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Commentary

THIS year's 'Farnborough Show'—or to give it its correct title, the Flying Display and Exhibition organized by the Society of British Aircraft Constructors and held at Farnborough Aerodrome was the twenty first of its kind to be staged by the Society since its first show at Hendon in 1932.

A twenty-first anniversary such as this is a convenient point to pause for a moment and to reflect on the remarkable changes that have taken place in the aircraft industry, particularly in the post war years. The rapid development in military strategy since 1945 has brought about a complete change of outlook for the industry. One of the principal results of the change of military policy has been a considerable reduction in orders for military aircraft, offset only partially by orders for guided missiles.

This loss of Government business has produced a sharp reaction within the industry and in order to survive, mergers and amalgamations have been the order of the day. This process has been accelerated during the past year by the creation of a Ministry of Aviation to take over the aviation responsibilities of the Ministry of Supply and of the Ministry of Transport and Civil Aviation, and the stage has now been reached where the British aircraft industry consists in the main of two large and powerful aircraft manufacturing groups, each with an immense background of experience, and technical resources, and able fully to compete in the world's markets. Not without some justification, therefore, has the S.B.A.C. been dubbed the Society of *Both* Aircraft Constructors.

But Farnborough is not only the shop window of the aircraft industry, it is a demonstration of the ever increasing contribution made by the electronic industry of this country, and this year some outstanding applications were on display, particularly in the field of navigation and air traffic control. One of these is the automatic landing system which was announced just over a year ago*. Developed initially by the Blind Landing Experimental Unit of the Royal Aircraft Establishment, the 'Autoland' system, as it has been called, is now being developed as a combined effort on the part of several electronic manufacturers for use in civil airlines. It has now been specified for the next generation of Britain's airliners and there is every prospect that it will become an internationally accepted navigational aid. The new strategic freighter aircraft of the Royal Air Force—the 100-ton Short Britannic—is already being fitted, and it will be the first aircraft in the world to be equipped with a fully automatic landing system suitable for civil airline use.

Considerable progress has also been made in the application of computer and data-processing techniques to air traffic control necessitated by the increased air traffic density at the major airports of the world, and by the fact that the amount of information being recorded by radar, radio, and other sources is becoming more than the human controller can handle in the time available. A computer for this purpose is to go into operation early next year at the Scottish Air Traffic Control Centre at Prestwick for experimental use on the North Atlantic air route in air traffic control and the automatic processing of flight information. The intention is to investigate the better use of air space by new control techniques and smaller separation standards, and the improvements to controllers' traffic handling capacity when the routine tasks are performed electronically. The computer will maintain an electronic file of flight progress information on as many as 100 aircraft, and will automatically print out flight progress strips, identify potentially conflicting paths, and indicate overdue position reports. The foregoing are but two of the many ways in which electronic aids are contributing to the safety of aircraft in flight. With the help of a host of magic 'black boxes' aircraft can take off and land in all but the very worst of weather conditions and can find their way with accuracy to any quarter of the globe. At all times they can remain in communication with the ground and they can 'see' the weather for miles ahead.

Yet in spite of all these measures it happens that on the rare occasion an aircraft fails and is lost, and it is of paramount importance that the reasons should be known. One solution to this urgent problem is the development of a magnetic tape recorder to be carried in the aircraft itself and designed to monitor the behaviour of the machine in flight.

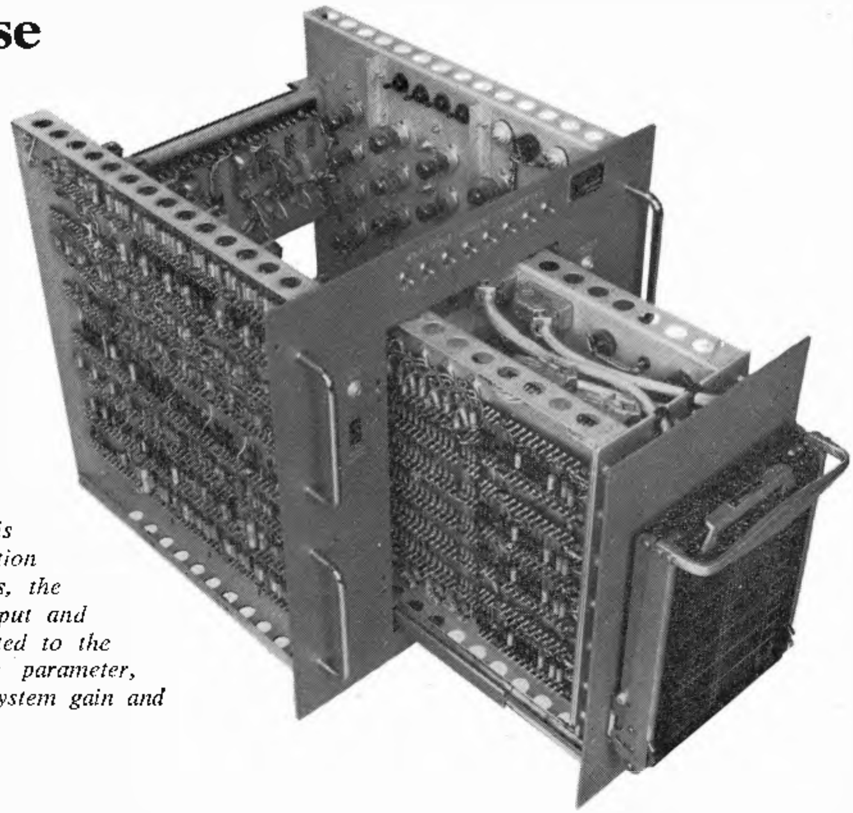
Transducers of various kinds are fitted to the engine and airframe so that temperatures, pressures, stresses and other vital data can be indicated from the very beginning to the end of a flight. The recording equipment itself is made sufficiently robust to withstand damage by fire and impact so that on recovery is available for analysis.

As was to be expected, there was little or nothing to be seen at Farnborough directly associated with a space research programme, although it is known that several electronic firms are carrying out their own 'private venture' research programmes.

* *'Autoland,' a Blind Landing System for Aircraft. Electronic Engng. 31, 534 1959*

A Special Purpose Analogue-Digital Convertor

By G. C. Henderson*, M.A.



The analogue-digital convertor described here was developed for use in a data-processing system for the analysis of time-multiplexed telemetry records. From inputs consisting of a non-linear voltage analogue of the parameter which is being measured, a number of calibration voltages, and a train of strobe pulses, the convertor derives a binary digital output and an analogue output, both linearly related to the value, in the required units, of the parameter, with automatic correction for overall system gain and level drifts.

(Voir page 666 pour le résumé en français; Zusammenfassung in deutscher Sprache auf Seite 674)

A number of flight parameters are monitored by transducers which are calibrated before flight. The transducer output voltages are sampled by a motor-driven switch and supplied to a modulator, thus producing a time-multiplexed frequency-modulated signal for telemetering. A number of known calibration voltages are also supplied to the switch; the frequencies generated on these calibration, or standards, channels thus correspond to a number of precise values of each parameter. In some cases, variable-inductance transducers are used, and switched in turn into the resonant circuit of an oscillator, to produce the frequency histogram. Then a number of fixed calibration inductors are connected to the switch, giving reference frequencies on these channels. Again, the frequencies on the standards channels correspond to precise values of each parameter.

The telemetry receiving equipment detects the time-multiplexed f.m. signal. The latter is made to beat with a local oscillator to obtain a difference frequency suitable for recording on magnetic tape. The tape supplies the input to the data-processing equipment, from which it is required to obtain a set of punched cards for each channel, having the elapsed time for each sample, and the corresponding data, punched in binary form. An analogue output is also required for photographic records and to permit monitoring of the channel output during playback.

The data-processing system analyses one selected telemetry channel at each playback operation, producing a voltage proportional to the channel frequency, and holding it until the next repetition of the channel. Five calibration, or standards, voltages are also generated and held in the same way. The occurrence of the selected channel, changing the channel data voltage to the new level, is indicated by a negative-going strobe pulse, which is used to initiate each operation of the convertor.

* *Bristol Aircraft Ltd.*

In this and similar systems, errors and non-linearities can be introduced as follows:

(a) The modulator has a slightly non-linear characteristic which can be calibrated and for which correction can be made, but

(b) it may suffer from changes in gain and level during flight.

(c) Slight changes in gain and level occur due to variations in tape playback speed and in other items of the demodulation equipment.

(d) The transducers used may have characteristics which are non-linear, the ratio of maximum to minimum gradients within the range being in some cases as large as 2 : 1.

The non-linearities (a) and (d) can be corrected by using the pre-flight calibrations. Since the standards and data follow the same path through that part of the system which is suspect, the variations caused by (b) and (c) can be taken to apply equally to all the information. An accurate analysis can therefore be made, but even with the aid of a large digital computer, the analysis of a flight record is laborious and expensive. It is also desirable that an analysis should be available in the shortest possible time.

The problem was to find the most effective method of obtaining the desired output, using all the available information, without resorting to the use of a digital computer. A number of schemes were considered and rejected. One of these, consisting of servo correction of the data voltage with reference to the standards, and with linearization provided by a diode function-generator, had to be abandoned because of the extremely long time-constants involved. The scheme finally arrived at provides an 8-bit output correct to within ± 1, in 4msec. The setting-up required for each channel consists of inserting jumper-leads into a plug-board according to the transducer cali-

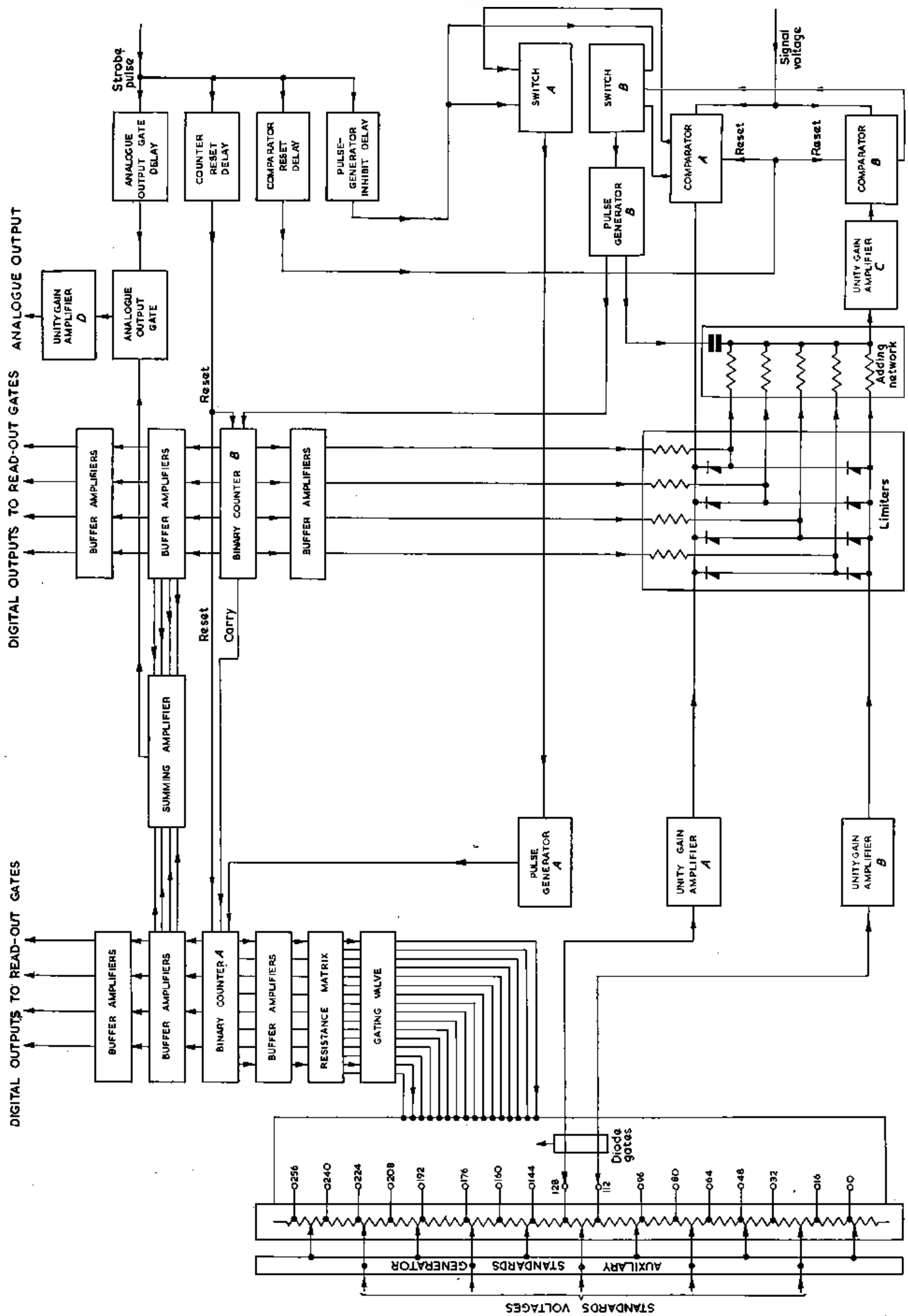


Fig. 1. General arrangement of the convertor

bration, and can be done in two or three minutes. As the plug-boards are removable, the setting up can be effected while another channel is being analysed. Hence the computer time thus occupied is negligible.

The block diagram of the convertor is shown in Fig. 1.

The principle of the convertor is that of comparing the analogue data voltage with a series of successively increasing voltages controlled by a binary counter and derived from a resistance chain which provides interpolation between the standards voltages. The registration by a voltage comparator of the transition through the point of equality produces from the counter a digital output dependent on which of the voltage steps corresponds to the transition point. The steps of the voltage staircase are associated not with fixed voltages but with voltages derived from the standards.

The five standards voltages at the input to the convertor are approximately 0, 20, 40, 60 and 80V, being subject to individual and collective variations for the reasons previously mentioned, up to 5V during playback. The data voltage representing the parameter may vary over the range -10V to $+90$V, going outside the range of the extreme standards only in exceptional circumstances. A strobe pulse is also fed into the convertor marking the occurrence of the appropriate data channel.

Function Generator

A patchcord system is mounted on the front panel of the convertor (see p. 602). A resistance chain, which consists of 680 equal resistors in series, is connected to the pins at the rear of the fixed unit, the junction points being numbered on the removable plug-board in half-digit steps from -40 to $+300$. Two further resistors connect the ends of the chain to negative and positive h.t. lines, so that a current of 5mA flows through the chain and the potentials at the extremities are about -10 and $+100$V respectively. For each channel, a suitable choice is made of the relationship between parameter range and the digital range such that the full parameter range lies within the numerical range 0 to 255. The relationship will then be

$$p = An + B$$

where: p = parameter, in the required units,
n = digital value,
A and B are constants,

and it will usually be convenient to arrange to have A integral, or a rational number.

Each standard now corresponds to a fixed digital value, from the transducer calibration curve. The standards voltages, which are supplied by low output impedance amplifiers, are available at points on the plug-board and are impressed on the resistance chain at the selected numbers by jumper lead connexions.

In order to increase the accuracy of fitting of the resistance chain potentials to the transducer calibration, a set of four intermediate auxiliary standards, with voltages midway between each pair of adjacent standards, are generated. Two external auxiliary standard voltages are produced to provide facilities for extrapolating from the standards, in case the data voltage should go outside the standards range. With certain restrictions, each auxiliary standard represents a precise value of the parameter, and hence can be assigned a digital value. These voltages are also connected by jumper leads to the appropriate point on the plug-board. This process sets up the resistance chain so that the correct output number can be obtained by finding the point on the chain at which the voltage is equal to the data voltage.

The remainder of the convertor is used to sample the voltages on the chain and compare them with the data voltage until it finds the point of equality. A further approximation is made here, in that the convertor samples only 17 equally spaced points on the chain, and makes a linear interpolation between these potentials to give 256 separate levels.

The possible error in the output number due to the approximations in the function generator is less than $\pm 0{\cdot}25$ per cent of full scale with the most non-linear transducer calibration curve encountered so far.

The Sampling Switch

Seventeen outputs are taken from the resistance chain to an array of diode gates constituting a two-pole 16-way

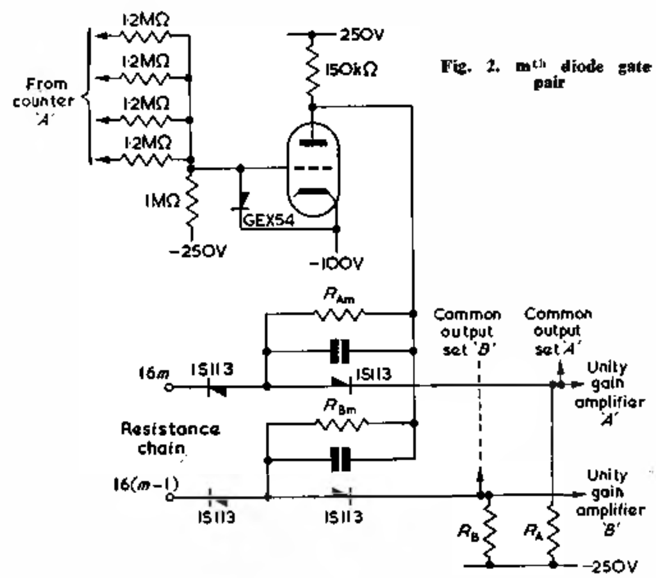


Fig. 2. m^{th} diode gate pair

electronic switch. The outputs are taken from the points 0, 16, 32....256 at 16-digit intervals.

There are two sets of diode gates, 16 in each set. Each set has a common output point, one of these points being connected to the input of unity gain amplifier (u.g.a.) A, the other to the input of u.g.a. B. One and only one gate in each set is open at any time, making the voltage at the common output point equal to the input voltage of that gate which is open.

The corresponding gates in each set are operated by a set of 16 gating valves, the m^{th} of which is shown in Fig. 2. The grid of the valve is connected through resistors to each of the four stages of a binary counter, which will be described later. The valve is cut off only if all the outputs to which it is connected are low (for the m^{th} gate, this occurs for a counter state of m-1). Otherwise, the valve conducts and the anode potential is some 50V below earth, when all the gate diodes are biased off. When the valve is in the cut-off condition all four diodes conduct. The voltages at the points 0, 16......vary by less than 20V from channel to channel, and the current in R_A can be estimated for the period when the m^{th} gate is open. The R_{Am} are chosen to conduct about twice this current so that approximately equal currents flow through the two diodes, making the potential drops across the diodes equal. The R_{Bm} are similarly chosen.

The gates associated with u.g.a. A are connected to the resistance chain at the points, 16, 32......256, and those associated with u.g.a. B at 0, 16......240. Pairs of gates are opened in ascending sequence by stepping counter A. Thus the output of u.g.a. A is always one step above that of u.g.a. B.

All the unity gain amplifiers used are feedback amplifiers (Fig. 3) consisting of a long tailed pair, a grounded

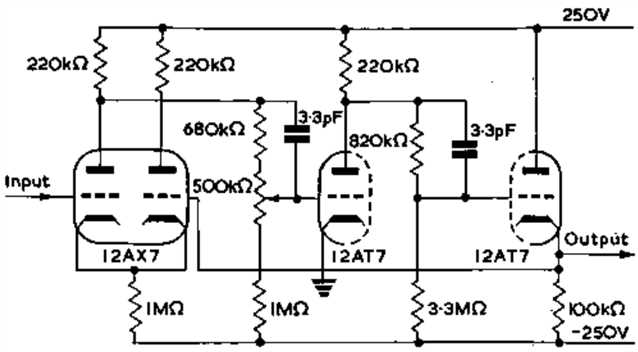


Fig. 3. Unity gain amplifier

cathode amplifier and a cathode-follower in cascade. The gain is constant throughout the range at about +1·0005, which is sufficiently close to unity for all these applications. The circuit has the necessary low output impedance, high frequency response, and good drift characteristics.

Counters

Counter *A* consists of four bistable multivibrator stages which will count from 0 to 15 at up to 12kc/s p.r.f. The two triodes of each stage share part of their anode load and the stage is triggered by applying a negative-going pulse to the point at which the anode loads divide[1] (see Fig. 4).

Each stage of the counter is connected to a pair of buffer amplifiers which have positive feedback to ensure fast operation. The anodes of these buffer amplifiers are connected to the gating valves by a resistance matrix so as to cut off only one gating valve for each state of the counter.

The bistable stages of counter *B* (see Fig. 4) are similar to those of counter *A*, but only one anode of each stage drives a buffer amplifier. The anode potentials of the latter are approximately − 100V in the 0-state and + 240V in the 1-state. For each buffer amplifier, two diodes are connected in series in the high resistance direction across the outputs of u.g.a. *A* and u.g.a. *B*. A resistor connects the junction point of each diode pair to the associated buffer anode. These junction point potentials are thus limited to the output voltage of u.g.a. *A* for an associated binary state of 1, and to the output voltage of u.g.a. *B* for a 0-state. Making the assumption that the small potential drops across the conducting diodes are constant over the voltage range, the outputs of the two unity gain amplifiers are slightly offset from the inputs, so that the voltages to which the junction points are limited are actually the voltages at the inputs of the unity gain amplifiers.

Each junction point is connected through a resistor to a common adding point. The resistors are in the ratio 1 : 2 : 4 : 8, resistors of higher value being associated with less significant binary stages. A resistor equal to the largest of these connects the adding point to the output of u.g.a. *B*. The voltage at the adding point is then equal to the input of u.g.a. *B* plus a fraction of the voltage difference between the u.g.a. inputs, this fraction being one-sixteenth of the number in counter *B*. The adding point is the input to unity gain amplifier *C* which reproduces the adding point voltage at low output impedance.

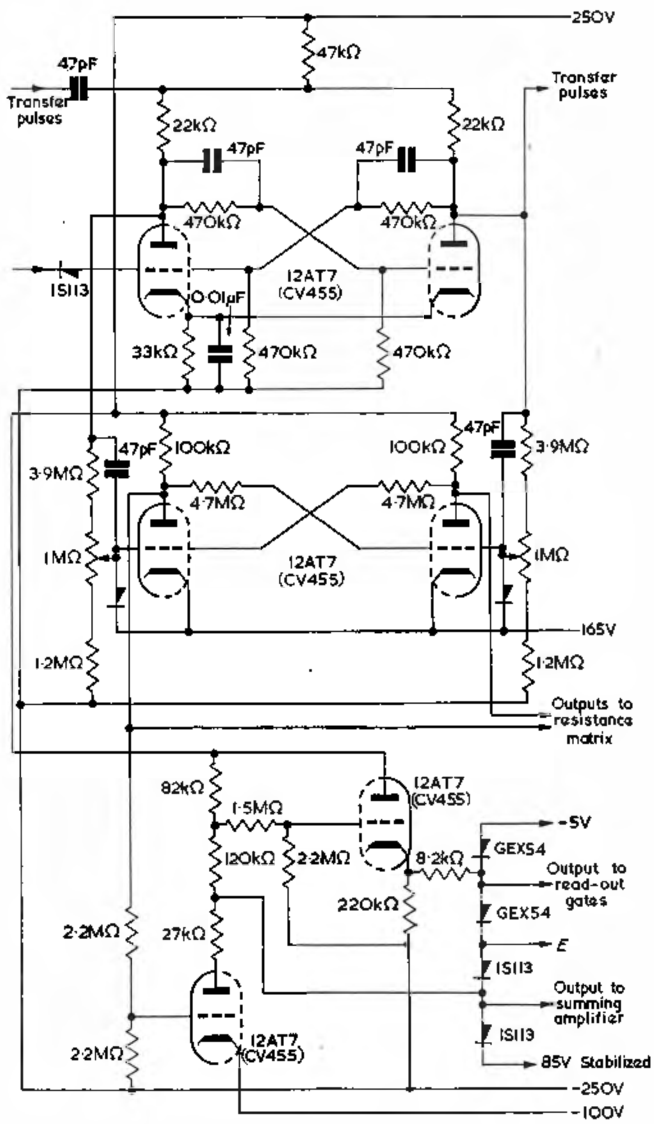
Control Circuits

A number of systems are available for controlling a scaling unit consisting of binary stages. For high-speed operation it is preferable to proceed by successive approximations from the most significant stages to the least significant, so that a result is achieved in a number of steps equal to the number of binary stages. The voltage generated by such a system takes both positive and negative-going steps, and this was not considered desirable here. It was originally intended to use a 10kc/s multivibrator to supply pulses to the counters, giving up to 255 steps. However, with a small amount of additional circuit complexity it proved simple to cut this number to about 34, and it was decided to retain these additions against any possible future requirement for faster operation. Each counter is operated by its own pulse generator, which is switched on and off as required by the operation of two voltage comparator circuits.

The pulse generator is a multivibrator circuit with one of the grid resistors returned to positive h.t. while the other is connected to the anode of a switching valve. The switching valve has two states—cut-off and heavily conducting. In the latter state the anode potential is low, producing a stable state of the multivibrator. When the switching valve is cut off the anode potential rises to positive h.t. and the multivibrator becomes astable, giving a square wave output at 12kc/s p.r.f. approximately.

The output of the multivibrator is taken from that anode which is at high potential in the stable state. This ensures that the multivibrator emits no further negative-going pulses after the switching valve is bottomed. This

Fig. 4. Counter A: divide by 2 stage with associated output circuits



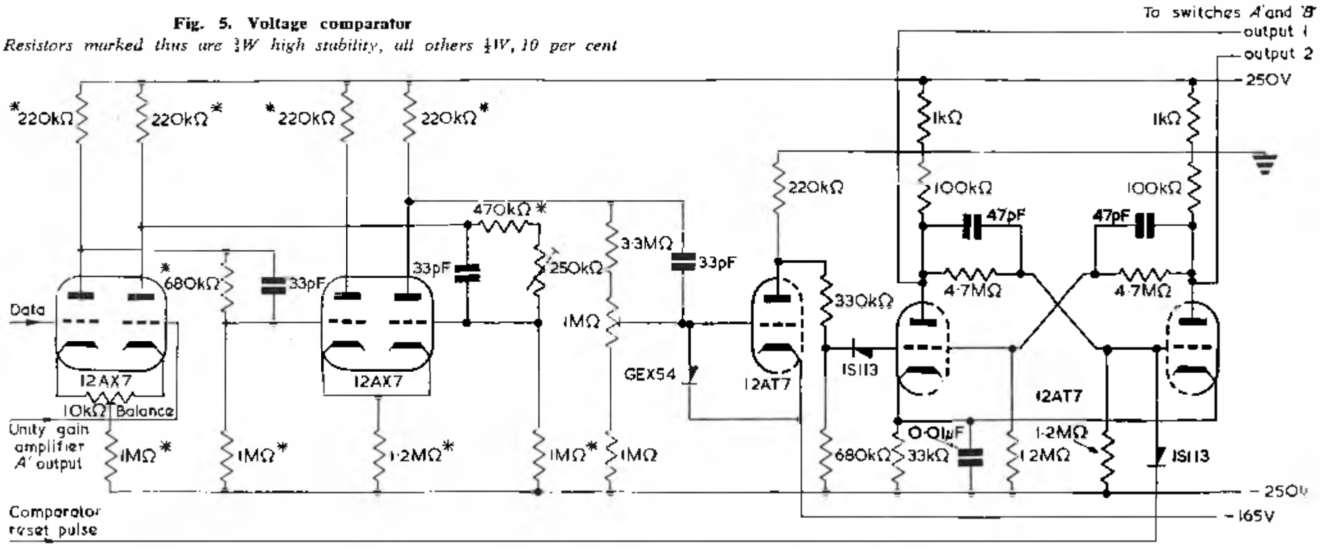


Fig. 5. Voltage comparator

* *Resistors marked thus are ½W high stability, all others ¼W, 10 per cent*

output is fed through a capacitor to the first stage of the associated counter.

The grid of switching valve *A* is connected through resistors to one output of comparator *A* and to the output of a delay circuit. Only when both input voltages are low will the valve be cut off, allowing pulse generator *A* to operate.

The grid of switch *B* is connected to one output of comparator *B*, to the same delay circuit, and to the output of comparator *A* opposite to that used for switch *A*. Pulse generator *B* will only operate when all three inputs to the switch are low.

The inputs to the comparators consist of the data voltage and a staircase-function voltage from u.g.a. *A* or *C*.

The output stage of the comparator is a grid-controlled bistable multivibrator. One grid is taken through a diode to the output of a delay circuit; pulses derived from the delayed strobe pulse are used to reset the comparators.

