{where } Q = C/C_d,\ \omega_0 = 1/CR$$

each integrator introduces a phase change of 90°. The circuit is stable in the presence of C_d, with a peak in the frequency response. The phasor response may be derived in a particularly simple form if it is assumed that R_1, R_2 and R_3 are equal. Then the operational amplifiers impose the following three relations:

$$\mathbf{V}_1 = -\mathbf{V}_3 - \mathbf{V}_{in},\ j\omega C\mathbf{V}_2 = -\mathbf{V}_1/R,\ j\omega C\mathbf{V}_3 = -\mathbf{V}_2\,(j\omega C_d + 1/R).$$

To find the response, $\mathbf{V}_1$ and $\mathbf{V}_3$ are eliminated.

$$\mathbf{V}_2/\mathbf{V}_{in} = \frac{C/C_d}{1 + j\,(C/C_d)\,(\omega CR - 1/\omega CR)} \quad \ldots\ldots (1)$$

It is customary with equations of this type to introduce parameters ω_0, $f_0 = \omega_0/2\pi$, and Q, related to the component values as follows:

$$\omega_0 = 1/CR,\ Q = C/C_d \quad \ldots\ldots\ldots\ldots (2)$$

Expression (1) then appears in the familiar form usually associated with resonant LC circuits.

$$\mathbf{V}_2/\mathbf{V}_{in} = \frac{Q}{1 + jQ\,(\omega/\omega_0 - \omega_0/\omega)} \quad \ldots\ldots\ldots\ldots (3)$$

It is, of course, equally correct to introduce frequency f, f_0 in place of the angular frequency ω, ω_0.

The peak of the response is at frequency f_0, determined by the CR product, so it is convenient to use ganged re-

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sistors to vary R through a range of rather more than ten to one, to cover a decade of frequency. Decade range changing is achieved by switching capacitors. The adjustment of selectivity or Q is obtained by varying the effective value of the component shown as C_d in Fig. 1. Continuous variation of a capacitor is impractical and the circuit illustrated in Fig. 2 is used. A potential divider, the 'Q control', feeds a fixed capacitor C_a through an emitter-follower. The input terminal of amplifier number 3 is a virtual earth, so the input current from C_a is $xC_a(dv_2/dt)$. Capacitance C_d would supply input current $C_d(dv_2/dt)$, so the circuit of Fig. 2 is equivalent to capacitance $C_d = xC_a$. It follows that the setting of the potential divider provides a means of adjusting the value of Q. If $C_a = 0{\cdot}1C$, the value of Q goes from 10 to infinity as the ratio x is reduced from 1 to 0. A useful feature of the arrangement is that the controls of Q and f_o are independent.

The size of the components is a matter of some interest in view of the low frequency requirement, and these are determined by the nature of available ganged resistors.

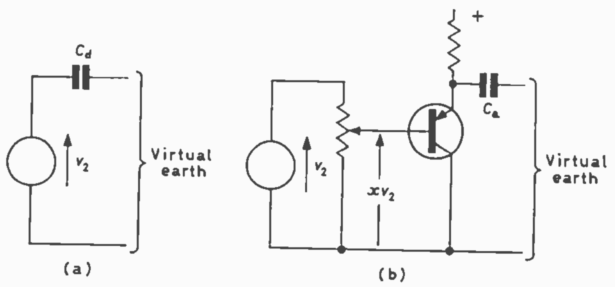


Fig. 2(a). Equivalent circuit associated with C_d in Fig. 1
(b). Circuit for obtaining a continuously variable equivalent of C_d, $C_d = xC_a$

It appears that the economic maximum resistance of ganged variable wire-wound resistors is $100\text{k}\Omega$, so if a frequency $f_o = 1\text{c/s}$ is to be available the value of $C(= 1/2\pi f_o R)$ would be $1{\cdot}59\mu\text{F}$. Operation at $0{\cdot}1\text{c/s}$ would require $15{\cdot}9\mu\text{F}$, and so on. Precise components of this magnitude are not readily available, so a modification of the basic circuit is sought to obtain an equivalent performance from capacitors of smaller size and to provide a method of precise adjustment of the frequency. The second requirement could be satisfied by the technique already described, and illustrated in Fig. 2, but this calls for larger rather than smaller capacitors. A more convenient modification is to change the loop amplification as a whole, by adjustment of the relative values of R_2 and R_3 in Fig. 1. This changes the amplification associated with amplifier 1 from unity to some value β. Then it can be shown that the value of ω_o in equation (3) is no longer $1/CR$ but is now $\beta^{\frac{1}{2}}/CR$. Thus, if $\beta = 0{\cdot}25$ the values of the capacitors can be one half of the original estimate.

In practice, the two capacitors shown as C in Fig. 1 will have different values, say C' and C'' and the resistors R will be R' and R'', not exactly equal. Further, the signal amplification may be adjustable by means of the ratio R_2/R_1 in Fig. 1, as well as the loop amplification. At this stage in the discussion the circuit response can no longer be described in the simple form given in expressions (1), (2) and (3) but must include the effects of the modification and imprecise values of components, as follows.

$$\mathbf{V}_1 = -(\alpha\mathbf{V}_{in} + \beta\mathbf{V}_3),\ \mathbf{V}_2 = -\mathbf{V}_1/j\omega C'R',$$

$$\mathbf{V}_3 = -\mathbf{V}_2\left[(xC_a/C'') + \frac{1}{j\omega C''R''}\right] \qquad (4)$$

i.e.:

$$\mathbf{V}_2/\mathbf{V}_{in} = \frac{\mu}{1 + jQ(\omega/\omega_o - \omega_o/\omega)} \qquad (5)$$

where

$$\omega_o = (\beta/C'R'C''R'')^{\frac{1}{2}} \qquad (6)$$

$$Q = C''/xC_a\,[C'R'/\beta C''R'']^{\frac{1}{2}} \qquad (7)$$

$$\mu = \alpha C''/\beta xC_a \qquad (8)$$

It will be recalled that parameters α, β, x in these equations are adjustable, by variation of pre-set resistors, so the circuit can be set to precise values of signal amplification μ, selectivity factor Q, and to a correct frequency calibration.

It has already been noted that C_a, C' and C'' may differ appreciably from their nominal values, so the adjustment of parameters α, β and x will differ for each decade of frequency coverage. This results in a proliferation of adjustable resistors, switched by the frequency range switch—but the adjustable resistors can be of a relatively inexpensive type.

Several points of interest arise from equations (6), (7) and (8). Firstly, it is apparent that the ganged tuning resistors need not be exactly equal, but if constant Q is to be maintained throughout a decade of frequency their *ratio* must be constant. The constancy of amplification μ does not rely even on this modest requirement. A further point relates to the setting-up procedure. Adjustment of ω_o, Q and μ should be made in sequence, otherwise the interaction of parameters x and β in equation (7) and α, β and x in equation (8) would lead to confusion. Thus the procedure is: set ω_o by β, then Q by x, then μ by α. A front-panel control, calibrated in Q, can be provided by a modification to the circuit of Fig. 2(b). The potential divider shown in the figure is the calibrated control, while preset resistors are switched in series at the top end by the decade frequency range switch. The smallest Q, largest x, setting is used in the setting-up procedure if the greatest accuracy is required.

To summarize the circuit description so far, it has been shown that the group of three operational amplifiers in Fig. 1 can provide a response of the form given in expression (5), and the frequency calibration, Q factor and amplification are capable of precise adjustment. Such a circuit has attenuation, at frequencies remote from the pass-band, of only 20dB/decade, which is inadequate for many investigations. It was felt that 40dB/decade was acceptable, and this can be provided by two such circuits simply in cascade. Such an arrangement requires a four-ganged set of variable resistors for tuning, and was found to be quite practicable. Greater versatility can be provided by coupling the two circuits together, by overall feedback as shown in Fig. 3. Then if the amount of feedback is of the correct value to give critical coupling the arrangement provides a flat-topped band-pass characteristic.

Coupled Pair of Circuits

The arrangement in its basic form is illustrated in Fig. 3. Without feedback, the response would be of the form:

$$\mathbf{V}_o/\mathbf{V}_{in} = \frac{\mu^2}{[1 + jQ\phi(f)]^2},\ \text{where } \phi(f) = f/f_o - f_o/f \qquad (9)$$

Assuming that $R_4 = R_1$, for simplicity of explanation, then the response with feedback is given by:

$$\mathbf{V}_o = \frac{(\mathbf{V}_{in} - K\mathbf{V}_o)\mu^2}{[1 + jQ\phi(f)]^2} \qquad (10)$$

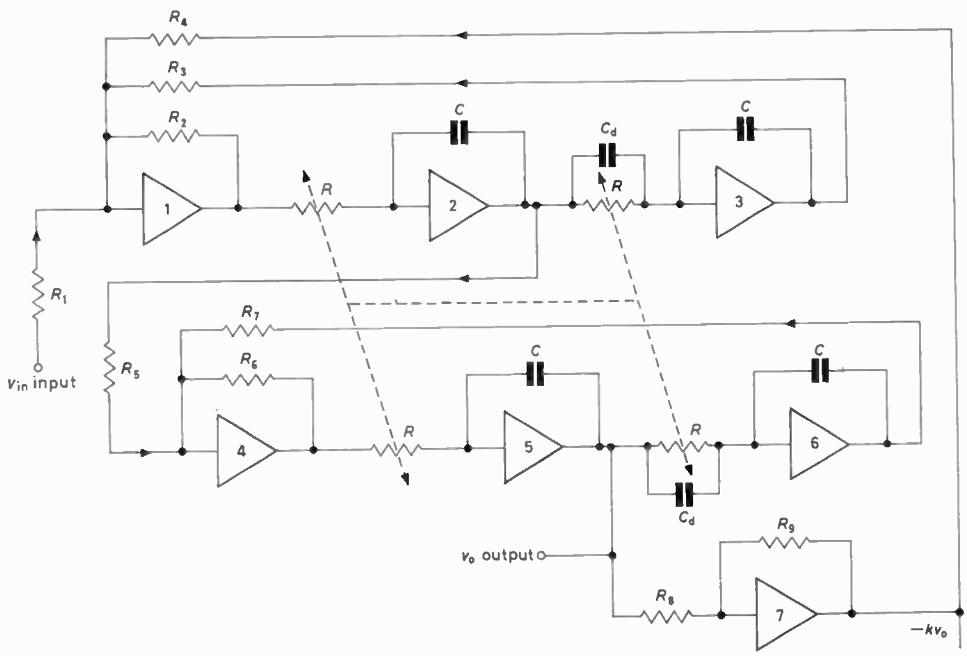


Fig. 3. Two single tuned circuits in cascade with overall feedback, forming a coupled pair

i.e.:

$$\mathbf{V}_o/\mathbf{V}_{in} = \frac{\mu^2}{[1 + jQ\phi(f)]^2 + K\mu^2} \quad \ldots\ldots\ldots\ldots (11)$$

Critical coupling is obtained by setting K to give $K\mu^2 = 1$. Then the amplitude response is given by:

$$V_o/V_{in} = \mu^2/2\,[1 + a^4/4]^{-\frac{1}{2}},\ \text{where}\ a = Q\phi(f) \quad \ldots\ldots (12)$$

This response is flat topped, with the 3dB bandwidth equal to $\sqrt{2}\,.\,f_o/Q$. No approximation has been made in deriving these results, but it is often useful to remember the approximate relation for the unwieldy function $\phi(f)$. For frequencies close to the resonant frequency f_o, $\phi(f) \simeq 2\,(f - f_o)/f_o$.

Operational Amplifiers

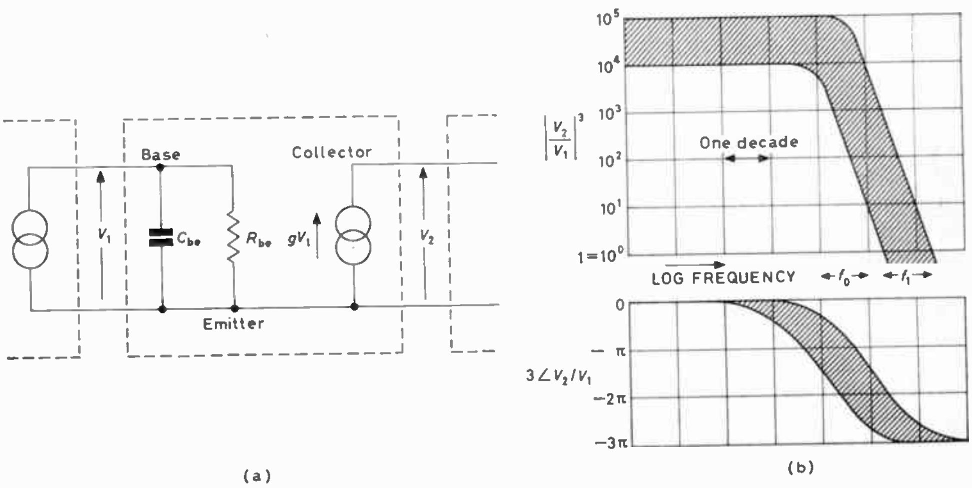
These amplifiers must have adequately large p.d. and current amplification if the performance of the instrument is not to deviate appreciably from the idealized response given by equation (11). An exact analysis is rather unwieldy, because imperfections in the amplifiers are partially compensated by the setting-up procedure, so the following arguments were used to form a basis for the amplifier design.

The components R, C, etc. in Fig. 3 will play the major part in determining the accuracy of the instrument, and will themselves vary with age and temperature by 1 per cent or so. It seems reasonable therefore, to permit the amplifiers to modify circuit behaviour by 0·1 per cent. This suggests that 60dB is adequate for the p.d. amplification, since the p.d. across a feedback component will then be within 0·1 per cent of the p.d. at the output terminals of the corresponding amplifier. A typical magnitude of feedback impedance is 100kΩ and will then present, at the input terminals of the amplifier, an effective impedance of 100Ω. It follows that the amplifier input impedance should be not less than 1 000 times this value, and should therefore be at least 100kΩ.

The amplifiers must produce a reversal of sense, will be directly connected, and should accommodate signals that make symmetrical excursions about the common earth line. It is fairly obvious that the heart of the amplifier will be a cascade connexion of three transistors in the common emitter configuration, that any such simple arrangement will be unstable when the feedback loop is complete, and that the problem of stabilizing the loop will be the major influence in the detailed design of the amplifier. The basic problem is illustrated in Fig. 4, which shows a simplified equivalent circuit of a single transistor stage and the frequency response of three such stages in cascade. The response is of the form $A^3/(1 + \mathrm{j}\,f/f_o)^3$, where $A = gR_{be}$ and $f_o = 1/2\pi C_{be}R_{be}$. The values of f_o will depend on the type of transistor used, and one will have to pay more for a large f_o. The shaded areas indicate the spread that may be expected with changes of transistor characteristics from sample to sample and at differing current levels. In passing it can be mentioned that it is not sufficient to achieve stability only under small signal conditions. A circuit is required to be stable throughout a period of a signal large enough to saturate the amplifier.

Fig. 4 shows that the phase change at unit gain is in excess of 180°, so the circuit will oscillate unless stabilizing networks are added. Phase advance networks for the frequency region about f_1 cannot be applied because of

Fig. 4(a). Simplified equivalent circuit of one stage
(b). Loop response of three stages, showing typical spread



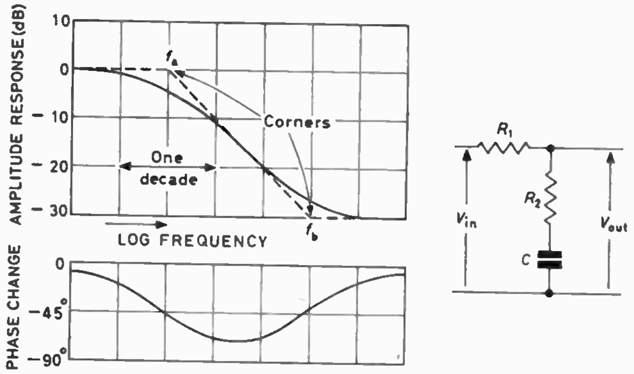


Fig. 5. Transitional lag for 30dB attenuation $R_1 = 29R_2$
Corner frequencies
$f_a = 1/2\pi C/(R_1 + R_2)$
$f_b = 1/2\pi CR_2$

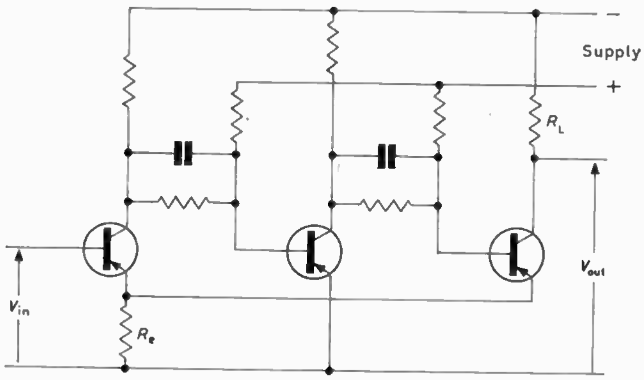


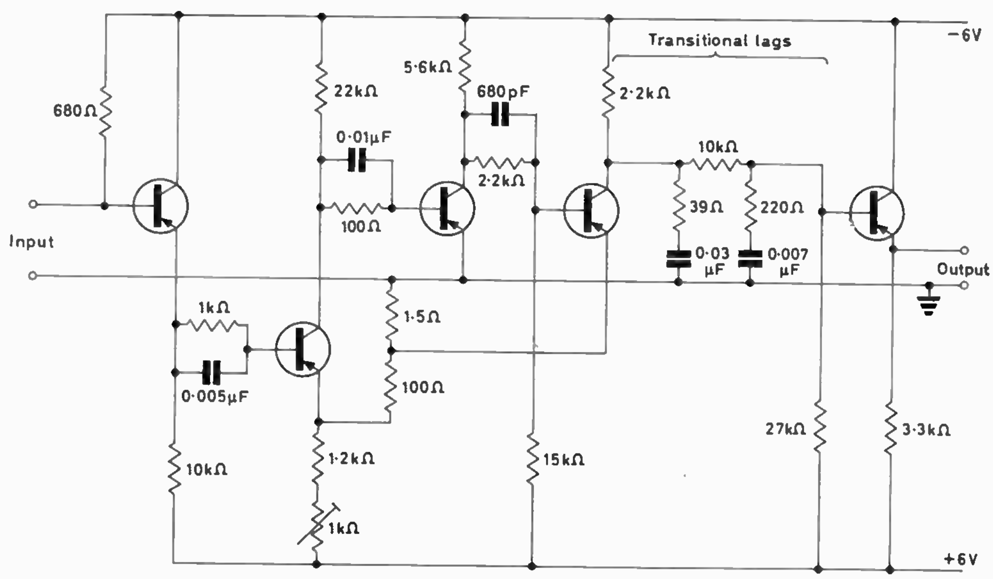
Fig. 6. Internal feedback gives almost precise amplification
$V_{out}/V_{in} \simeq -R_L/R_e$

the unpredictable nature of the response with different samples of a type of transistor. It would be possible to use the 'dominant lag' technique, but this requires a decade of frequency for every 20dB of attenuation and so would call for transistors whose current gain remained almost constant up to one thousand times the highest signal frequency. It was decided that the best solution would be to use two 'transitional lag' circuits, with equal corner frequencies, each giving 30dB attenuation[5,6]. The response of one such circuit is shown in Fig. 5(a), and a method of realizing this response is shown in Fig. 5(b). Two such circuits in cascade introduce 60dB attenuation with less than 180° phase lag, reverting to zero phase lag at high frequencies. If the low frequency gain of the original amplifier was 60dB the transitional lags would give a stable circuit, provided that their frequency range was safely below the corner frequency of the original circuit. In view of the spread in transistor characteristics it is necessary to modify the original circuit to ensure that the low frequency gain is in fact, close to 60dB as required by the stabilizing circuit. There is, fortunately, a very simple way of achieving this, by the method illustrated in Fig. 6. A detailed analysis confirms the following conclusions. The feedback loop via the resistance R_e, common to both first and third transistors, ensures that the signal p.d. between base and emitter of the first transistor is negligibly small at low frequencies where gain is large. Then the transconductance into R_L is very close to $1/R_e$, the p.d. amplification is R_L/R_e and can be set to 10^3 by resistance values such as 1Ω and 1kΩ. There is no difficulty over the stability of the internal feedback loop because the loop gain is moderate and involves only two common emitter stages.

The instrument as a whole was required to operate at frequencies up to 1kc/s so the lower corner frequency of the transitional lags should be above 1kc/s. Suppose it is decided to allow a moderate amount of gain reduction and choose the lower corner frequency half a decade above 1kc/s, at approximately 3kc/s. Thus the upper corner frequency of the transitional lags is at 100kc/s, and in the next half decade of frequency the loop amplification will have fallen almost to the critical value of unity. At this frequency the worst sample of the type of transistor chosen should still not have departed appreciably from its low frequency gain and phase shift in the common emitter configuration, Audio frequency transistors are not good enough; it is essential to use a 'radio frequency' type in spite of the fact that the signal bandwidth extends to only 1kc/s.

Two considerations remain before the final basic arrangement of the amplifier is settled. Firstly, the transitional lags require a high impedance load, so it will be convenient to add a transistor in the common collector configuration to provide the high input impedance. This fourth transistor can best be situated at the output end of the amplifier where it will provide a low output impedance. And finally, the input impedance of the amplifier as described so far is inadequately large. So a fifth transistor, also in the common emitter configuration, is added

Fig. 7. Arrangement of operational amplifier, 0-1kc/s
All transistors OC44



at the input end and serves also to play a part in the datum-setting arrangements.

The circuit illustrated in Fig. 7 evolved after a considerable amount of theoretical and experimental work and seven such amplifiers were built for inclusion in the circuit shown in Fig. 3. All proved to have adequate margins of performance at signal frequencies and adequate stability. But it is clear that transistors are not really very satisfactory devices for this type of application; a better amplifier could probably be made using one pentode valve and a cathode-follower. Transistors were employed because the particular application required the use of batteries.

A Particular Instrument

An instrument was designed and constructed using the principles outlined in the previous section. The main tuning control was a four-gang variable resistor, each section having a nominal maximum value of 100kΩ. Series pre-set resistors were adjusted to make the full swing of the variable resistors vary the total resistance through a ratio of rather more than ten to one, with a 10 per cent excess of ratio at each end to allow overlap of the frequency coverage when the range is switched. Three ranges were provided, 1 to 10, 10 to 100 and 100 to 1 000c/s, using nominal values 2μF, 0·2μF and 0·02μF for capacitors C in Fig. 3. Capacitance C_a in Fig. 2(b) was one-tenth of these values.

A function switch was provided to allow the use of either a single tuned stage, or two tuned stages in cascade, or two tuned stages coupled together with critical coupling if desired.

Performance

Extensive tests were made on the instrument and, as was expected, the deviation from the theoretical performance was such as could be attributed either to errors in the setting-up procedure or mechanical faults in the ganged resistors. These components were of a quite inexpensive type, approximately 2in in diameter, and exhibited some degree of backlash and mechanical distortion. Even so, it was possible to maintain the values of frequency, Q-factor, and amplification to within 2 per cent of the values indicated on the front panel of the instrument.

Freedom from instability is a matter of concern in a circuit containing a total of 420dB amplification, and it was a relief to find that no difficulties were encountered when the complete circuit was assembled. The circuit remained stable even with artificial internal battery resistance sufficient to drop the voltage from 6 to 5V. Surprisingly, apparently perfect performance was obtained even with the common battery lead disconnected.

The instrument has been used extensively in noise investigations during the past nine months or so, and has proved to be accurate, reliable and convenient. These properties are due to the work of Mr. E. S. Tay and Mr. T. R. N. Walford, who executed the analysis and design of the instrument as an undergraduate thesis topic in the Department of Electrical Engineering at Bristol University.

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Developments in H.F. Transmitting Equipment

The Marconi Co. Ltd has announced details of a new range of h.f. transmitting equipment for high grade point-to-point telecommunications. Known as the MST (Marconi self-tuning) transmitting system, the range covers all the equipment needed for a large modern transmitting station which can be entirely controlled by one man from a central control room. The running costs, with this new type of equipment, are reduced by a very considerable factor, and the equipment is such that capital costs and space requirements are also cut, the transmitters being only one-fifth the size of previous designs.

Some three years ago Marconi development engineers were set the task of providing an entirely new h.f. transmitting system, which would drastically reduce capital and running costs while providing reliability and stability of the highest order. Recent technical advances made this possible and today the MST system can provide a transmitting station of any size which requires only a single operator and a fraction of the maintenance staff employed in a comparable station using conventional techniques. The transmitters are suitable for unattended operation and use semiconductors throughout, except in the higher power r.f. stages. The need for moving parts has been eliminated in all but the final output stage, by the use of wideband distributed amplifiers.

The drive equipment provides all types of modulation used in h.f. communications and includes frequency synthesizers giving a choice of over 250 000 operating frequencies with a very much better accuracy and stability than crystal oscillators.

Most of the units making up the MST system have been designed to be compatible with existing equipment in order that they may be introduced individually into existing systems during progressive stages of modernization.

Up to the final stage, the system employs wideband distributed amplifiers which require no tuning whatsoever. The final stage is self-tuned by a frequency-following servo system and the aerial feeder system uses wideband matching transformers. Consequently, the only operation required in making a frequency change is the setting of decade dials on a frequency synthesizer unit. This enables one man to maintain full operational control of a complete station from line inputs to final radiation, and makes it possible for him to change frequency in as little as 20sec.

By using a wideband system the number of stages in a transmitting channel is considerably reduced. Developments in insulating materials, dielectrics and semiconductor rectifiers have made power supply components much smaller, which enables them to be mounted in the transmitter units.

The reliability of the equipment has been greatly improved by the use of distributed amplifier techniques in which a single valve failure will not cause a complete system breakdown. The risk of mechanical failure is also considerably reduced because there are no tuned circuits which employ moving parts, except in the final output stages, and it has been possible to use precision engineering techniques to ensure the highest mechanical reliability of this stage. With previous designs, the number of mechanically tuned stages was so great that it would have been prohibitively expensive to apply these techniques throughout. The number of maintenance technicians required to keep a station operating is therefore reduced considerably and in many cases it will only be necessary for a single maintenance shift to be employed for routine servicing work. The use of semiconductor devices in the power supplies and control circuits has enabled overall electrical efficiency to be improved, and running costs reduced by as much as 25 per cent.

Flexibility is also an important feature of the MST system. The comprehensive modulator unit will provide any type of modulation and, with the extensive patching facilities and remotely controlled aerial exchange, enable any transmitter or any drive channel to be used for any type of service, with a consequent reduction in the number of standby transmitters and drives needed for emergency or duplicated working.

A Logarithmic Time-Base

By R. N. Alcock*, M.A., M.Sc.

The design of a passive logarithmic function generating network is described. A step voltage is applied to the input and the output increases with the logarithm of time. The network consists of a number of integrators with differing time-constants. The time range for logarithmic operation increases with the number of integrators. An experimental one-shot time-base was constructed which operated between 22msec and 30sec to an accuracy of 2 per cent.

(Voir page 429 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 438)

A LOGARITHMIC time-base generates a voltage which is proportional to the logarithm of time over a limited range. Since the logarithm of small quantities tends to negative infinity the lower limit to the range of logarithmic operation must be a small, finite time.

A logarithmic time-base provides the horizontal deflexion for an oscilloscope when time dependent quantities must be observed in a single sweep over a wide range of time. An example is the measurement of the width of an unknown pulse which may vary between 0·1μsec and 10μsec. If the pulse were to trigger a calibrated logarithmic time-base the pulse width may be determined immediately, avoiding the selection of a suitable linear time-scale. Another example is the provision of a continuous record of a transient current over many decades of time, which may be the requirement of certain semiconductor measurements.

In the time-base to be described a voltage step is generated by a triggered multivibrator and passes into a passive network of resistors and capacitors. This network is a form of low-pass filter or integrator from which the output voltage varies as the logarithm of time. The network is of a simple design and may operate over an extremely wide range of time. A single-shot time-base was constructed and used to measure transient currents in a semiconductor[1].

The Logarithmic Function Generating Network

The network is shown in Fig. 1 and consists of a number of resistance-capacitance integrating networks with differing time-constants. The integrators have a common input and the outputs are added in a resistive network. If a step voltage, V_0, is applied to a single integrating circuit (Fig. 2) the voltage developed across the capacitor is given by:

$$V = V_0(1 - e^{-t/RC}) \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where

R is the resistance and C the capacitance.

If $t = RC$ $\quad V_0 = V_0(1 - (1/e)) \ldots. \quad (2)$

If $t \gg RC$ $\quad V = V_0 \ldots\ldots\ldots\ldots\ldots \quad (3)$

If $t \ll RC$ $\quad V = V_0 t/RC \ldots\ldots\ldots \quad (4)$

Consider now a number of these circuits with respective time-constants RC, nRC, n^2RC, n^3RC, etc. where n is a constant, normally greater than 2. A step voltage V_0 is applied to each of these networks and the voltages developed across each of the capacitors are shown in Table 1 at various times after the step. The sum of these voltages is also tabulated and all voltages are expressed as fractions of V_0. It is assumed that n is much greater than unity so that the expressions (3) and (4) are valid.

It is seen that, as the time increases by factors of n the output voltage increases in steps of V_0 provided that n is much greater than unity. The voltage is then proportional to the logarithm of time and the form of the relation is derived from Table 2.

$$(V/V_0) - 1 + (1/e) = \frac{\log(t/RC)}{\log n} \quad \ldots\ldots\ldots (5)$$

$$\text{or } (V/V_0) - 1 + (1/e) = \log_n (t/RC) \quad \ldots\ldots (6)$$

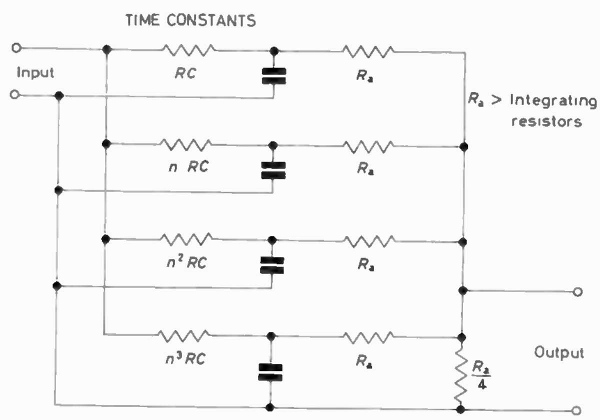


Fig. 1. Logarithmic function generating circuit

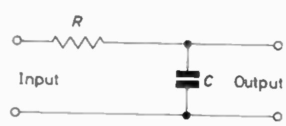


Fig. 2. RC integrating circuit

TABLE 1

TIME, t:	RC	nRC	n^2RC	n^3RC	----
Time-Constant of Integrator					
RC	$1-\frac{1}{e}$	1	1	1	
nRC	$\frac{1}{n}$	$1-\frac{1}{e}$	1	1	
n^2RC	$\frac{1}{n^2}$	$\frac{1}{n}$	$1-\frac{1}{e}$	1	
n^3RC	$\frac{1}{n^3}$	$\frac{1}{n^2}$	$\frac{1}{n}$	$1-\frac{1}{e}$	
⋮					
Added Output	$1-\frac{1}{e}+\frac{1}{n}+\frac{1}{n^2}+\frac{1}{n^3}$	$2-\frac{1}{e}+\frac{1}{n}+\frac{1}{n^2}$	$3-\frac{1}{e}+\frac{1}{n}$	$4-\frac{1}{e}$	

* *Mullard Research Laboratories.*

TABLE 2

$\frac{t}{RC}$	1	n	n^2	n^3	----
$\log \frac{t}{RC}$	0	$\log n$	$2 \log n$	$3 \log n$	
$\frac{V}{V_0}$	$1-\frac{1}{e}$	$2-\frac{1}{e}$	$3-\frac{1}{e}$	$4-\frac{1}{e}$	

If n is not considerably greater than unity the voltage contribution from the slowest integrator is reduced by a significant factor of $1/n$ and the range of accurate logarithmic operation is reduced.

The outputs are added resistively and, if there are p integrators, each output is attenuated by $1/p$ with the same reduction in the added output. The series adding resistors must exceed the integrating resistors to prevent changes in the integrator time-constants.

The Experimental Time-base

Performance of the Network

A network was constructed using seven integrators with time-constants ranging from 30msec to 30sec. n was made equal to $\sqrt{10}$, which by substitution in equation (5) gave a relation:

$$(V/V_0) - 1 + (1/e) = 2 \log (t/RC)$$

The output was observed to obey this relation between about 30msec and 30sec. The accuracy of the law was about 5 per cent using 10 per cent tolerance components and was improved by slight adjustments to the series adding resistors (all originally 1MΩ). If the output voltage was either high or low at a particular time it was corrected by adjusting the adding resistor from the integrator with a similar time-constant. The accuracy was improved in this manner to 2 per cent, still using 10 per cent tolerance components.