The multivibrator is said to be in the 'off' state immediately after reset. The other grid is taken through a diode to the output of a three stage difference amplifier. This point is at high potential if the data voltage input to the comparator exceeds the staircase voltage input. The output potential goes low as soon as the staircase voltage exceeds the data level. This immediately changes the multivibrator to the opposite, or 'on' state. Because of the diode on this grid, the multivibrator can only be returned to the 'off' state by resetting.

That output of each comparator which is low in the 'off' state is connected to the corresponding switching valve. The other output of comparator *A*, which gives the opposite sign of output, is connected to switch *B*. In conjunction with a delay circuit, the comparators control the operation of the pulse generators as described above.

Three delay circuits are used to control the operation of the main part of the system. Each consists of a monostable multivibrator preceded by an amplifier. The input is the negative-going strobe pulse, which initiates a large amplitude positive pulse at the output of the multivibrator. The amplifiers serve to isolate the delays from each other and provide pulses of nearly constant amplitude for reliable triggering of the multivibrator stages.

The pulse durations of the counter and comparator reset delays are respectively 200 and 400μsec. In each case the multivibrator pulse is differentiated; the positive pulse is passed to earth via a diode, leaving a negative pulse output suitably delayed with respect to the strobe pulse.

The counters and the comparators are reset by these pulses via a diode on each counter stage and on each comparator multivibrator stage.

In principle, both resetting operations could be effected at once, using one delay circuit, but in practice it was found difficult to make the counters reset instantaneously from certain states. Such a failure would turn both com-

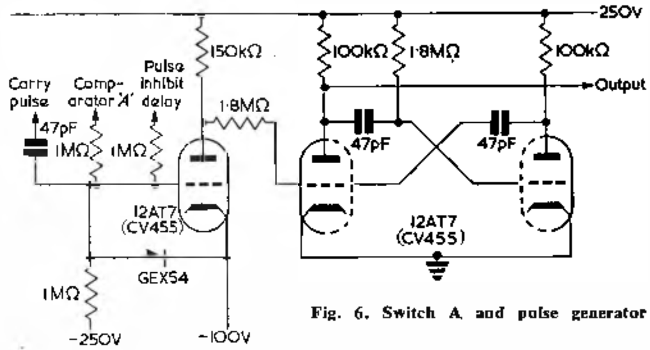


Fig. 6. Switch A and pulse generator

parators on again, without either pulse generator operating, resulting in a spurious output of 'zero.' The solution adopted proved to be the most satisfactory.

The 'pulse generator inhibit' delay has its output connected via resistors to the grids of the switching valves, so that for the duration of the delay, both pulse generators are held in the quiescent state. This allows all resetting to be completed before counting commences, some 600μsec after the occurrence of the strobe pulse.

Carry Facility

It is necessary in this system to include a carry facility such that if counter *B* has counted to 15 without triggering comparator *B*, then a further pulse from generator *B* sets counter *B* to zero, and simultaneously increases the number in counter *A* by one. This caters for data in the interval between the potentials corresponding to two such numbers.

Also, due to the attenuation of high frequencies by the limiters and adding network, the output of u.g.a. *C* follows rather slowly the comparatively large steps produced by the operation of counter *A*. Hence it is desirable that comparator *B* is always triggered by one of the smaller counter *B* steps.

To achieve this, comparator *A* is set up so that it will come 'on' when the staircase voltage gets within about a volt of the data input level. Thus if the final number in counter *B* is 0, 1, or 2, then pulse generator *B* has given

16, 17 or 18 pulses respectively, and the carry function has operated.

It is not possible to inject a carry pulse from counter *B* directly into the first stage of counter *A*, as the normal operation of pulse generator *A* would also affect counter *B*. A negative-going transfer pulse from the last stage of counter *B* is fed via a capacitor to the grid of switch *A*, large enough to override the signal from comparator *A*. The switch valve cuts off momentarily, and generator *A* gives out a single pulse to counter *A*.

Sequence of Operations

The sequence begins with the occurrence of the strobe pulse. This initiates the delays. The pulse inhibit delay prevents both pulse generators from operating regardless of the comparator states. At the end of the appropriate delay both counters are reset to zero. Subsequently both comparators are reset to the 'off' state.

If the signal is at a voltage level corresponding to a digital output of zero, both comparators will at once return to the 'on' state. If the signal is above the zero level but below the level corresponding to an output of about 19, comparator *A* will immediately go back to the 'on' state.

Then at the end of the pulse inhibit delay:

(a) If both comparators are 'on', neither pulse generator will start.

(b) If comparator *A* only is 'on", pulse generator *B* will start and continue to operate until comparator *B* goes to the 'on' state.

(c) If both comparators are 'off' pulse generator *A* will run, the inputs to the comparators consisting of an increasing staircase voltage, until comparator *A* is turned 'on'. Pulse generator *B* then starts, causing the input to comparator *B* to increase in a series of comparatively small steps, until comparator *B* is turned 'on', when pulse generator *B* is stopped.

In each case the number consisting of the eight binary digits in the two counters is the appropriate output for the particular strobing period. This number is held in the counters until they are reset to zero following the next strobe pulse.

It is possible, due to the occurrence of unexpectedly large swings of the parameter value, that data voltage levels which are outside the range of voltages between the extreme diode gate inputs may be supplied to the convertor. It is of course essential that these should not cause spurious readings from the equipment.

If the data level is below that of the lowest diode gate input, the number zero is read out. However, if the data level were at the opposite extreme, one or both comparators would remain indefinitely in the 'off' state, and the output number would be changing throughout the read-out period. It is desirable that such a data level should be represented as 255. It is possible to ensure this by the inclusion of suitable gating circuits, but a simpler if less elegant method is used here; the voltage supplied as data to the comparator is prevented by a diode circuit from rising above the voltage at the point 255 on the patch panel.

Output Circuits

The outputs from the convertor consist of the eight digital outputs which follow the number in the counters, and an analogue voltage proportional to the digital output. The analogue output is supplied by an analogue memory circuit, the output level being adjusted during each strobe period to the new level shortly after the end of the counting process.

Associated with each counter stage are three buffer amplifiers in cascade. The second one in each set is employed to supply the analogue output. The valve is cut off in the 0 state and bottomed in the 1 state. A tapping on the anode load is limited by diodes to swing between earth and the output of a +85V stabilized supply. These tappings are connected to a summing amplifier, which is a conventional operational amplifier. The input resistors are in the ratio of 128:64:32:....2:1. The feedback resistor is adjustable to give an output range of up to 50V. The reference voltage is variable, and may be adjusted to give 0V out for a counter reading of zero. Then the output is proportional to the number in the counters.

A delay circuit, with a pulse duration of about 5msec, is initiated by the strobe pulse. This delay gives both positive and negative going output pulses, which are amplified and used to control a gate consisting of four diodes in a bridge arrangement. The gate is opened by current passing through the diodes, thus charging or discharging a capacitor to the output potential of the summing amplifier. The gate is closed by cutting off the diode current, the capacitor retaining its charge during this period. The delay is timed to close the gate upon the occurrence of the strobe pulse, for a period longer than that which the counting process can possibly occupy. A unity gain amplifier has as its input the voltage on the capacitor fed by the gate. The output is thus the desired analogue voltage at low output impedance and can be used to drive a galvanometer for photographic recording.

The digital read-out gates in the computer are transistorized, and it is only necessary to supply them with inputs, at suitable voltage and current levels, which follow the states of the counters. The voltage at the anode of the analogue output buffer amplifier is fed to a cathode-follower. The output of the latter is taken through a resistor and limited by diodes to give the necessary voltage swing.

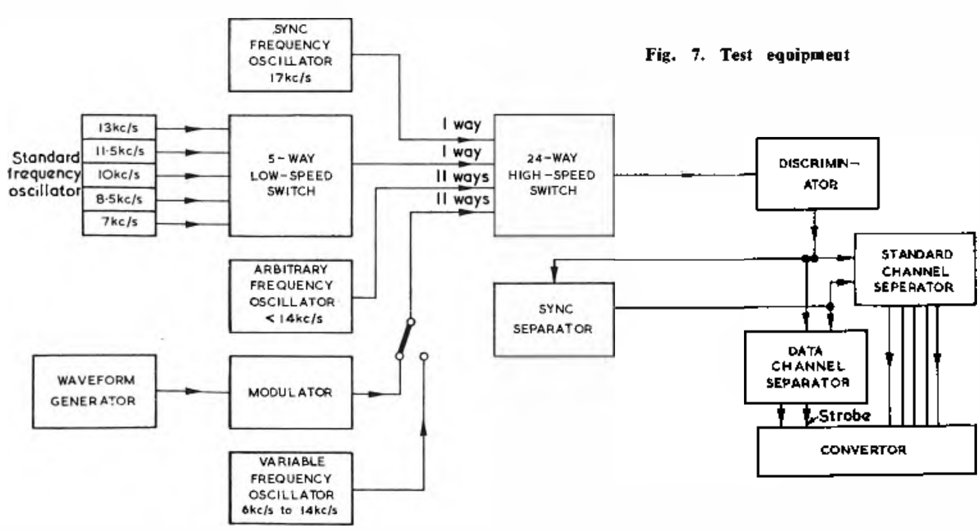


Fig. 7. Test equipment

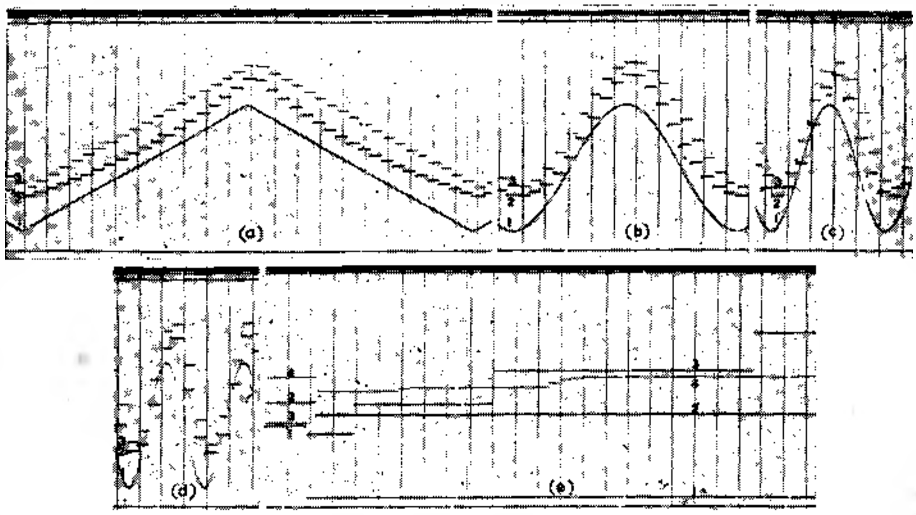


Fig. 8. Results of tests

(a) *Linearization for non-linear transducer characteristic. Trace 1. Input. Triangular wave of period 2sec. Trace 2. Data voltage. Trace 3. Analogue output.*

(b) *As (a) with sine-wave input at 1c/s.*

(c) *As (b) 2c/s sine-wave.*

(d) *As (b) 3c/s sine-wave.*

(e) *Level-correction with constant frequency input. Trace 1. D.C. shift applied to discriminator output level. Trace 2. Data voltage. Trace 3. Standards levels at input to sub-channel separator. Trace 4. The analogue output changes, returning to previous level within one cycle of standards.*

Tests

When the equipment is operating, an effective test of the greater part of the convertor system is to set up an arbitrary calibration curve on the patch panel, and using as data the voltage at some point on the resistance chain, to check that the corresponding output number is registered. The output number on such a check is normally found to be correct to within one digit throughout the range.

Further tests have been made on the convertor in conjunction with equipment which simulates the operation of the data-processing system (Fig. 7).

A 24-way switch is supplied with a set of oscillator signals. On one channel is the synchronizing frequency which is distinguished by being higher than any frequencies present on the other channels. Another switch contact is connected to the pole of a slower switch, which samples the outputs of a set of oscillators running at constant frequencies; this provides the standards channel. The remaining channels are alternately supplied by two oscillators, one at an arbitrary frequency, and another which can take several forms, the latter oscillator providing eleven data channels. The pole of the 24-way switch is connected to a discriminator with very linear characteristics. The discriminator output is fed to a sync separator unit which supplies the channel separators with a pulse at the occurrence of the sync channel. The channel separators can be set to select any channel with reference to the sync pulse. One is set to select the standards channel; the second picks out one of the data channels and gives a strobe pulse at the occurrence of this channel. The channel separators give outputs which remain constant during each cycle of the switch until the reoccurrence of the appropriate channel. The output of the standards channel separator is fed to a further set of five separators which give measures of the standards voltages. The convertor takes these voltages, in addition to the strobe pulse and the output of the data channel separator, and derives an output which is a measure of the frequency of the data oscillator.

Firstly, in tests using as data source an accurate oscillator, with the resistance chain set up to give a linear frequency/digit curve as described previously (function generator), the error between frequency input and digital output was always found to be less than $\pm 0{\cdot}5$ per cent, and that between frequency input and analogue output was less than ± 1 per cent of full scale.

Secondly, a reactance valve modulator was substituted as a source of data frequency. The modulator was operated on a very non-linear portion of its characteristic and driven by a voltage from a low frequency waveform generator. The modulator was calibrated accurately. The input waveform was thus the parameter, with the modulator simulating a non-linear transducer. Setting up the convertor patch panel from the modulator calibration, the convertor satisfactorily reconstituted a triangular wave input which was distorted by the modulator (Fig. 8).

Sinusoidal input waveforms of several frequencies were also used, the point of interest here being the frequency limitations of the convertor. These were found to be negligible in comparison to those imposed by the rate of transducer sampling (Fig. 8).

Thirdly, using a constant frequency input as data, a sudden shift was introduced in the level of the discriminator output over the whole range. This simulates a sudden change in the level of the airborne modulator characteristics. The convertor output changed at first, returning precisely to its original level as new voltages were registered by the standards channel separator.

Conclusions

Including the various approximations made, the overall accuracy of the digital output is generally not worse than ± 1 digit in 256. The approximations introduced by the function generator could be reduced by increasing either the number of auxiliary standards, or by increasing the number of diode gates in the sampling switch. However, an inherent limitation appears to exist in the precision with which voltages can be switched through the diode gates. These limits of accuracy are acceptable here, since they are much less than those on most of the transducers in use.

The scheme employed in the convertor is considered to achieve about the best practicable compensations for gain and level changes from the available telemetry information. The function generator provides an effective means of correcting for non-linear transducer characteristics. The system is applicable to time-multiplexed telemetry links in which data and calibration channels are transmitted serially through the same equipment.

Acknowledgments

The author wishes to thank the Bristol Aircraft Company Limited for permission to publish this article. Acknowledgment is due to Mr. T. C. R. S. Fowler who proposed the scheme, and to Messrs. P. Walker, J. D. Wilson, G. W. Boulton, and N. A. Purnell who took part in its development.

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STATIC SWITCHING

By G. T. Ohlsen*, B.Sc.

The purposes and advantages of static switching and its derivation from digital computer techniques are outlined. A comparison of existing techniques is made and a complete system employing NOR *units as the logic element is described, together with the treatment and solution of a simple problem.*

(Voir page 666 pour le résumé en français; Zusammenfassung in deutscher Sprache auf Seite 674)

THE aim of static switching is to replace contact-making devices, such as relays, contactors, push-buttons and limit switches by some form of magnetic or electronic bistable circuit elements which will perform an equivalent electrical function.

The advantages to be gained in the replacement of relays and contactors are the elimination of contact contamination, contact maintenance and mechanical wear due to moving parts. There is also the advantage, with most of the static switching schemes on the market, of much higher operating speeds which may be several orders higher than are attainable with relays.

While some form of mechanism is still necessary to actuate the static switching equivalent of push-buttons and similar devices, this is in general much simpler and the usually more troublesome contacts are again eliminated.

Origins

Apart from the ancillary devices such as push-buttons, the techniques of static switching are derived from the earlier work concerned with logical data handling in digital computers where the tendency has been to build logical networks from building-blocks of basic logic functions[1,2]. These logic functions are the well-known AND, OR, INVERTOR and DELAY.

The AND function, as shown in Fig. 1 is represented by a multiple-input, single-output network where signals must be present on all the input terminals before an output is generated (i.e. an output signal will be generated only when input signals *A* AND *B* AND *C* etc., are present.) This can be considered as analogous to an equivalent number of normally-open relay contacts connected in series, since the circuit will transmit only when relays *A* AND *B* AND *C* etc., are energized.

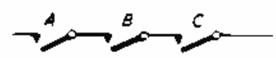
Similarly, the OR function as shown in Fig. 2 is a multiple-input, single-output network which will generate an output when any single input or combination of input signals is present. It is analogous to the parallel connexion of an equivalent number of normally-open relay contacts where the circuit will transmit when relay *A* OR *B* OR *C* OR any combination of these relays is energized.

The INVERTOR, or NOT, function is a single-input, single-output device which produces an output only when the input signal is absent and it is equivalent to a normally closed relay contact.

In the digital computer field the DELAY function is restricted to the fixed time delay of a digital pulse for a period of some few microseconds and the nickel or mercury delay lines employed find no application in static switching at the present time, where delays amounting to several seconds or minutes are frequently needed. For the remaining functions, the digital computer may employ diodes, transistors, thermionic valves or ferrite cores[3] as the bistable element; the conducting and non-conducting states or, in the case of ferrites, the saturated and unsaturated states representing conditions of output or no output.

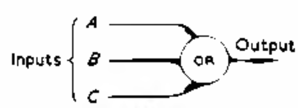
Thermionic valves have found no place in static switching, on the grounds of their reliability relative to other available devices and, although magnetic cores are being used by a number of manufacturers, these are tape-wound toroids rather than ferrites owing to the fact that most of these systems are operated at mains frequency and at higher power levels.

(a)

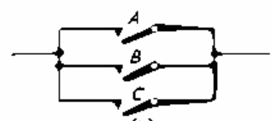


(b)

Fig. 1. (a) 3-input 'AND'
(b) Equivalent relay circuit



(a)



(b)

Fig. 2. (a) 3-input 'OR'
(b) Equivalent relay circuit

The main departure in technique is that most static switching systems are either d.c. or mains frequency operated rather than pulse operated, although at least one magnetic core system has been designed to be pulse-gated[4].

Choice of Switching Element

Since the prime aim is to replace relays and contactors by an equivalent logical building brick, the first consideration will be reliability. Second to this are considerations of simplicity, cost, bulk, and operating speed.

In general, the logic building brick is not capable of controlling a load and requires a simple power amplifier interposed between itself and the load. Hence the choice of switching element is not restricted by the type of load which may have to be controlled and may be assessed on the basis of the considerations mentioned earlier.

The cold-cathode tube forms one possible choice[5] and has been used in at least two static switching systems. It possesses the advantage of visual self-indication and is outstanding in this respect. However, its life expectancy is poor in comparison with cores and transistors and it requires relatively high voltage triggering signals. The anode supplies must be either a.c., half-wave rectified a.c., or pulsed, so that appreciable statistical delays are possible in a long cascaded chain and phasing problems occur.

Torriodal wound cores can be produced to give an indefinite life and provided that care is exercised in the

* *Associated Electrical Industries Ltd*

design and manufacture, units can be produced which will withstand mechanical mishandling of the completed wound core without deterioration in performance. Such cores, however, are costly and generally bulky, and suffer from the disadvantage of significant delays when cascaded; up to 5 cycles of the supply per core have been quoted in one case, and even if some form of flux resetting is employed on the inactive half cycle, the half cycle delay per core implies an overall system response no faster than that obtainable with relays. There is, in addition, the problem of phasing signals where a feedback loop is employed.

While the transistor cannot compare with the saturable core for thermal capacity and consequent inherent immunity from short-term fault conditions, it can nevertheless be readily designed into a wide range of logic units which will operate over a wide temperature range and the circuits can be made tolerant to large variations of supply voltage. The switching speed is of the order of 10μsec without taking any special precautions, although this is of course slow in comparison to switching speeds of less than 5mμsec which have been achieved with digital computer transistor logic[6].

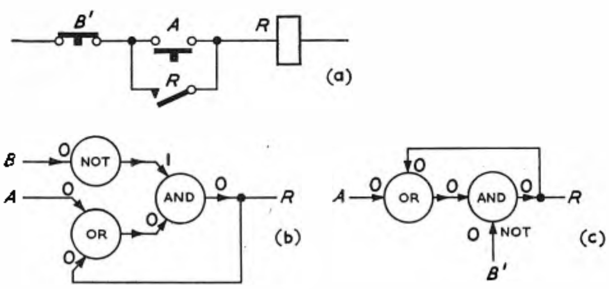


Fig. 3. Non-retentive memories

Diode AND and OR gates are commonly used in conjunction with magnetic core systems in order to reduce the complexity of the core windings[7]. Although such diode gates can be used exclusively in the solution of some problems, the signal source current drain increases very rapidly with the number of cascaded gates and in a long cascaded chain it is necessary to introduce current and voltage amplifiers to restore the signal levels[1]. The method is not satisfactory for use in the type of complex problem to which static switching is normally applied.

The transistor emerges very favourably on all counts from this comparison.

Additional Logic Functions

In addition to the functions AND, OR, NOT and DELAY, there is a need for a memory function in static switching. One type of memory is shown in Fig. 3(a). As can be seen from the equivalent relay circuit, the output *R* is self-retaining, once push-button *A* has been operated, until such time as push-button *B'* is operated. (The ' tick ' denotes a normally-closed contact.) This is termed a non-retentive memory, since it will always revert to the de-energized or ' off ' state in the event of a power supply failure. There are several ways of reproducing this function; by magnetic core-techniques, by combinations of AND, OR, and NOT gates, or by means of a flip-flop. Two possible solutions using AND, OR, NOT combinations are shown in Figs. 3(b) and 3(c) where the noughts and ones indicate respectively the absence or presence of a signal at switch-on. In Fig. 3(b) the AND gate will only give an output (*R*) if there is an output from the OR gate and signal *B* is not present. The OR output can be established by the momentary application of a signal at *A* and will be maintained by the signal fed back from output *R*.

Fig. 3(c) only requires the explanation that the AND gate is a hybrid, requiring the presence of the upper input and the absence of the lower input, for an output signal to be established.

Where it is required that, on the resumption of the power supply, the memory shall revert to its state immediately prior to a supply failure, an equivalent to the mechanically-latched relay is required. This can readily be reproduced by magnetic core techniques alone, or by the addition of a square-loop cored transformer to the emitter circuits of a transistor flip-flop.

Other basic logic functions are the NAND and the NOR, which are inverted-AND and inverted-OR functions respectively.

The NAND will produce an output signal provided that there is no signal on at least one of its input terminals and it is therefore equivalent to parallel-connected normally-closed relay contacts.

The NOR will only produce an output signal when there are no signals on any of its input terminals. This is equivalent to series-connected normally-closed relay contacts. So far as is known to the author, only transistors have been used in the design of the NOR function.

It is of interest to note that if a signal is defined as the presence of a voltage or current drive source, as is normal, and specific networks are designed to produce the functions AND, OR, NAND and NOR, then the functions of the AND and OR networks and of the NAND and NOR networks will be interchanged if a signal is now defined as the *absence* of voltage or current source.

Choice of Logic Functions

In determining the building blocks which are to form a static switching system, the same considerations apply as in making the choice of the basic switching elements, but in addition it is desirable to keep the number of different logic units as small as possible and to bear in mind the problems of maintenance.

Apart from the basic logic functions mentioned earlier, many permutations are possible, of a building block comprising multiple AND, OR and NOT inputs in various mixtures. A system based on these techniques will generally require both forms of memory as separate units, although the non-retentive memory can be synthesized from AND, OR and NOT functions as shown earlier. Some forms of delay unit will also be required.

Alternatively, the NOR unit can be utilized very simply to produce AND, OR, NOT and both memory functions. The NOT function is produced by commoning all the input terminals or by using one input only, leaving the remainder floating.

Fig. 4(b) shows the derivation of the AND function, where each input is first inverted, using a NOR unit as a NOT function. It should be emphasized that some, or all, of these NOT functions can be omitted by a suitable choice of signal input sense, if this is permissible in the particular problem.

The OR function is obtained as shown in Fig. 4(c) and the non-retentive memory is shown in Fig. 4(d). The latter is a simple flip-flop, with several advantages; the inverse of the output signal is available from the output of the left-hand NOR, and as many switch-on signals (such as *A*) and switch-off signals (such as *B*) can be employed as there are unused input terminals after completing the basic flip-flop connexions.

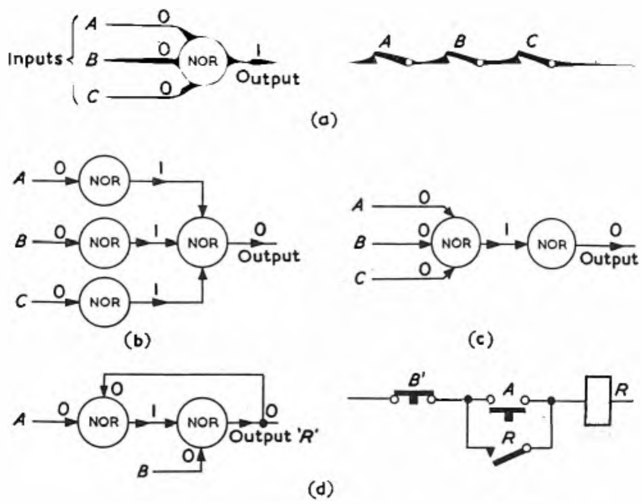


Fig. 4 (a) Basic 'NOR' relay equivalent
(b) 'AND' function
(c) 'OR' function
(d) Non-retentive memory relay equivalent

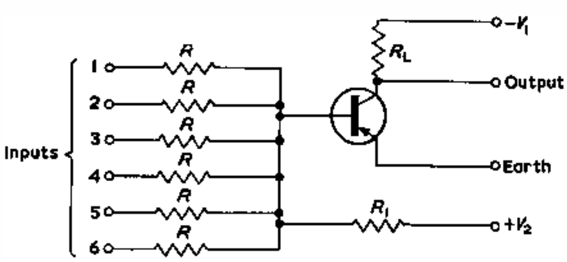


Fig. 5. Transistor 'NOR' circuit

The mode of operation is that the output of the left-hand NOR becomes zero on the application of signal A. If signal B is absent, all inputs to the right-hand NOR are zero and hence output R is generated. This is fed back to the left-hand NOR to maintain its zero output state when signal A is removed.

The output R can now become zero only if signal B is present, and since the feedback signal will then be zero, both NORS will revert to their initial state and remain in that state when signal B is removed.

Since the circuit is inherently symmetrical, some means must be provided to ensure the desired switch-on state. This may be accomplished by modifying a parameter of one or other NOR unit or more usually, by providing a transient signal at switch-on to set the memory state.

The NAND unit may similarly be used to derive the functions AND, OR, NOT and non-retentive memory, but the memory function is more complex, requiring four NAND units compared with two NOR units. The solution of a problem in terms of NAND units requires more mental effort than with NOR units and is generally more extravagant in components.

A Static Switching System

The author's company is pursuing the development of both NOR and multi-function units, employing transistors as the switching element but, since the author's concern has been solely the development of a static switching system based on the NOR unit, consideration will be limited to this type of system. The circuit of the transistor NOR is shown in Fig. 5. The pertinent design considerations have been adequately covered in a recent article[8].

Provided that there are no signal voltages on any of the six inputs, the transistor is cut off, due to the positive base bias applied from $+V_2$ via R_1. The output terminal is at a potential, substantially that of the $-V_1$ supply. This potential constitutes the output signal.

If any single input terminal, or any combination of input terminals, now has a negative going signal applied whose amplitude is of the same order of magnitude as $-V_1$, the transistor saturates and the output potential falls to approximately -200mV, representing the zero output state.

The switching speeds are of the order of 10μsec to switch from the unsaturated to the saturated state, and approximately 15 to 20μsec in the reverse direction. This slower switching speed is due to minority carrier storage effects. No attempt has been made to improve on these speeds which are at least three orders better than can be achieved by unforced relays. The hole storage effect has in fact been aggravated by overdriving the base to ensure that any production transistor will perform satisfactorily in the circuit.

Component values have been chosen so that the unit is stabilized against the effects of collector leakage current variations, and is thermally stable at temperatures in excess of the 55°C maximum operational ambient temperature.