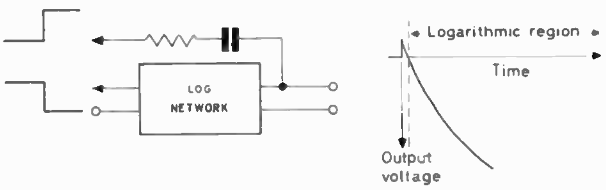
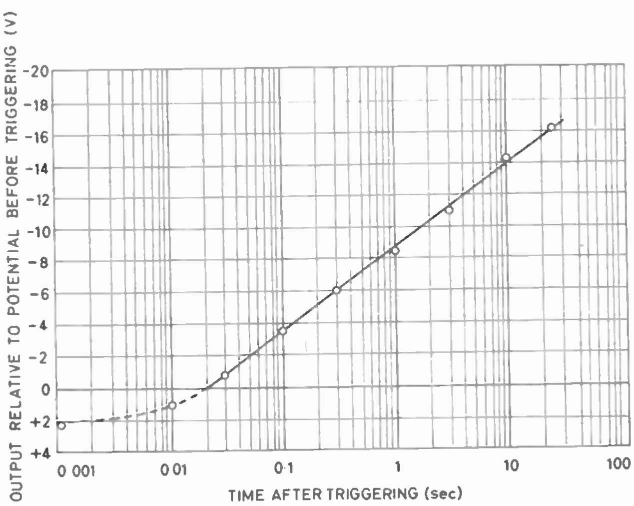


Fig. 3 (above). Modified logarithmic function generating circuit

Fig. 4 (below). Output of the logarithmic time-base



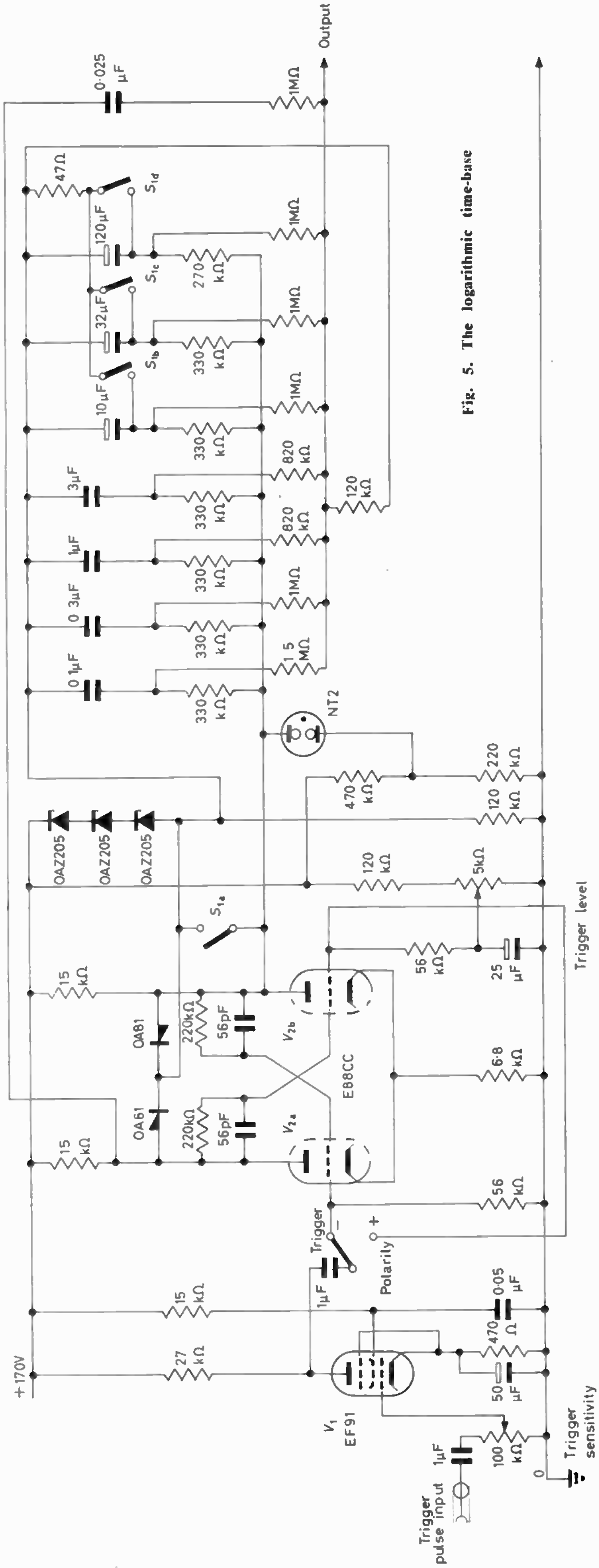


Fig. 5. The logarithmic time-base

A modification was added to eliminate the initial linear voltage rise of the fastest integrator and to ensure that, after the time-base had triggered, the output increased from zero in a logarithmic fashion. The variation of output voltage with time is shown in Fig. 4.

The modification, shown in Fig. 3, consisted of a differentiating circuit which by-passed the main network and was fed from a step voltage of opposite polarity to that of the main network. The time-constant of the differentiator was similar to that of the fastest integrator and provided a voltage spike which added to the main output but was of the opposite polarity. After a negative step was applied to the main network the output became slightly positive and then swung negative to begin the main sweep. The voltage passed through zero 22msec after the arrival of the step and the components of the differentiator were adjusted to provide the correct logarithmic law between 22msec and 30msec.

The Triggering Circuit

The complete time-base is shown in Fig. 5. A bistable multivibrator, V_2 is directly coupled to the function generating network. The bistable circuit is reset so that V_{2a} conducts and V_{2b} is cut off. A trigger pulse is amplified by V_1 and applied to the appropriate grid of V_2, depending on its polarity. The anode potential of V_{2a} rises and that of V_{2b} falls, providing positive and negative steps of equal magnitude which pass into the network.

In order to ensure that the voltage across the network is initially zero, one side is connected to a Zener diode stabilized potential of -22V below h.t. A catching diode on the anode of V_{2b} ensures that it is also initially at this potential. V_{2b} did not completely cut off in the initial condition and, in the absence of the diode, the potential of the anode of V_{2b} was between -5 and -15V below h.t. After V_2 has been triggered a catching diode on the anode of V_{2a} ensures that the amplitude of the positive step equals that of the negative step.

The circuit is reset by connecting the anode of V_{2b} to the standard voltage and, since some of the larger integrating capacitors take several seconds to lose their charge, three of them are discharged through a low resistance. A neon bulb indicates when the time-base is reset.

Conclusions

The design of a logarithmic function generating network using integrators has been described. On the application of a step voltage to the network the output increased with time in a logarithmic fashion over a certain time range. This time range increased with the number of integrators and its lower limit was of the order of the rise-time of the step voltage. The circuit might be expected to operate down to 0·1μsec.

A time-base was constructed with seven integrators which operated between 22msec and 30sec with an accuracy of 2 per cent. The calibration was relatively simple since the voltage rose from zero 22msec after triggering and the rate of rise in volts per decade of time was known. The time-base triggered once and was reset manually.

REFERENCE

1. Alcock, R. N. The Induced Conductivity of Arsenic Sulphide under Beta Ray Bombardment. M.Sc. Thesis. (London, 1962).

A Quartz Growing Plant

A new process that enables large quartz crystals to be grown in only 21 days—against Nature's 3 000 000 years— is being brought into operation at Harlow, Essex by Standard Telephones and Cables Ltd.

STC's recently opened £1M. crystal factory, which makes well over half Britain's output, is to introduce the new quartz crystals alongside imported natural quartz in its processing lines. As the new 'home grown' quartz becomes more established in manufactured units it will enable the Company to maintain and improve its competitive position in this market.

About 900 men and women are employed by STC on quartz processing and crystal filter manufacture. Total output is close to a million devices per year—over 20 per cent of Europe's total.

The cultured quartz plant is a self-contained facility separate from the main factory. This is the first commercial quartz growing plant in Europe and it is already producing large pieces of radio-grade quartz for the manufacture of crystal units for frequency control purposes.

Up to the present, STC has relied entirely on imports from Brazil for its natural quartz supplies, there being no other major source of natural quartz of suitable standard. This grade of quartz is expensive, and wastage in manufacture of the plates used in crystal units is high because of the irregular shapes of the raw quartz pieces and the frequent occurrence in the material of a certain type of structural defect known as 'twinning'.

The new plant will produce large blocks of quartz of regular shape and size, which will be practically free from defects, and which can be used more efficiently with useful overall saving in costs. The plant will not make STC completely independent of natural quartz, however, for the process used is essentially a recrystallization of natural quartz of fusing grade. This grade, consisting of chips which are much smaller than the radio-grade quartz now used, is very much cheaper and more abundant.

Recrystallization is effected from solution at elevated temperature and pressure in vertical, cylindrical, thick-walled vessels. Nutrient material is charged into a vessel, almost to half its height, and seeds—thin rectangular plates of radio-grade quartz—are supported on metal frames in the upper half of the vessel. Part of the remaining space is filled with a solution of sodium hydroxide (caustic soda), and the vessel is sealed and heated. As the temperature rises, the solution expands and begins to slowly dissolve some quartz. Before operational temperature is reached, the solution has expanded to fill the vessel and, as the temperature is raised further, pressure builds up rapidly in the vessel. The equipment is designed for use at pressures up to 30 000 lb./in^2. The control system brings the solution to a temperature of about 350°C at the top of the vessel and some 50°C higher at the bottom. The system maintains these temperatures constant for a suitable period after which the heating power is switched off.

During the process period there is a continuous interchange of solution between the lower and upper zones of the vessel by convection. The quartz chips dissolve slowly away in the lower zone and quartz is deposited from solution on to the seeds in the upper zone. A large percentage of the chips is thus transformed into the quartz blocks.

Quartz will be grown initially for low frequency crystal units, and future expansion of the plant will enable sufficient quartz to be produced to meet almost the Company's whole requirements.

Crystal units manufactured from cultured quartz are indistinguishable in performance from those made from natural quartz.

Short News Items

The Sixth International Conference on Medical Electronics and Biological Engineering is to be held at Tokyo, Japan, on 22 to 27 August, 1965.

The programme will include lectures and discussions on scientific and technical topics related to medical electronics and biological engineering, and special sessions will be organized in due course. There will also be an exhibition of associated equipment during the Conference.

Further information on submission of papers, hotel reservations, and exhibition arrangements can be obtained on application to the Conference Secretary-General: Prof. K. Suhara, c/o Japan Society of Medical Electronics and Biological Engineering, Old Toden Building, 1-1 Shiba-tamura-cho, Minato-ku, Tokyo, Japan.

The Fifth International Congress on Acoustics will be held at Liége, Belgium, on 7 to 14 September, 1965, under the chairmanship of Prof. J. Frenkiel.

Further details are available on application to the Congress Secretary, 33 rue Saint-Giles, Liége.

The Scientific Instrument Manufacturers' Association is to hold two specialized Exhibitions in Spain this year.

The first exhibition will be held in Madrid on 19 to 24 October to coincide with a conference being held to mark the 25th anniversary celebrations of the founding of the Consejo Superior de Investigaciones Cientificas. This organization is responsible for the co-ordination of all scientific research activities in Spain. The theme of the conference is "The Place of Science in Industry". It is being organized together with an exhibition of instruments, open to local manufacturers and suppliers, by the Patronato Juan de la Cierva, which is responsible for the direction of applied research in industry.

The second exhibition will be held on 29 to 31 October at the Barcelona Higher Technical College for Industrial Engineering by agreement with the Spanish Ministry of Education.

The British Radio Valve Manufacturers' Association (BVA) and the Electronic Valve and Semiconductor Manufacturers' Association (VASCA) announce that the total sales by member firms of the two associations for the year 1963 were as follows:

Valves and tubes . . . £42·7M.

Semiconductor devices £18·9M.

Export sales accounted for £11·2M. (approximately 18 per cent).

The Marconi Co. Ltd has signed an agreement with SIEDMA. SA (Societe Importation Exportation Distributrice Materiel Anglais) of 9 Avenue de L'Opera, Paris, whereby the latter company will be responsible in France for the sales and promotion of the complete range of specialized components marketed by the Marconi Company. This range includes waveguide isolators and loads, circulators, quartz crystal delay lines, crystal ovens and other specialized devices.

The British Electrical and Allied Manufacturers' Association (BEAMA) announces that in accordance with the new Divisional structure of the Association, an Electronics Division has been formed. The constituent parts are the Industrial Electronic Equipment Section, the Semiconductor Devices Section and the X-Ray Apparatus Section.

The Central Electricity Generating Board has awarded a contract to Pye Laboratories Ltd to develop a closed-circuit television camera which will enable internal inspection of nuclear reactor cores to be made during operation.

The camera will be designed to operate under high gamma and neutron radiation levels at temperatures of up to 400°C and pressures in the region of 200 lb/in². The contract will be carried out in association with the Generating Board's Berkeley Nuclear Laboratories.

Thorn Electronics Ltd has installed a closed circuit television system to provide surveillance of traffic on the M6 motorway. A 1½-mile section of road is being displayed including the A556 road junction. Pictures of the motorway are fed 5 000ft via a single cable and displayed in the police control room on television monitor screens. This is made possible by a new concept in relaying pictures, using a single cable and fully transistorized repeater amplifiers.

The power supply requirement of these amplifiers is extremely low and a large number can be fed at low voltage via the coaxial cable. Thus the need for individual mains supply points is avoided and the entire distribution system can if necessary be operated for long periods from a car type accumulator.

In addition to handling multiple vision channels, the Thorn system enables the single cable to be used to operate remotely a number of traffic warning signs and can allow voice communication between predetermined points on route.

The Institution of Electronic and Radio Engineers (formerly The British Institution of Radio Engineers) has issued a publication giving abstracts of papers which have appeared in its journal between 1952 and 1963. Arranged according to the Universal Decimal Classification, the abstracts cover nearly 900 papers, articles and reports published during the twelve-year period.

The publication, which is entitled "Abstracts of Papers published in the Journal of the British Institution of Radio Engineers 1952 to 1963 inclusive," is obtainable from the Institution of Electronic and Radio Engineers, 8 to 9 Bedford Square, London, W.C.1 (price 10s 6d including postage).

Cable and Wireless (Mid East) Ltd is building a £250 000 wireless receiving station at Salt Pans which will make Aden one of the world's key radio stations. The station is nearing completion and will be operational before the end of the year.

Thirty radio receivers and equipment are being installed in the two-storey building. Salt Pans will work as a sister station with Hiswa the company's wireless transmitting station at Aden completed in 1959/60. Hiswa has 28 transmitters.

Among the services these stations will operate will be:

Public Telegraph Services with London, Malta, Zanzibar, Addis Ababa, Bahrain, Hargeisa, Taiz, Djibouti, Mukulla, Sana'a, Kamaran, Seiyun, Meifah and Mogadiscio;

Leased Circuits with London, Bahrain and Nairobi;

Telex with London, Addis Ababa and Bombay;

Radio Telephony with London, Addis Ababa, Bahrain, Nairobi, Bombay, Hargeisa, Taiz, Djibouti, Mogadiscio and Karachi.

They will also serve as a radio relay on the London/Singapore, Hong Kong, Australia and Osaka routes, and will relay, among other services, the London/Japan Telex. In addition they will provide ship/shore services, and serve as a stand-by for the London/Sydney route via the Compac link of the Commonwealth telephone cable.

The Ministry of Public Buildings and Works has recently placed a contract worth £100 000 with Fairey Engineering Ltd for the construction of a third radio telescope at Jodrell Bank which will enable the research work into extra-galactic radio sources being carried out at Manchester University's Nuffield Radio Astronomy Observatory to be extended. The work will be financed by a grant from the Department of Scientific and Industrial Research to the University of Manchester.

The new instrument will be 100ft high, with an elliptical dish measuring 125ft by 84ft. A notable feature of the new design is that it will be possible to dismantle the telescope and move it to a different site when the research work demands it.

The new instrument will be used in conjunction with the 250ft Mark I steerable telescope at Jodrell Bank as an interferometer. To facilitate this, the new dish will be operated by remote control from the main observatory.

This new instrument, which is expected to come into operation by mid-1965, will greatly facilitate the accurate examination and classification of radio sources by the Jodrell Bank scientists, extending the existing research programme designed to determine the angular diameter of such sources. Already some 350 sources have been observed and this figure is expected to increase to about 2 000 when the new equipment comes into use.

Automatic exchange equipment, valued at over £327 000, to be used in the expansion and modernization programme of the Portuguese Department of Posts, Telegraphs and Telephones has been ordered from Automatica Electrica Portuguesea, S A R L. one of the companies operated by Plessey Overseas Ltd.

The telephone exchanges, which will be manufactured at the company's Lisbon factory, will be installed in the national network centres of Leiria, Agueda, Penafiel, Pacos Ferreira, Caldas da Rainha, Faro and Guimareas.

The Nippon Electric Co. Ltd (NEC) of Tokyo, has been awarded a contract to build a microwave communications system from the Indonesian Government. This system will link the major cities of Java and Bali Islands, covering a total distance of 1 100 miles.

The Nippon Electric Company has also received a contract to supply the Mexican Government with equipment for a 1 600 mile microwave communications system. This has followed a contract with the Australian and Indian Governments, under which the NEC is to build 1 000 mile and 1 100 mile microwave communications systems.

The BBC's new television and v.h.f. sound relay station at Ward of Bressay, near Lerwick, to be known as the Shetland Transmitting Station, has now been brought into operation. It radiates BBC Television (BBC—1) on Channel 3 (vision 56·75Mc/s, sound 53·25Mc/s) with vertical polarization. The three sound programmes are being broadcast on v.h.f., with horizontal polarization, on the following frequencies: Scottish Home Service, 92·7Mc/s; Light Programme, 88·3Mc/s; Third Programme/Network Three, 90·5Mc/s.

A receiving station has been built at Fitful Head which picks up the programmes from the BBC's Orkney transmitting station. The television programme is then fed over a microwave radio link to the transmitting station at Ward of Bressay; the three sound programmes are carried by Post Office line.

The National Research Council of Canada has placed an order valued at £350 000 with AEI Electronics Ltd for the control system of Canada's largest steerable radio telescope which will be erected at Algonquin Park, Ontario.

The system will control the 150ft reflector and its mounting—weighing 800 tons—to the high degree of accuracy required for astronomical work in winds of up to 50 mile/h. The telescope will be mounted in vertical and horizontal axes and will be made to follow the apparent motion of a master equatorial unit mounted at the intersection of the telescope's axes.

The master equatorial unit will be driven at a rate equal to the earth's speed of rotation, pointing steadily at the target star or radio source. Accuracy in pointing will be better than 10sec of arc.

Any difference between the position of the telescope in either axis and the master equatorial unit will cause a correcting signal from the error detector to be fed into the servo control system amplifiers.

The extreme cold, usual in Canadian winters, has been taken into account by design and erection engineers for installation and commissioning.

This is AEI Electronics' third major contract in the radio telescope field. It designed and supplied the control for the most accurate radio telescope in the world, the 210ft instrument at Parkes, Australia. It also received the main £250 000 contract for the 82ft satellite tracker now being erected at Chilbolton, Hampshire, for the Ministry of Public Building and Works.

The Compagnie Generale de Metrologie of Annecy, France, has recently become affiliated with the International Telephone and Telegraph Corporation (I.T. & T.).

Other affiliated companies in France of the I.T. & T. are the Compagnie Generale des Constructions Telephoniques, the Material Telephonique and the Laboratoire Central des Telecommunications.

The Fourth International Conference of the International Association for Analogue Computing (L'Association Internationale Pour le Calcul Analogique A.I.C.A.) is to be held at Brighton College of Technology, Moulsecoomb, Brighton 7, England, 14 to 18 September.

The conference is being organized by the British Computer Society and the A.I.C.A. under the aegis of the United Kingdom Automation Council and the main theme of the conference will be 'The theory and application of analogue and hybrid computing'.

Papers accepted by the conference have been divided into the following groups: Applications to industrial problems, including heat transfer problems; solution of mathematical problems; solution of partial differential equations, including network techniques; optimization techniques; applications to medical problems; modern developments in computing equipment; automatic programming techniques.

Registration forms and other particulars may be obtained from The BCS/AICA Honorary Secretariat, Ferranti Ltd, Kern House, 36 Kingsway, London, W.C.2.

'The Principles of Electronic Equipment Reliability' is the subject of a three-day course to be held at the Borough Polytechnic, London, S.E.1, on 23 to 25 June.

The lecturers on the course all have specialized knowledge of various aspects of this subject and are drawn from industry, Government establishments and universities. The course will give a general survey of reliability concepts applied to the design and use of electronic equipment.

Further information may be obtained from: The Secretary, Borough Polytechnic, Borough Road, London, S.E.1.

London STD telephone subscribers are now able to dial direct most of their calls to the Continent. Until recently this facility existed only for calls between London and Paris, but it has now been extended to cover the rest of France, Belgium and Switzerland, and the latest extension now includes West Germany and Holland.

Arrangements are being made for STD subscribers in Birmingham, Edinburgh, Glasgow, Liverpool and Manchester to be brought into the system later this year.

Early next year it is hoped to arrange for International Subscriber Dialling (ISD) to be extended to Sweden, Denmark, Austria and Italy and later, possibly, to Norway and Finland.

The South African Post Office has placed orders valued at over £¼M with Standard Telephones and Cables Ltd, London, for microwave equipment which will beam large numbers of telephone calls between Bloemfontein, Port Elizabeth, Cape Town and East London.

Equipment already on order for the 366-mile Johannesburg-Durban link, soon to be installed, brings the total of recent STC microwave orders from South Africa to well over £1M.

STC's latest microwave radio telephone system will be used to provide 960 telephone circuits over difficult routes in South Africa. The advanced features of this equipment have enabled the distance between radio relay stations to be increased to up to 70 miles in some instances against the more usual spacing of 30 to 40 miles.

The system operates in the 6000Mc/s frequency band, with a transmitter output of 10W and makes extensive use of transistors in the equipment.

The British Standards Institution has published Supplement No. 1 (1964) to B.S. 204 1964 (price 3s.) "Terms used in wired Broadcast and Broadcast Relay".

The Telecommunications Department of Malaya is developing its subscriber trunk dialling service throughout the country and recently the existing network, embracing Klang, Kuala Lumpur, Malacca, Port Swettenham, Seremban and Singapore, has been extended northwards to include subscribers in Ipoh, Penang and Sungei Patani.

The most recent addition to the network was Ipoh where every subscriber there can now dial calls direct to Kuala Lumpur, Malacca, Penang and Singapore.

In all these exchanges, equipment for the STD service has been supplied by G.E.C. (Telecommunications) Ltd. In addition, all calls to Penang via Ipoh are routed over the microwave radio link supplied by G.E.C. and operating between Ipoh and Penang. This link will also be used in the near future to extend the television service to Penang and the North.

The BBC has placed an order with Mullard Equipment Ltd for transmitting equipment to be installed at Guildford in connexion with the BBC 2 Television Service.

Guildford is one of the four 'shadow areas', the others being Reigate, Tunbridge Wells and Hertford, which the BBC proposes to fill by the middle of next year.

The Guildford translator will receive the transmission from the Crystal Palace transmitter on Channel 33 and re-transmit on Channel 46. The translator will be sited so that its receiving aerial is within an area of adequate field strength (not less than 80dB relative to 1μV/m and reasonably free from interference). The transmitting aerial, although mounted close to the receiving aerial, will be positioned so that it radiates the signal over what was previously the shadow area.

The combined video and sound power output is 1kW, but using an omni-directional aerial with a gain of 10dB, the available radiated power is about 10kW.

The translator comprises a power amplifier, driver and power supply. The single-stage power amplifier uses an air-cooled klystron. This gives two advantages. Firstly, a stable gain is achieved without the complexity of neutralization, and, secondly, a standard design of amplifier may be used since by fitting and tuning the appropriate cavities, the klystron can be set up to operate on any channel within Bands IV or V.

The translator-driver stage converts both sound and vision signals from one channel to another, the only restriction being that the re-transmitted signal cannot be on the same or adjacent channel as the received signal.

The receiver section of the translator-driver unit consists of an r.f. unit with fixed-tuned channel selection, crystal oscillator and first mixer stage, i.f. amplifier, phase compensation network and a.g.c. stages.

The transmitter section comprises a mixer and crystal oscillator which "translates" the received i.f. signal to the new channel, and tuned amplifiers which raise the level to 5W for driving the final klystron amplifier.

Automatic Telephone & Electric Co. Ltd is to supply and install its new 120 channel, single tube coaxial carrier telephone system under a scheme to modernize the trunk telephone service on the London Midland Region of British Railways.

The contract calls for the company's type C 120 A system, together with 146 miles of coaxial cable, which is being supplied by British Insulated Callender's Cables Ltd.

It will provide up to 120 speech circuits between London, Leicester and Derby over a single tube coaxial cable suspended from existing poles along the route.

The system employs small transistorized repeaters which can be located in shallow manholes and powered via the coaxial cable from the two terminals.

The Ultra Electronics Group has received orders from Canada and Denmark for its ultrasonic aid for the blind. In addition to the United Kingdom, eleven other countries have now ordered units for delivery from this year's pilot production run—Australia, Canada, Denmark, Germany, Holland, New Zealand, Northern Rhodesia, Norway, Sweden, Switzerland, and the United States.

The latest United States order, in addition to 14 units already earmarked for the states of Kentucky, Ohio and New Jersey, is for ten units from the Veterans' Administration Hospital in New York City.

The Canadian National Institute for the Blind, in Toronto, and the National Research Council, in Ottawa, are among the organizations to place the most recent orders, along with Danish State Schools in Copenhagen and Kalundborg; the Professor Strahl Blind Institute in Marbug, West Germany; and, in Britain, the Exeter Society for the Blind.

PUBLICATIONS RECEIVED

TRANSISTOR ACCESSORIES DATA SHEET issued by Newmarket Transistors covers the practical matters of lead identification, mounting arrangements etc. of their range of transistors. This first issue of the NKT accessories data sheet cover smaller devices in full detail and larger devices in part. It is intended to issue continuation paper covering the remaining aspects of mounting intermediate power, power and high power transistors. Copies of this first NKT accessories data sheet may be obtained on application to: Commercial Manager, Newmarket Transistors Limited, Exning Road, Newmarket.

FLUID AMPLIFIERS—this is a four-page technical bulletin produced by the Electronic Devices Department of Corning Glass Works and is available on request to Electrosil Ltd, Pallion, Sunderland. Described are fluid amplifier applications, the usefulness and properties of photo-sensitive glass in making the devices, design and fabrication techniques, and details of several operating devices.

COMPONENT TECHNOLOGY is a new quarterly publication of Plessey-UK Ltd. It will contain articles on the Company's latest component developments and techniques, especially on those items generally known as 'professional components'. All the articles will be by Plessey engineers and executives. Copies can be obtained from Plessey-UK Ltd. Ilford, Essex.

AUTO ISOLATING AND LOW VOLTAGE TRANSFORMERS is the title of a pamphlet reference No. G.T. 10 showing the full range of output ratings carried in stock and the six standard assemblies in which they are available from Gardners Transformers Ltd of Somerford, Christchurch, Hants. Copies of the pamphlet are available from the Company on request.

SEMICONDUCTOR CATALOGUE recently issued by Messrs. Siemens and Halske for R. H. Cole Electronics Ltd includes transistors, Hall effect devices, diodes, tunnel diodes, Zener diodes, photoelectric devices and both negative and positive temperature coefficient thermistors. Copies may be obtained on request to R. H. Cole Electronics Ltd. 26-32 Caxton Street, Westminster, London, S.W.1.

OPPORTUNITIES FOR BRITISH CONSUMER AND CONSUMER DURABLE PRODUCTS IN FRANCE is the title of a Report published on 4 May, of a survey recently carried out by the Export Council for Europe. The area covered in the survey, centred round the conurbation of Lyons, has a total population of more than four millions, is one of the fastest growing economic regions in France, and the country's most important consumer market after Paris. The survey shows that the buying potentiality of the region is very great, but that so far little impact has been made by British exporters. Further details may be obtained from the Information Officer, Mr. D. Weaver, Export Council for Europe, 21 Tothill Street, London, S.W.1.

THE WORK OF THE E.R.A. DURING 1963 is covered in the 43rd Annual Report presented at the recent Annual General Meeting of the Electrical Research Association, Cleeve Road, Leatherhead, Surrey.

RADIO INTERFERENCE SUPPRESSORS FOR AIRCRAFT are described in an 8-page booklet available from Standard Telephones and Cables Ltd. This is a range of high temperature, lightweight capacitors designed specifically for aviation use, and wound from metallized polyester film. STC Capacitor Division has conducted radio interference surveys on most of the current British civil and military aircraft in service and under development. The Division operates a fully equipped interference measurement service covering the frequency range 15kc/s to 600Mc/s. Copies of this publication are available from the Capacitor Division, STC, Footscray, Kent.

BOOK REVIEWS

Vacuum Technology

By A. Guthrie. 532 pp. Med. 8vo. J. Wiley & Sons. 1964. Price 94s.

Handbook of High Vacuum Engineering

By A. Steinherz. 358 pp. Med. 8vo. Reinhold Publishing Corpn. 1964. Price 96s.

RAPID developments have taken place in the vacuum field during the last few years. Recent applications of vacuum technology include precision electron beam machining, vacuum arc melting on a large scale, vacuum welding, vacuum freeze drying and the production of thin metallic films for micro-circuits or memory stores by evaporation or sputtering. On a larger scale, and especially in the U.S.A., large chambers are now needed for space simulation experiments, and in some of these cases it is necessary to maintain extremely low pressures. This calls for an advanced technology unknown ten years ago.

In such periods of technological advance when an increasing number of workers is engaged on vacuum systems, there is likely to be a need for books which describe the recent advances in vacuum engineering and technology in an up,-to-date way, even though a number of good books on the physical basis of the subject are already available.

These two books necessarily have much in common, although one covers a wider field than the other and they are addressed to different types of user. Both are up to date, thoroughly practical books. Where detailed descriptions of commercially available components are given, for instance, pumps and tables of soldering and brazing materials, they naturally refer in most cases to those available in the U.S.A. However, the corresponding British item is often either the same or so similar that this is no serious disadvantage; likewise the terminology used follows the "Glossary of Terms used in Vacuum Technology" laid down by the American Vacuum Society 1958. In the main this is similar to British practice as set out in British Standard 2951 : 1958, but allows a wider choice of units, for example, cubic feet as well as litres and degrees F as well as degrees C, so that conversion is necessary; copious conversion tables are, however, given in the first-named book.

"Vacuum Technology" is addressed to the technician and the clear explanations given assume very little previous knowledge of physics. The subject described by the title is covered in detail in its basic aspects, but little attention is given to particular industrial applications. The book is a non-mathematical text in which tables, graphs, nomograms, and simple rules are used extensively. Worked examples guide the user. Using the material in this book the technician should be able to choose the appropriate vacuum components, fabricate parts where necessary, set up a complete system and test it.

The introductory chapters give an elementary account of the nature of a vacuum and of vacuum systems and introduce the terms throughout, impedance conductance and pumping speed. The design and characteristics of different types of pumps are given; the more modern types briefly discussed include sorption pumping using active charcoal or zeolite, getters, evapor-ion and sputter-ion pumps and cryogenic pumps. It is interesting to note that cooled activated charcoal, which was in use for purification of the rare gases some thirty years ago, is now in the forefront as a pump. Another chapter gives much useful information on the properties of materials commonly used in vacuum systems and touches upon glass and ceramic to metal seals. Outgassing rates are given for some materials. Later chapters go into detail on cleaning techniques, fabrication techniques and soldering and brazing methods including a comprehensive list of solders. A few prescriptions for electroplating are also given. After describing in detail a number of components of a vacuum system, the author has an interesting chapter on very high and ultra high vacuum systems both small and large. The last chapter concerns finding and repairing leaks which is well discussed. The appendices contain among other things a valuable table of vacuum formulae and includes the conductance of pipes and apertures. The bibliography is comprehensive.

Although much of the explanatory matter is given in simple terms, the book is authoritative. It is full of useful practical information about vacuum systems in general. The length of the book could perhaps have been somewhat reduced by omission of material which is readily available elsewhere, e.g. an explanation of logarithms, and by omission of detailed instructions for the use of particular apparatus, e.g. the belium leak detector, which can surely be got from the makers' instruction sheet. The reviewer is not aware of any similar book addressed to the technician, and Prof. Guthrie has admirably filled a growing need. Many physicists and engineers will find the information contained within its pages very useful. This is an excellent book and should find wide usage.

The "Handbook of High Vacuum Engineering" is addressed to those who design and construct vacuum systems. The emphasis throughout is on engineering aspects and the need for very high or ultra high vacua (the latter being the region below 10^{-9} torr) is constantly in the forefront. In addition to basic techniques a wide field of applications is covered in varying degrees of detail.

Basic theory, based on the kinetic theory of gases, is compressed into a short chapter. The short treatment of materials of construction is informative especially with regard to outgassing rates. This is particularly important in the case of large systems at very low pressures and indeed the importance of the "gas load", that is the amount of gas evolved from the walls and other parts of the vacuum system, is made clear in many places in the book.

Pumps are adequately explained and a full account of modern methods is given; this is especially so with cryogenic pumping where speeds up to one million litres per second may be obtained. A large number of different types of pressure gauge are briefly explained, but the chapter on leak detection is rather too brief to be adequate. Seals, valves, baffles and traps are briefly discussed and a chapter on pumping system design gives some useful practical examples.

After a thorough section on various kinds of furnace one comes to applications. These include electron beam melting, described in some detail, electron beam welding, which offers the advantage of absence of contamination, and vacuum coating of both metallic and non-metallic substances on a substrate by evaporation and by sputtering, in which typical apparatus and procedures are well described. Further applications include drying and impregnation, freeze drying and space environment simulation. In the latter connexion methods are described for pumping a vessel of volume about 8000ft^3 down to a pressure below 10^{-8} torr. Smaller vessels of volume several cubic feet can be pumped down to the limit of the pressure gauge, in the region 10^{-15} torr using cryogenic means!

With such a wide coverage of subject matter many parts must necessarily be treated rather briefly. In a handbook one might expect to find a rather fuller tabulation of the various properties of substances used in vacuum equipment. The bibliography is extensive. The book should prove useful to vacuum engineers on account of the up-to-date coverage of a wide variety of applications.

A. F. PEARCE.

Foundations of Electrical Engineering (Fields—Networks—Waves)

By K. Simonyi. 848 pp. Med. 8vo. Pergamon Press. 1963. Price £5

THIS is Volume III of a four-volume series which is intended to present a unified treatment of the fundamental principle of electrical engineering. In reviewing the book in isolation from the rest, therefore, one has to remember that what may appear to be shortcomings of the book may not, in fact, be shortcomings of the series as a whole. For example, in a large book such as this, it seems strange that there are no examples worked to a numerical answer nor are there any examples for practice. These are, however, included separately in volume IV and therefore the student is obliged to buy at least one other book in order to make the maximum use of this one.

The book is divided into five parts, namely, General Survey, Static and Steady Fields, Network Analysis and Network Synthesis, Electromagnetic Waves, Survey of Further Developments, about five-sixths of the material being contained in the middle three parts. The treatment of fields and waves, which accounts for the major part of the book, is modern, lucid and comprehensive, covering a wide range of theoretical topics and including reference to applications and devices. The treatment of networks, on the other hand, is somewhat superficial in places, probably due to a regard for the overall size of the book, and while it is proper that networks should have been included in a unified treatment such as this it should not have been at the expense of depth. Only two pages are devoted to the synthesis procedure of Darlington, for example, and although examples of this and other synthesis procedures are given, no mention is made of how the positive realness of the functions being synthesized is first tested.

The book is well produced and is very readable, and apart from the fact that 'U' is used instead of 'V' and in places 'rot' is used instead of 'curl' there is little to indicate that it is a translated text.

To whom should the book appeal? Probably not to the first-year undergraduate and probably only in part to those in their second year, but to the third-year man and the post-graduate student it should have a considerable appeal as they will know enough of the subject to appreciate the viewpoint from which it has been written.

To have shown that so much can be derived from the same starting point of Maxwells' equations, thereby to have demonstrated the unity of the fundamentals of the subject ranks as a major contribution by the author.

C. S. GLEDHILL

Essays in Electronics

By M. G. Scroggie. 301 pp. Demy 8vo. Iliffe Books Ltd. 1963. Price 42s.

HOW fortunate is the modern student of radio and electronic techniques to have at his disposal the writings of Marcus Scroggie to elucidate and clarify the 'high falutin' verbiage of the average text book! Indeed my only complaint is that he wasn't born thirty years earlier so that the reviewer himself could have enjoyed during his student days the priceless advantage of his lucid and readable expositions.

Most readers of ELECTRONIC ENGINEERING will be familiar with Scroggie's earlier book—'Second Thoughts on Radio Theory'—and it may be said that this latest book of essays is a superb sequel to the earlier collection. No student and, even more emphatically, no teacher of radio or electronics can afford to be without a copy.

What Scroggie says on the fundamentals of the art is always of value but what adds so tremendously to its worth is the way he says it. Whether he is dealing with some mathematical conception, hyperbolic functions, Fourier analysis, Nyquist diagram or distortion in cathode-followers, Scroggie takes one gently by the hand and, with frequent touches of understanding humour, he makes the whole thing 'as plain as a pike-staff'. Who but Scroggie would have thought of explaining e by analogy with the activities of a rapacious money-lender; who would be so modest as to admit "Being rather slow on the uptake myself, perhaps I am excessively sympathetic with students about things they are supposed to know without being told. Nevertheless, I feel sure quite a lot of apparent stupidity is really the fault of the teachers".

There are twenty-two essays in this collection. The first pricks a number of bubbles in the realm of scientific theory, the second asks—and answers—What is an electric current?

Kirchhoff's Laws form the subject of the third. The chapters on e and on 'The Cosh and How to use it' are quite the most readable and straightforward explanations of these concepts ever seen. Vector Diagrams—so much of a.c. theory is easy when you know how, but the trouble is that there are so many schools of thought as to how to draw what we call 'vector diagrams' that the student is very apt to become badly confused. He won't if he follows Scroggie.

The chapter on 'The Great Stereophony Fake' is a masterpiece and though it may upset someone who has just spent £150 on a dual-channel hi-fi set-up most of us will agree with Scroggie "Why worry how it is faked so long as it sounds good?" The chapters on Negative Feedback and Non-linearity, and on Cathode-Follower Distortion are alone worth the price of the book.

Marcus Scroggie's writings over the past twenty years have been primarily addressed to the student of electronic principles to the enormous advantage of those fortunate young men. May I make a plea that he will devote his unique gifts of exposition during the next year or two to the writing of a text book on mathematics for Fifth and Sixth form levels.

G. R. M. GARRATT.

Electrical Engineer's Reference Book

Edited by M. G. Say. 1790 pp. 11th Edition. Crown 8vo. George Newnes Ltd. 1964. Price £6

This is arranged in thirty-three sections and it contains a comprehensive exposition of modern practice and a survey of the most recent information on new developments in all branches of electrical engineering.

Magnetohydrodynamic Generation of Electrical Power

Edited by R. A. Coombe. 207 pp. Demy 8vo. Chapman & Hall Ltd. 1964. Price 30s.

This book based on a series of lectures given at the Royal College of Advanced Technology, Salford in 1962, provides for the interested scientist the principles and problems of m.h.d. generation. It is designed so that a non-specialist may start with no previous knowledge of the subject but finish with the ability to read and understand the latest research papers.

The first three chapters are introductory and non-mathematical and survey the m.h.d. scene so that the subsequent chapters can be better understood. The specialist chapters 4-8 have been contributed by six professional scientists engaged on work relating to m.h.d. generation.

Electrical Who's Who, 1964-65

Compiled by 'Electrical Review'. 528 pp. Med. 8vo. Iliffe Books Ltd. 1964. Price 55s.

With this, the eighth edition, the 'Electrical Who's Who' enters its fourteenth year. Over a thousand new entries are included in the biographical section and after the deletion of those who have died or have left the electrical field there is a net gain of 400, maintaining the total at about 8 000.

Photo-Electric Devices in Theory and Practice

By H. Carter and M. Donker. 130 pp. Med. 8vo. Cleaver Hume Press. 1963. Price 25s.

The first part of the book outlines the theoretical principles in a simple style which will appeal particularly to part-time students while providing a valuable refresher course to those who have completed their academic studies. The second part then describes in detail over thirty photo-electric devices used in industry with numerous illustrations and much technical detail.

LETTERS TO THE EDITOR

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

Planar Transistors as Grounded Collector Stages

DEAR SIR,—The planar technique of transistor manufacture has made available units whose equivalent circuit parameters are a marked improvement on those of earlier transistors. The current gain h_{fe}, particularly at low currents, is much higher, while the output conductance h_{ob} and collector cut off current I_{CBO} are considerably lower (see Table 1). The grounded collector or emitter-follower stage is one circuit whose properties are strongly dependent on these parameters, especially as regards the input conductance. The circuit analysis of this connexion is covered in many textbooks[1]. Considering only the region where the emitter load resistor $R_E \gg 1/h_{ib}$ the equivalent input circuit reduces to that of Fig. 1. h_{bb} is the conductance of the base bias resistors necessary for reasons of circuit stability. A large value of h_{fe} reduces the conductance h_{ee} reflected from the emitter circuit. For the practical circuit of Fig. 2, h_{ee} is $18{\cdot}5 \times 10^{-9}$ mho; h_{ob} is small compared with this and the h_{bb} value of 22×10^{-9} mho. Total calculated input conductance of $42{\cdot}5 \times 10^{-9}$ mho compares well with the measured value of 45×10^{-9} mho.

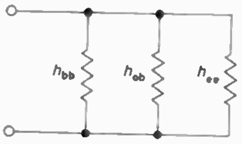


Fig. 1. Equivalent input circuit of grounded collector stage for $R_E >> 1/h_{ib}$
$h_{bb} = 1/R_B$
$h_{ee} = 1/(h_{fe} + 1) R_E$

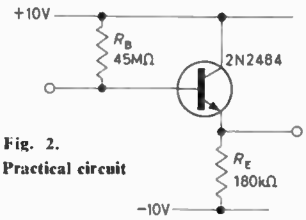


Fig. 2. Practical circuit

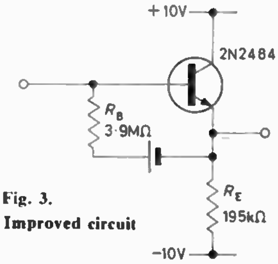


Fig. 3. Improved circuit

The input conductance is reduced even further by the circuit of Fig. 3, where base current is supplied by a small mercury battery connected to the output. The bias circuit conductance now becomes $h_{bb} = (1-A)/R_b = 2{\cdot}5 \times 10^{-9}$ mho, $A = 0{\cdot}99$ being the gain of the stage. The input conductance is now 23×10^{-9} mho, compared with the conventional emitter-follower value of around 10^{-6} mho.

Temperature can affect the operating conditions of the circuit of Fig. 3, through changes in V_{BE} and h_{FE}; I_{CBO} may be neglected below 75°C. Increase of h_{FE} with temperature, decreases the current drawn by the base, while decrease of V_{BE} increases the current through R_B. The net effect is to cause increased current flow into whatever source resistance is connected to the input. The measured value was 2×10^{-9}A/°C.

This temperature effect can be compensated for by adjusting the emitter current with a potentiometer in series with R_E.

TABLE 1

$T = 25°C;\ I_c = 50\mu A;\ V_c = 5V$

	h_{fe}	h_{ob} (mho)	I_{CBO} (A)
Alloy OC202	50	1×10^{-6}	10^{-9}
Planar 2N2484	300	2×10^{-9}	10^{-10}

Yours faithfully,

R. D. RYAN,
University of N.S.W., Australia.

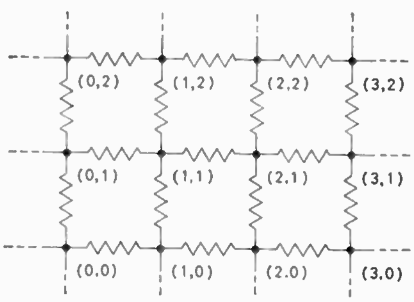
REFERENCE

1. JOYCE, M. V., CLARKE, K. K. Transistor Circuit Analysis. (Addison-Wesley, 1961).

Infinite Arrays of 1Ω Resistors

DEAR SIR,—My attention has been drawn to the letters of Messrs. Prabhakar and Kimar (December, 1963, page 829) and Mr. Lewkowicz (February, 1964, page 117). It may not be generally known that a mathematical treatment of this problem has been given by van der Pol and Bremmer ("Operational Calculus", C.U.P., page 365).

It is, moreover, possible to determine the resistance between any pair of nodes, not necessarily adjacent. For the square mesh shown below the resistance $R(m,n)$



between the nodes labelled (0, 0) and (m, n) is given by:

$$R(m, n) = 1/\pi^2 \int_0^\pi \int_0^\pi \frac{1-\cos m\theta \cos n\phi}{2-\cos\theta-\cos\phi}\, d\theta\, d\phi.$$

This integral can be evaluated to give the following results:

$R(1,0) = \frac{1}{2}$ $\quad R(1,1) = 2/\pi$
$R(2,0) = 2 - 4/\pi$ $\quad R(2,1) = -\frac{1}{2} + 4/\pi$
$R(2,2) = 8/3\pi$

and so on. It can also be shown that:

$$R(m,m) = 2/\pi\,(1 + 1/3 + 1/5 + \ldots\ldots\ldots\ldots + 1/(2m-1))$$

and that, for large values of m and n:

$$R(m,n) \simeq 1/\pi\,[\gamma + 3/2 \ln 2 + \tfrac{1}{2}\ln(m^2+n^2)]$$

where $\gamma = 0{\cdot}57722$ (Euler's constant).

For a cubic array in three dimensions, the resistance $R(l,m,n)$ between the nodes (0,0,0) and (l,m,n) is given by:

$$R(l,m,n) = 1/\pi^3 \int_0^\pi \int_0^\pi \int_0^\pi \frac{1-\cos l\theta \cos m\phi \cos n\psi}{3-\cos\theta-\cos\phi-\cos\psi}\, d\theta\, d\phi\, d\psi$$

Apart from the case $R(1,0,0) = 1/3$, this integral can only be evaluated by numerical methods.

It is interesting to note that whereas in two dimensions $R(m,n)$ increases indefinitely as m and n increase, in three dimensions $R(l,m,n)$ tends to a finite limit $(0{\cdot}50546)$ as $l^2+m^2+n^2 \to \infty$.

Yours faithfully,

R. E. SCRATON
Northampton College, London.

Transistor Low Drift D.C. Amplifiers

DEAR SIR,—In his article 'Transistor Low Drift D.C. Amplifiers' (May issue), Mr. Pinto mentions the mirror-image circuit. Essentially this consists of two identical multi-stage amplifiers, each with overall as against stage-by-stage degeneration, possibly sharing a common feedback resistance, and balanced only at input and output points.

One advantage of this arrangement is potentially better zero level stability. Perfect compensation requires that the products of causative drifts and intervening gains between point of generation and point of cancellation should be equal. While negative feedback can do nothing to reduce generation, it can stabilize and so permit accurate equalization of intervening gains. In the mirror-image arrangement, with its high open loop gain and high overall feedback, gain stabilization is maximal, ensuring that effective drift compensation and hence realizable stability is higher than in systems made up of a succession of separate stages individually stabilized and balanced, necessarily less thoroughly. Furthermore, the feasibility of complete 'locking' of all electrode voltages and currents reduces the causes of both zero shifts and gain variations.

Mr. R. G. Benson has pointed out that positive feedback can easily be applied to this amplifier, by connecting the dummy section input to a tap on the common feedback resistance. In this way virtual earth resistance can be made truly zero, an improvement to operational amplifiers, especially those used for current integration. This possibility is more readily realized in the valve configuration from which the circuit shown by Mr. Pinto in his Fig. 3 is derived, since it avoids the complication of significant base currents which may need to be backed off.

Yours faithfully,

G. I. HITCHCOX
Welwyn Garden City, Hertfordshire.

The Instruments, Electronics and Automation Exhibition

A description, compiled from information supplied by the manufacturers of a few of the exhibits at the I E.A. Exhibition at Olympia, London, from 25 to 30 May

(Voir page 421 pour la traduction en français; Deutsche Übersetzung Seite 430)

BARR & STROUD LTD

Kinnaird House, 1 Pall Mall East, London, S.W.1.

Morse Code Keying Device

(Illustrated below)

Barr & Stroud Ltd has developed a miniaturized device to key automatically a short predetermined morse code message for sending from a transmitter or a flashing light. In its present form it is designed for incorporation in a distress signalling unit for marine or aircraft use. It can be simply modified for other applications requiring a keyed sequence. The sequence can readily be changed.

It contains neither moving parts nor vacuum tubes, employing only semiconductors and ferrite cores. This gives a very high order of reliability, combined with small physical size. Power could be supplied by dry batteries and the requirements are for 60mW at 12V and

140mW at 4V. This enables codes to be generated continuously for a matter of weeks from the battery. The duration of the message sequence in the prototype is approximately 2min at a nominal keying speed of 6 words/min but this can be varied for different applications. The prototype is approximately 4cm × 9cm × 10cm and weighs about 200g.

EE 70 751 *for further details*

BECKMAN INSTRUMENTS LTD

Glenrothes, Fife, Scotland

Counters and Timers

(Illustrated below)

Instruments in the 6100 series incorporate plug-in units and are completely

solid-state with in-line, in-plane electroluminescent digital displays.

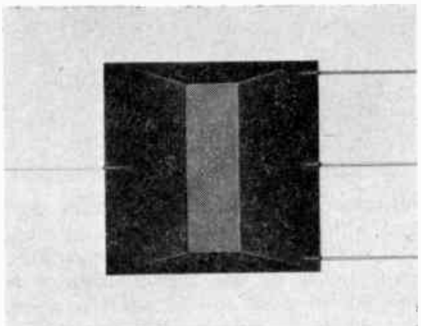
25Mc/s and 2·5Mc/s models in the 6100 series are available as 'events per unit time' meters and timers. The range and functions may be extended by means of plug-in accessory units. The 25Mc/s models accept plug-in units which extend their range directly to 100Mc/s and by heterodyning to 1 000Mc/s. All instruments of the series may be used with a voltage to frequency convertor plug-in unit which gives voltage readings directly on a digital display. When using the 100Mc/s plug-in unit time intervals down to 30µsec may be measured with a resolution of 10µsec.

EE 70 752 *for further details*

Hall Effect Voltage Generators

(Illustrated below)

This newly introduced range of Hall effect generators is manufactured by the



Helipot Division of Beckman Instruments Inc. Known as 'Hallefex' generators they are available in four models which provide high output sensitivity with high output and input resistance. The main difference between Hallefex solid-state voltage generators and other units is the vacuum deposited, micro-thin semiconductor film which provides a higher output sensitivity than previously possible and results in an effective air-gap of up to 15 times smaller than conventional Hall generators.

EE 70 753 *for further details*

BELL & HOWELL LTD

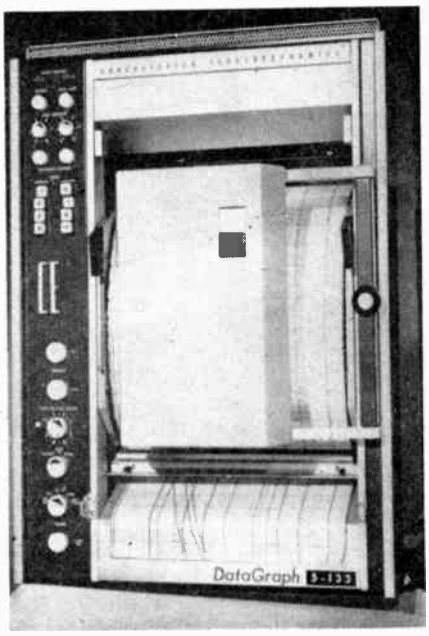
Consolidated Electrodynamics Division, 14 Commercial Road, Woking, Surrey

Recording Oscillograph

(Illustrated above right)

The type 5-133 Datagraph recording oscillograph, the latest in this company's range, is available as either a rack-mounted or bench-mounted instrument, it is a direct-writing recorder utilizing a high actinic light source as the galvanometer illuminator. Thirty-six or 52 channels of data on 12in wide light-sensitive paper are produced without chemical processing of any kind. Dynamic measurements form d.c. to 13kc/s can be made, and events with response times of 10msec, 1·0msec, or 0·5msec can be recorded. Features of the 5-133 include grid lines, timing lines, trace numbering, automatic shot length, event identification and push-button speed control.

The instrument's outstanding feature, however, is its ability, by means of the 'Dataflash' print-out system, to produce visible data up to 60 times faster than by any other known method.



Dataflash, an exclusive Consolidated development, embodies a special transport and latensification lamp which allow simultaneous recording, heating and application of high actinic light to produce a completely latensified oscillogram at recording speeds up to 16in/sec. Maximum recording speed is 160in/sec.

EE 70 754 *for further details*

BEULAH ELECTRONICS LTD

126 Hamilton Road, West Norwood, London, S.E.27

Closed Circuit Television System

The 'Beauvision' is a low-priced completely transistorized closed circuit television system built to industrial standards. The complete equipment includes a fully transistorized Vidicon camera of new design, an f/1·9 25mm lens with adjustable focus and iris, 100 yards of coaxial cable and a transistorized 8½in or 14in monitor.

The monitors, which are available

separately, have a frequency response of 5Mc/s (625 line) and require a video input of 0·8V to 1·5V peak-to-peak. The power consumption of the monitors is less than 30W.

EE 70 755 *for further details*

BRITISH AIRCRAFT CORPORATION

100 Pall Mall, London, S.W.1.

ELECTRONIC 'SPIRIT LEVEL'

(Illustrated below)

The 'Electrolevel' is a new electrical remote-reading (spirit) level which can supplement or replace the conventional spirit level in many engineering applications. The Electrolevel has been developed by the Industrial Systems Group of the British Aircraft Corporation, Guided Weapons Division.

The principle of the Electrolevel has been derived directly from the spirit level. A glass vial, with its upper surface ground to a uniform radius, is provided with three electrodes and is partly filled

with an electrically conducting fluid. Movement of the bubble changes the resistance values of the electrical paths between the electrodes, which are converted to the movement of an instrument pointer by a simple electrical bridge circuit.

This form of construction for a level-sensitive instrument is superior to any mechanically pivoted pendulum device because of its robustness, compact dimensions and freedom from stiction and wear. The Electrolevel thus has the dynamic characteristics of a spirit level but, by virtue of an electrical read-out, several important advantages are obtained. It can be mounted in remote or hazardous situations, can be totally isolated from thermal changes which seriously affect sensitive spirit levels, and provides a reading from a pointer-type instrument needing no mental averaging calculations.

Amplification of the bubble movement by the electronic detector is such that a bubble movement of only 0·001in can be readily displayed. This gives an additional advantage over all conventional spirit-levels, in that a much greater scale range can be provided in one sensing head, which in turn means that measurement of weave in, for instance, machine tool slideways can be made without the preliminary accurate levelling otherwise necessary.

The instrument is provided with three scale ranges giving a gradient range from $0{\cdot}005 \times 10^{-3}$in/in (1 arc second) to 10×10^{-3}in/in (33 arc minutes). Facilities are also provided for connexion to an auxiliary indicator or recorder and for use for six or more sensing heads via a selector switch.

EE 70 756 *for further details*

BRITISH PHYSICAL LABORATORIES

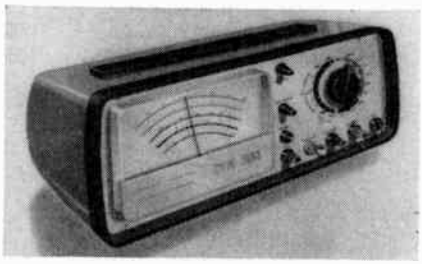
Radlett, Hertfordshire

TRANSISTORIZED VOLTMETER

(Illustrated below)

This equipment embodies the facilities of conventional valve-voltmeters as well as those of universal test sets. The ranges have been specially selected to suit the requirements of the engineer dealing with transistorized equipment.

Due to the development of novel circuit techniques and the use of silicon planar transistors, an exceptionally stable



instrument has resulted, free from drift and with an ensured long-term stability and accuracy over a wide temperature range. One of the special features is the provision of a calibration position, in which the gain of the amplifier is checked by injecting a standard voltage derived from a Zener diode. Owing to the very low current consumption it has been possible to dispense with an on/off switch, thus ensuring that the instrument is always ready for immediate use. On all ranges the meter is protected against overload, also when applying reversed polarity.

Particular attention has been paid to the ease of operation and the presentation of the results. All ranges are selected by a single control fitted with a specially styled knob and a multi-coloured scale, preventing any possible ambiguity of the selected range. The results are displayed on a "Vistaview" 5in scale meter, the various arcs being printed in different distinctive colours. As an additional aid to ease the reading, the arcs are of the expanded type which reduces the curvature resulting in minimum eye-strain.

The high input resistance and high sensitivity enable measurements to be taken without having to take into account the current drain of the instrument. The frequency range of the a.c. ranges is exceptionally wide, extending up to 100kc/s. This limit can be raised to well over 100Mc/s by the use of the external plug-in probe. Another most useful feature is the centre zero d.c. ranges. Apart from their obvious application for differential circuits, they are very useful for general use, as it saves reversing the leads according to the polarity of the external circuit. Needless to say, both terminals are insulated from earth which avoids the complications common to valve and mains operated instruments.

Three resistance ranges are provided enabling readings up to 100MΩ.

The instrument is housed in a modern styled fibre glass cabinet ensuring the strength required for a portable instrument. At the rear of the cabinet is a stowage space for accommodating the test leads and the r.f. probe

The internally fitted batteries ensure a long uninterrupted life. The battery condition can always be readily checked by selecting the 'Battery Check' range. Battery change involves a minimum of inconvenience.

The voltage ranges cover from 0 to 100mV to 0 to 300V d.c. and 0 to 1V to 0 to 300V a.c. The current range covers 0 to 1μA to 0 to 100mA d.c.

EE 70 757 *for further details*

COSSOR INSTRUMENTS LTD

The Pinnacles, Elizabeth Way, Harlow, Essex

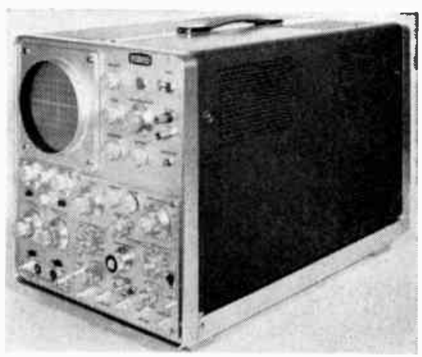
MODULAR OSCILLOSCOPE

(Illustrated below)

The solid-state modular oscilloscope type CD100 comprises a basic main frame containing the display device and power supplies, and one large aperture designed to accept a range of plug-in modules. Depending on the application, one module may supply both *X* and *Y* axes, or individual modules may be inserted to feed either axis of the display.

The fundamental bandwidth limitation on both axes in the main frame is that of the cathode-ray tube only, and typical modules include a range of single and dual trace d.c. amplifiers of bandwidths up to 35Mc/s and sensitivities of up to 500μV/cm, a range of sweep generators, some with delayed sweep facilities suitable for use with the above amplifiers; sampling units for bandwidth up to 100Mc/s; and a range of swept frequency oscillator heads for spectrum analysis from 20c/s to 1000Mc/s.

A complete oscilloscope basically com-



EE 70 154 *for further details*

new compact transistor analyzer PM 6503

combining a wide range of measuring facilities with small dimensions and reasonable price

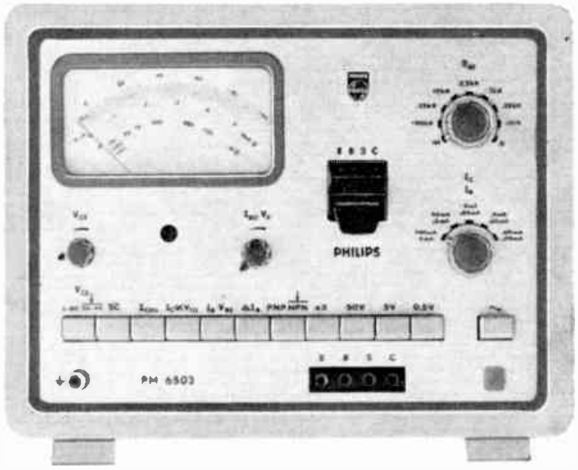
Suitable for measuring characteristics of pnp and npn transistors and diodes

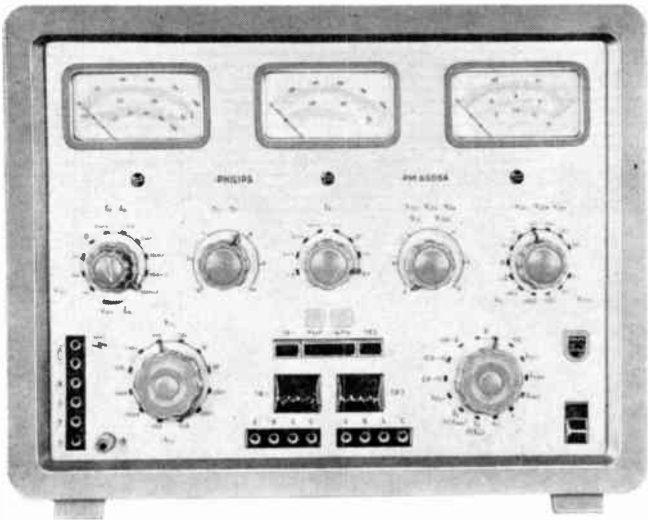
Easy connection of 3 or 4 lead transistors by means of a "snap-action" lever; adapters for TO3 and TO6-type transistors provided

Measuring facilities: short-circuit, rest currents I_{CEO} and I_{CER}, collector current as a function of collector voltage, base current or base-emittor voltage, break-through voltage and static current gain α_{fe}

Accurracy of voltage and current measurements 2 %, accuracy of current gain measurements 5%

Push-button selection of the parameter to be measured





transistor analyzer PM 6505A

new features

have been added to this high-quality instrument, including:
- higher sensitivity of rest current measurements (10 nA full scale)
- collector voltage range up to 60 V
- diode test voltages up to 300 V
- higher amplifier stability
- adapter for TO3 and TO6-type transistors

In addition, this Analyzer has four stabilized power supplies, interlocked controls and three moving-coil meters for clear and simultaneous indication of the voltages and currents of the component under test.

Measuring facilities: short-circuit, rest currents I_{CEO}, I_{CBO} and I_{EBO}, colletor current as a function of base current or base-emittor voltage, knee voltage, parameters h_{fe} and h_{ie} and junction curves

transistor tester PM 6501

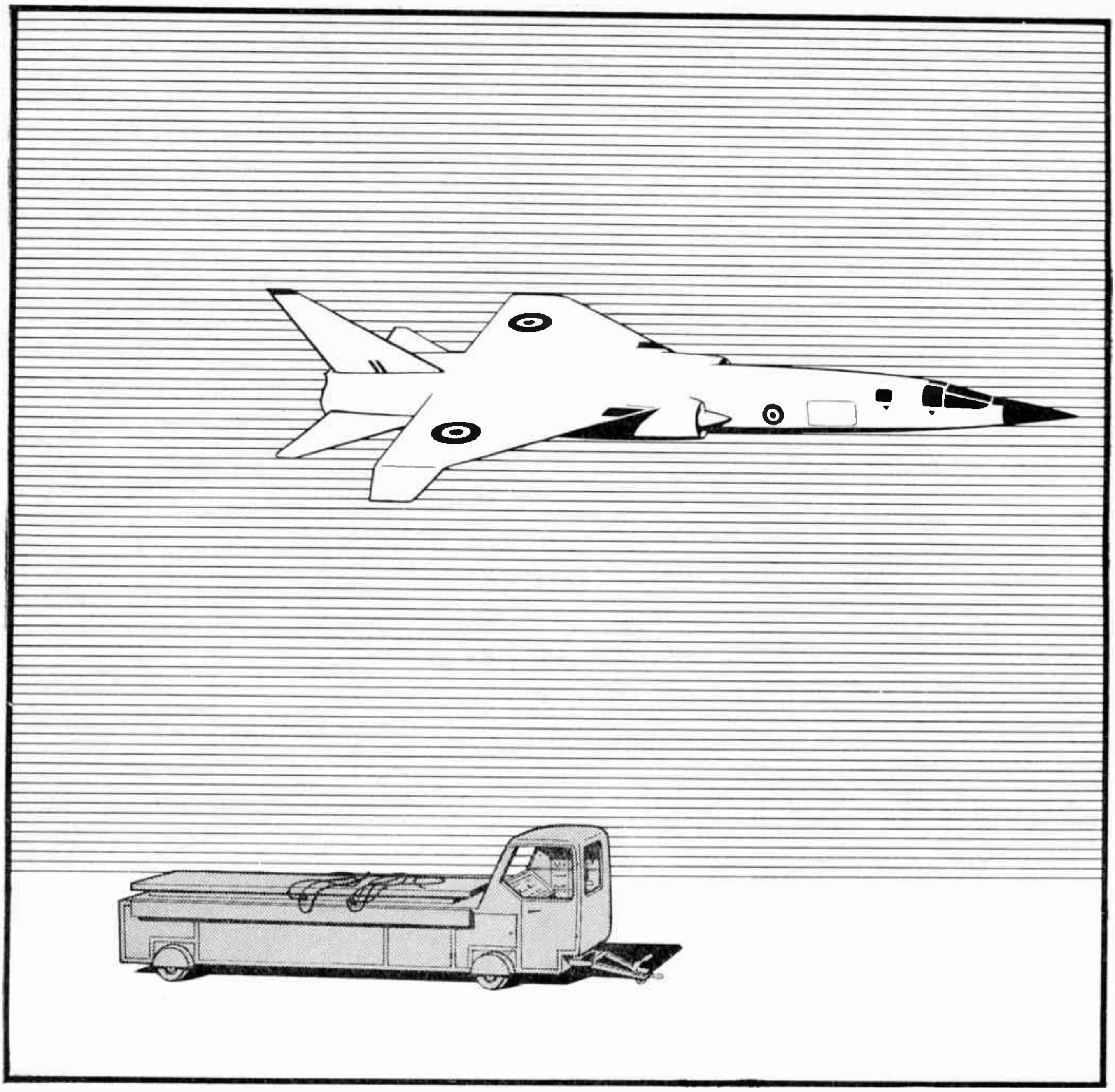
An exceptionally easy to operate tester for accurate and rapid checks on pnp and npn transistors of both low and medium power ratings.
Tests: short-circuit, collector current and current gain.
The applied test voltages are rectified sine waves.

PHILIPS

PHILIPS

electronic measuring instruments

Sales and Service all over the world
For the U.K.:
The M.E.L. Equipment Co. Ltd.,
207 Kings Cross Road, London WC1



CHECKMATES

Britain's TSR-2 will only have short warning of an impending sortie—but essential pre-flight testing by manual methods on this very sophisticated aircraft can take many hours. The only way to meet the requirement for rapid operational readiness is by reducing between flight inspection time through the use of automatic test equipment.

The Hawker Siddeley Dynamics T.R.A.C.E.*, working with superhuman speed and accuracy, will ensure the high degree of readiness required from the TSR-2. The rugged, mobile equipment will check electronic systems installed in the aircraft automatically under world-wide service conditions.

In military or civil use, T.R.A.C.E. saves time, reduces spares holdings and maintenance costs—either in hangar workshops, on flight aprons or at forward air strips.

* *Tape-controlled Recording Automatic Checkout Equipment.*

HAWKER SIDDELEY DYNAMICS LTD

Hatfield Aerodrome · Hatfield · Hertfordshire · England Telephone: Hatfield 2300 Cables: Hawsidyn Hatfield. Telex: 2234 prises a model CD100 display unit assembly, plus two modules; the range of such modules will be as follows: single wideband amplifier; dual wideband amplifier; differential amplifier; wideband differential amplifier; sweep unit; delayed sweep unit; sampling unit; *X-Y* plotter unit.

EE 70 758 *for further details*

THE ENGLISH ELECTRIC VALVE CO. LTD

Chelmsford, Essex

VACUUM VARIABLE CAPACITORS

(Illustrated below)

The English Electric Valve Co. Ltd has introduced a new series of high vacuum variable capacitors for 75A (r.m.s.) operation. Ten types, in two basic body forms, UG and UH, cover capacitance range to 2 000pF with peak r.f. voltages up to 30kV.

These capacitors feature the same details of performance and construction embodied in the now well-established 40A series. The same principle of standardization of component parts has been retained to ensure delivery of any type. The normal tuning arrangement is by

shaft rotation but this may be modified for axial pull operation.

Features of EEV 75A vacuum capacitors include: maximum electrical rating at frequencies up to 27Mc/s; *Q* greater than 10 000; minimum variation of characteristics between capacitors of the same type; attention to the envelope shape reduces glass losses and enables full rated voltage to be applied at the highest frequency; higher current ratings with special cooling; specially selected and tested vacuum bellows for long tuning life; low microphony; completely enclosed pumping seals; low tuning torque; minimum tuner backlash for greater retuning accuracy.

EE 70 759 *for further details*

FARNELL INSTRUMENTS LTD

Sandbeck Way, Wetherby, Yorkshire

SINE/SQUARE WAVE OSCILLATOR

(Illustrated above right)

This transistorized sine/square oscillator has been designed for general purpose use by electrical or mechanical engineering laboratories in industrial or educational establishments. It can be operated directly from the mains supply or from its own internal batteries.

A frequency range from 1c/s to 100kc/s is provided by a bridge type resistance-capacitance oscillator. A 3 per cent accuracy of dial reading ±0·5c/s is maintained throughout the whole

range and the frequency output remains practically constant from the point of switching on.

The sine wave output has less than 2 per cent harmonic distortion, while the rise and fall times of the square wave output are less than 0·3μsec; the sag or overshoot being within 5 per cent.

The attenuator is calibrated into a 600Ω load; four switch positions, 0dB, −20dB, −40dB and −60dB are provided in addition to a continuously variable control covering the range −6dB to +14dB; accuracy is within 3 per cent. The attenuator switch and fine control are also calibrated in peak-to-peak values; the maximum output being 12V peak-to-peak into 600Ω. The amplitude of the output voltage and the impedance remain practically constant, irrespective of the frequency position.

The oscillator output is floating with respect to earth and chassis and when operated from its internal batteries, may be used as a completely floating supply.

EE 70 760 *for further details*

FIELDEN ELECTRONICS LTD

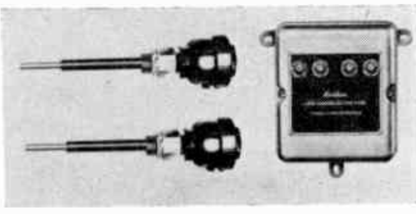
Paston Road, Wythenshawe, Manchester, 22

LEVEL CONTROLLER

(Illustrated below)

The 'Tektor TT6' is a solid state capacitance-sensitive level controller designed to give high stability with excellent discrimination, in a compact, robust and inexpensive form.

The transistorized 'switch' which is moulded in silicone rubber is designed to fit in the head of the extensive range of Fielden type 40 electrodes. The TT6 has exceptional stability against mains voltage and temperature variations. It is relatively insensitive to any resistive changes in the electrode system and once set will require no adjustment on installation or in use.



The bistable transistor output will switch 0·25A, sufficient for a 2·5W lamp. Single and double channel kits are available to provide power with control relays and indication lamps.