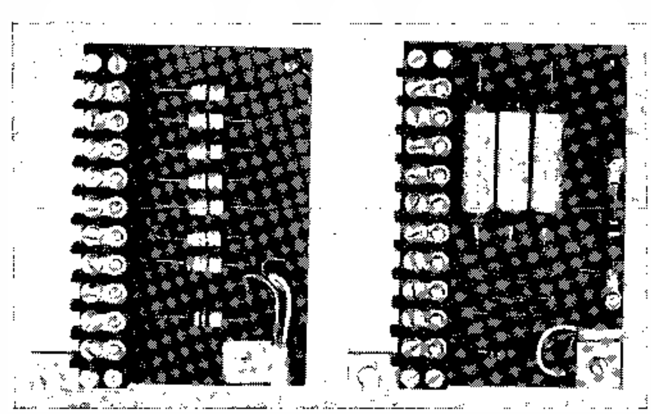
The supply voltages are $+20$V and -20V, derived from either a three-phase half-wave unsmoothed supply or a single-phase full-wave supply with shunt capacitor. Satisfactory operation is possible in the presence of ± 20 per cent supply voltage variations, and the input signals may be anywhere within the range -20V to -7V for correct operation. One NOR is capable of controlling 12 logic units paralleled on to its output.

The printed circuit construction is shown in Fig. 6, together with a time delay unit. Fig. 7 shows the circuit of this time delay unit, coupled at its input terminal to the output of a NOR unit.

Assuming that transistor VT_1 is cut off, capacitor C will rapidly charge to almost the full value of the supply voltage V_1, via diodes MR_1, MR_2 and MR_3 and the low value resistor R_L. The base of VT_2 is maintained slightly negative to earth by the forward voltage drop of MR_1 which is carrying a proportion of the charging current and an additional current due to R_1. VT_2 is therefore saturated and the output voltage is sensibly zero.

If VT_1 is now switched to saturation, the charge on C appears in the inverse sense across MR_1 and MR_3,

Fig. 6. Printed circuit construction of 'NOR' and delay circuits



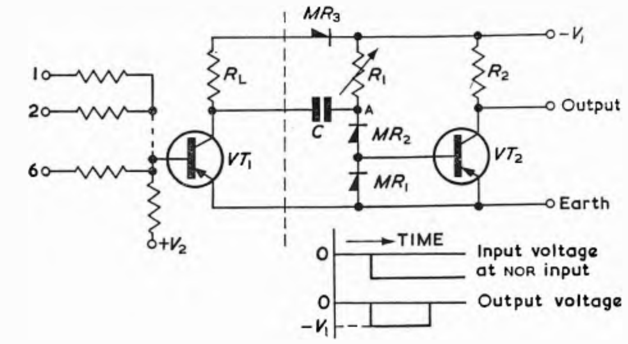


Fig. 7. Time delay unit

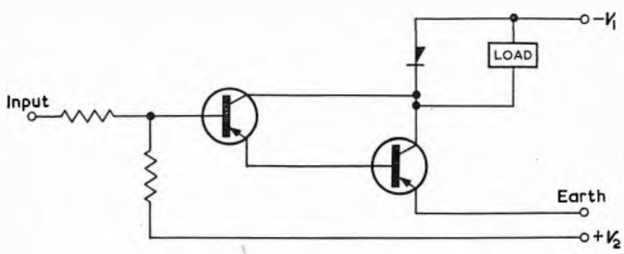


Fig. 8. Output unit

causing VT_2 to cut off and the full negative supply voltage to appear at the output terminal.

C discharges through the long time-constant circuit VT_1, C and R_1, and would ultimately recharge to the full voltage of the negative supply but for the fact that when the potential at point A becomes slightly negative to earth, VT_2 is again able to draw base current. Since C has only completed approximately 50 per cent of its discharge-recharge cycle, its rate of change of potential is still high and transistor VT_2 therefore saturates rapidly, reducing the output signal to zero once again.

Owing to the method employed in determining the potential at which C will switch VT_3, the timed interval is markedly insensitive to variations in supply potential, provided that these do not occur during the timed interval itself.

This unit has been designed to cover timing intervals in the range 0·2 to 20sec in three ranges, but this can be extended to a maximum of 2min by the use of additional external capacitance.

A variety of timing functions can be performed with this unit in conjunction with further NOR units.

A power output unit is necessary for controlling loads such as solenoids, heavy current contactors, and motors. The circuit of such an output unit is shown in Fig. 8. This is a simple compound transistor amplifier accepting signals from a NOR unit, or a time delay unit and capable of controlling d.c. loads of up to 72W at maxima of 24V and 3A.

For loads exceeding 72W, the circuit is modified slightly and a controlled silicon rectifier substituted in the output stage. These devices have only recently become available in this country, and load currents of up to 10A are possible with peak inverse ratings of approximately 300V. It is expected that these ratings will be significantly improved upon in the not too distant future.

Where the load to be controlled is greater than the capacity of the controlled rectifier, magnetic amplifiers may be used. Here, costs and the degree of necessity for maximum reliability are prime considerations. Loads of 100kW and more can be handled by magnetic amplifiers but the costs are necessarily high compared with contactors.

The remaining logic unit in the range is the sequence unit, shown in Fig. 9. This is a configuration of NORS, forming a ring counter with the overall feedback loop omitted. If this feedback loop is externally connected, eight discrete outputs are available which will step on in sequence for successive signals on the input terminal. These sequence units can be cascaded indefinitely and are directly analogous to the uniselector. Up to four NORS may be driven by each output.

Application to a Simple Problem

Fig. 10(a) shows a simple relay circuit together with its transmission functions in Boolean algebra. The Boolean conventions adopted are that multiplication represents the logical function AND, addition represents the function OR, and a ' tick ' represents a normally closed contact.

If these functions were directly translated into the equivalent NOR network, without making the simplifying step in the function for S, it would be found that twelve NOR units were necessary.

The resulting network for the simplified case is shown in Fig. 10(b) where the ' 0 's and ' 1 's represent the initial states of signals and outputs. Nine NOR units are seen to be necessary.

NOR units a, b and c are used purely as invertors, having only one input terminal connected. It can be seen that so long as at least one of the inputs A or B is zero, there will be at least one input signal to gate d, which will therefore have zero output. This performs the $(A' + B')$ term of the function for R.

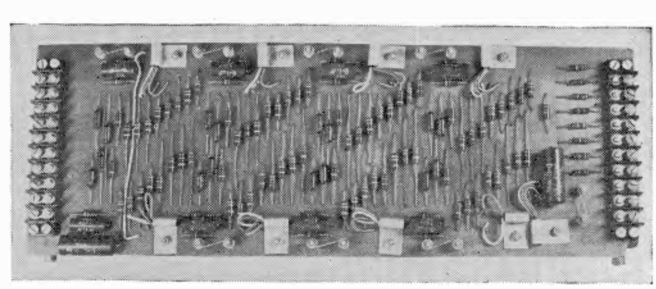
Provided that signal C is present, there will be zero output from gate c so that with a coincident zero output from d, both inputs to gate e will be zero and there will be an output from this gate. This causes gate f to have zero output and hence gate g will give the output R.

Similarly, if output signal S is present, gate f will have zero output and again, gate g will produce the output R. The operation so far described is seen to be equivalent to the conditions of operation of relay R in the relay circuit of Fig. 10(a).

If the designer is free to choose the sense of the input signals, A,B,C and D, it is apparent that gates a and c can be omitted if signals A and C are used in the inverse sense, hence reducing the number of NOR units required to seven.

The network was designed by working backwards from each output terminal in turn, using the minimal Boolean functions as a starting point. Where the Boolean function consists of two or more factors coupled by addition or OR signs, as in the case for output R, the signal must be inverted. Hence the input to gate g is the inverse of the original Boolean function as shown in Fig. 10(b).

Fig. 9. Construction of the sequence unit



Where the Boolean function involves multiplied factors only, as for outputs S and T or the input signal to gate g, a NOR is required with as many input terminals as there are factors in the expression. The input signal required at an input terminal is then the inverse of the particular factor appearing at the output terminal, as shown in Fig. 10(b) for gate f.

As a first step in designing such a network, the output requirements must be carefully scrutinized to see if any redundancy exists, as in the case of the expression for S. The derivation of the minimal expressions will obviously aid in arriving at a minimal network in terms of the number of NOR units required.

As the network synthesis proceeds it is necessary to inspect for duplication of required functions, as in the case of the R' input to gate h, which is available from the input to gate g, since this is a simple invertor.

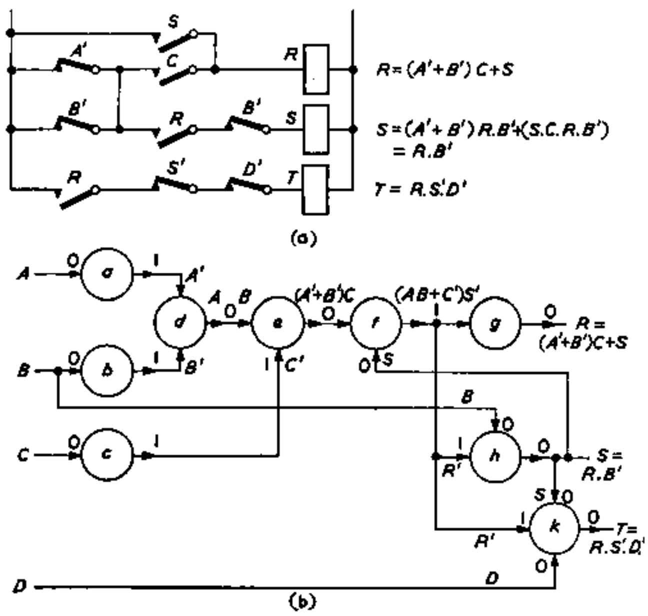


Fig. 10. Simple relay circuit and the 'NOR' circuit equivalent

Having completed the network, the input conditions should be inspected to see if any simplification is possible by inverting the sense of one or more input signals, as is possible in this case by inverting signals A and C and omitting gates a and c.

Although this method is straightforward, it does not unfortunately always result in a minimal network and it is sometimes possible to derive a simpler system by intuitive methods.

The network complexity may also depend on the manner in which the Boolean expressions are written down. For instance, using the above method, a solution to $A'B' + AB$ will require six NOR units whereas a solution to $(A' + B)(A + B')$ will require five NOR units, yet these two expressions have precisely the same meaning.

Control of Input Signals

Where push-button or limit switch operation of control signals is required, contactless devices are available in the A.E.I. static switching system. These are simple saturable reactors where a small toroidal wound core forms the fixed part in each device. The core is saturated by bringing a permanent magnet to within approximately $\frac{1}{8}$in of the core, when the resulting low inductance of the winding allows a half-wave rectified signal to be applied to the relevant logic circuit input terminal. It should be noted that mechanical contact is not necessary between magnet and core.

When used as a limit switch, this device will give an accuracy of $\pm 1/16$in in the operating point, which is adequate for the majority of industrial applications.

Much greater accuracies are possible by the use of a high frequency supply, and of such phenomena as ferro-resonance, but there is the disadvantage of increased complexity and cost.

Conclusions

In the author's opinion, the transistor NOR unit has advantages which make it more attractive than any other form of logic system. Apart from the inherent high switching speed of the transistor, the NOR can reproduce any required logical function with great simplicity.

The maintenance engineer requires an operational knowledge of the minimum possible number of logic units and a variety of aids to servicing an installation are available. In the simplest case, he requires only a voltmeter with one connexion to the system earth, using the other as a test prod to check for the presence or absence of a signal.

Alternatively, lamp indication can be provided at selected points in the network to indicate signal states or neons can be provided to indicate the state of every unit at all times.

It is impossible to assess the replacement ratio of NOR units to relays on the basis of simple examples such as that considered earlier. In many such instances, particularly cyclical and sequential problems, it will be found that three or even four NORS are required per relay for equivalent networks. However, in somewhat more complex problems involving upwards of say, twenty relays, the ratio will be found to be fairly closely two to one, if the relay is defined as having four changeover contacts available.

With increasing speeds of operation of machines and equipment in industry and the services, the time lags involved in manipulating control signals by means of relays and contractors can be a definite embarrassment. Plant shut-down due to fault conditions can be staggeringly expensive in some cases. Static switching offers a real gain in both of these circumstances.

A final benefit to the user is found in the schematic diagram. There is no longer the need to search for the elusive last contact of a particular relay: every single input and output of a unit has a clearly defined destination.

Acknowledgments

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The Differential Analyser and its Realization in Digital Form

(Part 1)

By P. L. Owen*, B.A., M. F. Partridge*, M.A., and T. R. H. Sizer*, A.M.I.E.E.

This article describes the differential analyser both in its original mechanical form and a later digital development. Briefly computers falling within this generic title deal with information of a continuously variable nature as in the solution of differential equations.

Interest in the differential analyser has recently been stimulated by the application of digital techniques resulting in the digital differential analyser (abbreviated to d.d.a.). This type of machine has great operational flexibility and the accuracy inherent in a digital system.

(Voir page 666 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 674)

THE principle of the differential analyser has been known for many years; its first form was probably that proposed by Lord Kelvin[1] in 1876. Dr. Vannever Bush[2] was responsible for the first practical mechanical machine produced at the Massachusetts Institute of Technology in 1930. Since then similar mechanical machines[3] have been built in the U.K.

Electronic forms of differential analysers have been avaiable commercially for some years consisting of arrangements of d.c. amplifiers and have proved invaluable in the solution of some types of differential equation. In recent years, however, an entirely new conception of the electronic differential analyser has been realized by the application of digital techniques resulting in the digital differential analyser.

The authors are convinced that the potentialities of the d.d.a. have yet to be fully appreciated. The object of this article, therefore, is to introduce the subject to a wider range of people and, in so doing, to stimulate interest in a fresh and highly important field.

The Process of Computation

In order to perform computation by mechanical or other means the calculations must first be broken down into basic operations. For example, the slide rule may be used to compute functions which can be reduced to multiplications and divisions. A desk hand machine which is only capable of addition and subtraction may, in theory perform any computation. In practise, it is assisted by means of tables of mathematical functions. Large automatic general purpose machines operate by reducing all computation to addition. Subtraction is achieved by the addition of the complement of the number, multiplication and division by successive addition and subtraction respectively. These four operations enable the machine to compute polynomials and rational functions. Transcendental functions such as θ and e^x, etc. are computed by means of expansion in terms of Chebycheff or other orthogonal polynomials.

Electronic analogue machines use the computing amplifier as a basic 'brick' to perform the operations of addition, multiplication by a constant, and integration with respect to time. This element is sufficient to enable any problem which may be formulated in terms of linear equations to be solved. Non-linear problems may be solved by the use of servo or electronic multipliers, mechanical cams, non-linear resistors etc.

Another type of machine is the differential analyser which has as its basic 'brick' a device which may integrate with respect to variables other than time. This facility in conjunction with an adder enables it to solve any problem which may be formulated in terms of linear or non-linear

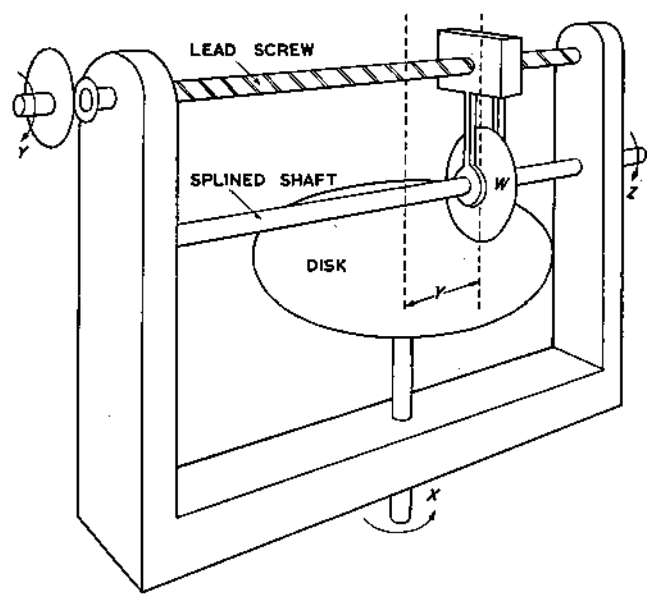


Fig. 1. The wheel and disk integrator

equations, e.g.:

(a) Multiplication of two variables:

$$XY = \int X \,.\, dY + \int Y \,.\, dX$$

(b) Computation of $\sin\theta$ and $\cos\theta$ as the solution of:

$$(d^2X/d\theta^2) + X = 0$$

(c) Multiplication by a constant:

$$KX = \int K \,.\, dX$$

Space does not permit the inclusion of further examples at this stage, but these three are sufficient to illustrate the versatility of the differential analyser. This article describes such a machine and, in particular, its realization in digital form.

The Mechanical Differential Analyser

The Wheel and Disk Integrator

The basic integrator of the differential analyser may take several different forms, one of the simplest of which is shown in Fig. 1. This type of integrator has two inputs and one output, each in the form of a shaft rotation. In Fig. 1 the input rotations are represented by X and Y.

* *Royal Aircraft Establishment, Farnborough*

and the output by Z. These quantities are the numerical measurements of the rotations, and may be revolutions, degrees or radians. For the convenience of description, it is assumed here that the rotations are measured in radians.

The X input shaft is mounted in bearings in the main framework, and attached to one end of this shaft is a flat circular disk which rotates with it. At right-angles to the X input shaft is mounted a second splined shaft which carries a wheel whose circumference is in contact with the disk. The wheel is free to slide along the second shaft, but the shaft constrained to follow any rotation of the wheel by splining. The position of the wheel on the splined shaft is determined by a bracket mounted on a lead screw which is rotated through gearing by the second input Y. The rotation of the splined shaft is the output Z.

In order to determine the relation between the inputs and output of this device suppose that the unit of distance is the radius of the wheel and that the gear ratio on the Y input has been so chosen that the lead screw moves the wheel unit distance along the splined shaft for a rotation of one radian of the Y input shaft. Also suppose that $Y = 0$ when the wheel is in contact with the centre of the disk. A small rotation δX of the disk causes a point on its sur-

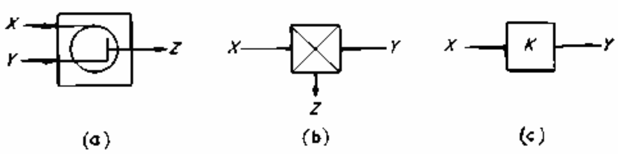


Fig. 2. Conventional symbols for differential analyser elements

face at a distance Y from the centre to move a distance $Y \,.\, \delta X$. This causes the circumference of the wheel, which rolls on the surface of the disk without slipping to move through the same distance. Since the wheel has unit radius, this distance represents the output rotation in radians, and the following fundamental relation between the inputs and the output of the wheel and disk integrator is obtained:

$$\delta Z = Y \,.\, \delta X$$

For a constant value of Y, say K, the relation between the input and output is:

$$Z = KX$$

thus showing how the device may be used as a constant multiplier. In practice this is an extravagant thing to do since the same result could be achieved by means of a simple gear train.

For variable Y the relation between the inputs and output is:

$$Z = \int Y \,.\, dX,$$

and the device integrates Y with respect to X.

Making use of the normal nomenclature for integration it is convenient to call X the independent variable and Y, the distance of the wheel from the centre of the disk, the integrand.

It should be again remarked that the independent variable or X input is, subject to the mechanical limitations of the device, completely unrestricted in its behaviour. For example, it may be the input from external equipment, or the output from another integrator. It is this facility which makes the wheel and disk integrator so much more versatile than the electronic analogue integrator in which the independent variable may be time only. Integration with respect to time is achieved with the wheel and disk integrator by simply rotating the X input at constant angular velocity.

Addition of Rotations

In order to solve problems by means of the wheel and disk integrator it is necessary to be able to add shaft rotations. Addition is most easily achieved with the mechanical differential gear. The differential gear is a familiar device and requires no explanation other than to state the fact that it normally gives the mean of two shaft rotations. For the purposes of constructing integrator schematics, however, it is regarded as an element which adds two shaft rotations since the factor of 1/2 may be compensated by gearing the output shaft.

Solution of Problems by Means of the Differential Analyser

The wheel and disk integrator and the differential gear are, in theory, sufficient to enable the differential analyser to solve any problem which may be formulated in terms of mathematical equations. In practice, however, it is economical to use a simple gear train when it is desired to multiply by a constant rather than use an integrator with a constant Y input.

In order to show how differential analyser schematics may be built up to solve problems it is convenient to have conventional symbols for the integrator, differential gear, and gear train. In Fig. 2(a) the integrator is shown as a plan drawing of the wheel and disk. The X or independent variable input is drawn tangential to the disk to show that they are mechanically connected, and the Y or dependent variable is connected to the wheel. The Z output is also connected to the wheel. Figs. 2(b) and 2(c) show suitable symbols for the differential gear and gear train respectively. The relationships beween the inputs and outputs of these three elements are:

for the integrator: $Z = \int Y \,.\, dX,$

for the differential: $Z = Y + X,$

for the gear train: $Y = K \,.\, X.$

For the development of schematics it is sometimes found convenient to express these relations in incremental form as: $\delta Z = Y \,.\, \delta X$, $\delta Z = \delta X + \delta Y$, and $\delta Y = K \,.\, \delta X$ respectively.

Some examples are now given of the solution of problems by the differential analyser.

(1) *Multiplication of Two Variables*

In order to derive the schematic for this operation the equation:

$$Z = X \,.\, Y$$

is written in incremental form as:

$$\delta Z = Y \,.\, \delta X + X \,.\, \delta Y.$$

The form of this relation shows that two integrators and one adder are required to perform multiplication and the schematic is shown in Fig. 3(a). The independent and dependent variable inputs of integator 1 are X and Y respectively, and for integrator 2 the corresponding inputs are Y and X. The answer is obtained by adding the outputs of the two integrators by means of the differential. The form of the schematic shows that the two inputs, i.e. X and Y are required to be repeated, an operation which may be achieved by simple gearing and symbolized by a 'black box' with one input and two identical outputs.

In order to use this device for multiplication it is necessary to display the inputs and output. This may be most conveniently done by mounting angular indicators on the input and output shafts. It is, however, necessary to set the origins or zero positions of these indicators, and an examination of the input-output relations shows how this may be done. Taking the case of the X input indicator first, the relation for the wheel and disk integrator 2 is:

$$Z = \int X \, . \, dy$$

and shows that the integrand which is the distance of the wheel from the centre of the disk is X. Thus the X input indicator must be set so that it gives a zero reading when the integrand of 2 is zero. Similarly, the Y input indicator must be set so that it gives a zero reading when the wheel of integrator 1 is at the centre of the disk.

The origin of the output indicator is determined by inserting an arbitrary set of initial conditions which satisfy the defining equations of the problem. In the case of multiplication suitable initial conditions could be $X = Y = Z = 0$, and these would be inserted by setting the output indicator to read zero when the two input indicators read zero.

Having set in an initial condition multiplication may now be performed by setting up the two factors on the input indicators. The product then appears on the output indicator.

(2) *The Solution of Second Order Linear Differential Equations*

Let the equation be:

$$A\,(d^2Y/dt^2) + B\,(dY/dt) + CY = 0$$

Integrating and rearranging:

$$dY/dt = -(1/A)\,(B \int (dY/dt) \, . \, dt + C \int Y \, . \, dt)$$

To construct the schematic suppose that dY/dt is available then the expressions:

$$Y = \int (dY/dt) \, . \, dt \text{ and } \int Y \, . \, dt$$

may be obtained by two successive integrations of dY/dt. The outputs of these integrators are multiplied by B and C respectively and added in a differential. Multiplying the output of the differential by $-(1/A)$ gives dY/dt which is used as the integrand of the first integrator. The resulting schematic is shown in Fig. 3(b). The solution Y is obtained by putting an indicator on the output of integrator 1. This schematic is interesting in that it uses a feedback technique to obtain the solution of the equation. The integration with respect to time is achieved by rotating the independent variable inputs of the integrators at a constant angular velocity. The particular angular velocity is dependent on what speed relative to real time it is required to solve the problem. For example, if it is required to solve the problem in real time, the angular velocity is one radian per second.

From the theory of second order equations it is known that the solution is determined by the initial values of dY/dt and Y. The schematic is therefore set up by inserting the initial value of $dY/$dt in the integrand of integrator 1, and the initial value of Y in the integrand of integrator 2 and the output indicator.

(3) *Computation of Reciprocal*

Let the defining equation be:

$$Y = (1/X)$$

This equation may be written in incremental form as:

$$\delta Y = -(1/X^2) \, . \, \delta X = -Y^2 \, . \, \delta X$$

Integrating:

$$Y = -\int Y^2 \, . \, dX$$

The schematic may be built up in the same way as that for the linear differential equation using a feedback technique. Assume that Y is available, Y^2 may be generated by means of an integrator whose integrand and independent variable are both Y according to the equation:

$$\tfrac{1}{2}Y^2 = \int Y \, . \, dY$$

The output of this integrator is multiplied by 2 to give the integrand of a second integrator whose independent variable input is X. The output of the second integrator is then Y which may be fed back to the first integrator. The resulting schematic is shown in Fig. 3(c).

A convenient set of initial conditions may be taken as $X = Y = 1$. Since Y^2 is also 1 these conditions may be inserted by making the integrands of integrators 1 and 2, 1 and -1 respectively. The output indicator is set to 1 and the schematic is ready for computation.

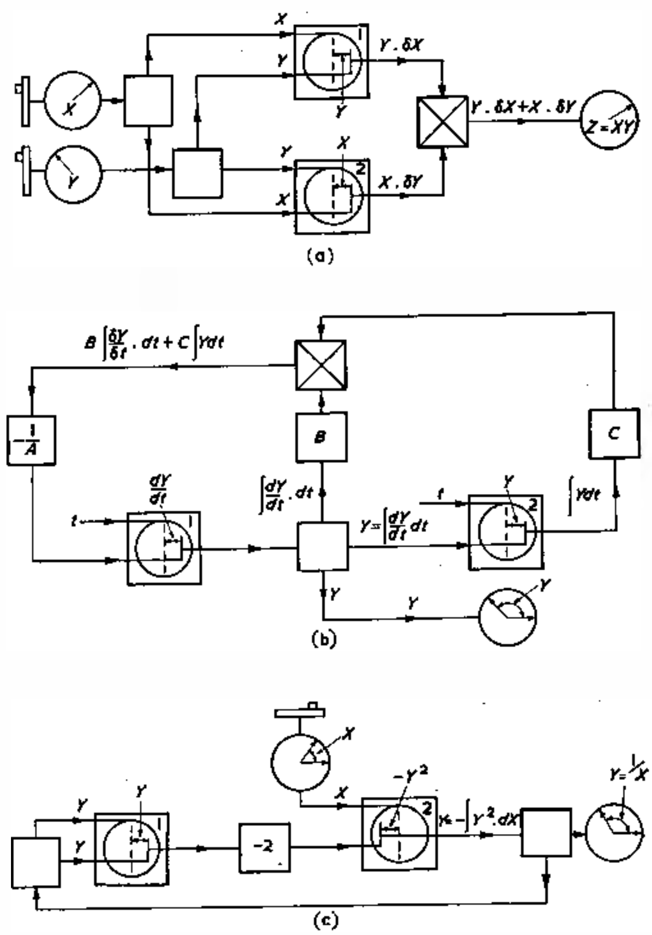


Fig. 3 (a) **Multiplication**
(b) **Solution of second order linear differential equation**
(c) **Computation of reciprocal**

In each of the preceding schematics the insertion of initial conditions is an essential part of the setting up procedure. This is a characteristic of the differential analyser and it must be performed for every problem. The machine, in fact, operates by relating the differences or increments of outputs to the increments of the inputs. Thus the incremental forms of the relations given previously give a truer picture of the process taking place in the differential analyser than the absolute or whole number forms of these relations.