In multipoint applications considerable savings are achieved by using common power supplies to several TT6 units and since coxial cable is not required, standard wiring may be used.

EE 70 761 *for further details*

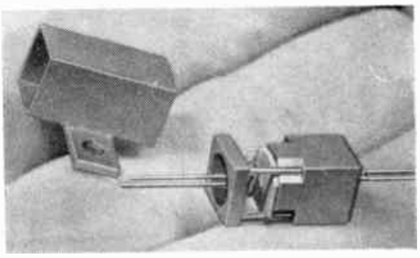
G.E.C. (Telecommunications) LTD

Telephone Works, Coventry

SUB-MINIATURE RELAY

(Illustrated below)

This new relay has been developed to give reliable operation within sub-miniature assemblies while being suitable for many general purpose applications including mounting on to printed circuit cards. It has a volume of less than 0·04in³ and has a mechanical life expectancy of 50 million operations. The relay has a single changeover contact action and contact reliability is achieved



by using solid precious metal contacts and a contact pressure of 10g. All organic compounds are excluded from the sealed contact compartment.

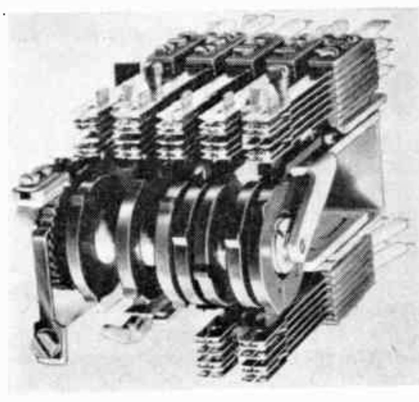
EE 70 762 *for further details*

7-CAM RATCHET RELAY

(Illustrated below)

This relay was developed from the two-cam version to provide a greater range of applications in pulse-operated circuits, being particularly useful for decimal and binary coding.

One such case is the transmission of decimal information in the 2 out of 5 code form which is widely used in modern data transmission and data handling techniques. Five cams may be used for this purpose, the other two pro-



viding an off-normal impulse for a 'start-from-zero' check and a 'carry-over' impulse to the next decade counter. The relay has all the attributes of the original ratchet relay, has the same mountings and occupies two relay positions.

EE 70 763 *for further details*

HEWLETT-PACKARD LTD

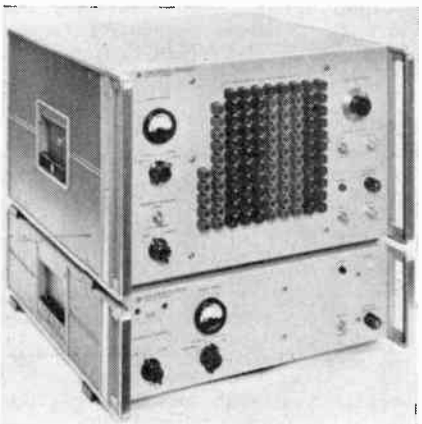
Dallas Road, Bedford

FREQUENCY SYNTHESIZER

(*Illustrated below*)

Hewlett-Packard Ltd has developed a broadband frequency synthesizer with a unique system of frequency selection.

This instrument, type 5100A/5110A, produces 5 000 million discrete frequencies ranging from 0·01c/s. All of these frequencies have a high degree of spectral purity. Their harmonic distortion is less than 30dB while the signal-to-noise ratio in a 3kc/s band centred on the output signal is better than 50dB.



In contrast to more commonly used indirect synthesis methods which depend upon the phase locking of many different frequencies, this new instrument utilizes direct synthesis through electronic addition, subtraction, multiplication and division of signals derived directly from the 1Mc/s internal standard, which has a stability of ±3 parts in 10^9 per day.

Very rapid switching is one of the major advantages of this direct synthesis method. Less than 1msec including all deadtime and transients is required to change frequency. Frequency selection can be accomplished manually with push-buttons or remotely through a system of simple contact closures.

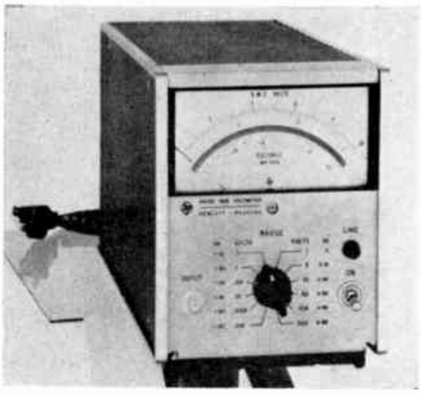
EE 70 764 *for further details*

TRUE R.M.S. VOLTMETER

(*Illustrated above right*)

This instrument (type 3400A) measures the actual root-mean-square value of a.c. voltages from 100μV to 300V, 10c/s to 10Mc/s. Precise r.m.s. measurements can be made of sinusoidal voltages or non-sinusoidal signals having crest factors as high as 10 at full scale or 100 at 10 per cent of full scale deflexion.

In addition r.m.s. values of alternating current may be measured by using the Hewlett-Packard model 456A current



probe. This probe merely clips around the current conductor providing an output voltage proportional to the measured current and of identical wave-form.

Response time is typically less than 2sec to within 1 per cent of final value for a step change. Overload protection is 40dB or 425V r.m.s., whichever is less, on each range. Input impedance is 10MΩ shunted by 25pF.

The 3400A features 12 full scale ranges, rugged taut band meter, and individually calibrated linear scale. In addition a d.c. output is provided proportional to meter reading, useful for driving a digital voltmeter, *X-Y* or strip chart recorder.

EE 70 765 *for further details*

HONEYWELL CONTROLS LTD

Greenford, Middlesex

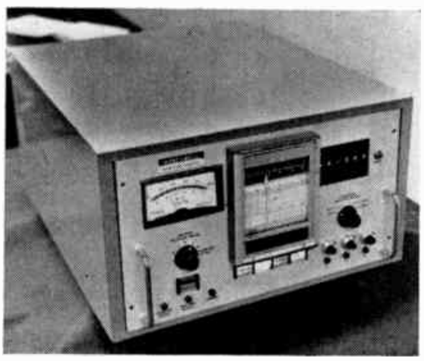
ON-LINE MASS FLOW COMPUTER

(*Illustrated below*)

Introduced by Honeywell's Special Systems division, this computer is built from standard plug-in modules and will accept input signals from such devices as pressure transducers, temperature probes or densitometers. It is also equipped with manual adjustments for constants such as orifice plate size, specific gravity, super compressibility and other factors.

Output signals can be used to indicate and record mass flow while total flow is shown on a counter output. Digital transmission is also possible.

Special features include internal signal conditioning circuits to calibrate the computer to a wide variety of transducers, and a built-in signal source for testing computer circuits.



The computer is designed for all types of industrial environments to operate within an accuracy of ±0·5 per cent in ambient temperatures of between 30° and 120°F.

EE 70 766 *for further details*

HUGHES INTERNATIONAL (UK) LTD

Glenrothes, Fife, Scotland

HALF-TONE DISPLAY UNIT

(*Illustrated below*)

The Model 203 'Tono-Corder' manufactured by Hughes Instruments is a portable integral unit which is used to display half-tone images and graphical data on a 5in cathode-ray storage tube.

The use of this instrument alleviates the necessity of expending engineering time and money for developing a display unit for each requirement. The half-tone images of the input signals are

presented on a 5in direct view storage tube in a manner that is ideal for immediate visual analysis or for more permanent photographic purposes.

Because the image is stored, the input signal can be accepted at a low data rate. Five or more grey shades are available, depending on the writing speed selected. The unit can also be used in high speed data applications. Then the data link is needed for only short intervals to update the display, and thus may be time-shared with other equipment. Writing speeds up to 30 000in/sec can be achieved and still provide images with good grey scale selectivity and high resolution.

The complete spectrum of grey shades for high-fidelity picture reproduction, along with extremely high brightness and controlled persistence make the unit easily adaptable for a great number of industrial, commercial, medical and military applications.

The high light output, of the order of 1 000 foot-lamberts at saturated brightness, presents a brilliant half-tone picture on weather radar even when viewed in full daylight.

The unit's high resolution, slow-scan capability is equally well suited for the transmission of pictures over conventional telephone lines. This narrow-

Leadership in Semiconductors

TEXAS INSTRUMENTS

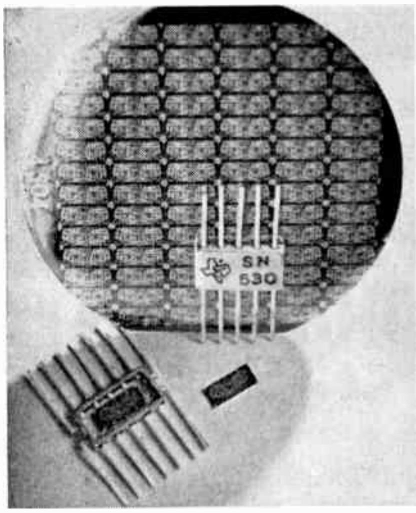
Looking logically at integrated circuits

New high-speed digital semiconductor networks

Series 53 SOLID CIRCUIT* semiconductor networks provide the designer with maximum flexibility through the use of AND/OR INVERT logic with the minimum number of different units.

Features include operation to 5 Mc/s, propogation delay times as low as 5 nanoseconds per AND gate, excellent loading capabilities and the ability to cascade non-inverting logic gates. Series 53 can fulfill most digital requirements in present day computer system applications.

Here is the Series 53 range:
SN530 Single phase, J-K flip-flop
SN531 5-input NAND gate
SN532 5-input AND gate
SN533 Dual 3-input AND gate
SN534 2 and 3-input AND gate
SN535 Clock driver/buffer



Series 53 network, Master Slice wafer*

Master Slice* wafer allows flexibility in mass production

Series 53 as well as TI's established Series 51 and Series 52 networks are made using the Master Slice* fabrication technique. All circuits in a series begin with a slice of silicon containing 50 or more sets of equivalent components.

For Series 53, each component set contains the equivalent of 28 NPN transistors, 10 PNP transistors, 5 capacitors and 26 resistors. Late in the production process, interconnections are made on the Master Slice* to form standard networks, or special networks built to customer specifications. This technique produces maximum network flexibility without sacrificing the economy and consistent reliability of the TI mass production system.

* *Texas Instruments Trademark*

NOW is the time to design semiconductor networks into new equipment

Semiconductor networks may be the answer to your design requirements for reliable, compact and economical circuitry... sooner than you think.

Why now?

Semiconductor networks are penetrating the electronics industry, in Europe as well as in the U.S., even faster than the transistor. Why? Partly because the industry now has the overall experience needed to avoid the sharp transition which we remember when vacuum tube equipment was "transistorized".

Reliability

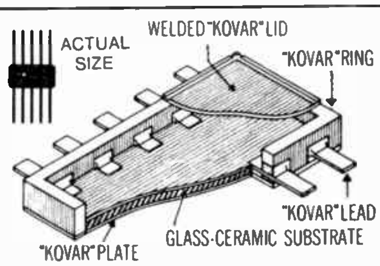
But primarily because experience in transistor reliability evaluation has quickly revealed the remarkable reliability improvements which semiconductor networks will bring. Early tests showed how an integrated circuit containing the equivalent of 20 parts could have the same failure rate as a single conventional transistor. Manufacturers now believe that in a few years a failure rate of around .0001 percent per 1000 hours will be achievable.

Industrial, consumer applications

In addition to the growing military market, industrial and consumer product manufacturers in the U. S. and Europe are moving rapidly to utilize reliable, compact integrated circuits.
For example, Zenith Radio Corporation in the U. S. recently announced a semiconductor hearing aid, developed with TI.

Production, prices

The industry stands just at the beginning of true mass production. Production at TI in 1963 increased eight-fold and more networks were shipped by TI in the fourth quarter of 1963 than the entire industry shipped in the second. And TI is confident that network prices will follow the pattern of steady downward adjustments established by transistors.
In short, the time is *now* for forward looking logic designers to plan for new standards of system reliability and economy with integrated circuits.



Flat package concept becomes standard

In 1959, while most manufacturers were packing more conventional components into transistor cans, TI took a bold short cut and announced the first fully integrated networks in flat packages. It is estimated that 60 to 70% of all integrated circuits sold today are in the flat package configuration.

The flat package provides the most efficient form factor for systems packaging. Shorter bonding leads permit a more rugged construction. Interconnections are easier. And the package is readily welded to printed circuit boards. The package shown above provides a 10 to 1 reduction in size over TO-5 cans when mounted. Total weight is less than 0.1 gram. Package dimensions are 6.4 x 3.2 x 0.9 cm.

Total capability... materials to systems assembly

As semiconductor network applications have developed, there has been a need for related test and assembly equipment. Such equipment is now available from TI for use with networks from TI and other manufacturers. A unique parallel gap welder has been developed to weld networks to printed circuit board. For large users, an in-line tester is available. And special carriers and test jigs assist handling and testing.

Data is now available on this equipment and on the complete line of TI Series 51, 52 and 53 networks. Write for it today

TEXAS INSTRUMENTS LIMITED

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EE 70 157 *for further details*

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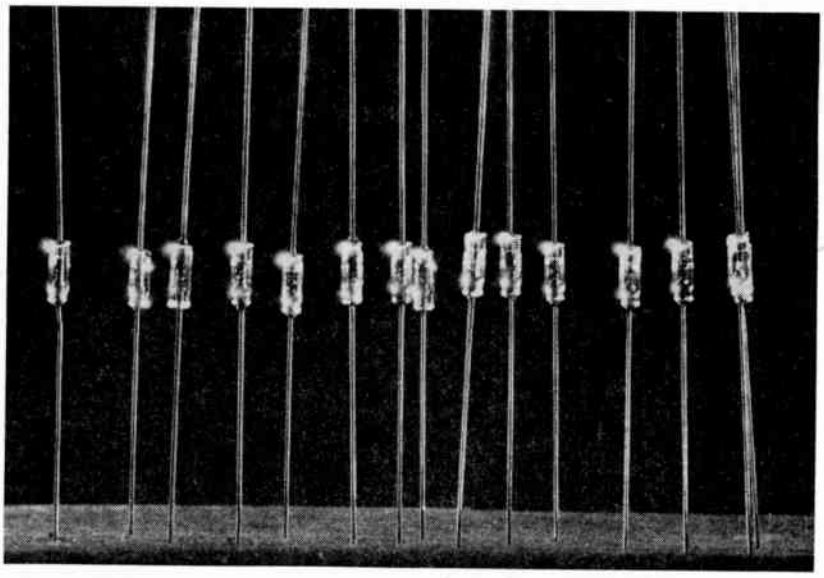
Solar Cells.



And, of course

PLANAR DIODES,

Miniature Power Rectifiers up to 400mA and 200 volts and Switching Diodes, from 200mA, 80 volts, 50nS to 20mA, 20 volts, 5nS.

Every device has been developed and manufactured wholly in Great Britain.

PLESSEY GROUP

Semiconductors Limited

CHENEY MANOR, SWINDON, WILTS.
TELEPHONE: SWINDON 6251

band type transmission, as used in a closed-circuit television application, for instance, eliminates the need for costly coaxial cable transmission. The high-fidelity pictures may be examined at very slow rates and even 'frozen' for photographing.

The high brightness of the screen and the integration characteristics of the instrument make it useful for pulling weak signals out of a high noise level. By re-scanning a known pulse the intensity of the pulse is built up while random noise is being continually erased.

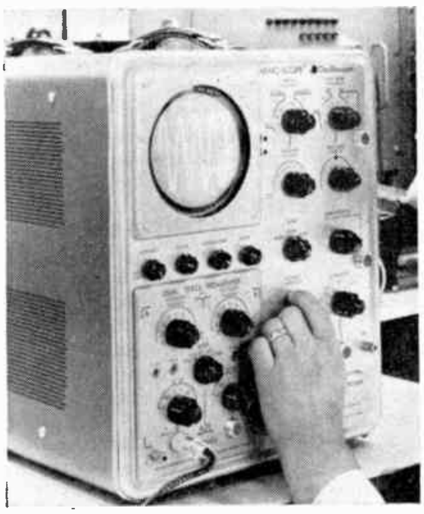
This type of application has considerable potential in space communications, and for a number of military situations. As used in radar p.p.i. display systems the Tono-Corder has the ability to cover the complete grey scale spectrum and provides maximum contrast for easy identification of cloud formations, ground clutter, and targets. Persistence may be adjusted for maximum duration over most of the 360° fading to black just ahead of the sweep.

EE 70 767 *for further details*

Storage Oscilloscope

(Illustrated below)

The Hughes 'Memo-Scope' oscilloscope functions both as a conventional cathode-ray oscilloscope and as a storage oscilloscope which can store a display on its screen as long as is desired, at a writing speed of 10^6in/sec. A distinctive feature is that all the advantages of single instrument versatility of application for the Hughes Memo-Scope oscilloscope are possible through available plug-in pre-amplifiers. Interchangeable units are available and each incorporates performance characteristics designed for compatibility with the Memo-Scope oscilloscope when operated either in the conventional or storage mode of operation. The oscilloscope makes use of the Memotron tube for both modes of operation. The Memotron tube contains a conventional cathode-ray tube gun and deflexion system as well as a P-1 type phosphor viewing screen. Normal operation as an oscilloscope



utilizes these parts of the tube. Behind the phosphor screen, separated by a small gap, is a storage assembly which consists of two fine screens, forming the storage mesh and collector mesh. Behind this assembly are two electron guns, called flood guns. These additional elements permit the storage of written information in the following manner. The flood guns emit a broad beam of electrons which are arranged by a collimating system so as to uniformly flood the storage mesh with low velocity electrons, thus providing it with a uniform negative charge. When the writing gun beam strikes any part of the storage mesh, it causes secondary emission to occur in the spots hit by the high-energy writing gun electrons. Through the secondary emission process, these areas loose more electrons than they acquire. Therefore, local positive charges result and the flood electrons are attracted through the positive areas, where they continue on to strike the phosphor screen. The phosphor screen is operated at sufficient potential to cause it to fluoresce in the normal manner. A bright trace results since each spot which is stored in this manner is continuously displayed, rather than written in a repetitive fashion as in normal cathode-ray tubes. The collector mesh, referred to previously, is for the purpose of attracting the secondary electrons released from the storage mesh so that the written areas of the storage mesh acquire, locally, the potential of the collector mesh, maintaining the charge pattern until the collector mesh potential is deliberately lowered below the critical value required for storage, thereby erasing the information.

EE 70 768 *for further details*

H.V.L. LTD

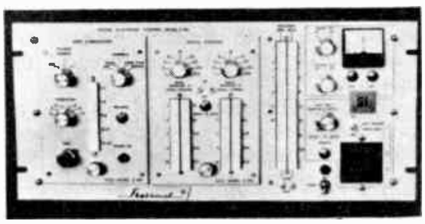
1 Cardiff Road, Luton, Bedfordshire

Digital Drift Stabilizer

(Illustrated below)

This instrument has been specifically designed to correct drift variations in multi-channel pulse height analysers. The 'Stabimat' will perform a continuous correction of gain drift occurring for any of the following reasons: detector and photomultiplier variations; e.h.t. variations; pre-amplifier and linear amplifier gain drifts; analogue-to-digital convertor drifts (including zero drift).

Working on entirely new principles, the 'Stabimat' uses solid-state digital techniques to ensure absolute accuracy of pulse height or energy conversion without deteriorating resolution.



The instrument has the following features: drift correction operates on absolute counts and is entirely independent of count rate; using digital techniques throughout, the correction system cannot contribute any drift; may be used with any multi-channel pulse height analyser; using the 'Stabimat' results in negligible loss of resolution. Drift can generally be corrected to better than 0·1 of a channel.

EE 70 769 *for further details*

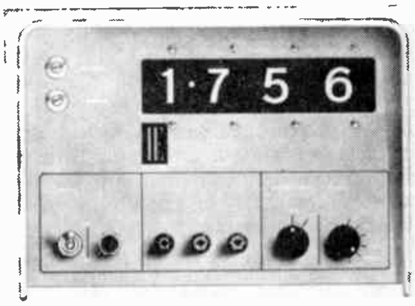
INTERNATIONAL ELECTRONICS LTD

132-135 Sloane Street, London, S.W.1

Digital Voltmeter

(Illustrated below)

The DSV.1 is basically a three-digit 0·1 per cent digital voltmeter. The switch enables the 1000 least significant digits to be subtracted from the input and this facility effectively doubles the range of



the instrument. The instrument has four basic ranges giving full-scale readings of 1V, 10V, 100V and 1000V, but the basic sensitivity of the instrument is such that it will operate directly from most common types of thermocouple to give a discrimination of 0·1°C over a range of 0 to 100°C. The circuits are totally solid-state and a very clear high reliability projection display is used. The maximum conversion time is 10msec and the instrument takes approximately 20 readings per second.

EE 70 770 *for further details*

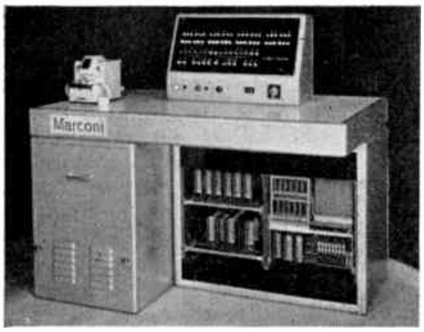
THE MARCONI CO. LTD

Chelmsford, Essex

High Speed Computer

(Illustrated on page 418)

This experimental computer is based on the use of microminiature silicon diode transistor logic modules with a stage delay time of as little as 5nsec. The compact construction resulting from the use of these microminiature techniques is a major factor in the high speed of the computer. The micrologic devices are mounted in type T0-5 modules and printed boards are used wherever possible. Intermodule wiring has been reduced to the absolute minimum, resulting in a computer that is smaller than a normal office desk. The computer works asynchronously



and uses a coincident current, ferrite core store which has a capacity of 4096 words. The computer uses a 24 bit word length and has a store access time of 0·4μsec and store cycle time of 1·2μsec. Thirty-two basic microprogramme orders have been provided and the order speed for fetch, add, subtract, etc., is 2·5μsec and, for multiplying, 10μsec. The operating panel includes voltage indicators to show the instantaneous contents of each register, as well as keys and switches for computer control and programming.

Connexions to peripheral devices are made via data and control highways. An autonomous store access facility allows external devices to have access to the store without interfering with the programme. Normal interrupt facilities are also included to handle up to 15 peripheral devices.

EE 70 771 *for further details*

MARCONI INSTRUMENTS LTD

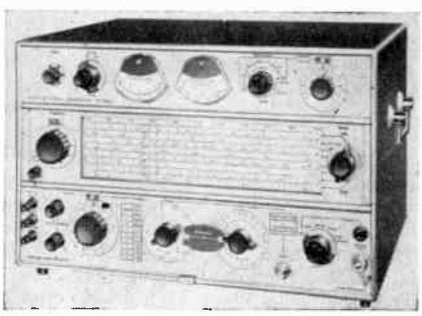
St. Albans, Hertfordshire

SOLID-STATE WIDE RANGE SIGNAL GENERATOR

(Illustrated below)

This new Marconi design, m.f./h.f. a.m. signal generator type TF 2002, gives high quality a.m. outputs from 10kc/s to 72Mc/s and features high discrimination (effective scale length of more than 2½ miles), exceptionally low leakage and spurious modulation, and a rugged compact construction. Weighing only 50lb (23kg) it is available in bench or rack mounting form and can be powered by mains or batteries.

Each of the eight frequency bands has a separate permeability tuned oscillator and output circuit for optimum performance throughout the range. The hand calibrated near-logarithmic tuning scale is displayed in a continuous zig-zag



pattern with scales running alternatively left and right. This new system cuts tedium and speeds up tuning at extremes of frequency bands.

Crystal check points are available at intervals of 1Mc/s, 100kc/s or 10kc/s with subsidiary points at ±1kc/s relative to the main points for use in bandwidth measurements. Above 100kc/s carrier frequency a direct-reading incremental tuning control, which can be standardized against the crystal check points, gives a discrimination of 0·025 per cent of carrier frequency.

Output up to 2V source e.m.f. at 50Ω is obtained via 20dB and 1dB step attenuators and is stabilized during tuning by automatic level control. Internal a.m. up to 100 per cent is produced by a continuously tuned oscillator covering the audio band. Envelope negative feedback ensures good modulation quality up to at least 80 per cent and modulation depth is independent of both carrier tuning and carrier level. External f.m. or phase modulation can be applied.

EE 70 772 *for further details*

ELECTRONIC COUNTER

(Illustrated above)

This solid state counter, type TF 2401, comprises a basic instrument into which plugs a frequency range unit and a function unit. The range unit determines the maximum input frequency which may be measured; the function unit determines the type of measurement which may be made. The plug-in units at present available are a 50Mc/s frequency range unit, a counter-timer function unit, and a 500Mc/s convertor unit.

When used with these units the instrument performs the following basic measurements: frequency, period, multiple period, time interval, frequency ratio, ratio of one frequency to a multiple of another, events during an externally applied time interval, totalizing, and the scaling down of an applied signal.

Features include an 8-digit read-out with memory, measurement units illuminated in the display window, and a self-check facility. Connecting the instrument to the mains supply energizes the oven, giving it time to stabilize without the necessity of energizing the rest of the counter.

A printer or remote read-out may be driven by the counter, and as an optional facility the instrument may be adapted to accept control from a remote source. The instrument can also be used as a time interval generator, providing pulses from 0·01c/s to 1Mc/s in decade steps; 1Mc/s and 10Mc/s outputs are also available on separate sockets.

In the design of the TF 2401, extensive use has been made of logic techniques; semiconductors, printed circuits and modular plug-in construction is used throughout. It will be available in bench or rack-mounting forms; the instrument is approximately 38lb (17kg) in weight.

EE 70 773 *for further details*

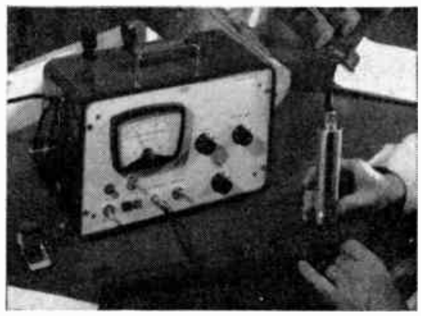
PANAX EQUIPMENT LTD

Holmethorpe Industrial Estate, Redhill, Surrey

RADIOACTIVE THICKNESS GAUGE

(Illustrated below)

For industrial purposes, Panax Equipment Ltd has developed a fully portable radioactive gauge for quick and accurate determination of surface coating thicknesses from only one side of the object. Intended primarily for measuring plastic



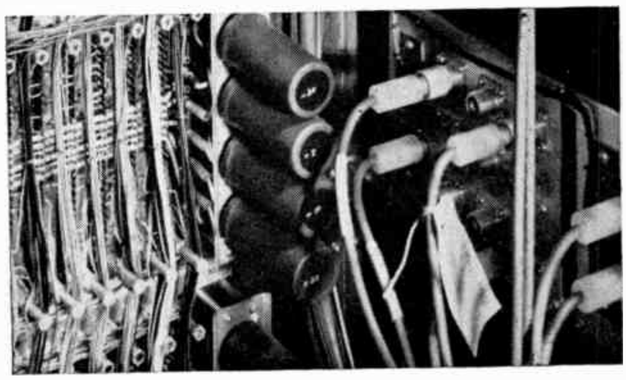
coatings, it can also deal with paint and plating applied to many materials. The instrument is of the 'backscatter' type, which technique is non-destructive and therefore suitable for quality checking of components during manufacture or in a laboratory. Any material deposited as a coating upon another may be measured in this way, providing there is sufficient difference between the atomic numbers of the two materials. Unlike most other backscatter gauges, the Panax instrument is not confined to flat or regularly shaped articles, and the design of the probe is such that the critical working distance between the radioactive source and the object remains substantially constant even with curvatures of small radius.

The radioisotope used is Promethium 147, which is a commonly used beta-emitting source for thickness measurement. It is mounted at one end of a small probe containing a Geiger-Muller tube and has a useful working life of more than 2½ years. The indicating instrument is similar to the Panax RM-202 ratemeter and has a moving-coil meter with an effective scale length of 3in. Plastic film thicknesses ranging from 50 millionths to 2 thousands of an inch can be measured and the sensitivity is such that full scale deflexion can be set to correspond to a measured thickness of 0·0005in. The large, open scale therefore makes accurate reading a simple matter, even for unskilled personnel.

MORE THAN 2 MILLION FEET

OF WANDLESIDE P.T.F.E. CONNECTING WIRES AND FLEXIBLES ARE USED ANNUALLY IN WIRING ENGLISH ELECTRIC LEO COMPUTERS

The delicate and sensitive "brain" of a computer requires the most intricate of wiring systems. Wiring is the life-blood of a computer, so it is essential that it is of the highest quality. Wandleside P.T.F.E. insulated wires and flexibles guarantee absolute accuracy and reliability under the most stringent conditions. We can manufacture to both Ministry and Commercial specifications.



If you have problems with

● MINIATURIZATION ● HIGH AMBIENT TEMPERATURE CONDITIONS ● SOLDERING IN CONFINED AREAS ● SOLDERING TO MINIATURE CONNECTORS OR COMPONENTS

Consult **WANDLESIDE WARREN WIRE COMPANY** *In Association with* WANDLESIDE CABLE WORKS LIMITED *(Falks Group)*

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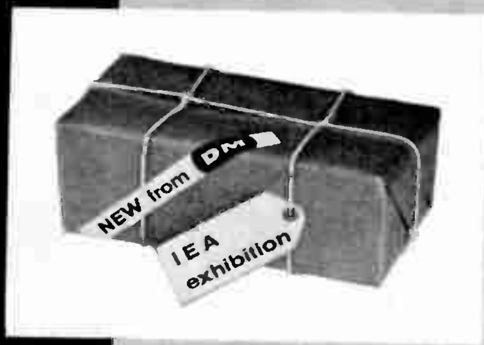
DC Voltmeter
Range:
10µV to 2KV
Accuracy: 0·01%

DM2004
DC Voltmeter
Range:
1mV to 1KV
Accuracy: 0·1%

DM2001
DC Voltmeter
Range:
50µV to 2KV
Accuracy:
0·025% f.s.d.

DM2003
AC-DC Voltmeter
DC Range:
1mV to 1KV
DC Accuracy: 0·1%
AC Range:
2V to 700V
AC Accuracy: 0·5%



Thoughtful design and high manufacturing standards are evident in all D.M. Digital Voltmeters. Instruments can be supplied to measure D.C. and A.C. voltage, current and resistance, and may include special D.M. features such as high sensitivity, maximum and minimum reading facilities, external scale control and a variety of output codes. A full range of data logging modules enables measurements from up to 1000 signal sources to be recorded in printed or punch-coded forms, with automatic off-limit warning for measurements falling outside preset limits. The product range includes high and medium performance instruments linked by a common factor—quality.

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DIGITAL MEASUREMENTS LIMITED

SALISBURY GROVE MYTCHETT ALDERSHOT HANTS TEL: FARNBOROUGH 3551

The gauge is transistorized and can be operated from mains or batteries. Complete with probe, it weighs approximately 16lb.

EE 70 774 *for further details*

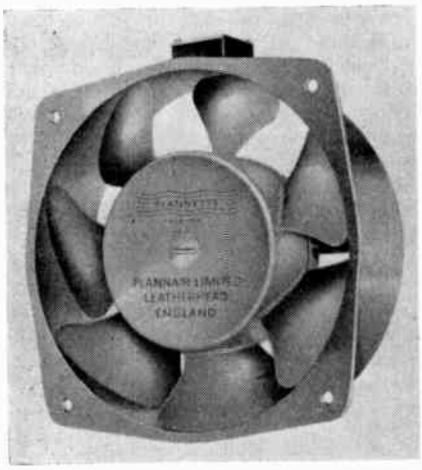
PLANNAIR LTD

Windfield House, Leatherhead, Surrey

AXIAL FLOW BLOWERS

(Illustrated below)

Two new models in the Plannetter range of axial flow blowers have been introduced. The two units are 10in and 12in in diameter respectively, and both have a depth of only 3in. The 10in Plannette has a performance of 560ft³/min while the 12in model provides 1 000ft³/min in free air conditions.



The new Plannettes are the latest additions to the Plannair range of high performance blowers designed for applications where space-saving is vital, more than 1 000 different versions having already been produced for aircraft, electronic and automation applications.

EE 70 775 *for further details*

PLESSEY (UK) LTD

Swindon, Wiltshire

CRIMPING TOOL

(Illustrated below)

Plessey (UK) are now producing a new 'UNIcrimp' tool.

This is a compressed-air driven version of the hand UNIcrimp, a universal, one-

handed automatic tool capable of making perfect square-form crimps on any size of wire or contact up to 12 A.W.G. Designed for bench mounting, with foot control if required, or operation as a portable tool (for example, on aircraft wiring), the power UNIcrimp is offered as a fully-proven production machine after completing a long and rigorous test programme. The machine's useful range has now been extended to include pre-insulated tags.

EE 70 776 *for further details*

RANK CINTEL LTD

Worsley Bridge Road, London, S.E.26

TRANSISTOR POWER SUPPLY

(Illustrated below)

Transistor power pack type 18920/1 is designed to deliver 6 to 30V at a maximum current of 500mA. The output

voltage is selected by means of a two position range switch and continuously variable fine control. Two miniature meters indicate output voltage and current respectively.

Complete protection of the unit and external equipment is provided by an electronic overload circuit which includes facilities for automatic and manual reset. The overload cut-out can be set to operate at any value by means of an internal control.

The output of the power pack is fully floating, but either terminal may be grounded by means of a short link.

EE 70 777 *for further details*

ALPHA-NUMERIC DISPLAY TUBE

This is a new form of alpha-numeric display cathode-ray tube, which overcomes some of the problems which arise when normal c.r.t.'s are used for this purpose. For example, the Matricon is capable of producing a brighter display and a higher rate of character generation than can be obtained with conventional tubes.

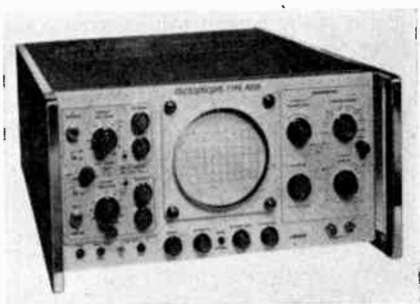
The principle of the 9in Matricon alpha-numeric display tube is that a broad beam of electrons flood a plate which has a matrix of apertures. Each of the apertures has an independent connexion, such that a pulse of about 25V suppresses the beam through it. In this way any desired character is formed in one go in an extremely short time.

Since all parts of a character are simultaneously illuminated the brightness is much greater than in cathode-ray tube character generators in which the character is formed by a single moving spot. Early tubes have produced characters in less than 10μsec, and the brightness is adequate for daylight viewing.