(3) *Digital Integration*

In order to construct the digital equivalent of the wheel and disk integrator it is necessary to examine in some detail the process taking place in this device. The quantity which is transmitted between wheel and disk integrators is shaft rotation. Shaft rotation is not an absolute quantity, an indicator mounted on the shaft may have its origin in any arbitrary position. If the output indicator for the multiplier schematic already described is set up in a position other than that dictated by the initial conditions an answer would still be obtained but it would be given by the equation:

$$Z = X . Y + C$$

where C is the displacement of the output indicator from its correct position. The schematic is, in fact, unable to

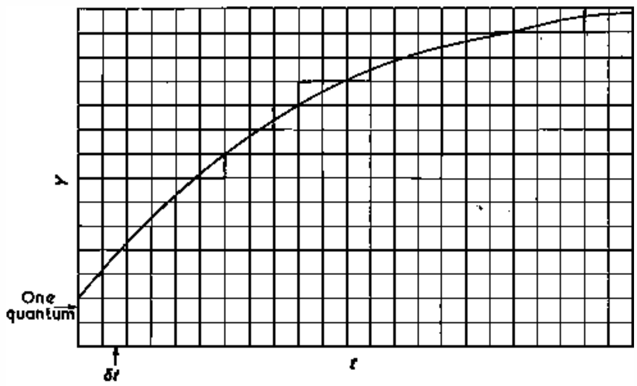


Fig. 4. Digital representation of a continuous function

detect, or correct for, an error of this form. Other such errors are caused if the input indicators are set up incorrectly relative to the integrands of their respective integrators.

In the case of the schematic of Fig. 3(b) errors undetectable by the machine could occur if the Y input shaft of integrator 2 received an input rotation error.

These points illustrate further that the differential analyser does not deal with absolute or whole numbers but rather with their differences or increments. Viewed from this aspect, the wheel and disk integrator as shown in Fig. 1, without its output indicator, is an increment or rate multiplier. The multiplying factor Y is determined by integrating the integrand input by means of the lead screw and the output increments are determined by the equation:

$$\delta Z = Y . \delta X$$

and the output rate is determined by the equation:

$$dZ/dt = Y . (dX/dt)$$

Digital Representation of Quantities

It is now possible to consider how to construct a digital integrator. It is necessary, however, as a first step, to describe how variable quantities may be represented in digital form.

Variable quantities may be represented by shaft rotations which may change continuously. On the other hand, digital numbers are discrete by nature, and change in steps. The least amount by which a digital number may change is one unit in the position of least significance of the representation. This least significant unit, or quantum, is determined by the accuracy to which it is required to represent the quantity.

Fig. 4 shows how a continuously variable quantity may be digitized. Each vertical step of the grid represents the smallest amount by which the digital representation may change, i.e. the quantum. Each horizontal step represents a small interval of time δt. The stepped line shows the corresponding digital representation and is obtained by taking the nearest horizontal grid line at the beginning of each time interval δt. As the quantization becomes finer and the time interval becomes shorter the representation becomes more accurate, but it never becomes exact since it is characteristic of the digital process that the number changes at the beginning of each time interval δt and remains constant during the interval.

Whereas the quantum or step size is determined from accuracy conditions, the time interval δt is determined by the speed of the machine, because machine operation consists of a series of cycles or iterations. During each iteration it is necessary to sample all the inputs and compute the output, operations which require a finite time for their performance. The time interval δt is determined by this cycle time and is referred to as the 'iteration period' of the machine. A typical figure is 2msec, giving an exceedingly accurate representation of variable quantities.

(To be continued)

A Coded Automatic Door Release

By J. D. Storer, A.M.I.E.E., A.M.Brit.I.R.E.

A simple combination lock is described. It is operated by push-buttons marked with the letters of the alphabet: four letters having to be selected in the correct sequence. The circuit consists of Uniselectors and relays.

(Voir page 666 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 674)

For a variety of reasons it may be desirable to restrict access to offices, laboratories, etc., to a limited number of staff. Issuing keys to everyone concerned is seldom satisfactory and it is usually uneconomic to employ a doorman and pass system at this level. An automatic door release system which is operated from outside by pressing lettered buttons in a prearranged sequence has proved to be a satisfactory answer to the problem.

Any such system must meet three main requirements, being foolproof, cheap and simple; the one now described has these merits.

General

The device is intended to restrict entry into a room or area to persons with prior knowledge of a sequence of four letters. The letters and their order can be changed quickly and easily, at will; and there are alarm circuits which operate whenever an incorrect letter is selected, or if more than one letter is selected.

It consists of a panel of buttons, each marked with a letter, mounted on a wall external to the door, a magnetic door lock, and a relay and code setting panel inside the secure area.

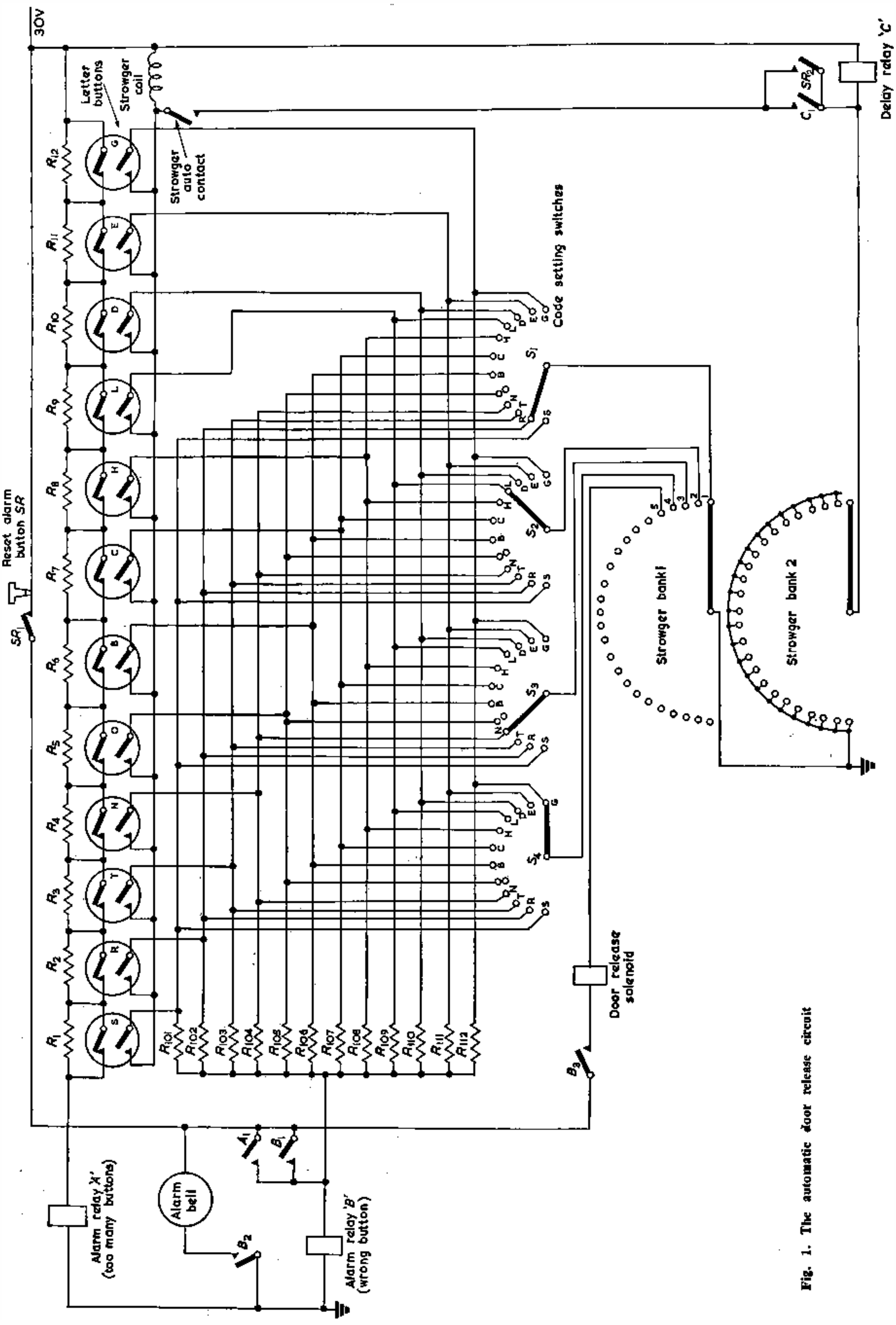


Fig. 1. The automatic door release circuit

Method of Operation

A circuit diagram is shown in Fig. 1. Twelve letter buttons are shown, and twelve contacts on each of the code setting switches $S_1 - S_4$: This provides 12^4 possible combinations, and as the panel of push-buttons contains all 26 letters the probability of fortuitously selecting the correct sequence is considerably less than this. In the diagram the switches are set to *RLNG*, if the push-buttons are operated in this order the sequence of events is as follows:—

(a) On operation of push-button *R*, the open contacts of *R* are closed connecting an earth via S_1 and the first contact of Strowger bank 1 on to the Strowger coil. This causes the Strowger to advance one step on to contact two.

(b) This ensures that when button *L* is pressed an earth is again applied to the Strowger coil via S_2 and the second contact of Strowger bank 1 causing it to step on to position 3.

(c) The process repeats as buttons *N* and *G* are operated so that the Strowger contact reaches position 5 where it applies an earth to the door release solenoid enabling the door to be opened.

(d) Simultaneously Strowger bank 2 has been rotating, as soon as the first button was pressed this bank applied an earth on to a delay relay which is timed to operate shortly after the door has been opened. When it operates it connects an earth via Strowger bank 2 and relay *C* to the 'auto' contact of the Strowger causing it to rotate until it reaches contact 1 when it stops due to the removal of the earth on Strowger bank 2. Thus the whole system is ready for another complete operation.

Consider now the effect of operating an incorrect button, suppose *C* is pressed instead of *R*. There is no circuit via S_1 to cause the Strowger to operate, but sufficient current flows through the Strowger coil and R_{107} to operate alarm relay *B*. This immediately self holds—contact B_1—and the alarm bell is operated continuously by the making of B_2. B_3 opens and removes the door release solenoid from circuit completely. This state of alarm can only be remedied by operating the reset alarm push-button, this breaks contacts *SR*1 restoring alarm relay *B*, and closes contacts *SR*2. If it is the first button that has been wrongly pressed *SR*2 being closed has no effect, but if it is any subsequent button—i.e. if the wiper of Strowger bank 2 has 'picked up" an earth—it connects an earth on to the Strowger auto contact causing the system to return to its normal quiescent condition.

Finally, consider the effect of operating two buttons simultaneously. Whenever a button is pressed its pair of closed contacts which are used to short-circuit a resistor are opened and the resistance is placed in series with alarm relay *A* which is normally operated. One resistor in series does not reduce the current sufficiently for the relay to drop out, but if two or more buttons are pressed simultaneously the current drops below operating level and the relay operates. Its contacts A_1 operate alarm relay *B* which self holds producing results described in the previous paragraph. It is worth noting that due to relay *A*, the alarm will usually operate when the system is first switched on, and the reset button must be pressed to bring the system to its normal quiescent state.

An Improved Fuel Cell

A low temperature fuel cell that can generate from three to five times more power per unit volume than other similar cells under development was announced recently by Dr. C. G. Williams, Director and General Manager of "Shell" Research Ltd. This development, by Shell's Research Centre at Thornton, in Cheshire, England, is regarded as a significant step forward in making these devices practicable.

The high output of Thornton's fuel cell results from the fundamental studies Thornton has made of fuel cell electrodes. This work has led to the development of inexpensive and easily fabricated electrodes that are highly active.

Development work has been carried out using hydrogen as the fuel, but the cell has demonstrated its ability to use other fuels and further work will be carried out in this direction.

The cell can operate with either alkaline or acid electrolytes. When run on hydrogen and oxygen at pressure of 3 lb/in², current densities of 70A/ft² can readily be obtained with both types of electrolyte at room temperature. If air is substituted for oxygen, there is little loss in performance. As the cell warms up to 60°C, the output is doubled. The power output is of the order of 3 to 5kW/ft³.

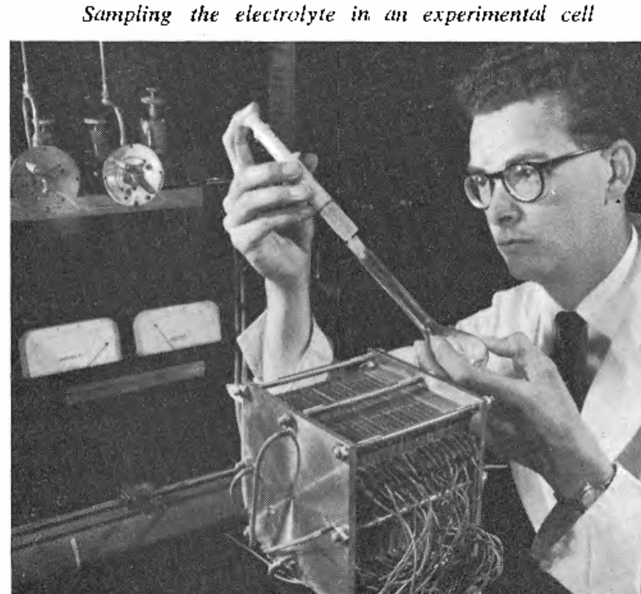
In discussing the electrolyte, Dr. Williams stated that the acid cell has a major advantage because it is free from troubles due to carbon dioxide. This gas, which is present in air and also in fuel gases derived from hydrocarbon fuels, destroys the activity of the alkaline electrolytes.

"Shell" has constructed multiple fuel cells with up to six cells per inch and believes that units having a power to weight ratio of 50 watts per pound are realizable.

Although this research shows that real advances in fuel cell design are possible, "Shell" Research does not, at the moment, intend to construct larger units as it is considered too early to predict the lines along which fuel cells will be developed. Their work is continuing and includes a study of fuels other than hydrogen.

The cell illustrated consists of 20 units and produces 50W. Although in this laboratory model the end plates are made of mild steel, plastic material could be used for this purpose and would result in a considerable reduction in weight.

Sampling the electrolyte in an experimental cell



A Cascode Trigger Circuit Using a PNP and NPN Transistor

By P. Arnoldt*, B.E.E.

A monostable trigger circuit employing a pnp and an npn transistor in a cascode arrangement is described. The circuit when preceded by a diode pump integrator forms a frequency dividing stage. Optimum conditions to ensure the safest operation with temperature variations are derived. Practical values for a stage reliably dividing by 10 over a temperature range of 5° to 50°C with input pulses of 100kc/s are given. The output pulse of such a stage is suitable for driving the input of a subsequent stage.

The trigger circuit can also be employed to generate sawtooth waveforms or operate as a time modulator.

(Voir page 666 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 674)

FREQUENCY division over a wide frequency range can be achieved employing the necessary number of binary scaling circuits with appropriate interconnexions. When division is required over a comparatively narrow frequency band, however, simpler arrangements such as thermionic valve circuits in conjunction with the diode pump circuit[1] can be engineered to divide reliably.

A pnp and an npn transistor can be connected in a cascode circuit arrangement to form a regenerative trigger circuit which, together with a diode pump circuit, can achieve safe division by at least 10 times. To form a divider, the capacitor C of the diode pump integrator in Fig. 4 can be connected to the input terminals of the trigger circuit of Fig. 1. After the desired number of input pulses when the voltage across C equals a preset value, a trigger action occurs and the input resistance of the trigger circuit changes from a high to a very low value causing C to be completely and quickly discharged. Output pulses which occur for the time that the transistors are hard on are available at a low source resistance and can conveniently drive subsequent dividing stages. The polarity of these pulses can be reversed by interchanging the pnp and npn transistors as well as the polarity of the supply.

The trigger circuit can also be used as a free running sawtooth oscillator or to generate a pulse which can be variably delayed with respect to an input pulse.

Operation of Basic Circuit

In most cases where the circuit may be used a capacitor is connected across the input terminals and so the basic circuit of Fig. 1 will be considered with this input connexion.

E_t has a magnitude less than the supply voltage E_s.

E_c has a magnitude just less than $E_s - E_t$ by an amount δV.

When e_{co} the voltage across C is less than E_t the trigger circuit is in the stable state because VT_1 is non-conducting and as a result VT_2 is held non-conducting. After C has been charged to a voltage equal to E_t, collector current will commence to flow in VT_1. The collector voltage of VT_1 will change in the positive direction and cause VT_2 to conduct. As a result the emitter voltage of VT_1 and VT_2 will change in the positive direction and make VT_1 conduct more. A regenerative loop exists and both VT_1 and VT_2 rapidly become hard on. The input resistance of the circuit becomes the sum of the base to emitter resistance of VT_1 and the collector to emitter resistance of VT_2. C discharges into this input resistance and when almost completely discharged VT_1 collector voltage commences to change in

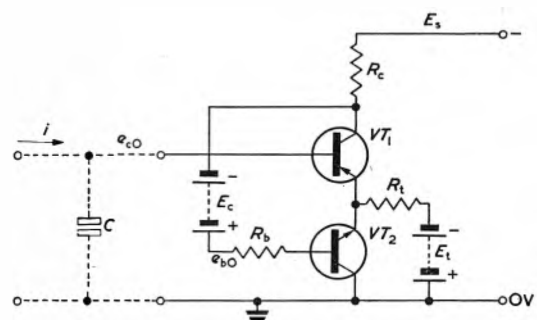


Fig. 1. Basic trigger circuit

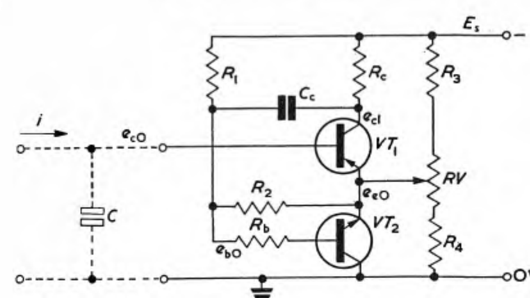


Fig. 2. Practical trigger circuit

the negative direction and the reverse action to that previously described quickly resets the circuit to the quiescent state provided that:

$$i < (E_s/h_{fe1}R_c)$$

where h_{fe1} = static forward current gain of VT_1 in common emitter connexion.

The requirements for the 'off' and 'on' states are as follows:

In the 'off' state:

$$E_c = E_s - E_t - \delta V$$
$$e_{co} < E_t$$

In the 'on' state:

$$i_{b1} \geq (E_s/h_{fe1}R_c)$$

where i_{b1} = the base current of VT_1.

$$i_{b2} = (E_c/R_b)$$

* Sir W. G. Armstrong Whitworth Aircraft Ltd.

where i_{b2} = the base current of VT_2.

$$h_{fe2}i_{b2} \geqslant (E_t/R_t) + i_{e1}$$

where h_{fe2} = static forward current gain of VT_2 in common emitter connexion and i_{e1} = emitter current of VT_1.

$$\therefore\ (h_{fe2}E_c/R_b) \geqslant (E_t/R_t) + (E_s/R_c) + i_{b1}$$

The discharge time is an involved function of C and the trigger circuit parameters, some of which vary during the discharge.

It is not convenient to employ a battery in the coupling circuit and in most cases this can be replaced by an R and C network.

Practical Circuit

A more practical circuit arrangement is shown in Fig. 2. The battery supplying E_c in Fig. 1 has been replaced by R_1, R_2, and C_c. The battery E_t and R_t have been replaced by an equivalent potentiometer circuit connected across

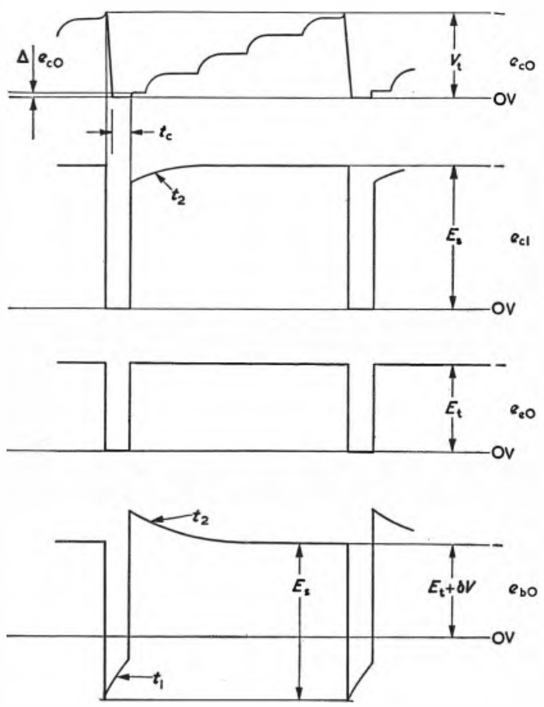


Fig. 3. Waveforms of the practical circuit operating as a frequency divider

the supply rails. The 'on' and 'off' conditions given for the basic circuit also hold for this circuit where:

$$R_t = \frac{(R_3 + RVx)(R_4 + RV(1-x))}{R_3 + R_4 + RV} \qquad (1 > x > 0)$$

and:

$$E_t = \frac{R_4 + RV(1-x)}{R_3 + R_4 + RV} \cdot E_s$$

In the 'off' or quiescent condition of the circuit, C_c is charged so that the voltage across it:

$$e_{co} = (E_s - E_t)\left(1 - \frac{R_2}{R_1 + R_2}\right)$$

$$e_{bo} = E_t + (E_s - E_t) \cdot \frac{R_3}{R_1 + R_2}$$

When the circuit has triggered to the 'on' state, C_c discharges towards 0V with a time-constant:

$$t_1 \simeq C_c \cdot \frac{R_2R_b}{R_2 + R_b} \qquad (R_1 \gg R_2)$$

This time-constant governs the time for which the 'on' condition holds and must be of sufficient duration to allow C to be completely discharged.

The condition:

$$i < (E_s/h_{fe1}R_c)$$

given for the basic circuit to reset need not hold in the practical case since the emitter current of VT_2 will commence to fall when C_c has been discharged to:

$$e_{cc} = (R_b/h_{fe2})\left((E_t/R_t) + (E_s/R_c) + i_{b1}\right)$$

causing the circuit to quickly reset to the 'off' state.

During the transition from the 'on' to the 'off' state a pulse of current flows into the discharged C producing a small step in voltage Δe_{co}. This is apparently caused by the effective capacitance of the reverse biased base to emitter junction of VT_1 being driven by the negative going voltage of the emitters e_{eo}.

When the circuit has reset to the 'off' condition C_c is recharged to its quiescent state with a time-constant:

$$t_2 \simeq C_c(R_c + R_2) \qquad (R_1 \gg R_2 \gg R_t)$$

The line joining the emitters can provide output pulses at a low impedance, also the collector of VT_1 is a convenient point to obtain pulses suitable for driving a subsequent stage.

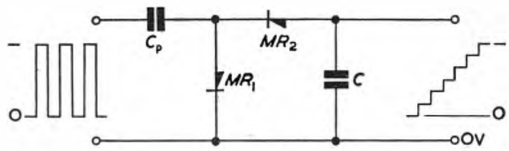


Fig. 4. Diode pump integrator

The waveforms showing the operation of the circuit in a frequency dividing stage are shown in Fig. 3.

Application to Frequency Division

A frequency dividing stage can be achieved by preceding the trigger circuit with a diode pump circuit, Fig. 4. The capacitor C in the previous discussion becomes the second capacitor in the pump circuit.

A square wave signal of the frequency to be divided is generated, the peak-to-peak voltage of which is equal in magnitude to E_s. This square wave voltage drives the diode pump and generates a staircase waveform across C. The desired number of pumps required to raise the voltage across C to E_t can be obtained by adjusting C_p.

The staircase voltage appearing across C will rise exponentially to E_s and for a required division of p times there is an optimum reference voltage E_t such that the amplitude of the voltage step which triggers the circuit will be a maximum. The larger this step can be made the greater the drift must become before an erroneous division occurs and hence the greater the safe temperature range of operation of the divider.

It has been shown[3] that the voltage v_p across C after p input pulses is given by:

$$v_p = E_s\left[1 - (C/(C_p + C))^p\right]$$

by putting $\dfrac{C}{C_p + C} = K$

$$v_p = E_s(1 - K^p)$$

Fig. 5 shows the last two steps in the staircase voltage across C. Ideally the trigger voltage v_t at which the circuit triggers should be midway between v_p and v_{p-1}. v_t is closely equal to the reference voltage E_t.

Let $v_p - v_{p-1} = \Delta v_p$

$$\Delta v_p = E_s (K^{p-1} - K^p)$$

$$\Delta v_p \text{ is a maximum when } \frac{\partial \Delta v_p}{\partial K} = 0$$

$$\frac{\partial \Delta v_p}{\partial K} = E\{(p-1)K^{p-2} - pK^{p-1}\}$$

$$= 0 \text{ when}$$

$$K = \frac{p-1}{p}$$

Also for optimum operation:

$$v_t = v_p - (\Delta v_p/2)$$

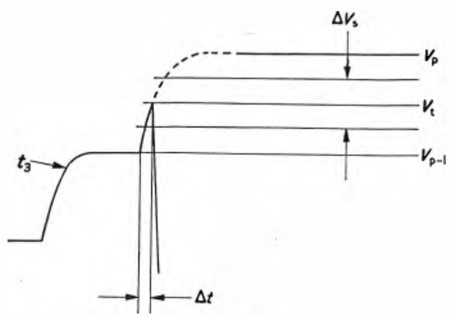


Fig. 5. Last steps in voltage across C

For $p = 10$, $K = 0{\cdot}9$ and if $E_s = -12\text{V}$:

$$\Delta v_p = 0{\cdot}47\text{V}$$

$$v_p = 7{\cdot}82\text{V}$$

$$v_t = 7{\cdot}58\text{V}.$$

Since v_t and E_t are directly proportional to E_s small changes in E_s do not change the optimum triggering condition and a highly stable h.t. supply is therefore unnecessary.

Departure from the optimum triggering condition can be caused by drift due to temperature in either the diode pump or the trigger circuit. Drift in v_p and v_{p-1} results from changes in C_p, C, the forward and reverse resistances of MR_1 and MR_2, the base emitter leakage current of VT_1 and Δe_{co}.

Changes in v_t can be caused by variations of the base emitter voltage of VT_1 at which the trigger action commences as well as changes in E_t owing to variations in the cut-off emitter currents of VT_1 and VT_2.

It is only necessary in this application to maintain the triggering point within the safe limits Δv_s. One method of achieving this is to connect R_1 to the 0V supply line and so adjust the change in the cut-off emitter current of VT_2 and hence E_t with temperature. In this way v_t can be adjusted to vary so that the triggering point is kept within the safe limits.

The position of the triggering point varies when the frequency of the input pulses is changed. Leakage paths across C cause this and it is this consideration which leads to the choice of a practical value for C.

The collector voltage e_{c1} is a suitable waveform for driving another dividing stage which is identical except for C_p, C and C_o which are all increased by a factor of p.

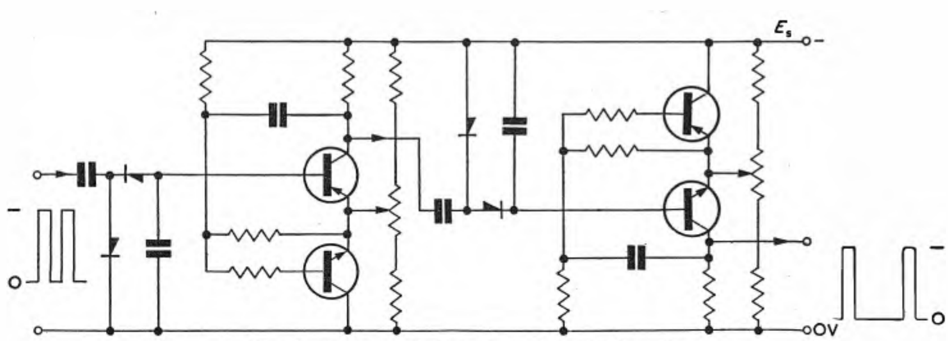


Fig. 6 Two cascaded complementary dividing stages

Any number of stages can be cascaded, division by p^n requiring $2n$ transistors.

If it is necessary to keep the time delay Δt between the leading edge of the output pulse and the leading edge of the corresponding input pulse to a minimum value, the time-constant:

$$t_3 \simeq R_g \cdot C_p \qquad (C_p \ll C)$$

should be made as low as possible by decreasing R_g, the generator resistance. This can be done by ensuring that the transistor of the driving circuit is 'on going' when C_p and C are being charged.

Fig. 6 shows two cascaded dividing stages, the second stage being the complement of the first. This connexion allows the least delay between the output pulse and its corresponding input pulse.

Experimental Results

Safe division by 10 has been achieved with 100kc/s input square waves driving a circuit having the following values:

MR_1 and MR_2	:	GEX54
VT_1	:	OC45
VT_2	:	OC140
C_p	=	86pF (high stability)
C	=	1 000pF ,, ,,
C_o	=	1 000pF ,, ,,
C_b	=	220pF ,, ,,
R_o	=	2·7kΩ
R_b	=	10kΩ
R_2	=	10kΩ
R_1	=	∞
R_4	=	750Ω (high stability)
R_3	=	1·2kΩ ,, ,,
RV	=	200Ω (wirewound).