Solid state circuits have been made to accept a 6-bit code and to emit the necessary pulses for the apertures of the Matricon. One such decoder-encoder can supply ten display tubes by time multiplex, the ten displays being independent.

It is also possible to draw mimic diagrams by means of one aperture and to label it with alpha-numeric data using the matrix of apertures.

EE 70 778 *for further details*



ROBAND ELECTRONICS LTD

Charlwood Works, Lowfield Heath Road, Charlwood, Horley, Surrey

OSCILLOSCOPES

(Illustrated above)

Roband Electronics Ltd has introduced a range of four oscilloscopes known as the RO50, RO51, RO55 and RO501. Each offers a different specification, but all have been designed to achieve a cost far below current levels, without sacrificing performance and reliability.

The RO50 (illustrated) is a wide band precision oscilloscope with signal delay employing the full range of Roband '5' series of plug-in units.

The RO51 has the same general precision characteristics as the RO50, but will accept the Roband '5' series of plug-in units in either X or Y giving XY and delayed sweep facilities.

The RO55 is a general purpose oscilloscope in a more portable form using the Roband '5' series of plug-in units.

The RO501 is an extremely portable 5in inexpensive laboratory and servicing unit which sets a high standard in its class for reliability and accuracy.

The RO50, RO51 and RO55 oscilloscopes form the basis of an integrated family which features the '5' series of Roband fully interchangeable plus-in units.

EE 70 779 *for further details*

THE SOLARTRON ELECTRONIC GROUP LTD

Victoria Road, Farnborough, Hampshire

INTEGRATING DIGITAL VOLTMETER

(*Illustrated below*)

The Solartron integrating digital voltmeter LM1420 is a compact, high performance instrument of considerable flexibility and low cost which uses a self-compensating, counter integrator technique, to achieve high accuracy and high resolution with maximum discrimination against unwanted signals.

The input circuits are completely floating with an isolation impedance greater than 10^6MΩ/150pF to mains earth, giving 150dB reflection of common mode interference up to 500V peak.

Advantage has been taken of the counters within the instrument to provide counting facilities (pulse counting, frequency and period measurements), with local or remote control in each case. The digital read-out is by neon number tubes housed behind a polaroid filter.

New manufacturing methods, including automatic testing of printed circuit boards and cable looms before final assembly, ensure a high standard of reliability.

The excellent performance of this digital voltmeter results from the counter integrator technique used. The applied signal voltage causes the output of an integrating amplifier to rise towards a preset trigger level, at which point it is reset by an accurately quantized charge. The rate of rise, and consequent number of reset charge pulses per unit time, is directly proportional to the input voltage. Digitization is achieved by counting these pulses over a definite period, to give a true average of the applied signal throughout that period, so minimizing the effects of spurious noise. The counting period selected is normally one cycle of the mains supply frequency to give maximum rejection of fundamental and harmonics of this frequency.

The timing oscillator controls the duration of the discharge pulse, as well as the timing period, so that any drift of oscillator frequency will vary the timing period and pulse duration equally, hence providing automatic compensation to retain reading accuracy.

The output from the counter integrator circuit is a train of pulses coupled to the counter circuit through a toroidal transformer. Power supplies to the input circuit are coupled through a similar transformer in the form of a 4kc/s square-wave. The input stages are therefore completely isolated from mains earth. Connexion to the input is via a panel-mounted, 3-way plug—'High' and 'Low' signal pair, and a 'Guard' connexion. Thus either 3 terminal guarded measurements or 2 terminal ('guard' strapped to 'low') measurements can be made. For most laboratory applications, 2 terminal connexion to the signal source will give adequate rejection of noise. For certain applications (e.g. data logging) the Guard can be taken to the source of common mode voltage, thus virtually eliminating the common mode loop. As a result of this a common mode rejection in excess of 150dB is obtained.

Voltmeter sensitivity may be doubled or quadrupled by ×2 or ×4 increase of counting period. This facility may be used to increase effective resolution for inputs below ½ scale, or ¼ scale respectively on any range. Inputs to both the timing and display counters are brought out to the rear of the instrument and may be used for pulse counting, frequency and period measurement, etc., with facilities for local or remote control.

The apparent input impedance of the voltmeter which is nominally 5 000MΩ on the 2V range, may be adjusted to approach infinity for short term operation.

The basic coverage of the instrument is 0 to 20mV to 0 to 1kV in 6 ranges.

EE 70 780 *for further details*

ULTRASONOSCOPE CO. (LONDON) LTD

Sodbourne Road, Brixton Hill, London, S.W.2

ULTRASONIC FLAW DETECTOR

(*Illustrated below*)

This new mark 2C instrument replaces the existing mark 2B portable instrument, and incorporates additional facilities and improvements. Particular efforts have been made to meet the requirements of those engaged on ultrasonic weld inspection whether on the workshop floor, on open site, or in the research laboratory.

To this end, several features not usually found in a portable flaw detector are incorporated. Very fast time-base speed and high trace brightness combine with a rectified or unrectified trace display to enable a comprehensive study of flaw echo shape. The operational frequency range of 0·5Mc/s to 10Mc/s and a maximum depth range of 24ft (in steel) extends the possible application range over a very wide number of non-destructive inspection problems. A 5in diameter high definition cathode-ray tube reduces operator viewing fatigue. To facilitate the setting of the necessary standards which determine the acceptance or rejection of the material under test, the amplitude of a defect echo on the trace can be set by an attenuator control.

Where the equipment is to be used for routine inspection a control may be brought into use to provide an extremely clean trace by contrasting small defect echoes against spurious echoes received from grain boundaries, the latter being reduced to a minimum value. To avoid the possible misuse of this facility a prominent warning light is illuminated when this control is being used.

Coarse and fine trace delay controls are incorporated allowing the operator to select any portion of the display for expansion across the full time-base length up to a maximum of 30in (in steel).

EE 70 781 *for further details*

VACTRIC CONTROL EQUIPMENT LTD

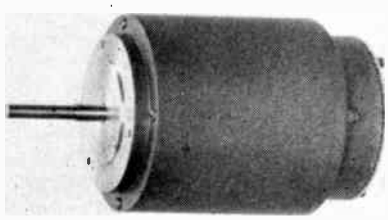
Garth Road, Morden, Surrey

SLOW SPEED SYNCHRONOUS MOTOR

(*Illustrated below*)

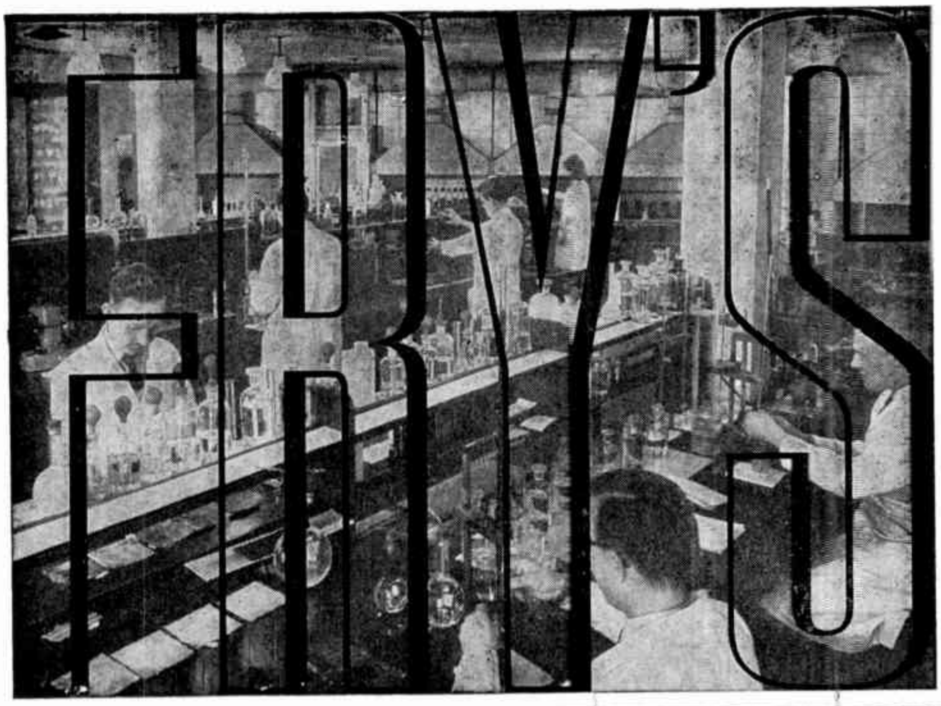
The new Vacsyn slow-speed synchronous motor is designed to produce a high torque at low speeds to obviate the need for reduction gears. At 50c/s, its synchronous speed is 60rev/min, giving a minimum synchronous torque of 150 oz-in, corresponding to an output power of 5·5W. The Vacsyn motor can also be used as a stepping motor.

The overall length, including the drive shaft is 7¼in and the diameter 4 3/16in. The maximum input current is 350mA and the maximum input power 35W.



EE 70 782 *for further details*

at



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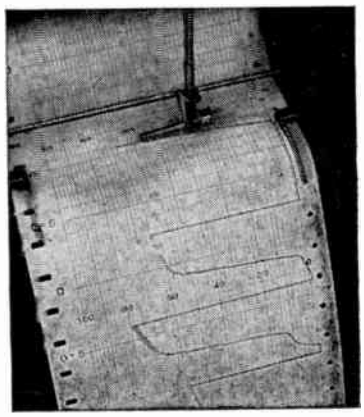

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Le Salon de L'AUTOMATION DE L'ELECTRONIQUE ET DES INSTRUMENTS

Description, basée dur des renseignements fournis par les fabricants, de certains des appareils exposés au Salon des Instruments, de l'Electronique et de l'Automation à l'Olympia de Londres du 25 à 30 mai 1964

Traduction des Pages 413 à 420

BARR & STROUD LTD

Kinnaird House, 1 Pall Mall East, London, S.W.1.

MANIPULATEUR À CODE MORSE

(Illustration à la page 413)

La société Barr & Stroud Ltd a mis au point un dispositif miniaturisé permettant la manipulation automatique d'un bref message en code Morse émis par un transmetteur ou un clignotant. Dans sa forme actuelle, il peut être incorporé à un coffret de commande de détresse d'avion ou de navire. Il peut être modifié aisément pour d'autres applications exigeant une séquence de manipulation. La séquence peut être changée sans difficulté.

Il ne contient ni parties mobiles ni tubes à vide, ne comportant que des semi-conducteurs et des noyaux de ferrite. Il est ainsi assuré d'une très grande fiabilité en dépit de ses dimensions réduites. L'alimentation peut être fournie par piles sèches, la puissance requise étant de 60 mW à 12 V et 140 mW à 4 V. On peut ainsi produire des codes de façon continue et pendant des semaines à partir de la batterie. La durée de la séquence de message du prototype est d'environ 2 minutes à une vitesse nominale de manipulation de 6 mots/minute. On peut, cependant, faire varier cette vitesse pour différentes applications. Le prototype mesure environ 4 cm × 9 cm × 10 cm et son poids est d'à peu près 200 g.

EE 70 751 *pour plus amples renseignements*

BECKMAN INSTRUMENTS LTD

Glenrothes, Fife, Scotland

COMPTEURS ET MINUTERIES

(Illustration à la page 413)

Les instruments de la série 6100 comprennent des éléments à fiches et ils sont entièrement constitués de corps solides. L'affichage numérique luminescent est du type linéaire et sur plan.

Les modèles à 25 MHz et à 2,5 MHz de la série 6100 sont prévus comme compteurs et minuteries "d'événements par temps unitaire." La gamme et les fonctions peuvent être étendus au moyen d'éléments accessoires à fiches. Les modèles à 25 MHz peuvent recevoir des éléments à fiches qui portent leur gamme directement à 100 MHz ou, par hétérodyne, à 1 000 MHz. Tous les instruments de la série peuvent être utilisés avec un convertisseur tension/fréquence interchangeable qui indique la tension directement sur une représentation numérique. Des intervalles de temps allant jusqu'à 30 µsec peuvent être mesurés avec une résolution de 10 µsec à l'aide de l'élément à fiches de 100 MHz.

EE 70 752 *pour plus amples renseignements*

GÉNÉRATEURS DE TENSION À EFFET HALL

(Illustration à la page 413)

Cette nouvelle gamme de générateurs à effet Hall a été réalisée par la Helipot Division de la société Beckman Instruments Inc. Désignés sous le nom de "Hallefex," ces générateurs sont livrables en quatre modèles assurant une sensibilité de sortie élevée alliée à une résistance d'entrée et de sortie également élevée. Ce qui distingue surtout les générateurs de tension constitués de corps solides Hallefex des autres appareils du genre c'est leur film semi-conducteur micro-mince à dépôt de vide qui donne une plus grande sensibilité de sortie que ce n'était le cas auparavant et produit ainsi un entrefer efficace de près de 15 fois plus petit que celui des générateurs à effet Hall classiques.

EE 70 753 *pour plus amples renseignements*

BELL & HOWELL LTD

Consolidated Electrodynamics Division, 14 Commercial Road, Woking, Surrey

OSCILLOGRAPHE ENREGISTREUR

(Illustration à la page 413)

L'oscillographe enregistreur Datagraph 5-133, le tout dernier dans cette gamme, est livrable pour montage sur bâti ou sur banc d'essai. C'est un enregistreur à lecture directe utilisant une source de lumière actinique élevée pour l'éclairage du galvanomètre. Trente six ou 52 voies de données sur papier sensible à la lumière de 30,48 cm de large sont produites sans aucun traitement chimique. Des mesures dynamiques du courant continu à 13 kHz peuvent être effectuées, et des phénomènes à temps de réponse de 10 msec, 1,0 msec ou 0,5 msec peuvent être enregistrés. Le Datagraph 5-133 comprend des lignes de réseau, des lignes de minutage, le numérotage de trace, la longueur de tir automatique, l'identification des phénomènes et la commande de vitesse par bouton-poussoir.

L'instrument se caractérise tout spécialement, cependant, par sa capacité de produire, au moyen du système d'impression "Dataflash," des données visibles soixante fois plus rapidement que par n'importe quelle autre méthode connue.

Dataflash est une réalisation exclusive de la Consolidated Electrodynamics Division. Il comprend une lampe spéciale de transport et d'intensification de la lumière qui permet l'enregistrement, le chauffage et l'application d'une lumière actinique élevée, le tout de manière simultanée, afin de produire un oscillogramme entièrement latensifié à des vitesses d'enregistrement pouvant atteindre 40,64 cm par seconde. La vitesse d'enregistrement maxima est de 406,4 cm/sec.

EE 70 754 *pour plus amples renseignements*

BEULAH ELECTRONICS LTD

126 Hamilton Road, West Norwood, London, S.E.27

SYSTÈME DE TÉLÉVISION À CIRCUIT FERMÉ

L'équipement "Beuvision" est un système de télévision à circuit fermé entièrement transistorisé, à bas prix et conçu selon les normes industrielles. L'installation complète comprend une caméra Vidicon entièrement transistorisée et d'une conception nouvelle, une lentille f/1,9 25 mm avec concentration et iris réglables, 100 yards de câble coaxial et un contrôleur transistorisé de 21,59 ou de 35,5 cm.

Les contrôleurs, qui sont livrables séparément, ont une réponse de fréquence de 5 MHz (625 lignes) et exigent une entrée vidéo de 0,8 V à 1,5 V crête à crête. La consommation électrique des contrôleurs est inférieure à 30 W.

EE 70 755 *pour plus amples renseignements*

BRITISH AIRCRAFT CORPORATION

100 Pall Mall, London, S.W.1.

NIVEAU À BULLE D'AIR ÉLECTRONIQUE

(Illustration à la page 414)

Le niveau à bulle d'air "Electrolevel" est un nouvel instrument électrique à lecture à distance pouvant compléter ou remplacer le niveau à bulle d'air classique dans de nombreuses applications. L'Electrolevel a été réalisé par le Groupe des Systèmes Industriels de la British Aircraft Corporation, Division des Armes Guidées.

Le principe de l'Electrolevel est entièrement basé sur le niveau à bulle d'air. Un flâcon de verre, dont la surface supérieure a été polie selon un rayon uniforme, est muni de trois électrodes et rempli en partie d'un liquide conducteur d'électricité. Tout mouvement de la bulle change les valeurs de résistance des parcours électriques entre les électrodes, qui sont converties au mouvement d'une aiguille d'instrument par un simple circuit électrique en pont.

Cette forme de construction pour un instrument sensible au niveau est supérieure à celle de tout dispositif à pendule pivotant mécaniquement en raison de sa robustesse, de ses dimensions compactes et de son absence d'usure. L'Electrolevel a ainsi les caractéristiques dynamiques d'un niveau à bulle d'air mais aussi de nombreux avantages importants grâce à la lecture directe. Il peut être monté à des emplacements éloignés ou dangereux et totalement isolé des changements thermiques qui affectent sérieusement les niveaux à bulle d'air sensibles. En outre, il fournit les indications d'un instrument à aiguille n'exigeant aucun calcul mental de moyenne. L'amplification du mouvement de la bulle par le détecteur électronique est telle q'un mouvement de bulle ne dépassant pas 0,001 pouce peut être facilement affiché. Cela constitue un avantage supplémentaire par rapport aux niveaux à bulle d'air classiques vu qu'une gamme d'échelle beaucoup plus étendue peut être assurée dans une seule tête sensible. De plus, on peut mesurer le tissage dans, par exemple, des machines-outils sans devoir recourir à la mesure de niveau préliminaire de grande précision qui serait autrement nécessaire.

L'instrument est muni de trois gammes d'échelle donnant une gamme en gradient de 1 seconde d'arc à 33 minutes d'arc. Il peut aussi être relié à un indicateur ou enregistreur auxiliaire et utilisé avec six têtes sensibles ou davantage au moyen d'un commutateur de sélection.

EE 70 756 *pour plus amples renseignements*

BRITISH PHYSICAL LABORATORIES

Radlett, Hertfordshire

VOLTMÈTRE TRANSISTORISÉ

(Illustration à la page 414)

Cet appareil comporte les avantages des voltmètres à tube classiques ainsi que ceux des contrôleurs universels. Les gammes ont été spécialement choisies pour répondre aux besoins de l'ingénieur s'occupant de matériel transistorisé.

Grâce à la mise au point de méthodes de circuit entièrement nouvelles et à l'emploi de transistors planaires au silicium, on a pu produire un appareil d'une stabilité exceptionnelle et exempt de dérive, d'une précision et d'une stabilité à long terme assurée dans une gamme de température étendue. Il se caractérise en particulier par sa position d'étalonnage qui permet de vérifier le gain de l'amplificateur en injectant une tension standard provenant d'une diode Zéner. En raison de la consommation électrique fort réduite, on a pu réussir à se passer d'un commutateur arrêt-marche, de sorte que l'instrument est toujours prêt au fonctionnement immédiat. Il est protégé contre les surcharges sur toutes ses gammes, même lorsqu'on applique une polarité inversée.

Un soin tout particulier a été apporté à la facilité du fonctionnement et à la présentation des résultats. Toutes les gammes sont choisies par une seule commande munie d'un bouton spécial et d'une échelle à plusieurs couleurs, empêchant ainsi toute possibilité d'erreur dans la gamme choisie. Les résultats sont affichés sur une échelle "Vistaview" de 125 mm, les différents arcs étant imprimés en différentes couleurs distinctes. Afin de faciliter encore la lecture, les arcs sont du type agrandi qui réduit la courbe et la fatigue visuelle au minimum.

La résistance à entrée élevée et la haute sensibilité permettent d'effectuer des mesures qui n'obligent pas de tenir compte de la consommation de courant de l'instrument. La gamme de fréquence des gammes alternatives est exceptionnellement étendue, atteignant 100 kHz. Cette limite peut être portée bien au-dessus de 100 MHz par l'emploi d'une sonde extérieure à fiche. Les gammes de tension continue centrales constituent également une particularité des plus utiles de l'appareil. En dehors de leur utilisation évidente dans les circuits différentiels, elles sont précieuses dans l'emploi général car on peut ainsi éviter d'inverser les conducteurs en fonction de la polarité du circuit extérieur. Il va sans dire que les deux bornes sont isolées de la masse ce qui évite les complications communes aux instruments à lampes et fonctionnant sur courant secteur.

Trois gammes de résistance sont prévues qui permettent des lectures allant jusqu'à 100 MΩ.

L'appareil est logé dans un élégant coffret en fibre de verre qui lui donne la protection nécessaire à un instrument portatif. L'arrière du coffret comporte un petit espace d'emmagasinage pour les conducteurs d'essai et la sonde.

Les batteries intérieures sont d'une longue durée garantie. On peut toujours vérifier sans difficulté l'état de la batterie en prenant la gamme dite de contrôle de la batterie. Le changement de la batterie entraîne un minimum de dérangement.

Les gammes de tension vont de 0 à 100 mV et de 0 à 300 V c.c. et de 0 à 1 V et de 0 à 300 V c.a. La gamme de courant s'étend de 0 à 1 μA et de 0 à 100 MA c.c.

EE 70 757 *pour plus amples renseignements*

COSSOR INSTRUMENTS LTD

The Pinnacles, Elizabeth Way, Harlow, Essex

OSCILLOSCOPE MODULAIRE

(Illustration à la page 414)

L'oscilloscope modulaire type CD100 constitué de corps solides comprend un cadre principal de base contenant le dispositif d'affichage et les alimentations, et une grande ouverture pour recevoir une gamme de modules interchangeables. Selon son application, un seul module peut fournir à la fois des axes X et Y, ou des modules individuels peuvent être insérés afin d'alimenter les deux axes de l'affichage.

La limite de largeur de bande fondamentale sur les deux axes du cadre principal est celle du tube cathodique seulement. Les modules typiques comprennent une gamme d'amplificateurs de courant continu à une ou à deux traces pour largeurs de bande allant jusqu'à 35 MHz et pour des sensibilités allant jusqu'à 500 μV/cm, une gamme de générateurs de balayage, dont quelques uns avec possibilité de balayage différé convenant pour les susdits amplificateurs, des éléments d'échantillonnage pour largeurs de bande maxima de 100 MHz, et une gamme de têtes oscillatrices à fréquence balayée pour l'analyse de spectres de 20 Hz à 1 000 MHz.

Un oscilloscope complet comprend fondamentalement un élément indicateur modèle CD100, ainsi que deux modules. La gamme des ces modules est comme suit: amplificateur à large bande simple; amplificateur à large bande double; amplificateur différentiel; amplificateur différentiel à large bande; élément de balayage; élément de balayage différé; élément d'échantillonnage; instrument de report X-Y.

EE 70 758 *pour plus amples renseignements*

THE ENGLISH ELECTRIC VALVE CO. LTD

Chelmsford, Essex

CONDENSATEURS VARIABLES À VIDE

(Illustration à la page 415)

La English Electric Valve Co. Ltd. vient de réaliser une nouvelle série de condensateurs variables à vide poussé pour fonctionnement sur 75 A (efficaces). Dix modèles, en deux formes de base, UG et UH, couvrent des gammes de capacitance de 2 000 pF avec des tensions HF de pointe atteignant 30 kV.

Ces condensateurs de 75A accusent les mêmes caractéristiques de performance et de construction que celles de la série éprouvée 40 A. Le même principe de normalisation des composants a été appliqué afin d'assurer la livraison rapide de n'importe lequel des modèles. Le dispositif d'accord normal est basé sur la rotation de l'arbre, mais il peut être modifié pour le fonctionnement à traction axiale.

Les condensateurs à vide EEV 75 A se distinguent par les particularités suivantes: régime électrique maximum à des fréquences allant jusqu'à 27 MHz; Q supérieur à 10 000; variation minima des caractéristiques entre condensateurs du même type; l'attention apportée à la forme de l'enveloppe réduit les pertes par le verre et permet d'appliquer la pleine tension nominale à la fréquence la plus élevée; régimes de courant plus élevés avec refroidissement spécial; soufflet à vide spécialement choisi et contrôlé pour une longue durée d'accord; faible microphonie; scellements de pompage complètement enfermés; faible couple d'accord; effet réactif d'accord minimum afin d'assurer une plus grande précision de réaccord.

EE 70 759 *pour plus amples renseignements*

FARNELL INSTRUMENTS LTD

Sandbeck Way, Wetherby, Yorkshire

Oscillateur à ondes carrées/sinusoidales

(Illustration à la page 415)

Cet oscillateur transistorisé à ondes carrées/sinusoïdales a été conçu pour l'usage universel des laboratoires mécaniques ou électriques dans les établissements industriels ou éducatifs. Il peut être utilisé directement sur courant secteur ou sur ses batteries intérieures.

Une gamme de fréquences de 1 Hz à 100 kHz est fournie par un oscillateur résistance-capacité du type en pont. Une précision de lecture d'échelle de 3% de ±0,5 Hz est maintenue sur toute la gamme et la sortie de fréquence demeure pratiquement constante à partir du point d'allumage.

La sortie d'onde sinusoïdale a une distorsion harmonique inférieure à 2%, tandis que les temps de montée et de chute de la sortie d'ondes carrées sont inférieurs à 0,3 µsec; la surmodulation est d'environ 5%.

L'atténuateur est étalonné dans une charge de 600 Ω; quatre directions de commutation, soit 0 dB, −20 dB, −40 dB et −60 dB, sont prévues en plus d'une commande à variation continue couvrant la gamme de −6 dB à +14 dB; la précision est de 3% près. La commande d'atténuation et celle de réglage précis sont également étalonnées en valeurs de crête à crête; la sortie maxima est de 12 V crête à crête dans 600 Ω. L'amplitude de la tension de sortie et l'impédance demeurent virtuellement constantes, quelle que soit la position de la fréquence.

La sortie de l'oscillateur est flottante par rapport à la terre et au châssis, et lorsqu'on l'obtient de ses batteries intérieures, elle peut être utilisée comme alimentation entièrement flottante.

EE 70 760 *pour plus amples renseignements*

FIELDEN ELECTRONICS LTD

Paston Road, Wythenshawe, Manchester, 22

Contrôleur de niveau

(Illustration à la page 415)

Le "Tektor TT6" est un contrôleur de niveau sensible à capacité constitué de corps solides et prévu pour assurer une stabilité élevée avec une excellente discrimination, sous une forme compacte, robuste et bon marché.

Le sélecteur transistorisé en moulage de caoutchouc de silicium a été étudié de manière à pouvoir l'incorporer à la tête de la gamme étendue d'électrodes Fielden type 40. Le TT6 a une stabilité exceptionnellement bonne par rapport aux variations de température et de tension secteur. Il est relativement insensible aux changements résistifs du système d'électrodes et une fois réglé ne nécessite aucun ajustage au cours de l'installation ou de l'emploi.

La sortie de transistor bistable peut commuter 0,25 A, c'est à dire un courant suffisant pour une lampe de 2,5 W. Des équipements à voie simple et double sont livrables et donnent la puissance aux relais de commande et aux lampes indicatrices.

Dans les applications à plusieurs prises, des économies considérables sont réalisées par l'emploi d'alimentations communes à plusieurs éléments TT6 et, vu que des câbles coaxiaux ne sont pas nécessaires, le câblage ordinaire peut être utilisé.

EE 70 761 *pour plus amples renseignements*

G.E.C. (Telecommunications) LTD

Telephone Works, Coventry

Relais sub-miniature

(Illustration à la page 415)

Ce nouveau relais a été mis au point pour assurer un fonctionnement sûr dans des assemblages sub-miniature, bien qu'il puisse également être utilisé dans de nombreuses applications générales, dont le montage sur plaquettes de circuit imprimé. Son volume est inférieur à 0,04 pouces cubes et sa durée de vie mécanique est de 50 millions d'opérations. Il est à une seule action de permutation de contact et la fiabilité du contact est assurée par l'emploi de contacts solides en métal précieux et une pression de contact de 10 g. Tous les composés organiques sont exclus du compartiment à contact scellé.

EE 70 762 *pour plus amples renseignements*

Relais à rochet à 7 cames

(Illustration à la page 415)

Ce relais a été réalisé à partir de la version à deux cames afin de pouvoir effectuer une gamme plus étendue d'opérations dans les circuits à impulsions. Il est particulièrement utile pour le codage décimal et binaire.

Un de ces cas est celui de la transmission de données décimales dans la forme de code de 2 sur 5 qui est utilisée dans une très grande mesure dans la transmission moderne de données et les méthodes de traitement de l'information. Cinq cames peuvent être utilisées à cet effet, les autres deux donnant une impulsion hors normale pour le contrôle de "marche à partir de zéro" et l'impulsion de "report" au compteur de décades suivant. Ce nouveau relais a toutes les qualités du relais à rochet original, ainsi que les mêmes montages et les mêmes deux positions de relais.

EE 70 763 *pour plus amples renseignements*

HEWLETT-PACKARD LTD

Dallas Road, Bedford

Synthétiseur de fréquence

(Illustration à la page 416)

Hewlett-Packard a mis au point un synthétiseur de fréquence à large bande comportant un système inédit de sélection de fréquence.

Le synthétiseur type 5100A/5110A produit, en effet, 5 000 millions de fréquences discrètes à partir de 0,01 Hz. Toutes ces fréquences ont un degré élevé de pureté spectrale. Leur distorsion harmonique est inférieure à 30 dB cependant que le rapport signal/bruit dans une bande de 3 kHz centrée sur le signal de sortie est supérieur à 50 dB.

Contrairement aux méthodes de synthèse indirecte plus communément utilisées, qui dépendent du verrouillage de phase de plusieurs fréquences différentes, le nouvel instrument utilise la synthèse directe par l'addition, la soustraction, la multiplication et la division électroniques de signaux provenant directement de l'étalon intérieur de 1 MHz, dont la stabilité est de ±3 parties dans 10^9 par jour.

La commutation très rapide est l'un des principaux avantages de cette méthode de synthèse directe. Moins d'une milliseconde, y compris les temps morts et les phénomènes transitoires, est nécessaire pour changer de fréquence. Le choix de la fréquence peut être effectué à la main à l'aide de boutons poussoirs ou à distance au moyen d'un système de simples fermetures de contacts.

EE 70 764 *pour plus amples renseignements*

Voltmètre numérique

(Illustration à la page 416)

Le voltmètre 3440 A présente des qualités de souplesse inhérente grâce à ses éléments à fiches du panneau frontal qui déterminent la fonction. Ils comprennent le sélecteur de gamme à fiches Hewlett-Packard 3441A pour le choix manuel de gammes totales de 9,999 et 999,9 V c.c.; le sélecteur automatique de gamme 3442A, qui ajoute des caractéristiques de gamme programmables et automatiques; l'élément à gamme automatique et à gain élevée 3443A avec des gammes de tension totales de 100mV à 1 kV et une résolution de 10 µV, et le multimètre 3444A avec tensions identiques aux gammes du 3443A, accouplées aux gammes de courant total de 100 µA à 1 A (résolution de 10 nA) et une gamme de résistance de 1 kΩ à 10 MΩ (résolution de 0.1 Ω). Vitesse de changement de gamme: automatique, donnant une lecture précise de 500 msec après toute nouvelle application de tension; sur programme, elle change de gamme en 40 msec.

D'autres particularités comprennent l'indication automatique de décimale et de polarité, la sortie décimale codée binaire pour les applications de systèmes et d'enregistreurs, l'impédance d'entrée constante de 10,2 MΩ, l'emmagasinage d'indications pour la lecture exempte de papillottements et entrée flottante jusqu'à 400 V au-dessus de la masse de châssis. La précision est de ±0,05 pour cent de la lecture +1 chiffre, y compris ±10% de variation de tension de ligne, gamme de température de 15° C à 40° C, effets de vieillissement de 5%.

Le 3440A peut être utilisé également pour chiffrer des sorties de convertisseurs Hewlett-Packard c.a., c.c., de multimètres électroniques universels, d'ampèremètres c.a. ou c.c., de contrôleurs de rapport d'ondes stationnaires, de mesureurs de puissance, etc.

EE 70 765 *pour plus amples renseignements*

HONEYWELL CONTROLS LTD

Greenford, Middlesex

Calculatrice de débit de masse sur ligne

(Illustration à la page 416)

Cette calculatrice, introduite par la Division des Systèmes Spéciaux de la société Honeywell, est formée de modules standard à fiches et peut recevoir des signaux d'entrée de dispositifs tels que transducteurs, sondes de température ou densitomètres. Elle est également pourvue de réglages manuels pour les constantes telles que les dimensions de la plaque d'orifice, la gravité spécifique, la supercompressibilité et d'autres facteurs.

Les signaux de sortie peuvent être utilisés pour indiquer et enregistrer le débit de masse cependant que le débit total est indiqué sur une sortie de compteur. La transmission numérique est également possible.

La calculatrice comprend des circuits de conditionnement du signal intérieur qui étalonnent la calculatrice en fonction d'une variété étendue de transducteurs, une source de signaux incorporée pour le contrôle des circuits de calcul.

La calculatrice a été conçue pour tous les types d'ambiances industrielles et elle fonctionne à un degré de précision de ±0.5% dans des températures ambiantes de 30° à 120° F.

EE 70 766 *pour plus amples renseignements*

HUGHES INTERNATIONAL (UK) LTD

Glenrothes, Fife, Ecosse

Indicateur d'images en simili

(Illustration à la page 416)

Le "Tono-Corder" modèle 203 construit par Hughes Instruments est un appareil portatif autonome permettant d'afficher des images en simili et des données graphiques sur un tube d'emmagasinage cathodique de 12,7 cm.

L'emploi de cet appareil permet de réduire la nécessité des dépenses de temps et d'argent qu'exige la mise au point d'un appareil d'affichage pour chaque besoin particulier. Les images en simili des signaux d'entrée sont présentées sur un écran cathodique à vision directe de 12,7 cm de façon idéale pour l'analyse visuelle immédiate ou pour des usages photographiques permanents.

Vu que l'image est emmagasinée, le signal d'entrée peut être reçu à un faible taux de données. Plusieurs tons de gris sont prévus, selon la vitesse d'écriture choisie. L'appareil peut également être utilisé pour les applications nécessitant l'enregistrement de données à grande vitesse. Le maillon de données n'est alors nécessaire que pour de courts intervalles afin de mettre à jour l'indication; elle peut être alors divisée horairement avec d'autres appareils. Des vitesses d'écriture de 30 000 pouces/sec peuvent être réalisées et fournir des images d'une bonne sélectivité d'échelle grise ainsi que d'une haute résolution.

Le spectre complet de tons de gris pour la reproduction de haute fidélité des images, parallèlement à une très grande brillance et une persistance contrôlée, rendent l'appareil facilement adaptable à un très grand nombre d'applications industrielles, commerciales, médicales et militaires.

L'entrée élevée de lumière, de l'ordre de 1 000 pieds lamberts à la brillance saturée, présente une image demi-teinte brillante sur radar météo, même lorsqu'elle est vue en plein jour.

La haute résolution de l'appareil, son pouvoir de balayage lent, conviennent également pour la transmission d'images par lignes téléphoniques classiques. La transmission du type à bande étroite, telle qu'utilisée pour la télévision en circuit fermé, obvie à l'emploi de la transmission par câble coaxiaux, toujours coûteuse. Les images de haute fidélité peuvent être examinées à de très faibles vitesses et même "congelées" pour la photographie.

La haute brillance de l'écran, ainsi, que les caractéristiques d'intégration de l'instrument, le rendent utile pour l'obtention de signaux faibles d'un niveau de bruit élevé. En balayant à nouveau une impulsion connue, on augmente l'intensité de l'impulsion tout en effaçant continûment les bruits aléatoires.

Ce genre d'utilisation est d'un potentiel considérable dans les communications spatiales, de même que pour un certain nombre d'applications militaires. Tel qu'il est employé dans les systèmes d'affichage de radar, le Tono-Corder a le pouvoir de couvrir tout le spectre d'échelle gris et donner un contraste maximum pour faciliter l'identification des formations de nuages, des parasites de sol et des cibles. La persistance peut être réglée pour une durée maxima sur la quasi totalité des 360°, ne s'estompant dans le noir que juste au-dessus du balayage.

EE 70 767 *pour plus amples renseignements*

Oscilloscope d'emmagasinage

(Illustration à la page 417)

L'oscilloscope Hughes "Memo-Scope" sert à la fois d'oscilloscope cathodique classique et d'oscilloscope d'emmagasinage pouvant conserver une image sur son écran aussi longtemps que nécessaire, à une vitesse d'enregistrement de 10^6 pouces/sec. Une des caractéristiques particulières est qu'il offre tous les avantages de la souplesse d'un seul instrument par l'emploi de préamplificateurs à fiches. Des éléments interchangeables sont prévus dont chacun comporte les caractéristiques de performance qui le rendent compatible avec l'oscilloscope Memo-Scope lorsqu'il est utilisé dans le mode de fonctionnement classique ou d'emagasinage. L'oscilloscope utilise le tube Memotron pour les deux modes de fonctionnement. Le tube Memotron contient un canon cathodique classique et un système de déviation, ainsi qu'un écran de vision luminescent type P-1. Ces pièces du tube sont utilisées pour le fonctionnement normal en tant qu'oscilloscope. Derrière l'écran luminescent, séparé par un petit entrefer, se trouve l'assemblage d'emmagasinage qui se compose de deux écrans fins formant le réseau d'emmagasinage et le réseau collecteur. Derrière cet assemblage, il y a deux canons électroniques appelés projecteurs électroniques. Ces éléments supplémentaires permettent d'emmagasiner des données écrites de la manière suivante: les projecteurs électroniques émettent un large faisceau d'électrons disposés par un système collimateur de manière à recouvrir uniformément le réseau d'emmagasinage d'électrons de faible vitesse, lui fournissant ainsi une charge négative uniforme. Lorsque le faisceau du projecteur frappe n'importe quelle partie du réseau d'emmagasinage, il provoque une émission secondaire dans les points atteints par les électrons du canon à haute énergie. Par suite de ce processus d'émission secondaire, ces zones perdent plus d'électrons qu'elles n'en acquièrent. Par conséquent, des charges positives locales en résultent et les électrons sont attirés par les zones positives où elles continuent de frapper l'écran luminescent. Ce dernier est utilisé à un potentiel suffisant pour le rendre fluorescent de manière normale. Il en résulte une trace brillante puisque chaque point emmagasiné de cette manière est affiché continûment plutôt qu'inscrit de façon répétée comme c'est le cas pour les tubes cathodiques ordinaires. Le réseau collecteur dont il a été question plus tôt sert à attirer les électrons secondaires produits par le réseau d'emmagasinage de sorte que les zones inscrites du réseau d'emmagasinage reçoivent localement le potentiel du réseau collecteur, maintenant le dessin de charge jusqu'à ce que le potentiel du réseau collecteur ait été délibérément abaissé au-dessous de la valeur critique nécessaire à l'emmagasinage, effaçant ainsi l'information.

EE 70 768 *pour plus amples renseignements*

H.V.L. LTD

1 Cardiff Road, Luton, Bedfordshire

STABILISATEUR DE DÉRIVE NUMÉRIQUE

(Illustration à la page 417)

Cet instrument a été spécifiquement conçu pour corriger les variations de dérive dans les analyseurs multivoies de hauteur d'impulsions. Le "Stabimat" corrige continûment toute dérive de gain se produisant pour les raisons suivantes: variations de détection et de photomultiplicateur; variations de EHT; dérives de gain d'amplificateur linéaire et de préamplificateur; dérives de convertisseurs analogiques/numériques (y compris la dérive zéro).

Fonctionnant suivant des principes entièrement nouveaux, le "Stabimat" utilise des techniques numériques basées sur l'emploi de corps solides afin d'assurer la précision absolue de la hauteur d'impulsion ou de la conversion d'energie sans dégrader la résolution.

L'instrument a les caractéristiques suivantes: la correction de dérive s'effectue sur les comptes absolus et elle est entièrement indépendante du taux de comptage; par l'emploi exclusif des méthodes numériques, le système de correction ne peut causer une dérive quelconque; il peut être utilisé avec n'importe quel analyseur multivoies de hauteur d'impulsion; l'emploi du "Stabimat" entraîne une perte insignifiante de résolution. La dérive peut être corrigée en général à plus de 0,1 d'une voie.

EE 70 769 *pour plus amples renseignements*

INTERNATIONAL ELECTRONICS LTD

132-135 Sloane Street, London, S.W.1

VOLTMÈTRE NUMÉRIQUE

(Illustration à la page 417)

Le DSV.1 est fondamentalement un voltmètre numérique de 0,1% à trois chiffres. Le commutateur permet de soustraire 1000 chiffres les moins significatifs de l'entrée et cette possibilité double efficacement la gamme de l'instrument. Ce dernier a quatre gammes de base donnant des lectures sur totalité de l'échelle de 1 V, 10 V, 100 V et 1000 V, mais la sensibilité de base de l'instrument est telle qu'il peut fonctionner directement à partir de la plupart des types communs de thermocouples et donner une discrimination de 0,1°C dans une gamme de 0 à 100°C. Les circuits sont entièrement constitués de corps solides et un dispositif d'affichage de grande fiabilité et très clair est utilisé. La durée maxima de conversion est de 10msec et l'instrument prend environ 30 lectures par seconde.

EE 70 770 *pour plus amples renseign;ments*

THE MARCONI CO. LTD

Chelmsford, Essex

CALCULATRICE À ACTION RAPIDE

(Illustration à la page 418)

Cette calculatrice expérimentale est basée sur l'emploi de modules logiques microminiatures transistorisés à diodes de silicium dont le temps de retard de l'étage se réduit à 5 nsec. La construction compacte résultant de l'emploi de ces méthodes de microminiaturisation constitue un facteur décisif dans la grande vitesse d'action de cette calculatrice. Les dispositifs micrologiques sont montés dans des modules du type 0-5 et des circuits imprimés sont employés autant que possible. Le câblage intermodulaire a été réduit au minimum absolu ce qui a donné une calculatrice plus petite qu'un table de travail ordinaire. La calculatrice fonctionne de manière asynchrone et utilise un réservoir à noyau de ferrite et à courant incident d'une capacité de 4096 mots. La longueur des mots est de 24 chiffres binaires et la durée d'accès du réservoir est de 0,4 μsec, tandis que la durée de cycle du réservoir est de 1,2 μsec. Trente deux ordres de microprogrammes de base ont été prévus et la vitesse d'un ordre de recherche, d'addition, de soustraction, etc. est de 2,5 μsec; elle est de 10 μsec pour la multiplication. Le panneau de fonctionnement comprend des indicateurs de tension qui montrent le contenu instantané de chaque registre, de même que les clefs et les commutateurs de commande de calcul et de programmation.

Les connexions aux dispositifs périphériques consistent en parcours de données et de commande. Un dispositif autonome d'accès au réservoir permet l'entrée de dispositifs extérieurs au réservoir sans gêner le programme. L'interruption normale prévue peut contrôler jusqu'à 15 dispositifs périphériques.

EE 70 771 *pour plus amples renseignements*

MARCONI INSTRUMENTS LTD

St. Albans, Hertfordshire

GÉNÉRATEUR DE SIGNAUX À GAMME ÉTENDUE ET CONSTITUÉ DE CORPS SOLIDES

(Illustration à la page 418)

Ce nouveau générateur de signaux modulés en amplitude de fréquence moyenne et haute fréquence, Marconi type TF 2002, fournit des signaux modulés en amplitude de haute qualité, de 10 kHz à 72 MHz. Il assure une bonne discrimination (longueur effective de l'échelle dépassant 2,5 milles), une fuite exceptionnellement faible et une modulation parasite insignifiante. De construction compacte et robuste, il ne pèse que 23 kg et peut être fourni pour montage sur banc d'essai ou bâti. Il est alimenté par courant secteur ou batteries.

Chacune des huit bandes de fréquence comprend un oscillateur accordé à perméabilité séparée, ainsi qu'un circuit de sortie pour une performance optima sur toute la gamme. L'échelle d'accord paralogarithmique étalonnée à la main est affichée sous forme de dessin continu en zigzag dont les échelles vont alternativement à gauche et à droite. Ce nouveau système réduit la monotonie et accélère l'accord aux extrêmes des bandes de fréquence.

Des points de contrôle au cristal sont prévus à des intervalles de 1 MHz, 100 kHz ou 10 kHz, avec des points subsidiaires à ±1 kHz par rapport aux points principaux pour l'emploi dans les mesures de largeur de bande. Au dessus d'une fréquence porteuse de 100 kHz, une commande d'accord incrémental à lecture directe, pouvant être normalisée en fonction de points de contrôle par quartz, donne une discrimination de 0,025% de la fréquence porteuse.

Une sortie de 2 V de force électromagnétique de source à 50 Ω est obtenue au moyen d'atténuateurs à plots de 20 dB et 1 dB. Elle est stabilisée durant l'accord par une commande de niveau automatique. Une modulation d'amplitude intérieure maxima de 100% est produite par un oscillateur à accord continu couvrant la bande acoustique. La contre-réaction d'enveloppe assure une bonne modulation d'au moins 80%. La profondeur de modulation est indépendante tant de l'accord de la porteuse que du niveau de la porteuse.

La modulation de fréquence extérieure ou la modulation de phase peuvent être appliquées.

EE 70 772 *pour plus amples renseignements*

COMPTEUR ÉLECTRONIQUE

(Illustration à la page 418)

Ce compteur constitué de corps solides, type TF 2401, comprend un instrument de base dans lequel on enfiche un élément à gamme de fréquence et un élément de fonction. L'élement à gamme détermine la fréquence d'entrée maxima pouvant être mesurée; l'élément de fonction détermine le type de mesure pouvant être effectuée. Les éléments à fiches actuellement livrables se composent d'un élément à gamme de fréquence de 50 MHz, d'un élément de fonction compteur-minuterie et d'un convertisseur de 500 MHz.

Lorsque l'appareil est utilisé avec ces trois éléments, il effectue les trois mesures de base suivantes: fréquence, période, période multiple, intervalle de temps, rapport de fréquence, rapport d'une fréquence au multiple d'une autre, phénomènes durant un intervalle de temps appliqué extérieurement, totalisation et comptage d'un signal appliqué.

Il comprend un dispositif de lecture à 8 chiffres avec mémoire, des éléments de mesure éclairés dans la fenêtre d'affichage et un dispositif d'autovérification. Lorsque l'instrument est relié au secteur, le four est amorçé ce qui lui donne le temps de se stabiliser sans qu'il soit nécessaire d'exciter le reste du compteur.

Un imprimeur ou un instrument de lecture à distance peut être entraîné par le compteur et on peut, facultativement, adapter l'instrument à recevoir la commande d'une source éloignée. Il peut être utilisé également comme générateur d'intervalle de temps, fournissant des impulsions de 0,01 Hz à 1 MHz en plots de décades; des sorties de 1 MHz et de 10 MHz peuvent aussi être prévues sur des douilles à part.

On a fait un usage étendu des methodes logiques dans la conception du TF 2401; des semiconducteurs, circuits imprimés et la construction modulaire interchangeable ont été employés sur une grande échelle. L'appareil sera fourni pour montage sur banc d'essai ou sur bâti. Il pèse environ 17 kg.

EE 70 773 *pour plus amples renseignements*

PANAX EQUIPMENT LTD

Holmethorpe Industrial Estate, Redhill, Surrey

JAUGE D'ÉPAISSEUR RADIOACTIVE

(Illustration à la page 418)

La société Panax Equipment Ltd a mis au point une jauge d'épaisseur entièrement portative destinée à l'usage industriel, notamment pour déterminer rapidement et avec précision l'épaisseur des revêtements de surface d'un seul côté de l'objet. Principalement conçu pour la mesure des revêtements en matière plastique, il peut cependant mesurer aussi l'épaisseur des couches de peinture ou des dépôts galvanoplastiques appliqués à de nombreux matériaux. Il est du type à diffusion inversion, c'est à dire non-destructif, et par conséquent convenant pour le contrôle de qualité de composants en cours de fabrication ou en laboratoire. Toute matière déposée sous forme de revêtement sur une autre matière peut être mesurée de cette façon, à condition qu'il y ait une différence suffisante entre les nombres atomiques des deux matières.

Contrairement à la plupart des jauges à diffusion inverse, l'appareil Panax n'est pas limité aux seuls objets plats ou de forme régulière. D'ailleurs la forme de la sonde est telle que la distance de travail critique entre la source radioactive et l'objet demeure sensiblement égale, même s'il y a des courbes de faible rayon.

Le radioisotope utilisé est le Prométhium 147, qui est une source d'émission beta communément utilisée pour la mesure d'épaisseur. Il est monté à l'une des extrémités d'une petite sonde contenant un tube Geiger-Müller et il a une durée de vie utile de plus de deux ans et demi. L'instrument d'affichage est semblable au compteur Panax RM-202 et comporte un dispositif à cadre mobile d'une longueur d'échelle effective de 7.62 cm. Des épaisseurs de fils plastiques de 50 millionièmes à 2 millièmes de pouce peuvent être mesurées et la sensibilité est telle que la déviation sur la totalité de l'échelle peut être réglée de façon à correspondre à une épaisseur mesurée de 0.0005 pouce. La grande échelle ouverte permet d'effectuer sans difficulté une lecture précise, même pour le personnel non qualifié.

La jauge est transistorisée et peut être utilisée sur courant secteur ou sur batterie. Son poids total, avec sa sonde, est de 7 kg environ.

EE 70 774 *pour plus amples renseignements*

PLANNAIR LTD

Windfield House, Leatherhead, Surrey

SOUFFLEURS DE FLUX AXIAL

(Illustration à la page 419)

Deux nouveaux modèles viennent d'être présentés dans la gamme Plannetter de souffleurs de flux axial. Ces deux appareils mesurent 25.4 cm et 30,4 cm de diamètre respectif, tous deux ayant une profondeur de 7.62 cm seulement. Le Plannette de 25.4 cm a une puissance de 15.84 m^3/minute dandis que le modèle de 30,4 cm fournit 28,31 m^3/minute dans des conditions d'air libre.

Les deux Plannettes constituent les dernières-nées de la gamme Plannair de souffleurs à haute performance conçus pour les applications ou l'économie d'espace est d'une importance capitale, plus de 1000 différentes versions ayant déjà été produites pour les applications aéronautiques, d'électronique et d'automation.

EE 70 775 *pour plus amples renseignements*

PLESSEY (UK) LTD

Swindon, Wiltshire

OUTIL DE SERTISSAGE

(Illustration à la page 419)

La société Plessey (UK) Ltd produit maintenant un nouvel outil de sertissage "UNIcrimp". Il s'agit d'une version à air comprimé de l'outil manuel, universel, à une main et automatique pour effecteur des sertissages carrés parfaits sur n'importe quelle dimension de fil métallique ou de contact jusqu'a 2,64 mm de diamètre. Etudié pour le montage sur banc d'essai, avec commande à pied si nécessaire, ou pour l'emploi comme outil portatif (par exemple, comme câblage aérien), l'outil UNIcrimp représente une machine de production éprouvée et ayant été soumise à un programme de contrôle long et rigoureux. Sa gamme d'applications a été étendue aux cosses pré-isolées.

EE 70 776 *pour plus amples renseignements*

RANK CINTEL LTD

Worsley Bridge Road, London, S.E.26

BLOC D'ALIMENTATION TRANSISTORISÉ

(Illustration à la page 419)

Le bloc d'alimentation transistorisé type 18920/1 a été conçu pour fournir 6 à 30 V à un courant maximum de 500 mA. La tension de sortie est choisie au moyen d'un commutateur de gamme à deux directions et d'une commande de réglage précis à variation continue. Deux instruments de mesure miniature indiquent la tension de sortie et le courant de sortie respectivement.

La protection complète de l'appareil et du matériel extérieur est assurée par un circuit de surcharge électronique qui comprend des dispositifs de réenclenchement automatique et manuel. Le disjoncteur de surcharge peut être mis en action à n'importe quelle valeur au moyen d'une commande intérieure.

La sortie du bloc d'alimentation est entièrement flottante, mais l'une ou l'autre des bornes peut être mise à la masse à l'aide d'un court maillon.

EE 70 777 *pour plus amples renseignement*

TUBE D'AFFICHAGE ALPHA-NUMÉRIQUE

Il s'agit d'une nouvelle forme de tube cathodique d'affichage alpha-numérique qui surmonte certains des obstacles qui se produisent lorsque des tubes cathodiques ordinaires sont employés pour cet usage. Le Matricon—ainsi que s'appelle le nouveau tube—peut produire une image plus brillante et un taux plus élevé de production de caractères que n'en produisent les tubes classiques.

Le principe du tube d'affichage alphanumérique Matricon, d'un diamètre de 22,8 cm, consiste à "inonder" d'un faisceau étendu d'électrons une plaque comportant une matrice d'ouvertures. Chacune de ces ouvertures a une connexion indépendante telle qu'une impulsion d'environ 25 V peut supprimer le faisceau passant à travers elle. De cette façon, tout caractère voulu est formé en une seule fois et en un temps extrêmement court.

Etant donné que toutes les parties d'un caractère sont éclairées simultanément, la brillance est beaucoup plus intense que celle des caractères produits par tube cathodique ordinaire dans lequel les caractères sont formés par un seul point mobile. Les premieres tubes de ce genre ont produit des caractères en moins de 10 μsec, la brillance étant suffisante pour la vision en plein jour.

Des circuits constitués de corps solides ont été réalisés qui peuvent recevoir un code à six chiffres binaires et émettre les impulsions nécessaires aux ouvertures du Matricon. Un de ces décodeurs-encodeurs peut alimenter dix tubes d'affichage par multiplex de temps, les dix affichages étant indépendants.

EE 70 778 *pour plus amples renseignements*

ROBAND ELECTRONICS LTD

Charlwood Works, Lowfield Heath Road, Charlwood, Horley, Surrey

OSCILLOSCOPES

(Illustration à la page 419)

La société Roband Electronics Ltd vient de présenter une nouvelle gamme de quatre oscilloscopes portant les références R050, R051, R055 et R0501. Le spécification de chacun des oscilloscopes est différente mais ils ont tous été conçus en vue de leur assurer un prix nettement inférieur aux prix courants, sans sacrifier la performance ou la fiabilité.

Le modèle R050 (illustré) est un oscilloscope de précision à large bande avec retard de signal, employant la gamme entière des éléments à fiches Roband "5".

Le R051 a les même caractéristiques générales de précision que le R050 mais peut recevoir les éléments interchangeables de la série Roband "5" soit en X ou en Y, donnant ainsi XY et des possibilités de balayage différé.

Le modèle R055 est un oscilloscope universel de forme plus portative utilisant la série des éléments interchangeables Roband "5".

Le R0501 est un appareil de 12,7 cm de laboratoire et d'entretien, extrêmement portatif et peu coûteux, se distinguant par sa grande fiabilité et sa précision.

Les oscilloscopes R050, R051 et R055 forment la base d'un groupe intégré comprenant la série "5" des éléments Roband pleinement interchangeables.

EE 70 779 *pour plus amples renseignements*

THE SOLARTRON ELECTRONIC GROUP LTD

Victoria Road, Farnborough, Hampshire

VOLTMÈTRE NUMÉRIQUE INTÉGRATEUR

(Illustration à la page 420)

Le voltmètre numérique intégrateur Solartron LM1420 est un instrument compact, sûr et d'un emploi des plus souples. Il est, en outre, peu coûteux. Grâce à l'emploi de la méthode d'autocompensation à compteur intégrateur, il permet d'atteindre une grande précision et une haute résolution, de même qu'une discrimination maxima contre les signaux indésirables.

Les circuits d'entrée sont entièrement flottants et d'une impédance d'isolement supérieure à 10^5 MΩ/150 pF par rapport à la masse secteur, donnant ainsi un rejet du mode commun d'interférence de 150 dB jusqu'à une pointe de 500 V.

Parti a été tiré des compteurs de l'instrument pour assurer des possibilités de comptage (comptage d'impulsions, mesure de fréquence et de période), avec commande locale ou éloignée dans chaque cas. La lecture numérique se fait par tubes de nombres au néon logés derrière un filtre polaroid.

Les nouvelles méthodes de construction, y compris le contrôle automatique des plaquettes de circuits imprimés et du câblage avant l'assemblage final, garantissent à l'appareil un degré élevé de fiabilité.

L'excellente performance de ce voltmètre numérique est due à la méthode de comptage intégré utilisée. La tension de signal appliquée fait monter la sortie d'un amplificateur intégrateur vers un niveau de déclenchement préréglé où elle est réglée à nouveau par une charge établie avec précision. Le taux de montée et, par conséquent, le nombre d'impulsions de charge réenclenchées par temps unitaire est directement proportionnel à la tension d'entrée. La digitization est réalisée en comptant ces impulsions pendant une période déterminée, pour donner une moyenne véritable du signal appliqué pendant toute la période, minimisant ainsi les effets de bruits parasites. La période de comptage choisie est normalement d'un cycle de la fréquence d'alimentation secteur afin de donner un rejet maximum de composantes de fréquence fondamentale et des harmoniques de cette fréquence.

L'oscillateur de minutage commande la durée de l'impulsion de décharge, de même que la période de minutage, de sorte que n'importe quelle dérive de la fréquence de l'oscillateur fera varier également la période de minutage et la durée d'impulsion, fournissant ainsi la compensation automatique pour retenir la précision de lecture.

La sortie du circuit intégrateur du compteur consiste en un train d'impulsions accouplées au circuit compteur à travers un transformateur toroïdal. Les alimentations vers le circuit d'entrée sont accouplées à travers un transformateur analogue sous forme d'onde carrée de 4 kHz. Les étages d'entrée sont donc complètement isolés de la masse secteur. La connexion à l'entrée se fait au moyen d'une fiche à trois directions montée sur panneau, à paire de signaux "haut" et "bas," et d'une connexion de garde. On peut ainsi effecteur des mesures gardées à 3 bornes ou à 2 bornes (la "garde" étant liée à "bas"). Pour la plupart des applications de laboratoire, la connexion à deux bornes à la source de signaux assure un rejet suffisant du bruit. Pour certaines applications, telles que la concentration de données, la "garde" peut être conduite à la source de la tension de mode commun, éliminant ainsi virtuellement la boucle de mode commun. Grâce à ce moyen un rejet de mode commun dépassant 150 dB est obtenu.

La sensibilité du voltmètre peut être doublée ou quadruplée par ×2 ou ×4 augmentations de la période de comptage. Cette possibilité peut être utilisée pour accroître la résolution effective pour des entrées au dessous d'une demi échelle ou d'un quart d'échelle respectivement sur n'importe quelle gamme. Des entrées aux compteurs de minutage et d'affichage sont aménagées à l'arrière de l'instrument et elles peuvent être utilisées pour le comptage d'impulsions, pour la mesure de fréquence et de période, etc., avec possibilités de commande locale ou éloignée.

Cette impédance d'entrée apparente du voltmètre qui est nominalement de 5 000 MΩ sur la gamme de 2 V peut être réglée de manière à approcher l'infini pour le fonctionnement à court terme.

La couverture de base de l'instrument est de 0 à 20 mV et de 0 à 1 kV en six gammes.

EE 70 780 *pour plus amples renseignements*

ULTRASONOSCOPE CO. (LONDON) LTD

Sudbourne Road, Brixton Hill, London, S.W.2

DÉTECTEUR DE FAILLES À ULTRA-SONS

(Illustration à la page 420)

Ce nouvel instrument Mark 2C remplace l'appareil portatif Mark 2B actuel. Il comprend des dispositifs supplémentaires et des perfectionnements. Un effort tout particulier a été apporté à satisfaire les besoins précis des techniciens du contrôle de la soudure par ultra-sons, soit en atelier, soit sur les lieux, soit en laboratoire.

A cette fin, plusieurs caractéristiques qu'on ne trouve pas habituellement dans un détecteur de failles portatif ont été ajoutées à l'appareil. Une très grande vitesse de base de temps et une brillance de trace élevée sont alliées à un affichage de trace redressé ou non-redressé afin de permettre d'effectuer une analyse détaillée de la forme de l'écho de la faille. La gamme de fréquences opérationnelle va de 0,5 MHz à 10 MHz et une portée maxima de 24 pieds (dans l'acier) étend la gamme d'applications possibles à un très grand nombre de problèmes de contrôle non-destructifs. Le tube cathodique de 12,7 cm à haute définition réduit la fatigue de vision de l'opérateur. Pour faciliter l'établissement des normes qui déterminent l'acceptation ou le rejet d'un matériau soumis au contrôle, l'amplitude d'un écho de défaut sur la trace peut être réglée par une commande d'atténuateur.

Lorsque l'appareil est utilisé pour le contrôle ordinaire, une commande de contact peut être mise en action. Elle fournit une trace extrêmement claire en mettant en relief les échos de petits défauts par rapport aux échos parasites de fond, ces derniers étant réduits à une valeur minima. Afin d'éviter tout emploi erroné de cette commande, un gros voyant lumineux d'avertissement est allumé lorsqu'elle est utilisée.

Des commandes différées de trace précise et approximative sont incorporées à l'appareil, permettant à l'opérateur de choisir n'importe quelle partie de l'image pour l'agrandir sur toute la largeur de la base de temps jusqu'à un maximum de 76,2 cm (dans l'acier).

EE 70 781 *pour plus amples renseignements*

VACTRIC CONTROL EQUIPMENT LTD

Garth Road, Morden, Surrey

MOTEUR SYNCHRONE À VITESSE RÉDUITE

(Illustration à la page 420)

Le nouveau moteur synchrone Vacsyn à vitesse réduite a été réalisé pour produire un couple élevé à des vitesses réduites et obvier ainsi à l'emploi de démultiplicateurs. A 50 Hz, sa vitesse synchrone est de 60 tours/minute, donnant un couple synchrone minimum de 150 onces-pouce correspondant à une puissance de sortie de 5,5 W. Le moteur Vacsyn peut aussi être utilisé comme moteur répartiteur.

Sa longueur hors-tout, y compris l'arbre de transmission, est 18,41 cm et son diamètre est de 10,63 cm. Le courant d'entrée maximum est de 350 mA et la puissance d'entrée maxima de 35 W.

EE 70 782 *pour plus amples renseignements*

Résumés des Principaux Articles

Un téléphone acoustique sous-marin pour scaphandriers autonomes par B. K. Gazey et J. C. Morris

Résumé de l'article aux pages 364 à 368

Un système téléphonique à courants porteurs acoustiques et à modulation de fréquence a été mis au point à l'usage des scaphandriers autonomes. Fonctionnant à une fréquence porteuse de 120kHz et émettant une puissance acoustique d'environ 1W, cet appareil a été contrôlé à des distances allant jusqu'à 500 yards. Le système est brièvement décrit et des détails d'essais expérimentaux sont donnés.

Une méthode électronique d'allumage pour véhicules automobiles par A. R. Hayes

Résumé de l'article aux pages 369 à 373

L'auteur décrit les conditions d'allumage à pleine charge d'un moteur particulier à l'aide d'une équation algébrique qui, lorsqu'elle est appliquée à un projet de base donné, indique le type de circuit nécessaire au contrôle électronique du minutage de l'allumage. Il indique, à titre d'exemple, un circuit éventuel dont le rendement se compare favorablement au système mécanique actuel.

Un magnétomètre de résonance magnétique nucléaire différentiel par D. E. P. Silver

Résumé de l'article aux pages 374 à 377

Il s'agit ici d'un instrument permettant de mesurer rapidement et avec précision la répartition du champ magnétique sur des zones à surface polaire étendue. Bien que la résonance magnétique nucléaire soit utilisée pour l'élément sensible, nulle mesure de fréquence n'est nécessaire. L'appareil peut être utilisé également avec de bons résultats pour un électro-aimant alimenté par une source de puissance non stabilisée. Un principe différentiel est utilisé suivant lequel les intensités de champ à divers points de l'entrefer polaire sont mesurées par rapport à quelque point arbitrairement fixé dans l'entrefer.

L'utilisation du calculateur analogique dans la recherche des opérations par D. Longley

Résumé de l'article aux pages 378 à 381

Le calculateur analogique est aujourd'hui pleinement reconnu comme instrument de base de l'ingénieur de contrôle. Sa souplesse d'emploi et sa facilité de programmation en font un moyen expérimental et théorique idéal pour la solution d'une foule de problèmes dynamiques. En outre, il permet l'ingénieur de se faire une idée précise du comportement du système étudié. Ces méthodes peuvent également être étendues à la science de la recherche des opérations. Dans cette dernière, le calculateur peut être utilisé comme simulateur de problèmes de contrôle de direction, ainsi que comme dispositif rapide et souple "d'ascension de colline". Cet article traite de cette dernière application de la calculatrice analogique et décrit des exemples de solution des problèmes de programmation linéaire et non-linéaire.

Analyse par calculatrice numérique de l'oscillateur de relaxation à diode tunnel par W. Cox et A. L. Riemenschneider

Résumé de l'article aux pages 382 à 385

Cet article a pour but d'indiquer une méthode basée sur l'emploi d'une calculatrice numérique permettant l'analyse de l'oscillateur de relaxation à diode tunnel. Des équations pour l'analyse en question dans le plan de phase à l'aide du mode de construction Lienard sont choisies. Ces équations sont utilisées pour mettre au point des programmes de calcul qui assurent la réponse de sortie de l'oscillateur directement à partir de la caractéristique de diode complète et des paramètres de circuit d'un deuxième système d'ordre. La methode reproduit fidèlement les formes d'onde de réponse avec une précision qui n'est limitée que par la précision avec laquelle les caractéristiques de l'élément non linéaire est établie et elle est aisément dans les limites de la dérive de composants normale.

Un générateur à plots aléatoires à faible fréquence par B. R. Wilkins

Résumé de l'article aux pages 386 à 389

L'auteur traite d'un circuit produisant une séquence aléatoire de valeurs de sortie discrètes, la probabilité d'une quelconque valeur de sortie étant réglable. Le circuit est disposé de manière à ce que ni les valeurs de sortie elles-mêmes ni les probabilités de leur apparition ne dépendent des propriétés de la source de bruit.

Des observations expérimentales sont indiquées afin de montrer que les répartitions de probabilités de sortie prévues sont obtenues en fait d'un générateur pratique.

Distorsion d'amplitude dans les réseaux non linéaires dans le cas particulier des systèmes de transmission de la porteuse par W. Dougharty

Résumé de l'article aux pages 390 à 393

Les rapports d'amplitude entre divers produits de distorsion sont examinés et exprimés sous une forme pratique au moyen de diagrammes. La distorsion prévue des tubes est également étudiée et diverses méthodes pour réduire la distorsion sont envisagées.

Analyse matricielle de l'oscillateur de Colpitts par G. Zelinger

Résumé de l'article aux pages 394 à 398

Les problèmes fondamentaux de réalisation des oscillateurs de Colpitts peuvent être étudiés et résolus par l'analyse matricielle. L'auteur de cet article examine certains circuits oscillateurs pratiques qui utilisent des transistors ou des lampes comme élément actif. Il montre que le système oscillatoire complet peut être synthétisé à partir d'un dispositif actif et passif décrit par une matrice d'admittance. Des équations d'étude peuvent être obtenues de la fréquence et des conditions d'oscillation en fonction des paramètres de circuit fondamentaux.

Il montre, en conclusion, qu'on peut apporter des simplifications mathématiques qui donneront néanmoins, des résultats significatifs pour les approximations techniques.

Filtre accordable pour basses fréquences à amplificateurs opérationnels par H. Sutcliffe

Résumé de l'article aux pages 399 à 403

La réalisation de filtres accordables à bande étroite pour des fréquences minima de 0,1Hz, en utilisant des éléments actifs et des circuits RC, est compliquée par les exigences d'ébavurage et d'accouplement L'auteur décrit un principe pour surmonter les difficultés et indique une méthode pour obtenir un filtre à Q constant équivalent à une paire accouplée critique. L'étude des amplificateurs opérationnels connexes à transistors forme une partie substantielle de l'article. Des détails sont donnés d'un filtre propre à la gamme de fréquences de 1 à 1000Hz.

Une base de temps logarithmique par R. N. Alcock

Résumé de l'article aux pages 404 à 406

La réalisation d'un réseau générateur de fonctions logarithmiques passives est décrite dans cet article. Une tension point par point est appliquée à l'entrée de sorte que la sortie augmente en fonction du logarithme de temps. Le réseau consiste en un nombre d'intégrateurs à constantes de temps différentes. La gamme de temps pour le fonctionnement logarithmique augmente selon le nombre d'intégrateurs. Une base de temps expérimentale unidirectionnelle a été construite qui opère entre 22ms et 30s à une précision de 2%.

Die Ausstellung für INSTRUMENTE ELEKTRONIK UND AUTOMATION

Beschreibung einer Auswahl der auf der Ausstellung für Messgeräte, Elektronik und Automation in den Olympia-Hallen, London, vom 25.-30. Mai gezeigten Geräte nach Angaben der Hersteller.

Übersetzung der Seiten 413 bis 420

BARR & STROUD LTD

Kinnaird House, 1 Pall Mall East, London, S.W.1.

AUTOMATISCHE MORSETASTUNG

(Abbildung Seite 413)

Barr & Stroud Ltd hat ein Kleingerät entwickelt, das eine kurze, vorbestimmte Morsenachricht für Ausstrahlung über einen Sender oder ein Blinklicht automatisch austastet. In der vorliegenden Ausführung ist es für Einbau in See- oder Luftfahrtnotrufgeräte gedacht, kann jedoch sehr einfach für andere Verwendungszwecke, die Tastfolgen erfordern, abgewandelt werden. Die getastete Folge kann ohne Schwierigkeiten geändert werden.