C was reduced from 2 000pF in order to keep Δt less than 1μsec. However, had an npn transistor been used in the driving stage, C could have been at least 2 000pF resulting in a decreased Δe_{co}. C_b was connected in parallel with R_b in order to speed up the regenerative transitions. Rise- and fall-times during the regenerative transitions were less than 0·5μsec for all waveforms. t_c was 6μsec and Δe_{co} was 1V. The circuit operated within safe limits over the temperature range 5 to 50°C with the potentiometer RV at a fixed setting.

A series of similar cascaded stages of the type shown in Fig. 2, giving division by 10^4 from 100kc/s input square-waves operated satisfactorily. The value of C in the first stage was 2 000pF increasing by a factor of 10 in each succeeding stage to 2μF in the last stage. Δe_{co} was negligible in the second and subsequent stages. This circuit divides safely over the input frequency range 80 to 120kc/s between temperatures of 5 and 50°C with a fixed setting on each potentiometer and is being used in ground equipment associated with an airborne tape recording system.

Other Applications

If a constant current generator is connected to the input of the circuit shown in Fig. 2, the voltage across C will rise linearly until $e_{co} = v_t$ when C will be quickly discharged and the linear charge recommenced. If the discharge current needs to be limited within the rating of the transistors a resistance of suitable value can be placed between C and the base of VT_1. A linear sawtooth voltage is available across C. The period of the oscillator can be varied by adjustment of RV and is directly proportional to E_t. When the potentiometer circuit is replaced by an active modulating stage of output resistance R_t, a time modulator is formed. The time between the trailing edge of any output pulse and the leading edge of the next pulse is directly proportional to the modulating voltage E_t. In either case the amplitude of the pulses available at the emitters will equal the modulating voltage.

If the current generator is repetitively pulsed, an output pulse can be formed which is variably delayed with respect to the start of the input current pulse. It is necessary for the circuit to reset as a result of the input current i falling to zero and not by the discharge of C_o. Hence the time-constant t_1 should be sufficient to ensure that transistor VT_2 is always held on until i falls to zero. In order to more quickly reset C_o the time-constant t_2 can be reduced if necessary by replacing R_2 with a diode. For the configuration of Fig. 2, the cathode of this diode is connected to C_c and the anode to the junction of the emitters. With this connexion, however, R_1 must be connected as shown so that the diode is slightly biased in the forward direction after C_c is recharged during the 'off' state. t_1 is thus increased and t_2 decreased as follows:

$$t_1 \simeq C_c\ R_b \qquad (R_1 \gg R_b)$$

$$t_2 \simeq C_c\ (R_c + R_t)$$

neglecting the forward resistance of the diode.

A further arrangement would be the circuit of Fig. 2 with C removed and the input terminals connected to a repetitive sawtooth voltage generator of suitable output resistance. The diode mentioned in the previous paragraph may be necessary to decrease t_2 to a suitable value. When the generator voltage reaches E_t, the circuit triggers on and stays on until the generator voltage falls quickly to zero and the circuit resets to its quiescent state. Output pulses are formed which can be varied in duration by E_t, the trailing edges of these pulses being coincident with the rapidly falling voltage of the sawtooth generator.

Silicon transistors may be necessary in some cases to achieve desired results.

Acknowledgments

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An Automatic Switch Testing Jig

With the development and increasing use of machines which produce articles in very large quantities, and of large flow-line production plants, a demand has arisen for reliable apparatus which will check the performance, measure, count and generally exercise a control over these machines or plants.

The General Electric Co Ltd has developed various static control equipments which make use of cold-cathode triodes, magnetic amplifiers and transistors, either separately or in combination. A typical application of such an equipment using cold-cathode triodes, is that employed on an automatic domestic-switch testing jig installed at the Witton Works of the Company's Engineering Group.

Designed and developed by the Company's Laboratories at Witton, the jig is being used for testing individually the G.E.C. 'Clipper' switches which are the latest addition to the 'Mutac' range of domestic switchgear. The equipment is capable of performing four separate tests on every switch to prove that:

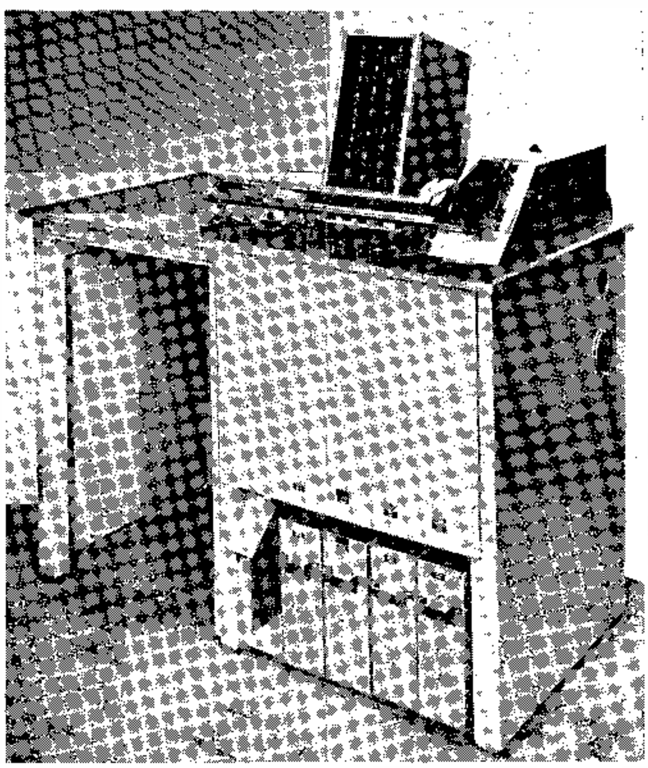
(1) The circuit is made with the switch in the closed position.
(2) The switch does not break the circuit too early in its travel.
(3) The switch does break circuit.
(4) The switch will re-make the circuit, and the dolly will return to the 'on' position by itself from the point of break.

The switches are tested at normal voltage and at 20 per cent over-current, at a rate of approximately one per second. Faulty switches are sorted and distributed to four separate bins and automatically counted. Satisfactory switches are fed to a box in front of the machine. Logic circuits incorporating cold-cathode discharge tubes are used for detecting the various types of fault and for initiating the sorting movements, which are then carried out by a pneumatically-powered mechanism.

The switches are loaded by the operator, into a channel type magazine, from which they are fed by a weight and pulley system into the testing position in the jig. Once loaded, the jig continues to test, without further attention.

The method of using the cold-cathode tubes in this application is that of 'voltage transfer. In this system it is arranged, by means of rectifier gating circuits, that the presence or absence of signals on intermediate tubes controls the passage of signals through the circuit; the tubes being connected in AND and OR gates as required.

The complete automatic testing jig for domestic switches



The Use of the Silicon Resistor in the D.C. Stabilization of Transistor Circuits

By D. H. Mehrtens*, B.Sc., and J. T. Zakrzewski*, A.M.Brit.I.R.E.

A new method of stabilizing the d.c. operating point of transistors, using the silicon resistor, is introduced and its application to both small-signal and power transistors is expounded. Practical evidence is given to show that it is possible, with this method, to obtain constant collector current over the whole operating temperature range of transistors in the great majority of cases.

(Voir page 666 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 674)

IN recent years the transistor has been rapidly replacing the thermionic valve in many applications, particularly where small size and low power consumption are required. There is every reason to believe that the rate of replacement will be maintained for some years to come, particularly as the outstanding problems of transistor manufacture and applications are overcome.

This article deals with one of the most undesirable effects in transistors from the viewpoint of the applications engineer, that of the variation of the d.c. working point with changes in ambient temperature—a phenomenon which places a severe limitations upon the exploitation of the potential high efficiency of transistor circuits compared with thermionic valve circuits.

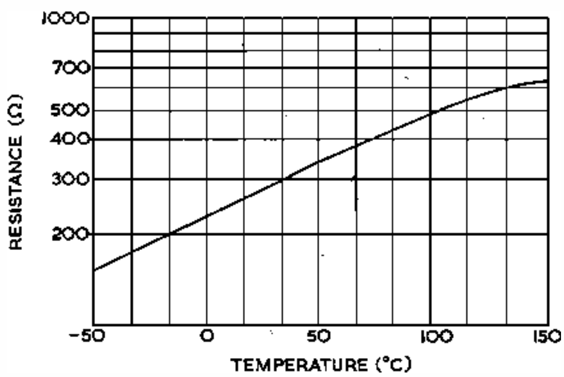


Fig. 1. Variation of resistance with temperature of the silicon resistor

The usual methods of stabilization are well known and are dealt with fully in the literature[1,2,3,4,5]. This article will deal with methods of using the silicon resistor for stabilization and to begin with the action of this device will be considered.

The silicon resistor is a newly available component with a positive resistance-temperature coefficient of about 0·7 per cent/°C. Fig. 1 shows the temperature/resistance characteristics of a typical sample.

The positive temperature coefficient is produced by doping the silicon with impurity elements to such an extent that the silicon is in the saturation region over the temperature range of interest, i.e. -50°C to $+150$°C. In this range the temperature is high enough to make the probability that all the impurity sites are ionized very great, but low enough for the probability that the valence band electrons have not enough energy to enter the conduction band to be also very great. Hence the number of carriers is substantially constant over the temperature range, and thus the only factor which affects the resistivity to any great extent is the thermal scattering of the carriers, which increases with rise in temperature in much the same way as in metals. Fig. 2 shows the simple band structure of an n-type semiconductor with impurity levels, all ionized.

It can be seen that as $E_a \ll E_g$, the requirement that all the impurity levels be ionized, but that interband transitions are forbidden, is easily met. Fig. 3 shows a plot of carrier density against the reciprocal of absolute temperature.

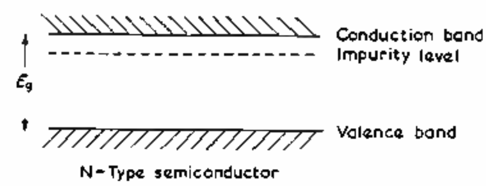


Fig. 2. Band structure of a simple semiconductor

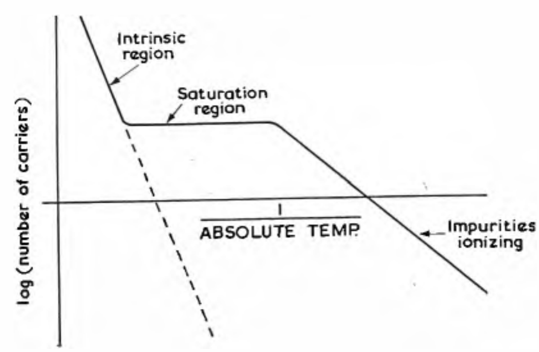


Fig. 3. Variation of charge density with temperature for a simple semiconductor

Fig. 4 shows a typical characteristic of conductance against the reciprocal of temperature for n-type silicon. The saturation region is clearly shown.

Methods of Stabilization

General Considerations

The main changes that cause a change in collector current are:

(a) An increase in I_{co}, the leakage current
(b) A change in $V_{b'e}$, the base-emitter voltage
(c) A change in β, the d.c. current gain of the transistor.

These changes usually cause the collector current to increase.

It will be convenient to consider separately the stabilization of power transistors from that of 'small signal'

* *E.M.I. Electronics Ltd.*

transistors, since different approaches to the problem are required for each type.

Small Signal Transistors

The term 'small signal' transistor is intended here to imply the low power transistor such as that used for voltage amplifiers, in which the dissipation at the collector does not appreciably increase the junction temperature above ambient. Also it is assumed that $V_{b'e}$, the base-emitter voltage of the intrinsic transistor, falls with increasing temperature.

Silicon Resistor Configuration

This discussion refers to the use of the silicon resistor in the configuration of Fig. 5.

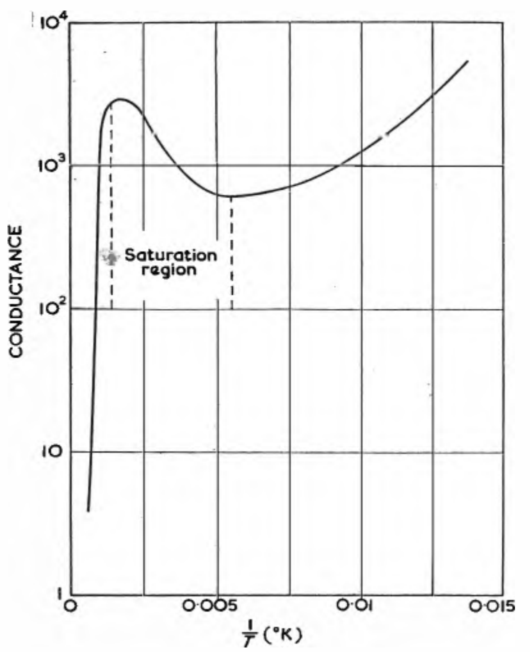


Fig. 4. Typical variation of conductance with temperature for silicon

The action of the circuit is briefly as follows:—

As the temperature rises, $V_{b'e}$ falls, and the resistance of the silicon resistor rises causing the voltage at the emitter of the transistor to rise in turn and correct for this effect, and also for the effect of I_{co}'.

Now it can be shown that $V_{b'e}$ changes with temperature according to the equation

$$\frac{dV_{b'e}}{dT} = \frac{V_{b'e} - E_g/q}{T} \quad \text{.. (Appendix equation (9))}$$

at constant emitter current, where E_g is the energy gap of the semiconductor, and T is the absolute temperature. Surprisingly, such literature as is available on this subject, tends to quote a somewhat arbitrary value for this rate of change, of anything between $-1{\cdot}9$mV to $-2{\cdot}6$mV/°C, in spite of the availability of this simple relationship.

It will be noted that if E_g/q is greater than $V_{b'e}$, the the value of $dV_{b'e}/dT$ will be negative but will be positive if $V_{b'e}$ is greater than E_g/q. The latter point does not appear to be widely recognized and will be returned to later.

It can also be shown, by analysing the d.c. conditions of the transistor circuit and then considering incremental changes in the various parameters, that the change in resistance of the silicon resistor required for complete stabilization is given by:—

$$\delta R_E = \frac{\delta V_{b'e}\dfrac{\beta}{1+\beta} + \delta I_{co}'\dfrac{R_b+R_E}{1+\beta}}{I_c - \dfrac{I_{co}' + \delta I_{co}'}{1+\beta}} \quad \text{.......... (1)}$$

where R_b is the d.c. base resistance, and changes in β are assumed to have negligible effect.

In general there will be two cases of interest, namely:—

(a) When the terms containing $\delta I_{co}'$ are small compared with the others.

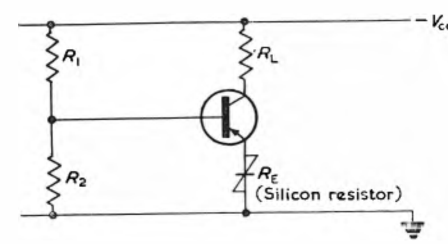


Fig. 5. Small signal stabilization circuit

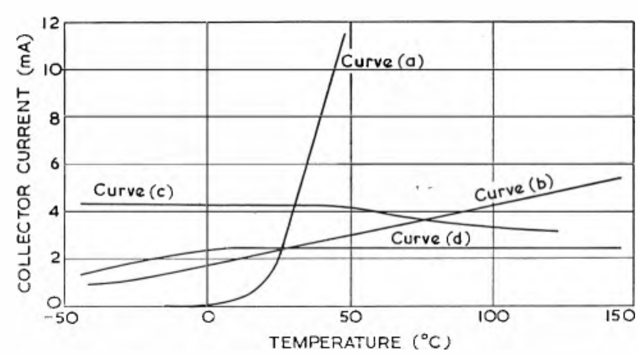


Fig. 6. Variation of collector current for the circuit of Fig. 5:—
(a) No emitter resistor
(b) Carbon emitter resistor
(c) & (d) Silicon emitter resistor

The equation then reduces to:—

$$\delta R_E = \frac{\delta V_{b'e}}{I_c}\frac{\beta}{1+\beta} \quad \text{.................. (2)}$$

(b) When the terms containing $\delta I_{co}'$ are not negligible, and thus no approximation is valid.

These two cases need separate attention if complete stabilization is to be obtained.

In case (a) it can be seen that as $dV_{b'e}/dT$ is a linear function of temperature, it is necessary, for stabilization to be achieved that dR_E should also be a linear function of temperature. Now the silicon resistor has an approximately exponential response with temperature, as shown in Fig. 1, and thus as the temperature rises, with this device incorporated in the emitter circuit alone, the change in emitter resistance would exceed the required amount—thus I_c would need to fall to balance the equation and the circuit would be over-stabilized.

Thus when using the silicon resistor alone in the emitter circuit, stability will be obtained only over the range in which R_E changes at an approximately linear rate with temperature. In case (b), where the full equation must be used, it may be possible to obtain complete stability over a much wider range, using the silicon resistor alone in the emitter, because in this case dR_E is no longer required to be linear, but is required to increase at high temperatures due to the influence of the terms containing I_{co}', a requirement which is met by the basic characteristic of the silicon resistor. This point will be given further consideration later on.

The results obtained in testing these arguments in the case when $\delta I_{co}'$ is negligible are indicated in Fig. 6.

The four curves show the change in collector current with temperature as follows:—

(a) With no emitter resistor

(b) With a zero temperature coefficient emitter resistor

(c) With a silicon resistor in the emitter circuit

(d) As (c) but with lower current at room temperature.

Effects which should be noted are: the very low value to which the collector current falls at low temperatures in

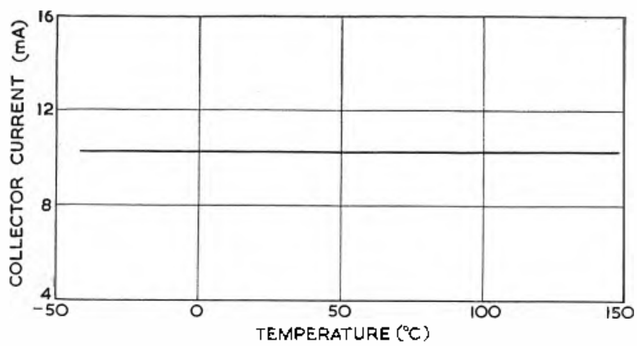


Fig. 7. Variation of collector current for the circuit of Fig. 5:— Parallel carbon and silicon resistors in the emitter line

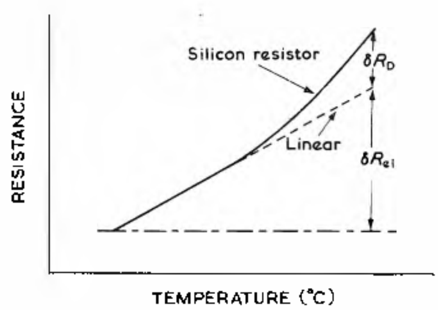


Fig. 8. Deviation from linearity of the silicon resistor characteristic

case (a), the still large change in case (b) and the predicted changes in cases (b) and (c) where the characteristics have a level section in which the resistance of the silicon resistor changes in an approximately linear manner with temperature.

In order to extend the level portion over the whole operating temperature range in this case, it is necessary for dR_E/dT to be constant. It can be shown that if the silicon resistor is shunted by a carbon resistor (R_S) of the correct value, the relationship will be linear to a good approximation. It has been found that, for the particular silicon resistors used by the authors over a range $-50°C$ to $+150°C$ the value of the shunting resistor R_s was given by:—

$$R_S = 4{\cdot}0 \ \delta R_E \ \ldots\ldots\ldots\ldots\ldots\ (3)$$

hence, by deriving δR_E from equation (2) the value of R_S may be obtained.

It can also be shown that this value is equal to the mean resistance of the silicon resistor in the temperature range. Thus, the values of both the silicon resistor and shunting resistor required may easily be calculated.

A graph obtained using a circuit with R_S selected in this way is given in Fig. 7, the remarkably high stability achieved is well evidenced.

It should be emphasized at this stage that accurate measurements of I_{co}', $V_{b/e}/I_b$, I_b/I_c variations were made by the authors for these calculations.

When the effects of $\delta I_{co}'$ are appreciable, it is possible to stabilize with a silicon resistor alone as follows.

Referring to Fig. 8 the deviation from linearity of the silicon transistor characteristic is δR_D. Now by calculating the value of δR_E from equation (2) δR_{e1} is obtained. If the calculation is then repeated using equation (1), and

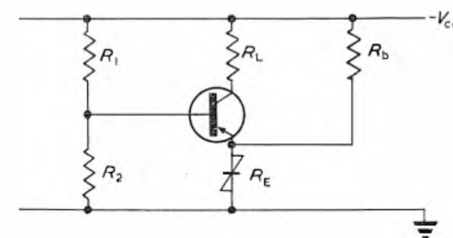


Fig. 9. A circuit for the stabilization of low collector current stages

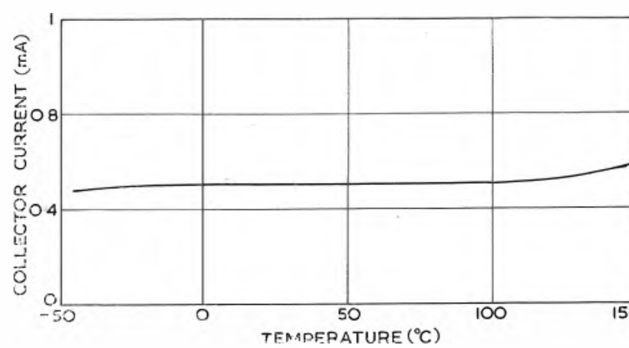


Fig. 10. Variation of collector current for the circuit of Fig. 9

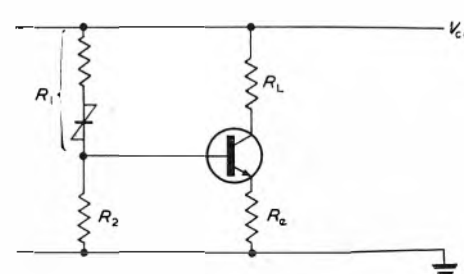


Fig. 11. Circuit for the stabilization of power stages using a silicon resistor in the bias chain

the increased value of δR_E obtained is equal to $\delta R_{e1}+\delta R_D$, stabilization will be obtained without the need for shunting of the silicon resistor. These two calculations will also permit an estimate of the increase in value of the shunting resistor required when $\delta I_{co}'$ is intermediate between the negligible and the appreciable categories.

The stability of the first stage of a d.c. amplifier is of the greatest importance, as any drift in this stage is amplified by the succeeding stages. Unfortunately, to minimize noise generation this stage is often operated at low currents. This would lead, with the circuit shown in Fig. 5 to the need for a silicon resistor of high resistance for stabilization. However, there is a method which may be employed to obviate this disadvantage, using the circuit of Fig. 9, in which it can be seen that an additional source of current through the silicon resistor is supplied via R_b.

The method has the disadvantage that, unless a very high V_{cc} is available and thus R_b is large and approximates to a constant current source, the current through the silicon resistor will not be constant, and thus the collector current will vary, reducing the degree of stabilization. In Fig. 10 is shown the result obtained using such a circuit, designed solely from manufacturer's data on the silicon resistor and transistor.

Power Transistors

The d.c. stabilization of power transistors, particularly those used in output stages presents different problems to those presented by small-signal stages. The problem may best be discussed under two main headings, namely:

(a) Class-*A* stages.

(b) Class-*B* stages.

The essential difference as far as stabilization is concerned is that under class-*A* conditions the quiescent emitter current is high, and under class-*B* conditions it is

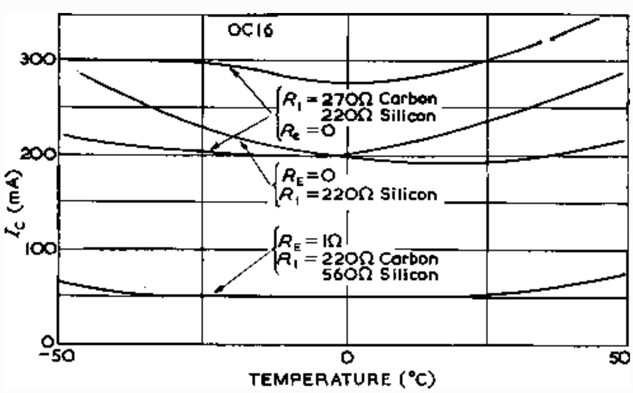


Fig. 12. Variation of collector current under various conditions for the circuit of Fig. 11

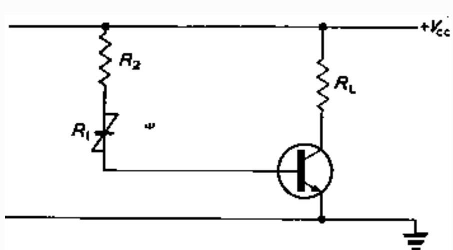


Fig. 13. Circuit for the stabilization of power stages using constant current biasing

low (often not much greater than I_{co}', the theoretical minimum). It is easily seen that it is undesirable to place the silicon resistor in the emitter circuit, as it will absorb appreciable power, cause a substantial voltage drop, and in class-*B* stages it could not be by-passed.

For these reasons, it was decided to consider the configuration shown in Fig. 11 in which the silicon resistor is included in the base bias chain.

It can be shown that the resistance value of the silicon resistor is,

(a) Approximately independent of the collector current.

(b) Dependent on temperature in a complex manner.

(c) Dependent on R_1, R_2, and V_{cc} in a complex manner.

As a result, it is extremely difficult to arrive at an optimum resistance value for it. Fig. 12 shows the result of some attempts to solve this equation for class-*A* stages. It will be seen that the results are poor compared with those for small signal stages.

For the stabilization of Class-*A* stages, it has been found that constant current biasing leads to a requirement for a silicon resistor with a linear-resistance temperature characteristic (Fig. 13).

The outstanding difficulty associated with this method is that effects due to changes in β are particularly severe, and may influence the value of δR_1.

It is easily shown that the value of δR_1 required is given by:—

$$\delta R_1 \simeq \frac{\delta V_{b'e}}{I_c}\,\beta + \delta\beta/\beta\,(R_1 + R_2 + R_{bb'}) \quad \ldots\ldots\ldots (4)$$

if effects of I_{co}' are small.

It is now appropriate to reconsider the equation for the change in base-emitter voltage ($V_{b'e}$) with temperature (Appendix equation (9); quoted earlier). It has been noted that if $V_{b'e}$ was greater than E_g/q the change would be positive. This situation only appears to exist in grown-

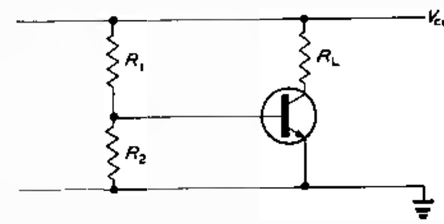


Fig. 14 A stage which is self stabilizing under special conditions

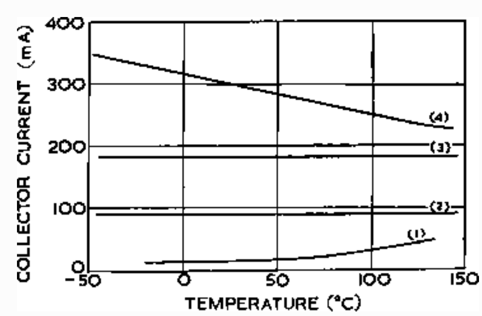


Fig. 15. Variation of collector current for the circuit of Fig. 13:—
(1) *under-stabilized*
(2) *fully-stabilized*
(3) *self-stabilized*
(4) *over-stabilized*

junction transistors which normally have a high $V_{b'e}$ for normal currents. By putting δR_1 of equation (4) equal to zero it can be seen that a positive change in $V_{b'e}$ would cause a drop in collector current and that this drop can be exactly balanced by the increase in collector current caused by the increase in β.

This condition occurs when:

$$\frac{\delta V_{b'e}}{I_c}\,\beta = \delta\beta/\beta\;R \text{ ignoring the effects of } I_{co}'$$

$$\text{where } R = (R_1 + R_2 + R_{bb'})$$

$$\text{now } R = \frac{V_{cc} - V_{b'e}}{I_c}$$

hence:

$$\delta V_{b'e} = \delta\beta/\beta\,(V_{cc} - V_{b'e}) \quad \ldots\ldots\ldots (5)$$

and is thus only dependent on the collector current in so far as it is a function of $V_{b'e}$. Thus in design for the balance point only V_{cc} need be considered.