Das Gerät enthält weder bewegliche Teile, noch Röhren. Die ausschliessliche Verwendung von Halbleitern und Ferritkernen gibt bei kleinen Abmessungen eine hohe Zuverlässigkeit. Die Speisung erfolgt aus Trockenbatterien, denen bei 12 V 60 mW und bei 4 V 140 W entnommen werden. Mit der Batterie kann man wochenlang laufend Morsenachrichten austasten. Bei einer Solltastgeschwindigkeit von 6 Worten je Minute hat der Prototyp eine Nachrichtenlänge von ungefähr 2 Minuten, die sich jedoch für verschiedene Verwendungszwecke ändern lässt. Bei Abmessungen von 4 cm × 9 cm × 10 cm wiegt der Prototyp rund 200 g.

EE 70 751 *für weitere Einzelheiten*

BECKMAN INSTRUMENTS LTD

Glenrothes, Fife, Schottland

ZÄHLER UND ZEITGEBER

(Abbildung Seite 413)

Die Geräte der Serie 6100 haben Einschub-Bausteine und sind in Festkörpertechnik mit einzeiliger elektrolumineszierender Ziffernanzeige in einer Ebene ausgeführt.

Modelle für 25 MHz und 2,5 MHz in der Serie 6100 sind als Messgeräte für "Vorgänge je Zeiteinheit" und Zeitgeber lieferbar. Bereich und Funktionen können durch Zusatzeinschübe erweitert werden. Das 25-MHz-Modell lässt sich durch Einschübe direkt auf 100 MHz und durch Überlagerung auf 1 GHz ausbauen. Alle Geräte dieser Serie sind mit einem Spannungs-Frequenzwandler-Einschub zu benutzen, der eine direkte Digitalanzeige von Spannungen erlaubt. Bei Verwendung des 100-MHz-Einschubs lassen sich Zeitspannen bis zu 30 μs herunter mit einem Auflösungsvermögen von 10 μs messen.

EE 70 752 *für weitere Einzelheiten*

HALLGENERATOREN

(Abbildung Seite 413)

Das neue Hallgeneratoren-Programm wird von der Helipot-Abteilung der Beckman Instruments Inc. gefertigt. Die mit "Hallefex" bezeichneten Generatoren sind in vier Modellen lieferbar, die bei hohem Eingangs- und Ausgangswiderstand eine hohe Ausgangsempfindlichkeit haben. Der Hauptunterschied zwischen den Hallefex-Festkörper-Spannungserzeugern und anderen Geräten ist die aufgedampfte mikrodünne Halbleiterschicht, die eine höhere Ausgangsempfindlichkeit als bisher erzielt und einen effektiven Luftspalt ergibt, der 15mal kleiner ist als in herkömmlichen Hallgeneratoren.

EE 70 753 *für weitere Einzelheiten*

BELL & HOWELL LTD

Consolidated Electrodynamics Division, 14 Commercial Road, Woking, Surrey

LICHTSTRAHL-OSZILLOGRAF

(Abbildung Seite 413)

Der Lichtstrahl-Oszillograf "Datagraph 5-133" ist das neuste Modell im Programm dieser Firma und kann entweder für Gestelleinbau oder als Tischgerät geliefert werden. Es ist ein direktschreibendes Registriergerät, das zur Beleuchtung des Galvanometers eine hochaktinische Lichtquelle betutzt. Auf einem 305 mm breiten lichtempfindlichen Papier können ohne chemische Behandlung irgendwelcher Art 36 oder 52 Datenkanäle aufgezeichnet werden. Man kann dynamische Messungen von 0...13 kHz vornehmen oder Vorgänge mit Einschwingzeiten von 10 ms, 1,0 ms oder 0,5 ms registrieren. Merkmale des 5-133 sind u.a. Gitterlinien, Zeitlinien, Spurnummerierung, automatische Aufzeichnungslänge, Vorgangskennzeichnung und Vorschubsteuerung mittels Drucktasten.

Die hervorstechende Eigenschaft des Gerätes ist jedoch seine Fähigkeit, mit Hilfe des "Dataflash"-Ausdrucksystems sichtbare Daten 60mal schneller zu erzeugen als irgendein anderes bekanntes Verfahren.

Dataflash ist eine Exklusiventwicklung der Consolidated und benutzt einen Spezialvorschub und Latensifizierungslampe, die gleichzeitiges Registrieren, Erwärmen und Anwenden chemisch hochwirksamen Lichtes zur Erstellung eines völlig latensifizierten Oszillogrammes bei Schreibgeschwindigkeiten bis zu 40 cm/s erlauben. Die höchste Schreibgeschwindigkeit ist 4 m/s.

EE 70 754 *für weitere Einzelheiten*

BEULAH ELECTRONICS LTD

126 Hamilton Road, West Norwood, London, S.E.27

INDUSTRIE-FERNSEHSYSTEM

"Beuvision" ist ein preiswertes, volltransistorisiertes Industrie-Fernsehsystem, das industriellen Vorschriften entsprechend gebaut ist. Die Ausrüstung umfasst eine volltransistorisierte Vidikonkamera neuartiger Konstruktion mit einem Objektiv 1:1,9, f = 25 mm mit einstellbarem Fokus und veränderlicher Blende, 91,5 m Koaxialkabel und einem transistorisierten Sichtgerät mit 216-mm- oder 356-mm-Bildschirm.

Die getrennt lieferbaren Sichtgeräte haben einen Durchlassbereich von 5 MHz (625 Zeilen) und benötigen ein Video-Eingangssignal von 0,8...1,5 V_{SS}. Die Leistungsaufnahme der Sichtgeräte ist niedriger als 30 W.

EE 70 755 *für weitere Einzelheiten*

BRITISH AIRCRAFT CORPORATION

100 Pall Mall, London, S.W.1.

ELEKTRONISCHE LIBELLE

(Abbildung Seite 414)

"Electrolevel" ist eine neue, elektrische Nivellier-Libelle mit Fernanzeige, die in vielen technischen Anwendungsmöglichkeiten die herkömmliche Libelle ergänzen oder ersetzen kann. "Electrolevel" wurde von der Gruppe Industrielle Systeme des Geschäftsbereiches Fernlenkwaffen der British Aircraft Corporation entwickelt.

Das Konzept des "Electrolevel" wurde direkt von der Libelle abgeleitet. Eine Glasampulle, deren obere Fläche mit gleichförmigem Radius geschliffen wurde, ist mit drei Elektroden ausgerüstet und teilweise mit einer elektrisch leitenden Flüssigkeit gefüllt. Eine Verschiebung der Libellenblase ändert die Widerstandswerte der elektrischen Bahn zwischen den Elektroden, die durch eine einfache Brückenschaltung in den Zeigerausschlag eines Messgerätes umgewandelt werden.

Durch seine Unempfindlichkeit, kompakten Abmessungen, Kleb- und Abnutzungsfreiheit ist diese Bauart eines niveauempfindlichen Instrumentes den mechanischen Pendeln mit Spitzenlagerung überlegen. Der "Electrolevel" hat die dynamischen Eigenschaften einer Libelle, durch die elektrische Anzeige werden jedoch verschiedene bedeutende Vorteile erzielt. Einsatz kann in entfernter oder gefährlicher Lage erfolgen; man kann das Gerät gegen Temperaturänderungen, die empfindliche Libellen ernstlich beeinflussen, isolieren und auf einem Zeigermessgerät ohne Berechnung des Durchschnitts im Kopf ablesen.

Die Verschiebung der Blase wird durch die elektronische Fühlerschaltung verstärkt, so dass ein Weg von 0,025 mm ohne Schwierigkeiten angezeigt werden kann. Dadurch ergibt sich gegenüber der herkömmlichen Libelle ein weiterer Vorteil, da für einen Messkopf ein viel grösserer Messumfang vorgesehen werden kann. Daraus ergibt sich wiederum, dass z.B. beim Messen der Welligkeit der Bettführungsbahn von Werkzeugmaschinen das sonst erforderliche genaue Vornivellieren überflüssig wird.

Das Gerät wird mit drei Skalenteilbereichen geliefert, die einen Neigungsbereich von 1 Bogensekunde ($0{,}005 \times 10^{-3}$) bis 33 Bogensekunden (10×10^{-3}) überstreichen. Anschlussmöglichkeiten sind für einen Zusatzanzeiger oder ein Registriergerät, sowie für bis zu sechs Messköpfe mit Drehschalterwahl vorhanden.

EE 70 756 *für weitere Einzelheiten*

BRITISH PHYSICAL LABORATORIES

Radlett, Hertfordshire

TRANSISTORISIERTES VOLTMETER

(Abbildung Seite 414)

Diese Ausrüstung verbindet die Eigenschaften herkömmlicher Röhrenvoltmeter mit denen von Universaltestgeräten. Die Bereiche wurden unter besonderer Berücksichtigung der Erfordernisse von transistorisierten Ausrüstungen bestimmt.

Neuentwickelte Schaltungen und Bestückung mit Silizium-Planartransistoren ergeben ein ungewöhnlich konstantes Gerät, das driftfrei ist und Langzeitkonstanz und -genauigkeit über einen grossen Temperaturbereich gewährleistet. Ein besonderes Merkmal ist die vorhandene Eichposition, in der die Verstärkung durch Anlegen einer von einer Zenerdiode abgegebenen Normalspannung geprüft werden kann. Der Stromverbrauch ist so niedrig, dass kein Ein-Ausschalter vorgesehen ist; das Gerät ist also jederzeit betriebsbereit. Alle Messbereiche sind gegen Überlastung und Spannungen umgekehrter Polarität geschützt.

Besondere Aufmerksamkeit wurde dem Betriebskomfort und der Darstellung der Messergebnisse gewidmet. Alle Bereiche werden mittels eines Bedienelementes eingestellt, dessen speziell entwickelte Form und mehrfarbige Skala jede mögliche Mehrdeutigkeit des eingestellten Bereiches verhindert. Die Ergebnisse werden auf einem "Vistaview"-Messgerät mit 125 mm Skalenlänge angezeigt, deren verschiedene Skalenbogen in klar unterscheidbaren Farben gedruckt sind. Zur weiteren Erleichterung des Ablesens sind die Skalenbogen gedehnt, wodurch die Krümmung vermindert und Augenermüdung verhindert wird.

Hoher Eingangswiderstand und hohe Empfindlichkeit ermöglichen das Durchführen von Messungen ohne Berücksichtigung des Stromverbrauchs des Gerätes. Der Frequenzumfang der Wechselstrombereiche ist ungewöhnlich gross und erstreckt sich bis zu 100 kHz. Bei Verwendung externer Einsteck-Messköpfe lässt sich diese Grenze auf über 100 MHz erweitern.

Ein weiteres, äusserst nützliches Merkmal ist der für Gleichstrombereiche in der Skalenmitte liegende Nullpunkt. Ausser der offensichtlichen Anwendungsmöglichkeit für Differentialschaltungen sind sie auch für Mehrzweckverwendung sehr nützlich, da sie Umpolen der Zuleitungen entsprechend der Schaltungspolarität überflüssig machen. Selbstverständlich sind beide Klemmen gegen Erde isoliert, um die röhren- und netzbetriebenen Geräten gemeinsamen Komplikationen zu vermeiden.

Die drei vorhandenen Widerstandsbereiche ermöglichen Messungen bis zu 100 MΩ.

Das Gerät ist in einem modern ausgeführten Glasfasergehäuse untergebracht, das die für ein tragbares Gerät erforderliche Festigkeit besitzt. Hinten im Gehäuse befindet sich ein Abteil zum Verstauen der Messkabel und HF-Messköpfe.

Eingebaute Batterien erlauben lange, ununterbrochene Benutzung. Die Batteriebeschaffenheit kann jederzeit durch Einstellen des Bereiches "Batterie-Test" geprüft werden. Das Auswechseln der Batterien bereitet keine Schwierigkeiten.

Die Messbereiche des Gerätes überstreichen von 0...100 mV bis zu 0...300 V=, von 0...1 V bis zu 0...300 V~ und von 0...1 μA bis zu 0...100 mA.

EE 70 757 *für weitere Einzelheiten*

COSSOR INSTRUMENTS LTD

The Pinnacles, Elizabeth Way, Harlow, Essex

MODULARER OSZILLOGRAF

(Abbildung Seite 414)

Der modulare Festkörper-Oszillograf CD 100 besteht aus einem Hauptgestell mit Sichtgerät und Stromversorgung sowie einer grossen Öffnung zur Aufnahme von Einschub-Moduln. Je nach Verwendungszweck kann entweder ein Modul die Signale für die X- und Y-Achsen abgeben, oder Einzelmoduln können die Darstellung je einer Achse speisen.

Die grundsätzliche Bandbreitenbegrenzung für beide Achsen ist im Hauptgestell durch die Elektronenstrahlröhre gegeben. Typische Moduln sind u.a. gleichspannungsgekoppelte Verstärker für Einzel- oder Doppelspur mit Bandbreiten bis zu 35 MHz und Empfindlichkeiten bis zu 500 μV/cm, sowie Ablenkgeräte für diese Verstärker, zum Teil mit Ablenkverzögerung, Sampling-Einschübe mit Bandbreiten bis zu 100 MHz und Wobbeloszillatoren für Spektralanalyse von 20 Hz bis zu 1 GHz.

Der komplette Grundoszillograf besteht aus einem Sichtgerät CD 100 und zwei Moduln, die aus folgendem Programm gewählt werden können:

Einzel-Breitbandverstärker, Doppel-Breitbandverstärker, Differentialverstärker, Breitband-Differentialverstärker, Ablenkgerät, Ablenkgerät mit Verzögerung, Sampling-Einschub, X-Y-Koordinatenschreiber-Einschub.

EE 70 758 *für weitere Einzelheiten*

THE ENGLISH ELECTRIC VALVE CO. LTD

Chelmsford, Essex

VAKUUM-ABSTIMMKONDENSATORSERIE

(Abbildung Seite 415)

Die English Electric Valve Co Ltd hat eine neue Hochvakuum-Abstimmkondensatorserie für Betrieb mit 75 A_{eff} eingeführt. Zehn Typen in zwei Gehäusegrundausführungen UG und UH überstreichen Kapazitätsbereiche bis zu 2000 pF mit HF-Spitzenspannungen bis zu 30 kV.

Diese 75-A-Kondensatoren haben dieselben Leistungs- und Konstruktionseinzelheiten wie die bereits gut eingeführte 40-A-Serie. Dasselbe Prinzip der Bauelementvereinheitlichung wurde beibehalten, um kurze Lieferfristen für alle

Typen zu gewährleisten. Abstimmung erfolgt normalerweise durch Drehen der Welle, doch kann auch Abstimmung durch axiales Ziehen vorgesehen werden.

Merkmale der EEV-Vakuumkondensatoren 75A sind: höchste elektrische Betriebsdaten bei Frequenzen bis zu 27 MHz; Q höher als 10 000; geringste Streuung der Kenndaten für Kondensatoren derselben Type; durch besondere Beachtung der Umhüllungsform werden die Glasverluste reduziert und das Anlegen der vollen Betriebsspannung bei höchsten Frequenzen ermöglicht; höhere Nennströme durch Spezialkühlung; speziell ausgesuchte und geprüfte Vakuumbälge für lange Abstimmlebensdauer; niedriger Mikrofoneffekt; völlig umschlossene Pumpdichtungen; niedriges Abstimmdrehmoment; geringstes Abstimmspiel für höhere Abstimmgenauigkeit.

EE 70 759 *für weitere Einzelheiten*

FARNELL INSTRUMENTS LTD

Sandbeck Way, Wetherby, Yorkshire

SINUS-RECHTECKWELLENGEBER

(Abbildung Seite 415)

Diescr transistorisierte Sinus-Rechteckwellengeber wurde für universelle Verwendung in Elektro- und Maschinenbaulabors in Industrie und Schulung entwickelt. Er kann direkt ans Netz angeschlossen oder aus internen Batterien gespeist werden.

Ein RC-Oszillator in Brückenschaltung ist für einen Frequenzbereich von 1 Hz... 100 kHz ausgelegt. Die Einstellunsicherheit ist im ganzen Bereich 3% ±0,5 Hz, und die Frequenzabgabe ist vom Einschalten an praktisch konstant.

Der Klirrfaktor der abgegebenen Sinuswelle ist niedriger als 2%, die Anstieg- und Abfallzeiten der Rechteckwelle kürzer als 0,3 μs; negative Dachschräge oder Überschwingen ist innerhalb 5%.

Der Abschwächer ist für einen 600-Ω-Abschluss geeicht; ausser vier Schalterstellungen für 0 dB, −20 dB, −40 dB und −60 dB ist ein stufenloser Regler mit einem Bereich von −6 dB bis zu +14 dB vorhanden; die Genauigkeit ist innerhalb 3%. Schalter und Feinregelung des Abschwächers sind auch in doppelten Scheitelwerten geeicht; die maximale Ausgangsspannung ist 12 V_{SS} an 600 Ω. Die Amplitude der Ausgangsspannung und die Impedanz sind von der Frequenzeinstellung praktisch unabhängig und konstant.

Der Oszillatorausgang ist erd- und massefrei und kann bei Betrieb mit internen Batterien als völlig schwebender Geber eingesetzt werden.

EE 70 760 *für weitere Einzelheiten*

FIELDEN ELECTRONICS LTD

Paston Road, Wythenshawe, Manchester, 22

FÜLLSTANDREGLER

(Abbildung Seite 415)

Der "Tektor T6" ist ein kapazitätsempfindlicher Festkörper-Füllstandregler, der in kompakter, robuster und preisgünstiger Form bei ausgezeichnetem Unterscheidungsvermögen höchste Konstanz aufweist.

Der mit Silikon-Kautschuk umpresste Transistor-Schalter ist für Montage auf das reichhaltige Sortiment von Fielden-Elektroden der Type 40 ausgelegt. Der TT6 hat eine ausgezeichnete Stabilität gegen Netz- und Temperaturschwankungen. Er ist gegen Widerstandsänderungen im Elektrodensystem verhältnismässig unempfindlich, und—einmal eingestellt—arbeitet er bei Installation oder in Betrieb ohne Nachregelung.

Der bistabile Transistorausgang kann 0,25 A schalten—genug für eine 2,5-W-Lampe. Mit Stromversorgung, Steuerrelais und Signallampen ausgestattete Einzel- und Doppelkanal-Bausätze sind lieferbar.

Bei Mehrfachinstallation kann man durch Verwendung gemeinsamer Stromversorgungen für mehrere TT6-Ausrüstungen wesentliche Ersparnisse erzielen, und da keine Koaxialkabel erforderlich sind, können Standardleitungen benutzt werden.

EE 70 761 *für weitere Einzelheiten*

G.E.C. (Telecommunications) LTD

Telephone Works, Coventry

KLEINSTRELAIS

(Abbildung Seite 415)

Dieses neue Relais wurde für zuverlässigen Betrieb im Subminiatur-Zusammenbau entwickelt, ist jedoch für viele Mehrzweck - Anwendungsmöglichkeiten einschliesslich Montage auf Leiterplatten geeignet. Es hat ein Volumen von 6,5 cm^3 und eine mechanische Lebensdauer von 50 Millionen Schaltungen. Das Relais wirkt als Einzelumschalter, und die Kontaktzuverlässigkeit wird durch massive Edelmetallkontakte und 10 g Kontaktdruck erreicht. Alle organischen Verbindungen sind von dem abgedichteten Kontaktabteil ausgeschlossen.

EE 70 762 *für weitere Einzelheiten*

7-NOCKEN-FORTSCHALTRELAIS

(Abbildung Seite 415)

Bei diesem Relais handelt es sich um eine Weiterentwicklung der 2-Nocken-Ausführung, mit der der Anwendungsbereich in impulsbetriebenen Schaltungen verbreitert wird. Das Relais ist beim Dezimal- und Binärkodieren besonders nützlich.

Eine dieser Anwendungsmöglichkeiten besteht bei der Übertragung von Dezimalinformation im "Zwei-von-Fünf"-Kode, der heute weitgehend für Datenübertragung und -aufbereitung benutzt wird. Fünf Nocken können für den Kode verwendet werden, die anderen für nicht normale Impulse wie eine "Start-von-Null"-Prüfung und einen "Übertragungs"-Impuls zum nöchsten Dekadenzähler. Das Relais hat alle Eigenschaften des ursprünglichen Fortschaltrelais, dieselbe Befestigung und nimmt zwei Relaisplätze ein.

EE 70 763 *für weitere Einzelheiten*

HEWLETT-PACKARD LTD

Dallas Road, Bedford

FREQUENZNORMAL

(Abbildung Seite 416)

Hewlett-Packard hat ein Breitband-Frequenznormal mit einem einzigartigen System für Frequenzeinstellung entwickelt.

Das mit Type 5100A/5110A bezeichnete Gerät erzeugt 5000 Millionen diskrete Frequenzen von 0,01 Hz ab. Alle diese Frequenzen haben hohe Spektralreinheit; ihr Klirrfaktor ist geringer als 30 dB, und der Geräuschabstand ist in einem auf das Ausgangssignal zentrierten 3-kHz-Band besser als 50 dB.

Im Gegensatz zu dem üblicherweise benutzten indirekten Syntheseverfahren, das auf der Phasenstarre vieler verschiedener Frequenzen beruht, findet in dem neuen Gerät direkte Synthese durch elektronische Addition, Subtraktion, Multiplikation und Teilung von Signalen statt, die direkt einem internen 1-MHz-Normal mit einer Konstanz von $\pm 3 \times 10^{-9}$ je Tag entnommen werden.

Ein Hauptvorteil dieser direkten Synthese ist sehr schnelles Schalten. Die Umschaltung der Frequenz erfordert einschliesslich Totzeit und Einschwingen weniger als 1 ms. Die Frequenzeinstellung erfolgt manuell über Drucktasten oder ferngesteuert mittels eines einfachen Systems, das nur Schliessen von Kontakten erfordert.

EE 70 764 *für weitere Einzelheiten*

DIGITALVOLTMETER

(Abbildung Seite 416)

Die die Arbeitsweise bestimmenden. auf der Frontplatte einsteckbaren Bausteine geben dem Gerät 3440A eine innewohnende Anpassungsfähigkeit. Folgende Hewlett-Packard-Einsteckbausteine sind lieferbar: Bereichwähler 3441A für manuelle Einstellung von Bereichen mit

Endwerten 9,999 und 999,9 V=; Automatischer Bereichwähler 3442A, der automatische und programmierbare Bereichwahl ermöglicht; der Selbsttätige Bereichwähler mit hoher Verstärkung 3443A für Spannungsbereiche mit Endwerten von 100 mV bis zu 1 kV und einem Auflösungsvermögen von 10 μV; und das Mehrfachmessgerät 3444A, das dieselben Spannungsbereiche wie der 3443A, ausserdem aber Strombereiche mit Endwerten von 100 μA bis zu 1 A (Auflösung 10 nA) und Widerstandsbereiche von 1 kΩ bis zu 10 MΩ (Auflösung 0,1 Ω) hat. Geschwindigkeit der Bereichumschaltung: bei automatischem Betrieb wird 500 ms nach Anlegen einer neuen Spannung eine genaue Anzeige erzielt; die programmierte Umschaltung erfolgt innerhalb 40 ms.

Andere Merkmale sind die automatische Komma- und Polaritätsanzeige, binärkodierte Dezimalausgabe für Registriergeräte und Systemzwecke, konstante Eingangsimpedanz 10,2 MΩ, Speicherung der Anzeige für flimmerfreies Ablesen und erdfreier Eingang bis zu 400 V über Chassismasse. Die Genauigkeit liegt innerhalb ±0,05% der Anzeige ±1 Ziffer und berücksichtigt ±10 % Netzschwankungen, einen Temperaturbereich von 15°...40° C, 5% Überschreiten des Bereichendwertes und Alterungseinflüsse.

Das 3440A kann man auch für die Digitaldarstellung der Ausgangssignale der Hewlett-Packard-Geräte einsetzen: Wechselstrom-Gleichstromwandler, elektronische Universal-Mehrfachmessgeräte, Stromzangen-Amperemeter für Gleich- und Wechselstrom, Stehwellenverhältnismesser, Leistungsmesser usw.

EE 70 765 *für weitere Einzelheiten*

HONEYWELL CONTROLS LTD

Greenford, Middlesex

PROZESSGEKOPPELTER MENGENFLUSS-RECHNER

(Abbildung Seite 416)

Die Honeywell-Abteilung für Spezialsysteme hat diesen Rechner eingeführt, der aus Standard-Einschubmoduln zusammengebaut ist und Eingangssignale von Einrichtungen wie z.B. Druckgebern, Temperaturfühlern und Densitometern aufnimmt. Er ist auch für die Handeinstellung von Konstanten, z.B. Blendenscheibengrösse, Dichte, Überverdichtbarkeit und anderen Faktoren, eingerichtet.

Ausgangssignale können den Mengenfluss anzeigen und registrieren, während ein Zählerausgang den Gesamtdurchsatz gibt. Digitalübertragung ist auch möglich.

Besondere Merkmale sind interne Signal-Konditionierungsschaltungen zum Eichen des Rechners für eine breite Auswahl von Messwertgebern und eine eingebaute Signalquelle zum Testen der Rechnerschaltungen.

Der Rechner ist für industrielle Umgebungszustände aller Art konstruiert und kann in Umgebungstemperaturen von −1°...+49° C mit ±0,5% Genauigkeit arbeiten.

EE 70 766 *für weitere Einzelheiten*

HUGHES INTERNATIONAL (UK) LTD

Glenrothes, Fife, Schottland

HALBTON-SICHTGERÄT

(Abbildung Seite 416)

Der "Tono-Corder" ist ein von Hughes International hergestelltes tragbares Gerät für die Darstellung von Halbtonbildern und grafischen Daten auf dem 127-mm-Schirm einer Elektronenstrahl-Speicherröhre.

Einsatz dieses Gerätes mindert den Aufwand an Zeit und Geld, der für die getrennte Entwicklung von Sichtgeräten für jede Aufgabe erforderlich wäre. Die Halbtonbilder der Eingangssignale werden auf einer 127-mm-Speicherröhre für Direktbeobachtung in solcher Weise dargestellt, dass sie für sofortige visuelle Analyse oder dauerhaftere fotografische Aufzeichnung ideal geeignet sind.

Eingangssignale können mit geringer Datengeschwindigkeit eingegeben werden, da das Bild gespeichert wird. Je nach gewählter Schreibgeschwindigkeit werden fünf oder mehr Grautönungen wiedergegeben. Man kann das Gerät auch für Anwendungszwecke mit hoher Datengeschwindigkeit einsetzen und die Datenverbindungsleitung nur für kurze Zeitspannen belegen, um die Darstellung auf den neusten Stand zu bringen; sie steht dann für Zeitmultiplexbetrieb mit anderen Geräten zur Verfügung. Schreibgeschwindigkeiten bis zu 760 m/s sind erreichbar und geben noch Bilder mit guter Grauskalenselektivität und hohem Auflösungsvermögen.

Durch das vollständige Spektrum grauer Farbtöne für hochwertige Bildwiedergabe, zusammen mit äusserst grosser Helligkeit und geregelter Nachleuchtdauer, lässt sich das Gerät ohne Schwierigkeiten einer grossen Anzahl von industriellen, kommerziellen, medizinischen und militärischen Aufgaben anpassen.

Die hohe Lichtabgabe—in der Grössenordnung von 10 000 Lux—gibt selbst bei Beobachtung in starkem Tageslicht ein leuchtendes Halbtonbild der Wetterradarinformation.

Das hohe Auflösungsvermögen und die Möglichkeit eines langsamen Hinlaufs geben diesem Gerät seine Eignung für Bildübertragung über herkömmliche Fernsprechleitungen. Dieses Schmalband-Übertragungsverfahren wird z.B. für Industriefernsehzwecke verwendet, so dass der grosse Aufwand für Koaxialkabel vermieden wird. Die hochwertigen Bilder können sehr langsam untersucht und sogar für Fotografie stillgehalten werden.

Grosse Bildhelligkeit sowie die Integrationseigenschaften des Gerätes ermöglichen es, schwache Signale aus dem Geräuschhintergrund herauszubringen. Durch Abtasten eines bekannten Impulses kann die Impulsstärke aufgebaut und das regellose Geräusch kontinuierlich gelöscht werden.

Diese Einsatzmöglichkeit hat für den Nachrichtenverkehr im Weltraum und eine Anzahl militärischer Situationen eine grosse Zukunft. Bei Verwendung des "Tono-Corder" in Radar-PPI-Sichtgerätsystemen steht das gesamte Grauskalenspektrum zur Verfügung und gibt den höchsten Kontrast für leichte Kennung von Wolkenbildung, Bodentrübung und Zielen. Das Nachleuchten kann fast über die vollen 360° auf maximale Dauer eingeregelt werden und wird erst kurz vor der Abtastung ausgeblendet.

EE 70 767 *für weitere Einzelheiten*

SPEICHEROSZILLOGRAF

(Abbildung Seite 417)

Der Hughes-Oszillograf "Memo-Scope," kann bei Schreibgeschwindigkeiten bis zu 2,5 × 16⁶ cm/s sowohl als herkömmlicher Elektronenstrahloszillograf wie auch als Speicheroszillograf, dessen Anzeige sich beliebig lange speichern lässt, arbeiten. Besonders hervorstechend ist, dass alle Vorteile der Anwendungsvielseitigkeit eines Einzelgerätes durch lieferbare Vorverstärkereinschübe für den Hughes-Memo-Scope erhalten bleiben. Die Einschübe sind austauschbar und haben Kenndaten, die mit dem Memo-Scope-Oszillografen sowohl in der herkömmlichen wie in der Speicherarbeitsweise voll vereinbar sind. Für beide Arbeitsweisen wird die Memotron-Röhre mit herkömmlichem Strahlerzeuger, Ablenksystem und P1-Schirm benutzt. Hinter dem Leuchtschirm und durch einen kleinen Spalt von ihm getrennt liegt das Speichersystem. Es besteht aus zwei feinen Metallgeweben, die das Speichergitter und das Kollektorgitter bilden. Hinter diesen Elementen wiederum liegen zwei Strahlerzeuger, die Flutkanonen. Diese zusätzlichen Elemente ermöglichen die Speicherung eingeschriebener Information auf folgende Weise: die Flutkanonen emittieren einen breiten Elektronenstrahl, der mittels eines Kollimatorsystems so angeordnet ist, dass das Speichergitter gleichmässig mit langsamen Elektronen bestrahlt wird und dadurch eine gleichmässige negative Ladung erhält. Wenn der Strahl des Schreibstrahlsystems auf einen beliebigen Teil des Speichergitters aufschlägt, treten an den von den energiereichen Elektronen des Schreibstrahls getroffenen Punkten Sekundäremissionen auf. Durch die Sekundäremissionen verlieren diese Gebiete mehr Elektronen als sie aufnehmen. Es treten daher örtlich positive Ladungen auf, und die Flutelektronen werden durch diese positiven Gebiete angezogen und schlagen schliesslich auf den Leuchtschirm auf. Am Leuchtschirm liegt eine Spannung, die hoch genug ist, um in normaler Weise Fluoreszenz hervorzurufen. Es entsteht eine helle Schreibspur, da jeder gespeicherte Punkt auf diese Weise dauernd dargestellt wird und nicht wie bei normalen Elektronenstrahlröhren in wiederkehrender Form geschrieben wird. Das früher erwähnte Kollektorgitter zieht die vom Speichergitter emittierten Sekundärelektronen an, so dass die beschriebenen Gebiete des Speichergitters örtlich den Spannungspegel des Kollektorgitters annehmen. Das Ladungsbild wird auf diese Weise aufrechterhalten, bis die am Kollektorgitter liegende Spannung absichtlich unter den kritischen Wert gesenkt und damit die Information gelöscht wird.

EE 79 768 *für weitere Einzelheiten*

H.V.L. LTD

1 Cardiff Road, Luton, Bedfordshire

DRIFTKONSTANTHALTER IN DIGITALTECHNIK

(Abbildung Seite 417)

Das Gerät wurde speziell für die Korrektur der Driftabweichungen in Mehrkanal - Impulshöhenanalysatoren entwickelt. "Stabimat" nimmt die kontinuierliche Korrektur der Verstärkungsdrift vor, die aus irgendeinem der folgenden Gründe auftritt: Schwankungen im Detektor oder Photovervielfacher, Hochspannungsschwankungen, Verstärkungsdrift in Vorverstärkern und linearen Verstärken, Drift in Analog-Digitalwandlern (einschliesslich Nullpunktdrift).

"Stabimat" arbeitet nach völlig neuen Prinzipien in Festkörper-Digitaltechnik, um absolute Genauigkeit der Impulshöhe oder Energieumwandlung ohne Verschlechterung des Auflösungsvermögens zu gewährleisten.

Das Gerät hat folgende Merkmale: die Driftkorrektur beruht auf absolutem Zählen und ist völlig unabhängig von der Zählgeschwindigkeit; Digitaltechnik wird durchgehend angewendet; das Korrektursystem kann zu keiner Drift beitragen; mann kann das Gerät mit jedem Impulshöhenanalysator benutzen; Einsatz des "Stabimat" führt zu vernachlässigbar niedrigem Abfallen des Auflösungsvermögens. Drift kann im allgemeinen auf besser als 0,1 eines Kanals korrigiert werden.

EE 70 769 *für weitere Einzelheiten*

INTERNATIONAL ELECTRONICS LTD

132-135 Sloane Street, London, S.W.1

DIGITALVOLTMETER

(Abbildung Seite 417)

Das Modell DSV.1 ist im Grunde genommen ein dreistelliges 0,1%-Digitalvoltmeter. Der Schalter ermöglicht Abziehen von 1000 am wenigsten geltenden Ziffern vom Eingang, was den Bereich des Gerätes effektiv verdoppelt. Die vier Grundbereiche geben Vollausschlaganzeigen von 1 V, 10 V, 100 V und 1000 V; aber die Grundempfindlichkeit des Instruments erlaubt direkten Anschluss an die gängigsten Thermoelementtypen, wobei im Bereich 0... 100° C ein Unterscheidungsvermögen von 0,1° C erzielt wird. Es werden nur Festkörperschaltungen und eine sehr klare, hochzuverlässige Projektionsanzeige verwendet. Die maximale Umsetzzeit ist 10 ms, und das Gerät führt je Sekunde rund 20 Messungen aus.

EE 70 770 *für weitere Einzelheiten*

THE MARCONI CO. LTD

Chelmsford, Essex

SCHNELLRECHENANLAGE

(Abbildung Seite 418)

Dieser Versuchs-Elektronenrechner beruht auf Silizium-Dioden-Transistor-Logikmoduln in Mikrominiaturtechnik mit einer Stufenverzögerung von nur 5 ns. Die kompakte Konstruktion ergibt sich aus der Anwendung dieser Mikrominiaturtechnik und ist ein Hauptfaktor der hohen Geschwindigkeit des Rechners. Die Mikrologik-Bausteine sind in Moduln der Type TO-5 eingebaut, und wo immer möglich fanden gedruckte Schaltungen Verwendung. Verdrahten der Moduln wurde auf das absolute Mindestmass reduziert, wodurch der Rechner kleiner als ein normaler Schreibtisch ist. Er arbeitet asynchron und benutzt einen Koinzidenzstrom-Ferritkernspeicher mit einer Kapazität von 4096 Worten. Die Wortlänge ist 24 Bits, die Speicherzugriffzeit 0,4 μs und die Speicherzykluszeit 1,2 μs. Es sind 32 Mikroprogramm-Befehle vorgesehen, und die Befehlsgeschwindigkeit für Heranholen, Addieren, Subtrahieren usw. ist 2,5 μs, für Multiplizieren 10 μs. Das Bedienfeld ist mit Spannungsmessern ausgerüstet, die den momentanen Inhalt jedes Registers anzeigen, sowie mit Tasten und Schaltern für die Steuerung und Programmierung des Rechners.