A further method of stabilization usually applicable to class-A stages only, may be used if the stage may be biased at or near the point where $V_{b'e}$ is equal to E_g/q and hence $dV_{b'e}/dT$ is nearly zero.

Consider the standard configuration of Fig. 14.

The stage illustrated is self-compensating if it is biased such that $dV_{b'e}/dT$ is slightly positive and balances the change in I_c due to change in β. The last effect will usually be small, and the condition for stability is reached when:

$$\delta V_{b'e} = (I_c/\beta).\ R_p.(\delta\beta/\beta)$$

where $R_p = (R_1R_2)/(R_1 + R_2) + r_{bb'}$

In the constant current biased case the effects of $d\beta/\beta$ are large, and as $d\beta/\beta$ tends to diminish at high temperatures it tends to correct for changes in I_{co}'. However, in this case the effect is quite small and compensates less well for the effect of I_{co}'.

Results Obtained from Stabilized Class-A Stages

Some results obtained in practice using the above methods of stabilization with constant current biasing are shown in Fig. 15.

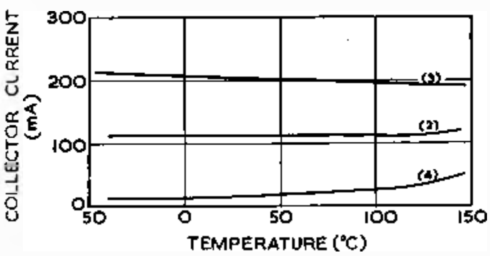


Fig. 16. Variation of collector current for the circuit of Fig. 14:—
(1) *under-stabilized*
(2) *self-stabilized*
(3) *over-stabilized*

Curve (1) shows the collector current increasing with increase in temperature. In this case $dV_{b'e}/dT$ is negative, as is normal for small signal transistors. Curve (2) results from the base-emitter voltage increasing with temperature to such an extent that it overcomes the effects of increasing current gain (β), and causes the collector current to decrease with increase in temperature. Curve (3) shows the optimum characteristic: in this case the effects of change in $V_{b'e}$ are being balanced by the change in β. Constant collector current over a wide temperature range is obtained and the characteristic compares well with that obtained for small signal transistors. Curve (4) shows the results obtained using a silicon resistor to stabilize the current, at a value at which the effects of changes in β are not large enough to balance changes in $V_{b'e}$. It should be noted that the silicon resistor used had a resistance of 500Ω, demonstrating the fact that the optimum resistance values of the silicon resistor for low current stabilization are high.

Fig. 16 shows results obtained using the conventional biasing method.

Curve (1) exhibits the now familiar fall in collector current with temperature. There is little fear of thermal runaway in this case as no external temperature device is used for stabilization. Curve (2) shows a self stabilized circuit where the change in $V_{b'e}$ is almost zero, and only slightly positive thus correcting for the small effect of the change in β with temperature, as explained above. It will be noted that the effects of I_{co}' are in evidence as would be expected from the theoretical considerations outlined earlier.

It should be noted that the inclusion of a temperature sensitive device in a transistor circuit, does not, by itself, prevent thermal runaway, so that the two cases where the transistor is self-stabilizing are extremely important in that there is no fear of thermal runaway if the stabilization technique is correctly applied.

The Stabilization of Class-B Stages

The stabilization of class-B stages has been found to present considerable difficulty, and while it is possible to achieve very good stabilization using the silicon resistor, compared with conventional methods, it has not been possible to obtain complete stability of collector current over the whole operating temperature range. In most cases of interest, constant current biasing cannot be used as the resistance of the silicon resistor would be impracticably high.

At a certain value of bias voltage $dV_{b'e}/dT \rightarrow 0$ but the bias voltage of a class-B stage is usually selected for too low a value of I_c to allow use of this fact in stabilization. In some cases, however, where high power transistors are concerned, it may be necessary to bias at relatively high currents to avoid crossover distortion and under this condition the method described for class-A stabilization may be applied.

It would appear that the only practicable method for general application would be that of Fig. 11 employing a base resistor. The authors have obtained reasonable results using this method but feel that unless the relevant parameters are known to a high degree of accuracy, empirical methods will generally be used in these applications.

Conclusion

It has been shown that, using the silicon resistor it should be possible to obtain constant collector current over the whole operating temperature range of currently available transistors, in the great majority of cases. The main exception would appear to be power transistors operated under class-B conditions. The important case of power transistors operating under class-A conditions, when the circuit is self-stabilizing and no external stabilizing device is required, has been dealt with at some length.

The following transistors were used in the tests described:

pnp germanium alloyed
pnp silicon alloyed
npn silicon grown.

There appears to be no reason why the methods derived should not be applicable to other types of transistor as well.

Appendix

The Variation of Base Emitter Voltage, $V_{b'e}$, with Temperature

It can be shown that the current across the base-emitter junction in a transistor is given approximately by the equation:

$$I = (qD_PC/W)\exp(-E_g/kT)\exp(qV_{b'e}/kT) \quad \dots\dots (6)$$

where q = charge on carriers
D_P = diffusion constant
W = width of base region
E_g = energy gap of semiconductor
k = Boltzmann constant
T = absolute temperature

$V_{b'e}$ = intrinsic base-emitter voltage

C = a constant

for a pnp transistor, with a similar expression for npn transistors. Rewriting the above equation while keeping I constant:

$$I_o = A \exp\{(qV_{b'e}/kT) - (E_g/kT)\} \quad \ldots\ldots \quad (7)$$

where A is a constant of the transistor $= qD_bC/W$ and

$$\ln(I_o/A) = (qV_{b'e}/kT) - (E_g/kT) \quad \ldots\ldots\ldots\ldots \quad (8)$$

differentiating $V_{b'e}$ with respect to T then:

$$\left(\frac{\partial V_{b'e}}{\partial T}\right)_{I_o} = (k/q)\ln(I_o/A)$$

(assuming that $E_g \neq f(T)$)

$$\text{i.e.:} \quad \left(\frac{\partial V_{b'e}}{\partial T}\right)_{I_o} = \text{a constant.}$$

now from equation (3) above:

$$\ln(I_o/A) = (qV_{b'e}/kT) - (E_g/kT),$$

$$\text{hence} \quad \left(\frac{\partial V_{b'e}}{\partial T}\right)_{I_o} = \frac{V_{b'e} - (E_g/q)}{T} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

hence if $V_{b'e}$ is in volts

and E_g is in electron volts (eV)

$$\left(\frac{\partial V_{b'e}}{\partial T}\right)_{I_o} \text{ is in volts per degree.}$$

NOTE E_g is not completely independent of temperature but the effect is small in the temperature range under consideration. Typical values for E_g are:

Germanium: 0·78eV
Silicon: 1·1eV

Acknowledgments

The authors acknowledge with thanks the permission granted by the Directors of E.M.I. Ltd to publish this article.

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I.L.S. Installation at London Airport

The completion of work on the first installations of the new STC Instrument Landing System at London Airport was announced recently.

Designed and manufactured by Standard Telephones and Cables Limited, this equipment, known as STAN 7/8, was exhaustively evaluated by the Ministry of Aviation at Hurn Airport last year and has been ordered for installation at many major airports including Gatwick, Prestwick, Ringway and Renfrew. Overseas installation work is in progress at Brussels and Zurich.

The STAN 7/8 represents a major advance in i.l.s. ground equipment techniques in respect of beam stability and equipment reliability.

There are three main elements in the London Airport installations: the localizer, for azimuth guidance; the glide path, for elevation guidance; and the monitoring and remote control equipment for system supervision. No. 1 runway is equipped for landings from either direction and has two separate and independent sets of equipment.

The localizer operates on any one of 39 channels within the 108·1 to 111·9Mc/s band and provides guidance in the horizontal plane (azimuth) with respect to the runway centre line.

The transmitter consists of two identical r.f. and modulator sections which feed two independent aerial arrays. The composite radiation pattern consists of two signal zones from the main 'course' array, plus two signal zones from the smaller 'clearance' array, modulated at 90c/s and 150c/s and lying on either side of the runway centre line. The basic frequencies of the two coarse and clearance arrays differ by 9·5kc/s.

The clearance pattern is, in effect, a rough guide to the pilot as to which side of the approach runway he is flying. Upon reaching the narrow 'course' radiation pattern his receiver takes up and indicates the information from this narrower and stronger beam.

The clearance array provides non-ambiguous and useful navigational information throughout 360°, and in addition, a 'back course' to facilitate navigation into the front course.

Operated on any one of 21 pre-set channels, the glide path equipment gives guidance information in the vertical plane (elevation) to enable the aircraft to arrive at the correct height over the end of the runway. The r.f. and modulator sections of the glide path equipment are basically similar to a single section of the localizer transmitter.

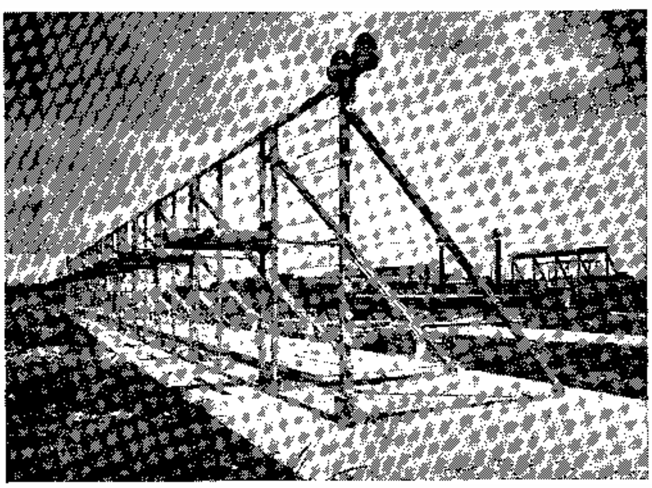
The composite aerial radiates, on a common frequency, two patterns modulated at 90c/s and 150c/s. This produces two signal zones lying above and below and overlapping the desired glide path.

The STAN 7/8 equipment employs a constant impedance double sideband mechanical modulation system. This modulator has considerable advantages over others in that, apart from its substantially constant input impedance; it is less complex and not subject to variations which may occur due to the ageing or failure of valves and other electronic components.

The new STAN 7/8 Instrument Landing System differs from other static systems in having greater freedom from course bends resulting from site imperfections and from the dangers of radiating false course information. This is achieved by the use of an extremely narrow beam for course guidance and the clearance radiation pattern which effectively masks any reflections which may arise from secondary lobes.

In addition to these features, the overall system reliability is ensured by a comprehensive, fully transistorized fail/safe monitoring system linked to a refined, fully automatic change-over unit.

An STC Instrument Landing System installation at London Airport: in the foreground is the 'course' aerial array (85ft wide by 12ft high) and in the background is the 'clearance' array (9ft wide by 13ft high)



'ISABEL'

(Iso Status Accumulating Binaries using Extraordinary Logic)

By J. A. Goss*, B.Sc., A.R.C.S.

An improved logical arrangement of a decimal counter based on bistable elements is described. The advantages over usual methods are described, and the performance of various circuits using this method is given.

(Voir page 666 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 674)

To construct an aperiodic counter stage to operate in a radix (scale) of n, it is necessary to have a device or circuit which is capable of remaining in any one of n stable states indefinitely, but can be switched successively through its n states on receipt of input pulses. In order to drive succeeding stages, a carry signal must be available when the state changes from (n-1) to 0.

If n can be factorized into n_1, n_2 .... a scale of n counter can be realized by cascading independent stages counting in scales of n_1, n_2 .... In the usual case of $n = 10$, the factors are 2 and 5.

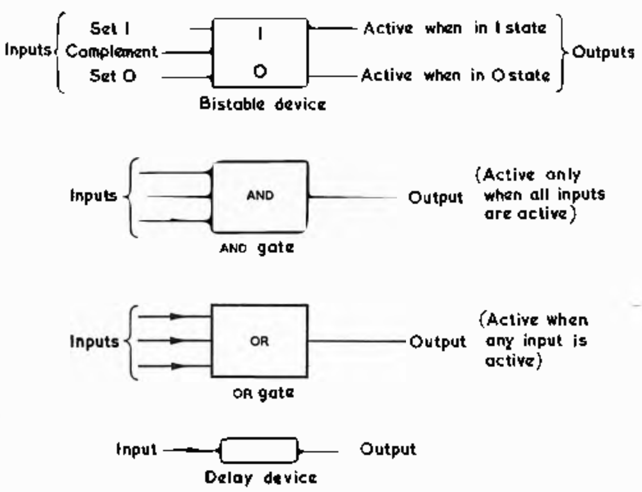


Fig. 1. Logical symbols

Owing to the well defined 'on/off' characteristic of various electronic devices, circuits operating in a scale of 2 can be readily realized using standard components. To construct a symetrical 'ring' of n elements which is n-stable is unwieldy (increasingly so as n increases) unless each element is bistable independently of the state of the other elements. This is uneconomic since n elements will count in a scale of n when arranged as a ring, but 2^n as cascaded binaries.

This situation has led to the universal adoption of radix 2 for computers, and the realization of decimal counters either by constructing special 10 stable devices (e.g. Dekatrons and Trochotrons), or by modifying the interconnexions of four cascaded binaries.

Existing Methods of Modifying Binaries to Scale of Ten

Since m independent binaries have 2^m different states, four binaries are required to provide 10 states, and the circuit must be arranged to step through 10 of the possible 16 states in one cycle. It is convenient to 'factorize' the system, i.e. have independent binary and scale of 5 circuits cascaded.

Feedback Methods

Fig. 1 shows the logical symbols used throughout this discussion; it should be noted that a bistable device with a 'complement' (change state) input contains implicitly two AND gates and two delays to provide the temporary store ('steering' circuits). A straightforward scale of 16 cascaded binary counter is shown in Fig. 2. This may be conveniently divided by the dotted line into a binary (left) and scale of 8 (right). It can be shown that to reduce the 8 states to 5, two feedback paths are required. There are

Fig. 2. Scale of 16

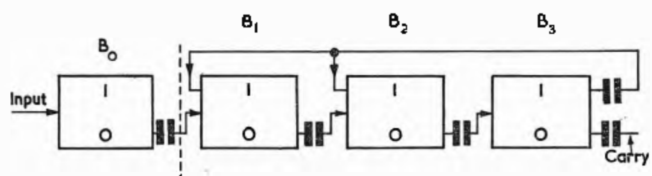


Fig. 3. Scale of 10 (feedback method)

various logical arrangements of these feedback paths, one of which is shown in Fig. 3. The circuit counts in the normal binary scale until reaching 0111 (decimal 7); (note that in giving the state of the counter as a four digit binary number, the first digit corresponds to the state of B_3, the second to B_2, etc.). The 8^{th} input pulse changes B_3 to 1 and a pulse is fed back to reset B_1 and B_2 to 1, leaving the counter in the state 1110. Thereafter, normal binary counting proceeds and the 10^{th} input pulse leaves the counter at 0000.

The disadvantage of this system is that the resolution time of the decade is limited by the successive operations which take place at the 8^{th} input pulse, all of which inherently take a finite time. Also the carry pulse is delayed by four binary carry periods with respect to the 10^{th} input pulse. This is of no consequence when such decades are used as a totalizer, but is important in applications such as a digital time-base or delay generator.

Feed Forward Methods

Feed forward methods involve controlling the switching of some binaries according to the state of the other, rather than the straightforward carry and reset connexions in Fig. 3. One such method of constructing a decade is shown in Fig. 4. Assuming the binaries are initially at 0000, the count

* *Racal Engineering Ltd*

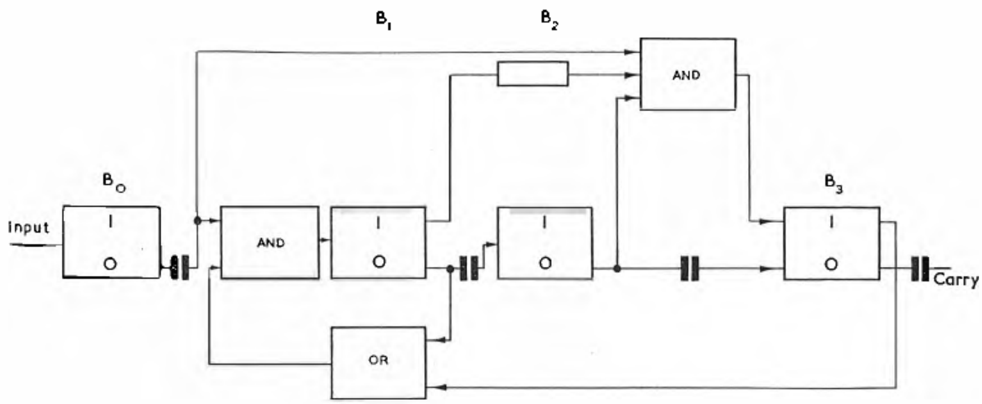


Fig. 4. Scale of 10 (feed-forward method)

It can be seen that flip-flop A requires to be 'set 1' on the next trigger pulse received whenever the decade is in the state 0, 3, 5 or 7. Hence the logical function required for the flip-flop input A_1 is derived from the flip-flop states corresponding to decimal 0, 3, 5 or 7, i.e. $\bar{A}\,\bar{B}\,\bar{C}\,\bar{D} + \bar{A}\,B\,C\,D + \bar{A}\,\bar{B}\,\bar{C}\,D + \bar{A}\,\bar{B}\,C\,D$. Similarly the function for the A_0 gates is $A\,\bar{B}\,C\,\bar{D} + A\,\bar{B}\,\bar{C}\,\bar{D} + A\,B\,\bar{C}\,\bar{D} + A\,B\,\bar{C}\,D$, and so on.

follows the normal binary scale until 0011 (decimal 3). On the 4th input pulse, the output pulse from B_0 is inhibited from complementing B_1, but can pass through to the 'set 1' input on B_3, and the decade is now in state 1010, i.e. 6 states of the normal binary count have been eliminated. The circuit thereafter counts in straightforward binary code and hence cycles on 10 input pulses. Note that the delay unit is logically necessary but in practice sufficient delay may be provided by propagation through B_1. The delay time must be longer than the width of the differentiated output from B_0 but shorter than the period between such pulses.

Although the number of successive operations which must take place within the resolution time has been reduced from four to one compared with Fig. 3 there is still the same delay of the carry pulse, and the physical construction of the gates will probably require more circuits than the feedback method.

Logical Arrangement of 'Isabel'

The evolution of the feed forward method which uses a combination of cascaded binaries and routeing of trigger pulses according to the state of some binaries suggests a system in which a common trigger pulse is routed to all binaries according to their state.

The logical arrangement of the general case of such a decade is shown in Fig. 5. The flip-flops A, B, C, D have only 'set 1' and 'set 0' inputs; 'complement' inputs are not provided (hence they cannot strictly be called binaries). Each flip-flop input is fed by an AND/OR gate combination; each AND gate having as its inputs the input pulse to the decade and the appropriate delayed outputs of the flip-flops. Such a decade is capable of counting in any 4 bit code, and the required inputs to the gates can be found by inspection of the code. For example, consider the arbitrary code in Table 1.

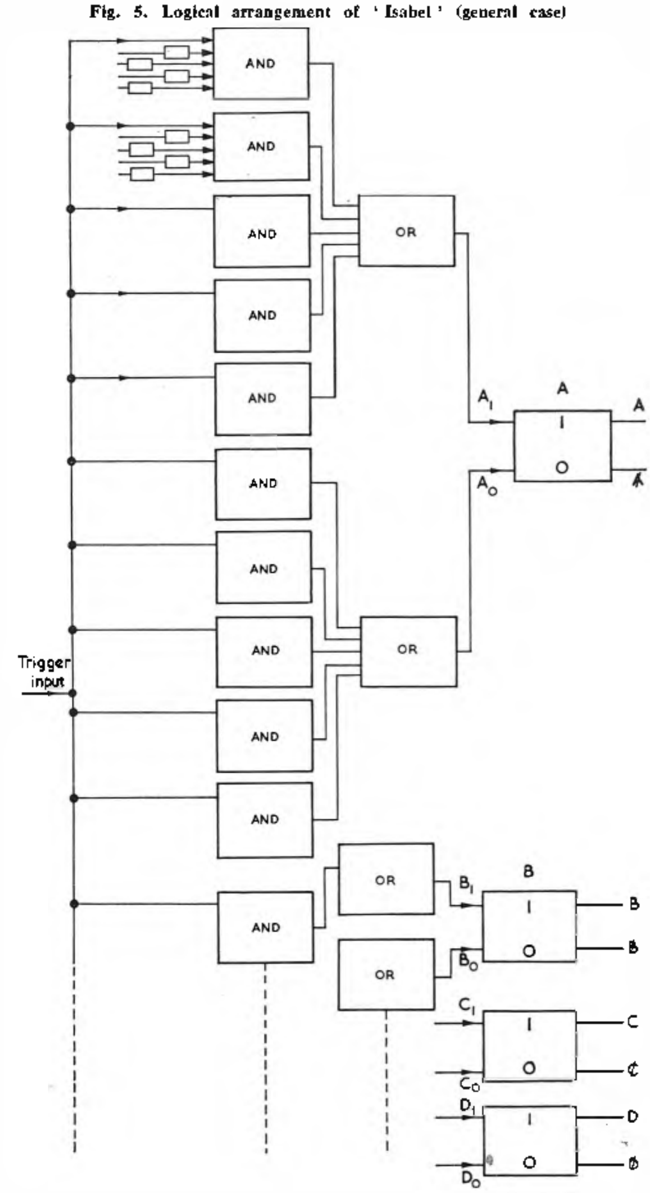
TABLE 1

DECIMAL	FLIP-FLOP STATES A	B	C	D
0	0	0	0	0
1	1	0	0	1
2	1	0	1	0
3	0	1	1	1
4	1	0	0	0
5	0	0	0	1
6	1	1	0	0
7	0	0	1	1
8	1	1	1	0
9	1	1	0	1

At first sight this system apears complex and uneconomical, but considerable simplification is possible.

It should be noted first that although the delay units shown are logically necessary, sufficient delay can be provided in practice by the propagation time through the

Fig. 5. Logical arrangement of 'Isabel' (general case)



flip-flops and the physical arrangement of the gates, with no additional circuits.

Secondly, although the logical expressions for the gate inputs given above are sufficient, there is some redundancy, and the necessary expressions may be considerably simplified. For example, consider the expression for A_1:

$$A_1 = \not{A}\,\not{B}\,\not{C}\,\not{D} + \not{A}\,B\,C\,D + \not{A}\,\not{B}\,\not{C}\,D + \not{A}\,\not{B}\,C\,D.$$

Any combination which does not occur in the decimal code may be added to the right-hand side without affecting the function in practice. Hence, adding $\not{A}\,\not{B}\,C\,\not{D} + \not{A}\,B\,\not{C}\,\not{D} + \not{A}\,B\,\not{C}\,D + \not{A}\,B\,C\,\not{D}$ and grouping terms:

$$\begin{aligned} A_1 &= \not{A}\,\not{B}\,\not{C}\,\not{D} + \not{A}\,\not{B}\,\not{C}\,D + \not{A}\,\not{B}\,C\,\not{D} + \not{A}\,\not{B}\,C\,D + \\ &\quad \not{A}\,B\,\not{C}\,\not{D} + \not{A}\,B\,\not{C}\,D + \not{A}\,B\,C\,\not{D} + \not{A}\,B\,C\,D \\ &= \not{A}\,[\not{B}\,\not{C}\,(\not{D} + D) + \not{B}\,C\,(\not{D} + D) + \\ &\qquad B\,\not{C}\,(\not{D} + D) + B\,C\,(\not{D} + D)] \\ &= \not{A}\,[\not{B}\,\not{C} + \not{B}\,C + B\,\not{C} + B\,C] \\ &= \not{A}\,[\not{B}\,(\not{C} + C) + B\,(\not{C} + C)] \\ &= \not{A}\,[(\not{B} + B)] \\ &= \not{A} \end{aligned}$$

i.e. the gating requirements for the A_1 flip-flop input have been reduced from four AND gates each with five inputs feeding an OR gate to a single 2 input AND gate. Although the other expressions for the code above do not simplify so radically, by suitable choice of code it is possible to obtain functions which are all of a form requiring only a single 2 or 3 input AND gate in each case (no OR gates being required). Such a code is shown in Table 2.

The sufficient gating functions in this case are:

$$\begin{aligned} A_0 &= \not{B} & C_0 &= \not{D} \\ A_1 &= BC & C_1 &= D \\ B_0 &= AC & D_0 &= C \\ B_1 &= C\not{D} & D_1 &= \not{A}\,\not{C} \end{aligned}$$

and the required logical arrangement is shown in Fig. 6. Other advantages of this code are:

(a) One flip-flop (A) changes from 1 to 0 only when the decade changes from decimal 9 to 0 and hence provides a carry signal to succeeding decades without further complication.

(b) No flip-flop is required to trigger faster than half the input frequency.

(c) This code is the nearest approach to a 'unit distance' code possible for a 4 bit decimal code, i.e. at the most steps only one flip-flop changes state, and never more than two. This eases trigger power requirements in the physical system.

A disadvantage of this code is that it is not weighted, i.e. a voltage analogue of the decimal number cannot be derived from a weighted sum of the flip-flop states. This is preferable where the stored count is to be indicated on a meter, but in the application envisaged for 'Isabel' decoding to '1 out of 10' is required, and a decoding matrix for this purpose is equally complex whatever code is used.

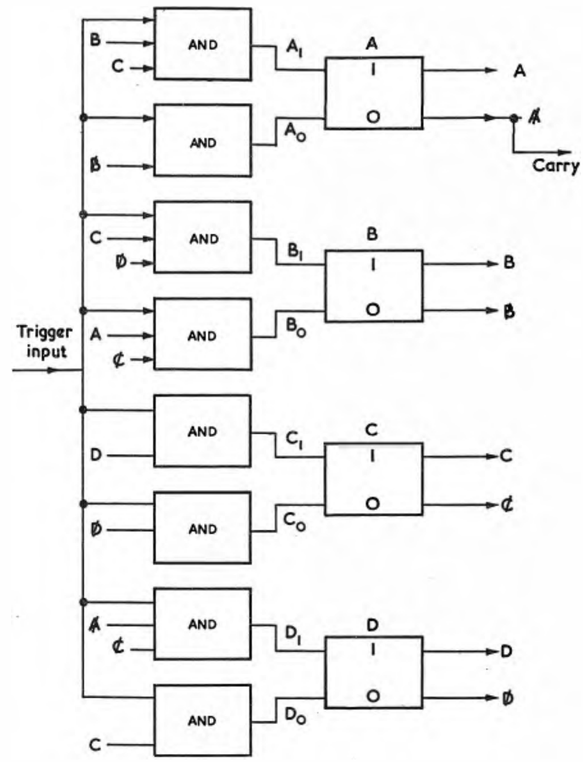


Fig. 6. Logical arrangement of 'Isabel' (practical case)

Advantages of the 'Isabel' system in general are:

(a) The carry delay time is reduced to the delay of one gate and one flip-flop.

(b) Only two types of 'building blocks' are required; there are no requirements for special items such as reset driving stages necessary in a high speed feedback system.

A disadvantage is that more trigger input power will probably be required to drive eight gates compared with the complement input to a single binary.

A compromise may be effected by arranging a decade as a cascaded binary plus scale of 5 'Isabel.' In this case the trigger input to the decade feeds only the single binary, but the carry delay time is increased by a factor of 2.

A suitable code is shown in Table 3, where A is the binary, and B, C, D form a scale of 5. The gating functions required for the scale of 5 are:

$$\begin{aligned} B_0 &= \not{C} & B_1 &= C \\ C_0 &= D & C_1 &= \not{D} \\ D_0 &= \not{C} & D_1 &= BC. \end{aligned}$$

TABLE 2

DECIMAL	FLIP-FLOP STATES A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	1
3	0	0	1	0
4	0	1	0	0
5	0	1	0	1
6	0	1	1	1
7	1	1	1	0
8	1	1	0	0
9	1	0	0	0

TABLE 3

DECIMAL	FLIP-FLOP STATES A	B	C	D
0	0	0	0	0
1	1	0	0	0
2	0	0	1	0
3	1	0	1	0
4	0	1	1	0
5	1	1	1	0
6	0	1	1	1
7	1	1	1	1
8	0	1	0	1
9	1	1	0	1

Physical Realization of Isabel Logic

The units required are:

(a) A bistable flip-flop with 'set 0' and 'set 1' inputs, and normal and inverted outputs with well defined voltage levels each capable of driving up to two AND gate inputs.

(b) An AND gate accepting as inputs one or two flip-flop outputs and the trigger input, preferably including a controlled delay on the inputs from flip-flops, and negligible delay on the trigger input.

Transistor circuits only will be considered.

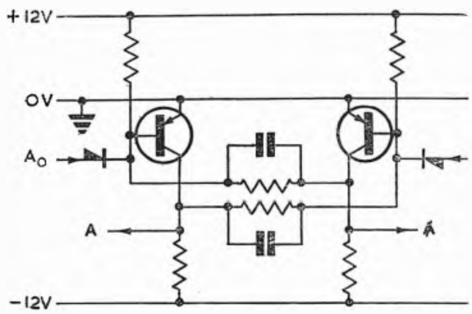


Fig. 7. Basic flip-flop

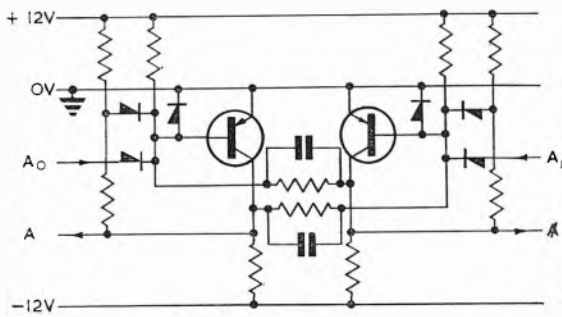


Fig. 8. High speed flip-flop

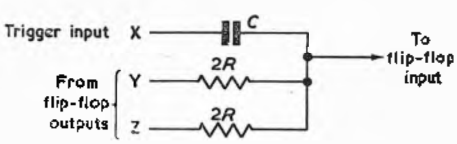


Fig. 9. 'Resistance logic' AND gate

Flip-Flops

The design is conventional, shown basically in Fig 7.

A 'defined current' circuit gives insufficiently controlled output levels in this application, hence a 'defined voltage' configuration is used. The relatively positive output level is well defined by the bottoming voltage of the transistor concerned. The negative output level depends on load current, but is sufficiently defined for this application; clamping being unnecessary.

'Set 1' and 'set 0' inputs are by positive pulses via diodes on to the bases.

For a given transistor type, speed can be increased by:

(a) Avoiding transistor saturation by suitable non-linear negative feedback on each transistor.

(b) Reducing the base voltage swing by placing a diode across the base-emitter junction (in the opposite sense).

A flip-flop incorporating these refinements is shown in Fig. 8.

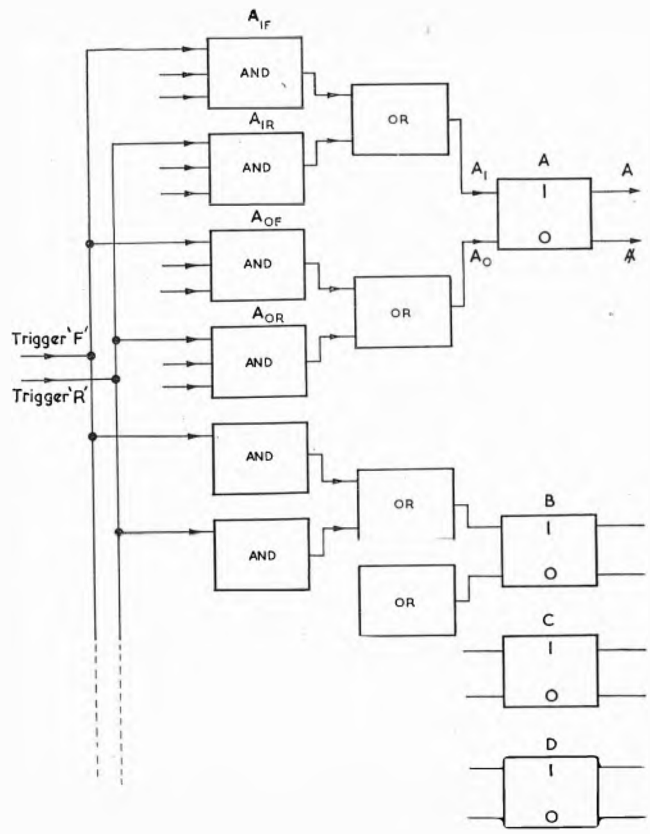


Fig. 10. Reversible 'Isabel'

AND Gates

The requirements of the gates suggests the use of 'resistance logic,' since a maximum of two inputs plus trigger is required and a delay on the inputs from the flip-flops is necessary. Such a gate is shown in Fig. 9.

If the decade is quiescent, inputs Y and Z will be at either zero or −12V (approx.), according to the state of the flip-flops feeding them. Hence the output will be at zero, −6V, or −12V. If a positive pulse or step of amplitude say 4V is now applied to input X, the output will rise to +4V, −2V or −8V respectively. Only in the first case, i.e. when both inputs Y and Z are at zero (active), would a flip-flop connected to the gate output be triggered.

Note that after the Y and/or Z inputs have changed state, the gate output settles to the new potential with a time-constant *CR*, and this provides the effective delay required. There is of course no delay of a positive step applied at X.

Gates requiring to be fed from only a single flip-flop output (plus trigger pulse) use only a single resistor of value *R*.

By using this circuit for the gates, the only additional components required by 'Isabel' compared with four cascaded binaries with steering circuits (scale of 16, as Fig. 2) are 4 resistors.

Performance of Practical Circuits

Decade 'Isabel' using Medium Speed Switching Transistors

The target specification was a reliable decade operating up to an input frequency of 1·2Mc/s, and development commenced with this configuration using OC42 transistors. On a prototype unit a maximum input frequency of 1·8 Mc/s was obtained. The flip-flop circuit was as Fig. 7 with the addition of base clamp diodes. The above frequency limit was, however, only obtained by critical adjustment of the input pulse amplitude and mark-to-space ratio, and the rise-time required on the trigger pulse was considerably shorter than the output from the flip-flops. Since shaping stages would thus be required between cascaded decades of this type, it was considered that a binary plus scale of five 'Isabel' would be a better configuration, in which case the shaper requirements are eased, and the shaper is contained within the decade.

Binary plus Scale of Five 'Isabel' using Medium Speed Transistors

Using similar flip-flops to those described immediately above, a binary divided correctly at input frequencies up to 3·0Mc/s, and a scale of five 'Isabel' with optimum input pulse to 2·0Mc/s. Cascading these circuits and coupling with a reasonably economical shaper (using a single OC140), a maximum input frequency of 2·1Mc/s was obtained.

Sixteen such decades have since been constructed using unselected transistors and diodes, with 10 per cent tolerance resistors and capacitors throughout. Maximum input frequencies ranged between 1·7 and 2·5Mc/s, and at 1·2Mc/s, all units functioned correctly with either supply rail varied ± 50 per cent at ambient temperatures up to 55°C.

Binary plus Scale of Five 'Isabel' using High Speed Switching Transistors

By using micro alloy diffused base transistors type 2N501 in the flip-flop circuit shown in Fig. 8 (but with ordinary low frequency diodes), a maximum input frequency of 23Mc/s was obtained under ideal conditions. At the design maximum of 12Mc/s similar tolerances to supply voltage variation and temperature were found to those given above.

Reversible Decade

The method of routeing trigger pulses in a decade 'Isabel' suggests that by the addition of a second set of gates a reversible counter can be constructed. The logic diagram is shown in Fig. 10.

Gates A_{1F}, A_{0F}, etc., are fed by the 'trigger F' line. Gates A_{1R}, A_{0R}, etc., are fed by the 'trigger R' line and logical functions necessary to step the flip-flops in a descending decimal scale. Hence a pulse on the 'trigger F' line increases the count by 1, and a pulse on the 'trigger R' line subtracts 1.

Such decades may be cascaded by deriving 'carry' and 'borrow' signals from the logical functions:

Carry ...... A changes from 1 to 0 when B=0

Borrow ...... A changes from 0 to 1 when B=0.

A low speed reversible decade using this system has been constructed using OC71 transistors (flip-flop circuit as in Fig. 7). The maximum input frequency is approximately 10kc/s.

Conclusions

The results obtained from a representative number of the 1·2Mc/s decades, and prototypes of the 12Mc/s unit indicate that with a given transistor type and component cost a more reliable and flexible decade can be constructed using the 'Isabel' configuration than the feedback or feed forward methods.

Acknowledgments

The author wishes to thank Mr. N. Elson for many helpful discussions on the theory of decimal counters, and the Directors of Racal Engineering Ltd for permission to publish this article.

A High Speed Line Printer

The new high speed line printer manufactured by The National Cash Register Co Ltd, can be directly coupled to a computer or used off line. In the latter case, it prints information previously recorded on either magnetic film (as produced by National-Elliott 405 and 803 electronic data processing systems) or magnetic tape.

The equipment consists of three intercoupled units, containing:—

(1) Printing and paper feed mechanisms.

(2) A set of thyratron valves which, in association with capacitors and solenoids, activate the printing devices.

(3) A buffer which reads the magnetic film and sends instructions to the thyratrons.

Its nominal speed is over 600 lines/min. This rises considerably when printing is restricted to numerals alone. Models now being installed in the U.S.A. can print alpha-numerical information at up to 900 lines/min.

Each line usually contains up to 80 characters in any of 120 printing positions. But 120-character lines can be printed without difficulty or modification to the equipment.

The typeface is mounted on continuously rotating wheels. There are 120 of these, one for each printing position. Each wheel carries the full range of 56 letters, numerals and symbols. The wheels are keyed to a common shaft, forming a cylinder with 56 horizontal rows of identical characters.

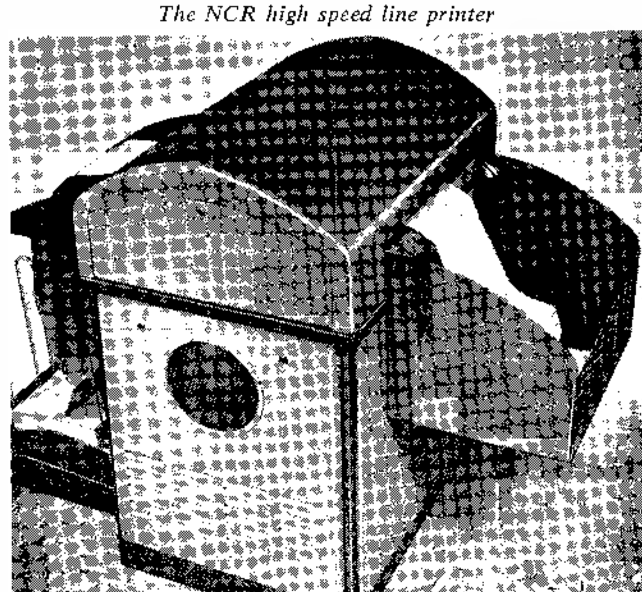
The continuous web of paper passes between the wheels and a corresponding series of hammers which knock the paper against the type when the characters required are in the printing position. The hammers are actuated by the thyratron valves, according to signals received from the buffer unit. Type impressions are made via a carbon ribbon.

Before each line of type is printed, 80 characters are read through the magnetic film and stored in the buffer memory, where they are repeatedly scanned until every character has been printed. The machine then reads another block of 80 characters while the paper is automatically advanced to the next printing position. Lines containing between 80 and 120 are printed in two parts.

Vertical format is controlled by an electronic unit which reads instructions pre-punched into an easily-changed loop of plastic tape. Horizontal format is controlled by electrical connexion units, individually selected by signals recorded on magnetic film. Four of these units are plugged into the printer before a job starts.

The machine handles normal weights of paper as used in punched card machines and tabulators. The maximum form width is 22in (12in printing line) and the maximum depth 22in. Line throwing is done at the rate of over 4 000 lines/min.

The NCR high speed line printer



An Improved Automatic Method for Measurement of Ionospheric Absorption

By L. Thomas*, Ph.D.

Ionospheric absorption has been measured at University College of Swansea by an automatic method during the I.G.Y. The equipment described is an improvement of an earlier model recording the mean echo amplitude over an interval of about one minute. The whole system is synchronized to one pulse per second trigger voltages thus providing improved compensation for background noise signals and the minimum interference with other services. The general performance of the equipment is discussed and a comparison made between automatic measurements and those made by the standard manual method.

(Voir page 666 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 674)

IN this article a brief description is given of an equipment which has been used to make routine vertical incidence measurements of ionospheric absorption at Swansea during the International Geophysical Year.

Early methods of automatic recording of signal strength[1] suffered from difficulties associated with the rapid fading of the signal. In order to overcome these difficulties Farmer[2] designed an apparatus which integrated the echo amplitude over a time interval long in comparison with the fading period. At the end of this interval the integrated voltage was registered on a recording galvanometer. A development of this system was introduced by Jenkins and Ratcliff[3] who made use of an improved form of integrator. In addition a comparison unit compensated for the noise signal included in the integrated voltage. More recently, automatic systems have been developed providing continuous records of ionospheric absorption[4,5].

Automatic recording techniques can be based on measurement of echo amplitude, logarithmic echo amplitude, or echo power. In the present work it was decided to make use of automatic amplitude measurement. This offers the advantage of simplicity in design and is directly related to the widely used manual method of measurement[6]. It was necessary to compensate for the disturbing influence of noise signals which was often serious. The equipment is based on the system used by Jenkins and Ratcliff but in an improved form.

General Principles

The principle of the recording system has been fully discussed elsewhere[3] and will not be described in detail here. The output from the receiver is passed through two gated amplifiers to two similar integrators and the gate generating pulses are adjusted such that one integrator receives the echo signal together with background noise and the other receives a sample of noise. After integration over a period of about one minute, the difference in outputs of the integrators is applied to a pen recorder and represents the mean echo amplitude over this period.

The location of the observation site made it imperative that special steps be taken to ensure minimum interference with other services. For this reason transmissions at the rate of one pulse per second were used. The transmitter, gate generator, time-base and time-base calibration circuits

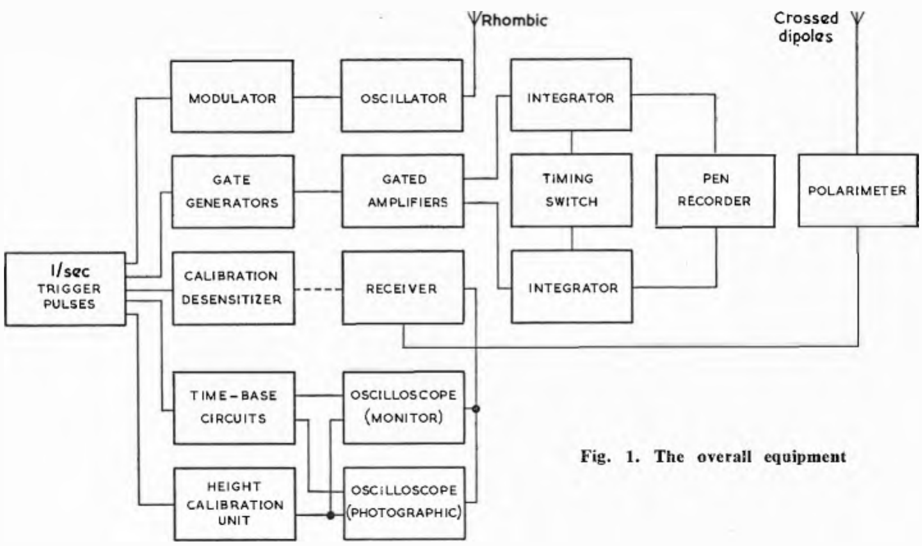


Fig. 1. The overall equipment

were synchronized to one pulse per second trigger voltages derived from the a.c. mains through a count down circuit. The low repetition rate makes it possible for the comparison gate pulse to be exactly 1/50th of a second later than the echo gate pulse, thus giving exact compensation for the mains-locked noise.

From experience gained with the equipment of Jenkins and Ratcliff it has been possible to effect a number of improvements in the circuits. In particular, variations in the peak amplitude of short noise signals could cause the operating point of the gated amplifiers to wander in an uncontrolled manner. This effect has been eliminated by replacing the resistance-coupling circuits in the gated amplifier unit by direct coupling. This alteration also obviated the need to limit the output of the receiver and to desensitize it during the emission of the radio frequency pulse.

The integrator circuit used is again that of Williams and Ritson[7]. The integrating capacitor is chosen to give the best compromise between adequate output from the integrator and freedom from saturation when large signals are

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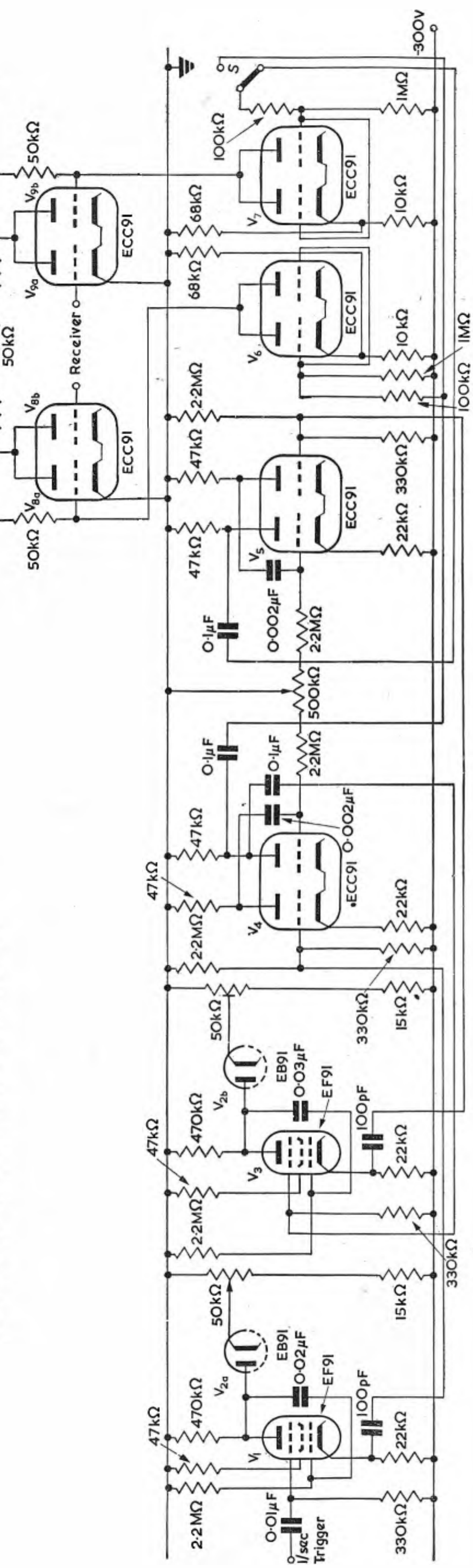


Fig. 2. The gate generators and gated amplifiers circuit

supplied. With the small rate of input given by the one pulse per second system this involves decreasing the integrating capacitors from the 8μF values used by Jenkins and Ratcliff to 1μF. The balance and linearity of the two integrators have been carefully checked for the operating period of 58sec. It was essential to use very high quality capacitors and resistors and identical mechanical layouts. The timing circuit of Jenkins and Ratcliff has been replaced by a Venner clock driving two switch contacts. The first contact operates a relay applying the difference in integrator output voltages to the pen recorder at the end of the integrating period. Two seconds later the second contact activates a relay resetting the integrators to zero.

The block schematic diagram of the modified overall equipment is shown in Fig. 1.

The Transmitter

The low duty factor makes it possible to use a comparatively small h.t. transformer and a compact layout of the components of the transmitter. Three such transmitters are incorporated in a single post-office rack. Each consists of a self-oscillator of the Hartley type using a CV398 valve operated under class-C conditions. It is necessary to shunt the variable tuning capacitor with a suitable fixed capacitor in order to match the low impedance of the valve and minimize harmonic content. A series of plug-in coils provides a wide frequency range. The peak power is about 3kW.

The pulse generator consists of a suppressor-triggered phantastron valve driving a pulse forming multivibrator. Grid modulation is employed.

The transmitting aerials are vertical rhombics terminated in 800Ω non-inductive resistors.

The Receiver

The signals are received on a communication receiver suitably modified for pulse reception. This involved adjustments of i.f. bandwidths and time-constants, and disconnexion of the a.g.c. line.

Two dipoles are employed. These are placed along the perpendicular sides of a right-angled triangle and are resonant at a frequency of 2·2Mc/s, which is half way between the operating frequencies of 2·0 and 2·4Mc/s. Because of the inconvenient lengths it has been necessary to employ inductive loading at the ends of these aerials. A phase change of 90° is introduced in the feeder from one of these aerials, to provide a circularly polarized system selecting the ordinary ray. The suppression of the extraordinary component is not complete because of the end-to-end arrangement and the coupling with other aerial systems, but the differentiation between the *o* and *x* signals is quite adequate.

The Recording System

The gate generators and gated amplifiers circuit is given in Fig. 2.

The phantastron circuit V_1 provides a trigger of variable delay relative to the one per second pulse input. This trigger initiates the monostable multivibrator circuit V_4, the pulse from which is used to operate the first gated amplifier. This pulse also serves to trigger the second phantastron V_3 which is adjusted, by means of the preset 50kΩ potentiometer, to introduce a delay of 1/50th second before initiating the second multivibrator circuit V_5. The positive going pulses from V_4 and V_5 are clipped and amplified in V_6 and V_7 respectively, these valves being normally biased beyond cut-off. The anode loads of these two valves form the grid resistors of V_{8a} and V_{9b}. These valves are normally taking

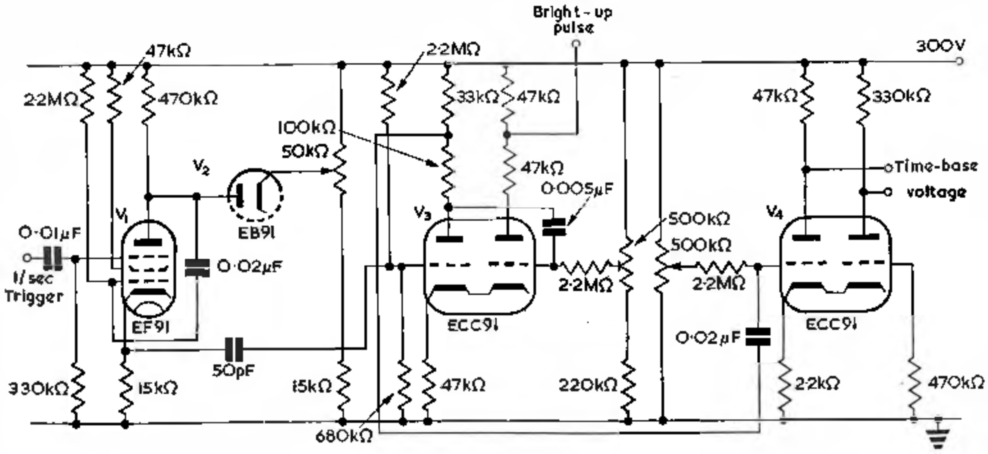


Fig. 3. Time-base circuit for photographic tube

grid current, the strapped anodes of V_{8b} and V_{9a} having very low voltages. No amplification of the receiver signal is possible. With the arrival of pulses at the grids of V_6, V_7, the grids of V_{8a}, V_{9b} are taken below cut-off, the anodes of V_{8b} and V_{9a} rise towards + 300V and the receiver signal is amplified for the duration of the gate pulses. The outputs of these gated amplifiers are taken to a cathode-follower valve for monitoring purposes and through d.c. restorer circuits to the integrators.

The pedestal voltages appearing at the anodes of V_{8b} and V_{9a} are balanced by arranging that these two stages have equal gains and the pulses have equal widths. In order to satisfy the first condition, the drive pulse from V_4 is used as a trigger for both gated amplifiers by means of the switch *S*. The 50kΩ potentiometer in the anode circuits of V_{8b}, V_{9a} is then adjusted to give equal integrator outputs. The switch *S* is returned to the normal working position and the 500kΩ potentiometer in the grid circuits of V_4, V_5 is also adjusted to give equal integrator outputs, indicating gate pulses of equal width.

The Display Chain

The time-base circuit for the photographic tube is shown in Fig. 3. A similar circuit produces the time-base for the visual presentation, apart from some component changes to provide greater spot speed and flexibility of phase control.

The trace of the photographic tube is intensity modulated by the output of the receiver and height calibration marks derived from a 3kc/s Hartley oscillator synchronized to the one second pulses. This presentation is recorded on 35mm film providing a permanent record of echo height.

The actual display of the monitor tube can be selected by means of a three-way switch. In the first position the echo pattern is displayed as *Y* deflexions. In the second position the same pattern is shown using a more contracted time-base which is convenient for normal monitoring. The third position of the switch displays the cathode-follower outputs of the gated amplifiers; this facilitates the alignment of the echo on one of the gates and checking the position of the comparison gate. In all three positions of the switch, *Y* deflexion is used to register the height calibration marks.

Calibration of Recording System

In order to calibrate the overall recording system it is necessary to apply known signals to one of the gated amplifiers. In the absence of a pulsed signal generator it is essential to desensitize the receiver during the period of the comparison gate. The system employed is represented in the block schematic diagram of Fig. 4.

A one per second desentisizing pulse of variable duration

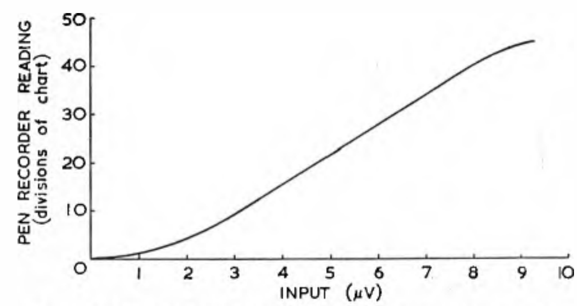


Fig. 5. Example of calibration curve for recording system

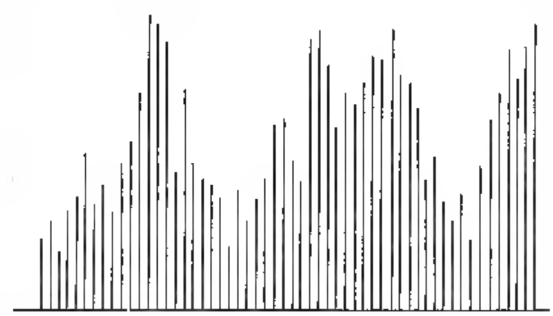
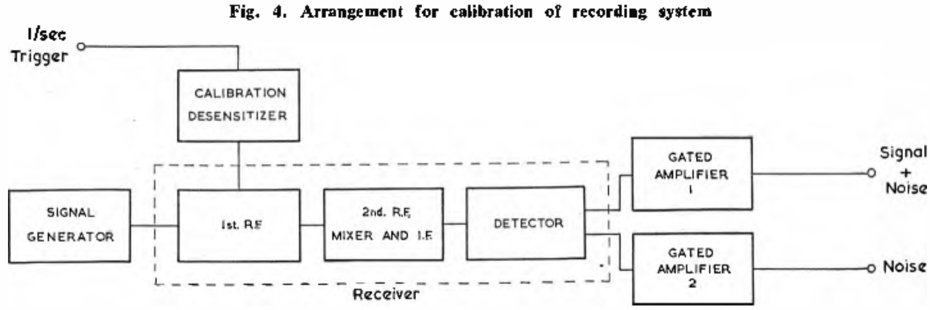


Fig. 6. Typical amplitude record

and phase holds the suppressor grid of the first r.f. stage at – 120V, thus preventing the passage of the signal during the comparison gate. This switching at the early stage of the receiver ensures that the comparison gated amplifier will receive the greater part of the receiver noise. In practice, with zero input from the signal generator the difference in output from the integrators is zero.