Verbindungen mit Peripheriegeräten werden über Daten- und Steuerwege hergestellt. Eine unabhängige Speichersucheinrichtung erlaubt externen Geräten Zugriff zum Speicher ohne Behinderung des Programms. Normale Trenneinrichtungen sind für bis zu 15 Peripheriegeräte vorhanden.

EE 70 771 *für weitere Einzelheiten*

MARCONI INSTRUMENTS LTD

St. Albans, Hertfordshire

GROSSBEREICH-FESTKÖRPER-MESSENDER

(Abbildung Seite 418)

Der neue Marconi AM-Messender TF 2002 für Mittel- und Hochfrequenzen gibt hochwertige Signale von 10 kHz...72 MHz ab, weist grosses Unterscheidungsvermögen (eine effektive Skalenlänge von über 4 cm), ungewöhnlich niedrige Stromverluste und Störmodulation auf und ist haltbar und kompakt konstruiert. Er wiegt nur 23 kg, ist im Tischgehäuse oder für Gestelleinbau lieferbar und kann vom Netz oder mit Batterien betrieben werden.

Jedes der acht Frequenzbänder hat einen getrennten Oszillator mit Permeabilitätsabstimmung und eine Ausgangsschaltung, die optimale Leistung über den ganzen Bereich ergibt. Die handgeeichte, nahezu logarithmische Abstimmskala ist in einem kontinuierlichen Zickzackmuster ausgeführt, in dem die Skalen umschichtig von links und rechts beginnen. Dieses neue System ist weniger mühselig und beschleunigt das Abstimmen auf die äussersten Enden von Frequenzbändern.

Kristall-Eichpunkte sind in Abständen von 1 MHz, 100 kHz oder 10 kHz und für Bandbreitenmessungen mit Hilfspunkten bei ±1 kHz Abstand von den Hauptpunkten vorhanden. Über 100 kHz Trägerfrequenz ermöglicht eine Zusatzfeineinstellung mit Direktablesung, die gegen die Kristall-Eichpunkte geprüft werden kann, eine Unterscheidung von 0,025 % der Trägerfrequenz.

Ausgangssignale bis zu 2-V-Quellen-EMK werden über einen 20-dB- und 1-dB-Stufenabschwächer entnommen und während der Abstimmung durch automatische Pegelregelung konstantgehalten. Interne AM bis zu 100 % wird durch einen kontinuierlich über das Tonfrequenzband durchstimmbaren Oszillator erzeugt. Hüllkurven-Gegenkopplung gewährleistet hohe Modulationsqualität bis zu mindestens 80%, und der Modulationsgrad ist sowohl von der Trägerabstimmung, als auch vom Trägerpegel unabhängig. Externe FM oder PM ist möglich.

EE 70 772 *für weitere Einzelheiten*

ELEKTRONISCHER ZÄHLER

(Abbildung Seite 418)

Der Festkörper-Zähler TF 2401 besteht aus einer Grundausrüstung, in die Frequenzbereichzusätze oder ein Funktionsbaustein eingeschoben werden können. Die Bereichzusätze bestimmen die höchste Eingangsfrequenz, die man messen kann, der Funktionsbaustein die durchzuführende Messart. Folgende Einschübe sind zur Zeit lieferbar: ein 50-MHz-Frequenzbereichzusatz, ein Zähler-Zeitgeber-Funktionsbaustein und ein 500-MHz-Umsetzer.

Mit diesen Einschüben kann das Instrument folgende Grundmessungen durchführen: Frequenz, Zeitabschnitt, Mehrfachzeitabschnitte, Zeitintervall, Frequenzverhältnis, Verhältnis einer Frequenz zu einem Mehrfachen einer anderen, Vorgänge während eines extern bestimmten Zeitintervalls, Summieren und Untersetzen eines angelegten Signals.

Merkmale sind u.a. eine 8stellige Anzeige mit Speicher, im Anzeigefenster beleuchtete Messeinheiten und eine eingebaute Kontrolle. Anschluss des Gerätes ans Netz führt dem Thermostaten Energie zu und gibt ihm Zeit, sich zu stabilisieren, ohne dass der Rest des Zählers unter Spannung steht.

Der Zähler kann ein Druckwerk oder eine Fernanzeige treiben, und eine wahlweise Einrichtung ermöglicht Fernsteuerung des Gerätes. Bei Einsatz des Gerätes als Zeitintervallgeber gibt es Impulse von 0,01 Hz...1 MHz in Dekadenstufen ab; Ausgangssignale bei 1 MHz und 10 MHz können getrennten Buchsen entnommen werden.

Im TF 2401 findet die Logik-Technik weitgehende Anwendung, und es werden durchweg Halbleiter, gedruckte Schaltungen und modulare Einschubkonstruktion benutzt. Das Gerät wird im Tischgehäuse und für Gestelleinbau lieferbar sein und wiegt ungefähr 17 kg.

EE 70 773 *für weitere Einzelheiten*

PANAX EQUIPMENT LTD

Holmethorpe Industrial Estate, Redhill, Surrey

RADIOAKTIVER DICKENMESSER

(Abbildung Seite 418)

Panax Equipment Ltd hat für die schnelle und genaue Bestimmung der Beschichtungsdicke von nur einer Seite eines Gegenstandes ein tragbares, radioaktives Messgerät für Industrieeinsatz entwickelt. Es ist hauptsächlich für das Messen von Kunststoffbeschichtungen gedacht, kann aber auch Farb- oder plattierte Überzüge auf beliebigen Werkstoffen messen. Das Gerät arbeitet nach dem Rückstreuprinzip, einer zerstörungsfreien Technik, und ist daher besonders für die Qualitätskontrolle von Bauelementen in der Fertigung und im Labor geeignet. Man kann jedes als Schicht auf einen anderen Werkstoff niedergeschlagene Material auf diese Weise messen, vorausgesetzt dass zwischen den Kernladungszahlen der beiden Materialien genügend Unterschied besteht.

Ungleich den meisten anderen Rückstreumessgeräten ist das Panax-Instrument nicht auf flache und regelmässig geformte Teile beschränkt, und der Messkopf ist so konstruiert, dass selbst bei Krümmungen mit kleinen Radien der kritische Betriebsabstand zwischen der radioaktiven Quelle und dem Teil im wesentlichen konstant bleibt.

Das Radioisotop ist Promethium 147, das im allgemeinen als beta-emittierende Quelle für Dickenmessungen benutzt wird. Es ist in ein Ende eines kleinen Messkopfes eingebaut, der ein Geiger-Müller-Zählrohr enthält, und hat eine nützliche Betriebslebensdauer von mehr als 2½ Jahren. Das Anzeigegerät ist dem des Panax-Ratemeters RM-202 ähnlich und hat ein Drehspulmessgerät mit einer effektiven Skalenlänge von 76 mm. Plastik-Schichtdicken von 1,27 µm...0,05 mm können gemessen werden, und die Empfindlichkeit ist so hoch, dass ein der gemessenen Dicke von 0,013 mm entsprechender Vollausschlagwert eingeregelt werden kann. Die grosse offene Skala erlaubt selbst ungelerntem Personal genaues Ablesen.

Das Gerät ist transistorisiert und kann vom Netz oder Batterien betrieben werden. Komplett mit Messkopf wiegt es 7,25 kg.

EE 70 774 *für weitere Einzelheiten*

PLANNAIR LTD

Windfield House, Leatherhead, Surrey

AXIALGEBLÄSE

(Abbildung Seite 419)

Im Plannetten-Programm für Axialgebläse wurden zwei neue Modelle eingeführt, die 254 mm bzw. 305 mm Durchmesser haben und beide nur 76 mm tief sind. Das 254-mm-Plannette hat eine Leistung von 15,9 m³/min, und das 305-mm-Modell liefert in Aussenluft 28,3 m³/min.

Die neuen Plannetten sind die jüngsten Ergänzungen des Plannair-Programms für Hochleistungsgebläse für Anwendungszwecke, in denen Raumersparnisse von grösster Bedeutung sind. Mehr als 1000 verschiedene Ausführungen wurden bereits für Verwendung in der Luftfahrt, Elektronik und Automation gefertigt.

EE 70 775 *für weitere Einzelheiten*

PLESSEY (UK) LTD

Swindon, Wiltshire

ANSCHLAGWERKZEUG

(Abbildung Seite 419)

Plessey (UK) Ltd stellt nunmehr ein neues "UNIcrimp"-Werkzeug her.

Es handelt sich um eine Druckluftausführung des Hand-UNIcrimp, das universelle, einhändige, automatische Anschlagwerkzeug, mit dem sich perfekte quadratische lötfreie Verbindungen mit Drähten oder Kontakten jeder Grösse bis zu 2,05 mm Durchmesser herstellen lassen. Das Kraftmodell des UNIcrimp wird als vollerprobte Maschine in der Fertigung für Tischmontage, auf Wunsch mit Fusssteuerung, oder als tragbares Werkzeug (e.g. für die Verkabelung von Flugzeugen) angeboten, nachdem es ein langes und strenges Testprogramm absolviert hat. Die Nutzbarkeit der Maschine wurde durch die Möglichkeit, vorisolierte Anschlüsse zu verarbeiten, erweitert.

EE 70 776 *für weitere Einzelheiten*

RANK CINTEL LTD

Worsley Bridge Road, London, S.E.26

TRANSISTOR-STROMVERSORGUNG

(Abbildung Seite 419)

Die Transistor - Stromversorgung 18920/1 wurde für die Abgabe von 6...30 V bei einem Höchststrom von 500 mA ausgelegt. Die Ausgangsspannung wird mittels eines Bereichschalters mit zwei Stellungen und einer stufenlosen Feinregelung eingestellt. Zwei Miniaturmessgeräte zeigen Ausgangsspannung bzw. -strom an.

Eine elektronische Überlastungsschaltung mit Einrichtungen für automatische und manuelle Rückstellung gibt dem Gerät sowie externen Ausrüstungen vollen Schutz. Durch einen internen Regler lässt sich die Abschaltung für jeden beliebigen Überlastungswert einstellen.

Der Ausgang der Stromversorgung ist völlig erdfrei, doch kann jede der Klemmen durch eine kurze Lasche geerdet werden.

EE 70 777 *für weitere Einzelheiten*

ALPHANUMERISCHE MATRIXRÖHRE

Es handelt sich um eine Elektronenstrahlröhre neuer Form für alphanumerische Darstellung, die einige der Probleme löst, die bei Verwendung normaler Elektronenstrahlröhren für diesen Zweck auftreten. So kann die "Matricon" z B. eine hellere Darstellung hervorrufen und Symbole schneller schreiben als herkömmliche Bildröhren.

Das Prinzip der alphanumerischen 229-mm-Matrixröhre "Matricon" ist, dass ein breiter Elektronenstrahl eine Platte mit einer Öffnungs-Matrix überflutet. Jede dieser Öffnungen hat einen unabhängigen Anschluss, so dass ein

Impuls von ungefähr 25 V den durchgehenden Strahl unterdrücken kann. Auf diese Weise kann jedes gewünschte Symbol in äusserst kurzer Zeit und auf einmal gebildet werden.

Da alle Teile des Symbols gleichzeitig beleuchtet werden, ist die Helligkeit viel grösser als in Elektronenstrahlröhren, in denen die Symbole durch einen sich bewegenden Einzelpunkt gebildet werden. Die ersten Röhren erzeugten Symbole in weniger als 10 μs mit ausreichender Helligkeit für Tageslicht-Beobachtung.

Festkörperschaltungen wurden entwickelt, die einen 6-Bit-Kode aufnehmen und die für die Öffnungen des Matricon erforderlichen Impulse abgeben. Ein solches Gerät für das Verschlüsseln-Entschlüsseln kann im Zeitmultiplexbetrieb zehn Matrixröhren speisen, wobei die zehn Darstellungen voneinander unabhängig sind.

Es ist auch möglich, mit einer Öffnung Blindschaltbilder zu zeichnen und sie mittels der Öffnungs-Matrix mit alphanumerischen Daten zu kennzeichnen.

EE 70 778 *für weitere Einzelheiten*

ROBAND ELECTRONICS LTD

Charlwood Works, Lowfield Heath Road, Charlwood, Horley, Surrey

OSZILLOGRAFEN

(Abbildung Seite 419)

Roband Electronics Ltd stellt die vier Oszillografen RO50, RO51, RO55 und RO501 eines neuen Programmes vor. Für jedes Modell gilt ein unterschiedliches Pflichtenblatt, sie sind jedoch alle daraufhin konstruiert, den Preis ohne Einbusse an Leistung oder Zuverlässigkeit wesentlich unter das derzeitige Niveau zu senken.

Das abgebildete Gerät RO50 ist ein Breitband - Präzisions - Oszillograf mit Signalverzögerung, für den alle Einschübe der Roband-Serie 5 geeignet sind.

Modell RO51 hat dieselben allgemeinen Präzisionseigenschaften wie der RO50, nimmt jedoch die Roband-Einschübe Serie 5 für X oder Y auf, so dass man X-Y und verzögerte Ablenkung benutzen kann.

Modell RO55 ist ein Mehrzweck-Oszillograf in tragbarer Ausführung mit Einschüben der Roband-Serie 5.

Der RO501 ist ein sehr bequem tragbares, preiswertes 127-mm-Instrument für Labor und Service, das in seiner Klasse einen neuen Massstab für Zuverlässigkeit und Genauigkeit erzielt.

Die Oszillografen RO50, RO51 und RO55 bilden eine integrierte, mit den voll austauschbaren Einschüben der Roband-Serie 5 ausgerüstete Familie.

EE 70 779 *für weitere Einzelheiten*

THE SOLARTRON ELECTRONIC GROUP LTD

Victoria Road, Farnborough, Hampshire

INTEGRIERENDES DIGITALVOLTMETER

(Abbildung Seite 420)

Das Integrierende Digitalvoltmeter LM1420 der Solartron ist ein kompaktes, sehr anpassungsfähiges und preiswertes Hochleistungsmessgerät. Eine selbstausgleichende Zähler-Integratortechnik wird benutzt, um hohe Genauigkeit und hohes Auflösungsvermögen mit maximaler Unterdrückung ungewünschter Signale zu erzielen.

Die Eingangsschaltungen sind völlig erdfrei mit einer Isolationsimpedanz von über 10^5 MΩ, 150 pF zur Netzerde und geben 150 dB Unterdrückung von Gleichtakt-Störsignalen bis zu 500 V_s.

Das Vorhandensein von Zählern in diesem Instrument wurde ausgenutzt, um Zählen von Impulsen sowie Messen von Frequenzen und Perioden—in jedem Fall mit örtlicher oder Fernsteuerung—vorzusehen. Die Anzeige erfolgt mittels Neon-Zifferlampen, die hinter einem Polaroidfilter angeordnet sind.

Neue Fertigungsmethoden einschliesslich automatische Prüfung gedruckter Schaltungen und einbaufertiger Kabelsätze vor der Fertigungsmontage gewährleisten hohe Zuverlässigkeit.

Die ausgezeichnete Leistung dieses Digitalvoltmeters ist auf die angewandte Zähler-Integratortechnik zurückzuführen. Die angelegte Signalspannung verursacht ein Ansteigen der Ausgangsspannung eines integrierenden Verstärkers auf einen vorbestimmten Triggerpegel, bis sie in diesem Punkt durch eine genau quantierte Ladung zurückgestellt wird. Die Anstiegsrate, und damit die Anzahl der Rüskstelladungsimpulse je Zeiteinheit, ist der Eingangsspannung direkt proportional. Digitaldarstellung erzielt man durch Zählen dieser Impulse über eine begrenzte Zeitspanne, und das gibt den wahren Durchschnitt der angelegten Spannung über diese Zeitspanne, wobei gleichzeitig der Einfluss von Störgeräuschen auf ein Mindestmass reduziert wird. Als Zählzeitspanne wird üblicherweise eine Periode der Netzfrequenz gewählt, um die höchste Unterdrückung dieser Grundfrequenz und ihrer Harmonischen zu erlangen.

Der Taktgeber steuert die Dauer der Entladungsimpulse sowie der Zeitspanne, so dass jede Drift der Taktgeberfrequenz die Zeitspanne und Impulsdauer in gleichem Masse ändert, wodurch Selbstausgleich erfolgt und die Anzeigegenauigkeit aufrechterhalten wird.

Die Zähler-Intergratorschaltung gibt eine Impulsreihe ab, die durch einen Ringkernübertrager in die Zählschaltung gekoppelt wird. Die Stromversorgung für die Eingangsschaltung ist in Form einer 4-kHz-Rechteckwelle durch einen ähnlichen Übertrager gekoppelt. Die Eingangsstufen sind daher vollkommen von der Netzerde isoliert. Anschluss an den Eingang ist über einen 3poligen Stecker im Bedienfeld: "Hoch"- und "Niedrig"-Signalpaar sowie ein Schutzkontakt. Auf diese Weise lassen sich entweder 3polige gesicherte Messungen oder 2polige Messungen (Schutz mit "Niedrig" verbunden) vornehmen. Für Laborverwendung wird eine zweipolige Verbindung zur Signalquelle im allgemeinen ausreichende Störunterdrückung geben. Für gewisse Verwendungszwecke (z.B. Datenerfassung) kann der Schutzkontakt mit der Quelle der Gleichtaktspannung verbunden werden, wodurch die Gleichtaktschleife praktisch beseitigt wird. Es ergibt sich dann eine Gleichtaktunterdrückung von über 150 dB.

Die Empfindlichkeit des Voltmeters kann durch 2fache oder 4fache Verlängerung der Zählperiode verdoppelt oder vervierfacht werden. Von dieser Möglichkeit kann man in jedem Bereich Gebrauch machen, um das effektive Auflösungsvermögen für Eingänge, die unter ½ bzw. ¼ des Bereichendwertes liegen, zu erhöhen. Eingangsklemmen für den Zeitzähler und die Anzeigezähler sind nach hinten herausgeführt, so dass sie für Impulszählen, Frequenz- und Periodenmessungen usw. mit örtlicher oder Fernsteuerung zur Verfügung stehen.

Der Eingangswiderstand, der für den 2-V-Bereich einen Nennwert von 5 GΩ hat, lässt sich für Kurzzeitbetrieb auf nahezu unendlich einregeln.

Der Grundmessumfang des Gerätes ist von 0...20 mV bis zu 0...1 kV in sechs Bereichen.

EE 70 780 *für weitere Einzelheiten*

ULTRASONOSCOPE CO. (LONDON) LTD

Sudbourne Road, Brixton Hill, London, S.W.2

ÜBERSCHALL-RISSPRÜFER

(Abbildung Seite 420)

Das neue Baumuster 2C, das das bestehende tragbare Gerät Baumuster 2B ersetzt, enthält zusätzliche Einrichtungen und Verbesserungen. Es wurde besonders darauf Wert gelegt, den Ansprüchen derjenigen zu genügen, die im Werk, Aussendienst oder Forschungslabor Schweissstellen mit Überschall prüfen.

Das Gerät hat deshalb mehrere Eigenschaften, die man normalerweise nicht in einem tragbaren Rissprüfer findet. Sehr schnelle Zeitablenkung und grosse Spurhelligkeit sind mit berichtigter und unberichtigter Spurdarstellung verbunden, um eine umfassende Untersuchung der Rissechoform zu ermöglichen. Der Betriebsfrequenzbereich von 0,5...10 MHz und eine erreichbare Höchsttiefe von 7,30 m (in Stahl) erweitern den Anwendungsbereich auf eine grosse Anzahl von Probleme der zerstörungsfreien Prüfung. Die Ermüdung des

Beobachters wird durch die hochzeilige 127-mm-Elektronenstrahlröhre verringert. Zur Erleichterung des Einstellens der erforderlichen Norm, die die Annahme oder Zurückweisung des zu prüfenden Werkstoffs bestimmt, kann die Amplitude des Fehlerechos der geschriebenen Kurve mittels eines Abschwächers eingestellt werden.

Wenn die Ausrüstung für laufende Prüfung eingesetzt wird, kann man einen Verkürzungsregler einschalten, um durch Kontrast zwischen dem kleinen Fehlerecho und den auf einen Mindestwert reduzierten, von Korngrenzen zurückgeworfenen Störechos eine klare Spurdarstellung zu erhalten. Ein auffälliges Alarmlicht leuchtet bei Benutzung dieser Regelung auf, um Missbrauch zu verhindern.

Grob- und Feinregelung der Spurverzögerung erlaubt Auswahl eines beliebigen Abschnittes der dargestellten Kurve für Dehnung über die gesamte Länge der Zeitablenkung bis zu einem Höchstwert von 9,15 m in Stahl.

EE 70 781 *für weitere Einzelheiten*

VACTRIC CONTROL EQUIPMENT LTD

Garth Road, Morden, Surrey

LANGSAMLAUFENDER SYNCHRONMOTOR

(*Abbildung Seite 420*)

Der neue, langsamlaufende Vacsyn-Synchronmotor wurde für Abgabe eines hohen Drehmomentes bei niedrigen Geschwindigkeiten konstruiert, um Reduktionsgetriebe überflüssig zu machen. Bei 50 Hz ist die Synchrongeschwindigkeit 60 UPM und das niedrigste Synchrondrehmoment 8,37 cmkg. entsprechend einer Leistung von 5.5 W. Der Vacsyn-Motor kann auch als Fortschaltmotor benutzt werden.

Die Gesamtlänge einschliesslich Treibwelle ist 190 mm, der Durchmesser 106,5 mm, Der Höchsteingangsstrom ist 350 mA und die gesamte Energieaufnahme 35 W.

EE 70 782 *für weitere Einzelheiten*

Zusammenfassung der wichtigsten Beiträge

Ein akustischer Unterwasser-Fernsprecher für frei schwimmende Taucher von B. K. Gazey und J. C. Morris

Zusammenfassung des Beitrages auf Seite 364-368

Ein frequenzmoduliertes akustisches Trägerfernsprechsystem für frei schwimmende Taucher wurde entwickelt. Es arbeitet mit einer Trägerfrequenz von 120 kHz, überträgt ungefähr 1 W Schalleistung und wurde für Entfernungen bis zu 450 m erprobt. Das System wird kurz beschrieben und die Erprobungsversuche eingehend behandelt.

Eine elektronische Methode der Zündungsvorstellung in Kraftfahrzeugen von A. R. Hayes

Zusammenfassung des Beitrages auf Seite 369-373

Die Zündungsanforderungen eines bestimmten Motors bei Vollast werden durch eine algebraische Gleichung, die—wenn auf ein vorgeschlagenes Grundschema angewandt—auf die zur elektronischen Steuerung des Zündzeitpunktes erforderliche Schaltungsart hinweist. Als Illustration wird eine denkbare Schaltung gegeben, deren Arbeitsweise im Vergleich mit dem heutigen mechanischen System Vorteile aufweist.

Ein Differentialmagnetometer für magnetische Kernresonanz von D. E. P. Silver

Zusammenfassung des Beitrages auf Seite 374-377

Ein Instrument wurde entworfen, mit dem die Magnetfeldverteilung über grosse Poloberflächen schnell und genau gemessen werden kann. Trotzdem für das Fühlglied magnetische Kernresonanz benutzt wird, sind keine Frequenzmessungen erforderlich. Die Anordnung kann auch mit Erfolg für einen Elektromagneten, der von einer nichtstabilisierten Stromquelle gespeist wird, verwendet werden. Ein Differentialprinzip wird angewendet, nach dem die Feldstärken an verschiedenen Punkten des Polspaltes in Bezug auf einen willkürlich festgelegten Punkt im Spalt gemessen werden.

Eine Anwendungsmöglichkeit für Analogrechner in der Verfahrensforschung von D. Longley

Zusammenfassung des Beitrages auf Seite 378-381

Der Analogrechner ist nunmehr als erprobtes Hilfsmittel des Systemingenieurs anerkannt. Seine Anpassungsfähigkeit und einfaches Programmieren erlaubt eine theoretische und praktische Einstellung zur Lösung einer Unzahl dynamischer Probleme und gibt dem Ingenieur gleichzeitig Einsicht in das wahre Verhalten der zu untersuchenden Systeme. Diese Technik kann auch auf die Verfahrensforschung ausgedehnt werden, wo der Rechner sowohl als Simulator für Probleme der Unternehmensführung, wie auch als schnelles, anpassungsfähiges "kletterndes" System eingesetzt werden kann. Der Beitrag beschäftigt sich hauptsächlich mit der letzteren Anwendungsmöglichkeit des Analogrechners, und die Lösung linearer und nichtlinearer Programmierungsprobleme wird gegeben.

Digitalrechneranalyse des Tunneldioden-Kippgenerators von C. W. Cox und A. L. Riemenschneider

Zusammenfassung des Beitrages auf Seite 382-385

Die Aufgabe dieses Beitrags ist, zu zeigen, dass eine Digitalrechnermethode die Lösungen für den Tunneldioden-Kippgenerator geben kann. Die für die Analyse des Tunneldioden-Kippgenerators in der Phasenebene gewählten Gleichungen folgen Lienards Konstruktion. Diese Gleichungen werden für die Entwicklung von Rechnerprogrammen benutzt, die direkt von den kompletten Diodenkenndaten und Schaltungsparametern eines Systems zweiter Ordnung die genaue Ausgangscharakteristik des Generators ergeben. Das Verfahren gibt die Ausgangswellenformen zuverlässig mit einer Genauigkeit wieder, die nur durch die Genauigkeit begrenzt wird, mit der die Kenndaten der nichtlinearen Elemente bekannt sind, und die ohne weiteres innerhalb der Grenzen der Bauelementedrift liegt.

Ein niederfrequenter, zufallsveränderlicher Stufengenerator von B. R. Wilkins

Zusammenfassung des Beitrages auf Seite 386-389

Der Beitrag beschreibt eine Schaltung, die eine zufallsveränderliche Folge diskreter Ausgangswerte erzeugt, wobei die Wahrscheinlichkeit jedes beliebigen einzelnen Ausgangswertes einstellbar ist. Die Schaltung ist in solcher Weise ausgelegt, dass weder die Ausgangswerte selbst, noch die Wahrscheinlichkeiten ihres Vorkommens von den Eigenschaften des Rauschgenerators abhängen.

Versuchsmässige Beobachtungen werden gegeben, um zu zeigen, dass die erwarteten Wahrscheinlichkeitsverteilungen des Ausgangs tatsächlich mit einem praktischen Generator erzielt werden.

Amplitudenverzerrung in nichtlinearen Netzwerken mit besonderer Bezugnahme auf Trägerübertragungssysteme von W. Dougharty

Zusammenfassung des Beitrages auf Seite 390-393

Die Amplitudenbeziehung zwischen verschiedenen Verzerrungsprodukten wird besprochen und in geeigneter Form mittels Diagrammen ausgedrückt. Die von Röhren zu erwartenden Verzerrungen werden auch in Betracht gezogen und verschiedene Schemen, die zur Herabsetzung der Verzerrung vorgeschlagen wurden, aufgeführt.

Matrizenanalyse des Colpitts-Oszillators von G. Zelinger

Zusammenfassung des Beitrages auf Seite 394-398

Die grundsätzlichen Entwurfsprobleme des Colpitts-Oszillators werden untersucht und mittels Matrizenanalyse gelöst. Praktische Oszillatorschaltungen, die entweder Transistoren oder Röhren als aktive Elemente haben, werden besprochen. Es wird gezeigt, dass sich das vollständige Schwingsystem aus einem aktiven und passiven Vierpol aufbauen lässt, die ihrerseits durch eine Leitwertmatrix beschrieben werden können. Für die Schwingfrequenz und Schwingbedingungen werden Gleichungen in Form von grundsätzlichen Schaltungsparametern abgeleitet.

Abschliessend wird gezeigt, wie mathematische Vereinfachungen, die aber noch für die technische Näherung bedeutsame Resultate ergeben, eingeführt werden können.

Abstimmbare Filter für Niederfrequenzen mit Funktionsverstärkern von H. Sutcliffe

Zusammenfassung des Beitrages auf Seite 399-403

Die Konstruktion abstimmbarer Schmalbandfilter aus aktiven Elementen und RC-Netzwerken für Frequenzen bis zu 0,1 Hz herunter wird durch das erforderliche Trimmen und mechanische Kuppeln kompliziert. Ein beschriebenes Prinzip überkommt diese Schwierigkeiten, und mit der gegebenen Methode können Filter mit konstantem Q erstellt werden, die einem kritisch gekoppelten Paar gleichwertig sind. Die Konstruktion des zugehörigen, mit Transistoren bestückten Funktionsverstärkers bildet einen wesentlichen Teil des Beitrags. Einzelheiten eines für den Frequenzbereich 1 Hz . . . 1 kHz geeigneten Filters werden gegeben.

Eine logarithmische Zeitablenkschaltung von R. N. Alcock

Zusammenfassung des Beitrages auf Seite 404-405

Der Entwurf eines passiven Netzwerks für die Erzeugung logarithmischer Funktionen wird beschrieben. Eine Sprungspannung wird an den Eingang gelegt, und der Ausgang nimmt mit dem Logarithmus der Zeit zu. Das Netzwerk besteht aus einer Anzahl von Integratoren mit unterschiedlichen Zeitkonstanten. Der Zeitbereich für die logarithmische Arbeitsweise wächst mit der Anzahl der Integratoren. Eine versuchsmässige Einmal-Zeitablenkungsschaltung wurde aufgebaut, die zwischen 22 ms und 30 s mit 2% Genauigkeit arbeitet.

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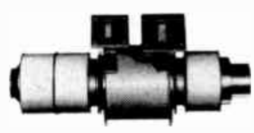

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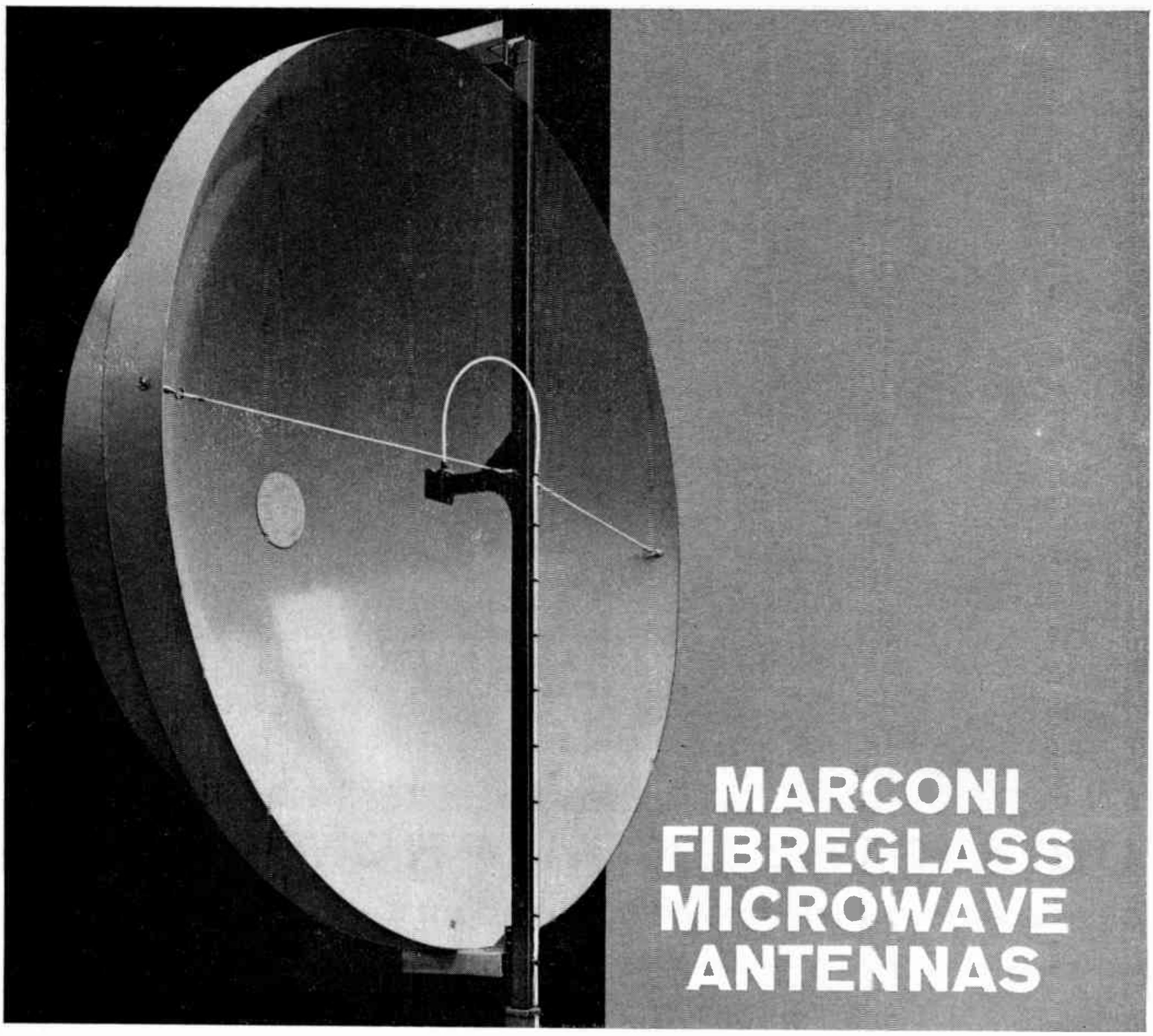

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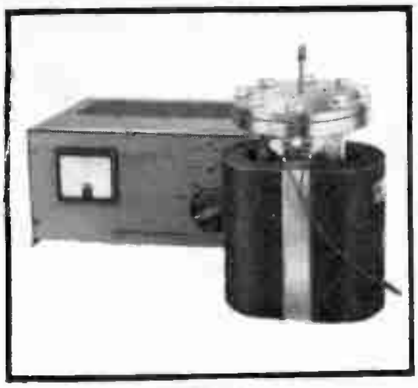

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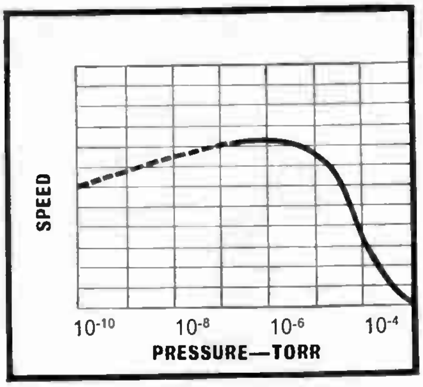

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