A series of calibration curves is drawn for each frequency and check measurements carried out regularly. An example of such a curve is shown in Fig. 5. The receiver gain is always preset to such a level that the signal is fading on the linear part of this curve. The

Fig. 4. Arrangement for calibration of recording system



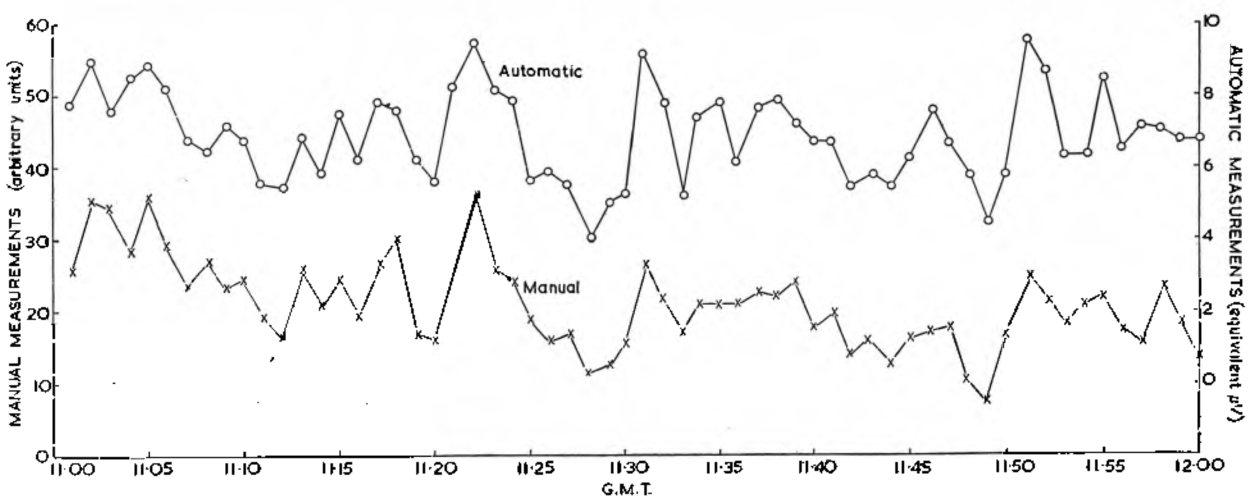


Fig. 7. Mean echo-amplitudes measured on 2·4Mc/s using the automatic and manual methods at Swansea

effective median or mean input can be read from the calibration curve.

Performance of Equipment

General

This equipment has been used to make measurements of ionospheric absorption on a routine basis since November 1957. A sample of the pen recording obtained is shown in Fig. 6.

After the initial adjustment and to balance integrator drifts and pedestal voltages, the equipment could be left unattended for six or more hours. Rigorous and frequent checks on integrator and receiver drifts showed that these factors could be neglected.

The introduction of d.c. coupling in the gated amplifier stages has removed many of the difficulties associated with the earlier model of Jenkins and Ratcliff[3], and the use of a repetition rate of one pulse per second has improved the compensation for background noise and has eliminated complaints of interference. In the system described by Bowhill, Bulman and Mittra[4], difficult and critical conditions have to be satisfied in the design of the circuit. The design requirements and the setting-up procedure in the present arrangement have proved to be both simple and stable.

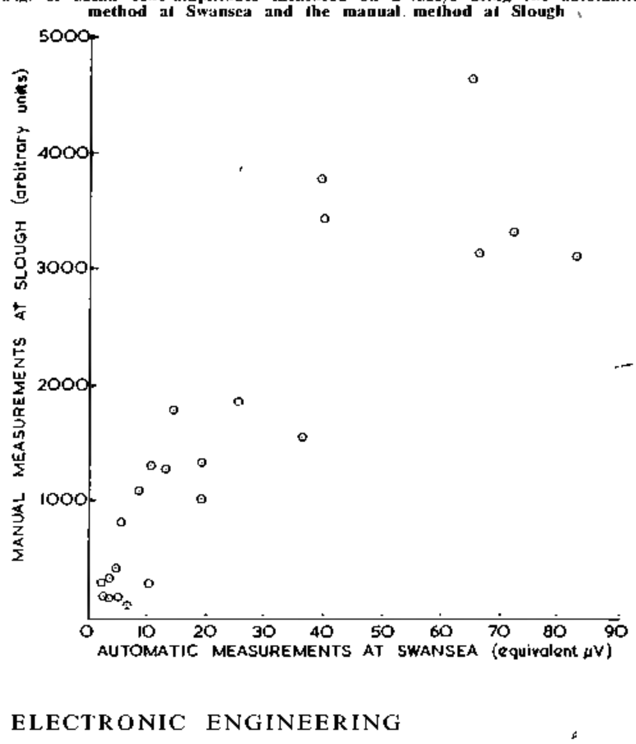
The receiver incorporated in the present equipment does not satisfy the requirements for accurate pulse amplitude measurements as given by Piggott[8]. These defects cause most of the curvature in the calibration chart, Fig. 5. However, it is clear that the system does provide a convenient method for making pulse amplitude measurements and requires the minimum of attention.

Comparison with Manual Method

Simultaneous measurements of average echo amplitude over periods of one minute have been made on several days at Swansea using the automatic equipment and a standard manual equipment fed from a separate but nearby set of aerials. A sample of the results obtained is shown in Fig. 7 which gives the observations on 2·4Mc/s between 11.00 and 12.00 G.M.T. on 2 January, 1959. The automatic readings give the mean echo amplitude over 58sec and the manual readings are the mean of six measurements made at 10sec intervals during the corresponding minute interval. The variability of the manual observations indicates that the standard deviation for a single random measurement would be 35 per cent. Since there are six samples in a manual measurement the sampling error is 14 per cent. The corresponding error for the automatic measurement is 8 per cent compared with which the inevitable small reading errors are negligible. The minute to minute changes of the measurements made on the two equipments give an apparent correlation coefficient of 0·75; after allowing for the known sampling errors[9] given above this figure becomes 0·95. The lack of correlation at certain periods such as 11.34 to 11.39 G.M.T. can be attributed to interference preventing accurate manual measurements.

A comparison of measurements on 2·4Mc/s taken using the automatic system at Swansea and the manual method at the D.S.I.R. Radio Research Station, Slough, is shown in Fig. 8. The values represent the mean amplitudes for intervals of 15min near noon in the period 13 November, 1958 to 17 December, 1958. This sampling time of 15min is necessary to minimize inaccuracies due to focusing effects of the ionosphere. The correlation coefficient of 0·72 found in this examination can be compared with the value 0·85 found by Beynon and Davies[10] for winter months in their study of manual observations on 2·0Mc/s at Swansea and Slough. However, it must be noted that during the author's period of observations the mean value of f_oE at noon,

Fig. 8. Mean echo-amplitudes measured on 2·4Mc/s using the automatic method at Swansea and the manual method at Slough



3·0Mc/s, was rather near the operating frequency, 2·4Mc/s, and that the h′-f pattern for the E layer showed the presence of variable ledges which could seriously modify the local reflection conditions. Moreover, the times at which the two measurements were actually made differed by up to an hour. In these circumstances the apparent value, 0·72, is as high as could be reasonably expected.

Conclusions

The examples given above form part of an extended investigation to compare the performance of this improved automatic method with that of the standard manual method of measurement. From this comparison it is concluded that, in general, measurements by the automatic method are consistent with those by the manual method and have greater accuracy under conditions of external interference. In addition, the improved method offers the many advantages of an automatic system, particularly during a programme of routine measurements such as that of the International Geophysical Year.

Acknowledgments

The author acknowledges the encouragement and advice of Professor W. J. G. Beynon in this work. Considerable help in the construction of this equipment was provided by Mr. T. B. Jones, and Dr. D. M. Parkyn who was also responsible for the count down circuit. Finally, the author is indebted to Mr. W. R. Piggott, of the D.S.I.R. Radio Research Station, Slough, for valuable discussions on the presentation of this paper.

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A Regulated Power Supply*

The circuit described will maintain a substantially constant output voltage despite input voltage changes of ±10 per cent and load current changes of ±10 per cent. Rectification of the alternating current is achieved with two silicon controlled rectifiers and the gates of the rectifiers are controlled via saturable reactors.

Description of Single Phase Circuit

The silicon controlled rectifiers are fed from windings $N.P$ as though they are rectifiers in a centre-tapped circuit.

Assume that the anode of silicon controlled rectifier 1 is positive from 0° to 180° and anode of silicon controlled rectifier 2 is positive from 180° to 360.° The winding A is arranged to produce a trigger pulse at F between 0° and 180° i.e. when the anode of silicon controlled rectifier 1 is positive. Thus silicon controlled rectifier 1 will conduct from the instant of triggering until 180° (when the anode potential is zero). Similarly, winding B will produce a pulse at G at some time between 180° and 360° and the current will flow until 360°.

It is essential that gate pulses are not produced when the corresponding anode is negative (i.e. non-conducting) or the silicon controlled rectifier will be damaged. The diodes MR_2 and MR_3 ensure that unidirectional currents flow through the gate resistors (100Ω each).

Firing Circuit

Consider the circuit of winding A. If SX_2 is unsaturated the winding R will have a high impedance and a small amplitude of half-wave current will flow through the diode MR_2 and the 100Ω resistor. If SX_2 is saturated at any time during this current flow the winding R will have a low impedance and the current through MR_2 etc, will rapidly rise to a large value and a trigger pulse will appear across the 100Ω resistor.

The instant of triggering will depend on the flux level which will be controlled by the current in winding R.

Further Considerations

Since the current in winding R is unidirectional the core of SX_2 will need to be reset and this can be achieved by winding Q which drives a unidirectional current through MR_1. Similarly winding M and its load is provided as an image for winding K. Diodes MR_1 and MR_2 conduct alternatively and diodes MR_3 and MR_4 conduct alternately.

Control Windings

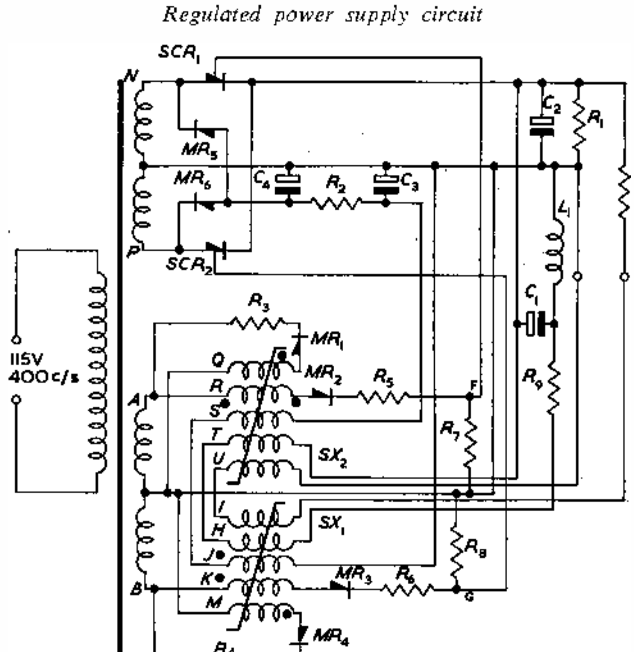
The control windings I and U are in series and produce a steady flux in the saturable cores SX_1 and SX_2 which is proportional to the steady current in the windings.

The reference windings T and H produce a constant flux in the saturable cores.

These two fluxes are compared by means of the core and the resultant flux (which controls the firing-pulse position in time) will rise or fall as the output voltage rises and falls and acts in such a way that the output voltage of the unit is constant and unaffected by variations in the load current.

The control windings S and J act in a similar manner and compensate for changes in the supply voltage.

Regulated power supply circuit



* *A Communication from E.M.I. Ltd.*

Systems Using Transistors and Transductors

By D. A. Ramsay*, B.Sc. (Hons.)

(Part 3)

(Voir page 526 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 531)

Signal Magnetic Amplifiers in Transistorized Systems

Auto-Self-Excited Magnetic Amplifiers

FIG. 18 shows the basic circuit of a type of d.c. to d.c. magnetic amplifier which has been used in an otherwise transistorized system where neither the zero stability nor the output voltage level of a required stage of amplification could be met by a transistor amplifier and where the use of a valve amplifier would have reduced to a lower order the overall robustness and reliability of the system. This circuit comprises two auto-self-excited magnetic amplifiers[10] whose outputs V_1 and V_2 are combined in a series-summing network (R_1, R_2, R_L) to provide a push-pull d.c. output.

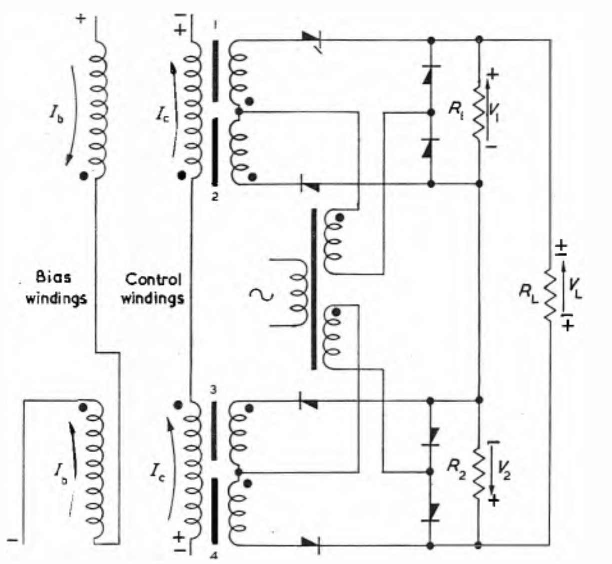


Fig. 18. Series-summed push-pull d.c. to d.c. auto-self-excited magnetic amplifier

The output circuit and output voltage of one side of this amplifier are identical in form to those of the full-wave flux-reset magnetic amplifier of Fig. 8, but in this case the control voltage or current (I_c) is applied directly to the transductor control winding and the cores need not be composed of rectangular loop material.

In an auto-self-excited magnetic amplifier the minimum flux density in a core, which again determines the firing angle (equation (11)), is established, not by imposing a resetting voltage across the control winding as in a flux-reset magnetic amplifier, but by impressing a controlling magnetizing force on the core. This control magnetizing force is proportional to the mean value I_c of the current in the control circuit.

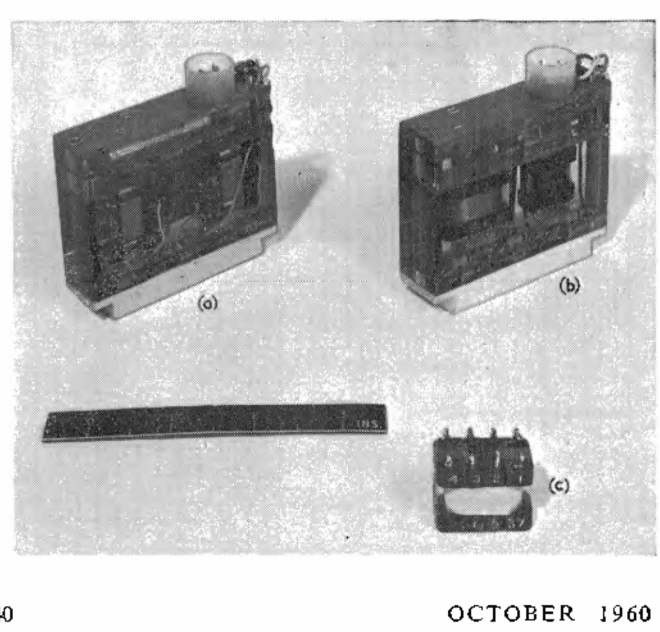
Owing to the high inductive impedance of the control circuit (at least one of the cores embraced by the control winding is unsaturated at any instant), the response time of an auto-self-excited magnetic amplifier is usually of the order of 10 cycles of the supply. This long response time, however, goes with high power gain (e.g. $\times 10^5$) owing to the effect of the control current being integrated over a number of cycles of the supply. The (power gain $\times$ bandwidth) product of an auto-self-excited amplifier would be similar to that of a flux-reset amplifier with the same transductor elements. The auto-self-excited amplifier can provide isolation of input and output circuits and good zero stability (of the order of 10^{-9}W referred to the input circuit).

Fig. 19 shows two encapsulated auto-self-excited magnetic amplifiers. One is a push-pull d.c. amplifier with a voltage gain of $\times$ 30, an input impedance of 15kΩ and provides a zero to $\pm$40V smoothed d.c. output into a 10kΩ load. Overall negative voltage feedback is used to improve linearity (better than 1 per cent). It has a power gain of about 1 400 and responds to signal frequencies up to about 10c/s. The zero stability is 3.10^{-9}W for a $\pm$5 per cent voltage variation in the supply and a 20°C to 50°C ambient temperature variation. The total consumption is 3W from the 2 400c/s power supply. (The maximum possible efficiency of a d.c. push-pull magnetic amplifier of this type is 17 per cent).

The circuit of the second amplifier shown in Fig. 19 is essentially that of one side of the push-pull amplifier described above. This amplifier provides, with a voltage gain of $\times$30, a single-ended d.c. output of zero to 110V into a 20kΩ load.

The construction of the amplifiers shown in Fig. 19 is similar to that of the flux-reset magnetic amplifiers described earlier. The transductor elements use the same type of bobbin and size of U-lamination but in this case the core material is 0·004in thick 'Mumetal' laminations. As is usual in auto-self-excited magnetic amplifiers the

Fig. 19. D.C. signal magnetic amplifiers
(a) Voltage gain × 30, output 0 to ± 40V
(b) Voltage gain × 30, output 0 to + 110V
(c) Two-core transductor



* *The General Electric Company Limited, Stanmore, Middx.*

transductor elements are combined in pairs, control and bias windings being wound over both cores.

The Second-Harmonic Magnetic Modulator

This modulator is a two-core transductor whose output voltage is at twice the a.c. supply frequency and of an amplitude proportional to a signal voltage or current applied to a control winding. If followed by a fixed frequency a.c. amplifier it can allow large amplification of a d.c. signal. This magnetic modulator can be made to have a very low noise level (order of 10^{-18}W), very low drift (3.10^{-17}W has been achieved in a highly refined system using valves[11]) and almost perfect linearity. If followed by a transistor a.c. amplifier it seems likely that an input zero stability of say 10^{-12}W should be fairly easy to attain. The second-harmonic magnetic modulator should have a lower drift level than a diode or transistor chopper and be more convenient than a mechanical chopper.

High-Frequency Magnetic Amplifiers

Since the bandwidth of a transductor is proportional to its a.c. supply frequency and its core volume is (very

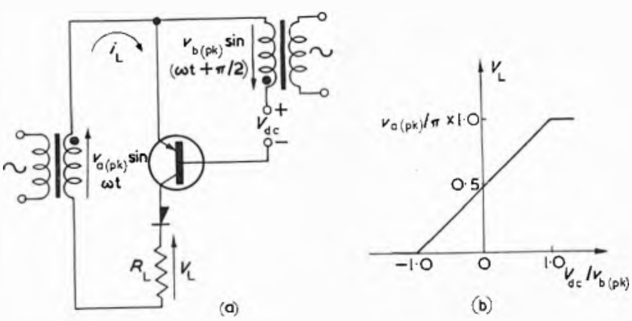


Fig. 20. (a) Half-wave switching transistor amplifier: d.c. to d.c. (b) Mean load voltage (V_L)/d.c. signal voltage (V_{dc}) curve

approximately) inversely proportional to this frequency, transductors should use as high a supply frequency as other factors allow. Until recently the lack of suitable higher frequency power sources and of suitable transductor cores largely limited transductors to using the standard power frequencies of 50c/s, 400c/s, 1 600c/s and 2 400c/s. The development of simple transistor invertors has now made available high frequency power supplies of a robustness and reliability comparable with those of transductors. In the past few years a number of magnetic systems have been described[3,12,13,14,15] which use supply frequencies ranging from 5kc/s to 2·5Mc/s.

Collins[12] generally discusses magnetic amplifier operation at r.f. and describes a 200kc/s amplifier supplying 2W into 150Ω.

Bonn[13] gives an account of magnetic amplifiers, essentially half-wave flux-reset circuits, which are capable of operating at frequencies as high as 2·5Mc/s and states that their power gain at this supply frequency is 3, this being comparable to the power gain obtainable with the best commercially available transistors in 1957. At 1Mc/s supply frequency the power gain of these amplifiers is 5 to 7 which makes them practicable for a digital computer at this frequency. This computer comprises 1 500 of these magnetic amplifiers. Their toroidal cores are formed of twelve wraps of 1/32in wide tape, ¼mil thick, of 4-79 Molybdenum 'Permalloy' on 0·1in diameter stainless steel bobbins (walls 3 to 4mil thick). Pairs of cores with related circuit components are hermetically sealed in small cans.

Switching Transistor Power Amplifiers

Amplifiers using transistors as switches in circuits analogous to those of magnetic amplifiers can have the high efficiency and, if required, the facility of operating directly from an a.c. power supply which are features of magnetic amplifiers. There are in any case advantages to be obtained from using transistors in a switching mode of operation. Operating as a switch, a transistor can control more than four times its class-*A* rated power and a circuit which uses transistors in a switching mode is relatively insensitive to changes in the characteristics of the transistors due to temperature, ageing or manufacturing tolerances.

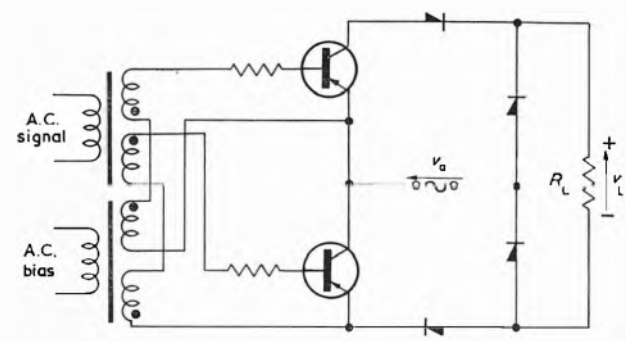


Fig. 21. Full-wave switching transistor amplifier: a.c. to d.c.

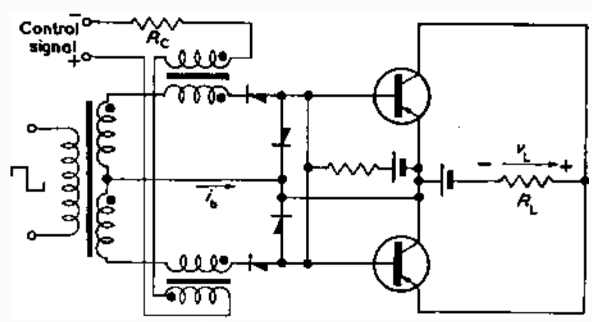


Fig. 22. Switching transistor amplifier controlled by an auto-self-excited magnetic amplifier

Milnes[16] has proposed a number of circuits using transistors with switched mode of operation. The simplest of these is shown in Fig. 20. This circuit is similar to the half-wave flux-reset circuit of Fig. 4(a) and has the same partly suppressed half-wave output voltage; the switching transistor takes the place of the transductor element. Fig. 21 shows a full-wave switching transistor amplifier in which the operation of the output circuit is similar to that of a full-wave flux-reset magnetic amplifier. This transistor amplifier requires, however, an a.c. input signal, i.e. a supply frequency carrier which is amplitude modulated by the signal.

Collins[14] describes an amplifier which combines the high gain and linearity of a magnetic amplifier with the high power handling capabilities of switching transistors. When a magnetic amplifier is supplied by a square wave a.c. power supply the firing angle becomes proportional to the control signal (compare equation (11) for the sinusoidal a.c. supply case). The control signal therefore linearly modulates the width of the rectangular output pulses. This simple pulse-width modulator is very suitable for controlling the on-off ratio of switching power transistors. (It is also easier to generate a square-wave rather than a sinusoidal power supply with a transistor invertor.) Collins states that the amplifier shown in Fig. 22 (the magnetic amplifier is a biphase auto-self-excited circuit) with the magnetic amplifier supplied from a 5kc/s square-wave transistor invertor and $R_c = 20\text{k}\Omega$, gives a maximum output of 47W at a power gain of 45dB and a response time of 0·2msec. Decreasing the control winding resistance to its minimum value of 52Ω increases the power gain to 72dB and the response time to 85msec.

The limited peak voltage of transistors restricts the output voltage of all the switching transistor amplifiers described above. Frenzel and Gutzwiller[17] have described a semiconducting switching device which can withstand a high peak voltage and which is therefore of great interest in this field. This is a controlled silicon rectifier (Fig. 23) which, it is stated, can switch kilowatts of power at hundreds of volts with high speed (1μsec).

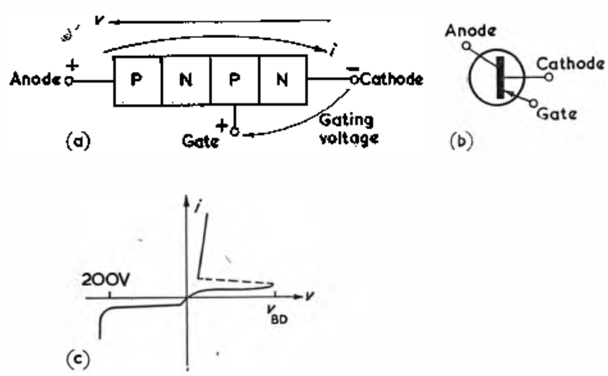


Fig. 23. Controlled silicon rectifier
(a) Construction
(b) Symbol
(c) Current voltage characteristics

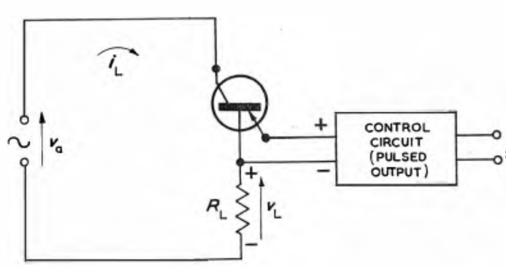


Fig. 24. Half-wave controlled rectifier amplifier

With the gate terminal isolated this pnpn diffused junction device offers a high impedance to either forward or back voltages but when the forward voltage exceeds a critical value (V_{BD}) the impedance drops to a very low level. The application of a positive voltage to the gate terminal with respect to the cathode (1 to 2V) switches the device from the non-conducting state without the necessity of exceeding the breakdown voltage. Control by the gate electrode is only recovered after the forward voltage and current have been reduced to zero.

Fig. 24 shows an elementary half-wave amplifier using this device (compare Fig. 4(a)). For precise control of the firing instant a gating pulse with a steep wavefront is required; a magnetic amplifier would be well-suited for this requirement.

Transductor and Switching Transistor Systems

Transductors using a.c. supply frequencies above, say, 2kc/s can be small and suitable for use in encapsulated assemblies mounted on printed circuit boards, so that in conjunction with transistors the useful properties of these transductors can be exploited to provide systems that are small, highly efficient and robust. Accounts of a number of such systems have been published in the past few years.

Keister[15] for example, describes a four-quadrant voltage multiplier composed of transductors and switching transistors. This multiplier is mounted on a single printed circuit plate and is a few cubic inches in volume. It consumes 250mW from a 12V battery. The circuits are driven by a 5kc/s square wave a.c. generator. (This generator is the simplest form of the magnetic timing multivibrator which is described below.) The method of multiplying requires a 0 to 180° phase shift of the 5kc/s square wave. The pulse-width modulated outputs of two series-connected transductors, fed from the 5kc/s square wave a.c. supply, are combined to provide this.

The most remarkable of these published magnetic-transistor systems is the 48-channel telemetering equipment for a 20in diameter satellite, described by Matthews *et al*[3,4], in which minimum weight, minimum operating power and maximum reliability over a wide range of ambient conditions are essential. This equipment uses four different types of transductor and switching transistor devices and these are briefly described below as applications of the magnetic core properties described earlier in this article.

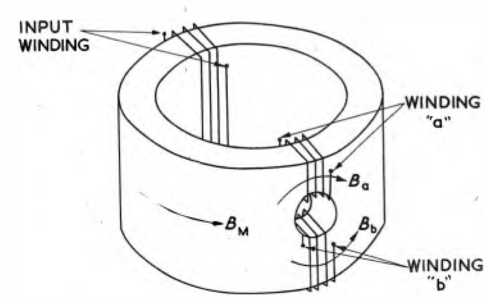


Fig. 25. Two-aperture core for peak memory or for counter with non-destructive read-out

Timing Multivibrator

A battery in series with a resistive transducer (e.g. thermistor, pressure gauge) is connected by a switching transistor to a winding on a rectangular *B-H* loop core whose flux density B is at $-B_r$. The time taken for B to rise to $+B_s$ is, from equation (9), inversely proportional to the voltage applied to the winding; this winding voltage is equal to the battery voltage less the voltage drop in the transducer resistance due to the flow of magnetization current. (Compare the resetting voltage in a magnetic amplifier with resistance control element.) The time taken for B to go from $-B_r$ to $+B_s$ is therefore a measure of the resistance of the transducer.

When the core runs into positive saturation a regenerative transistor base winding on the core switches off this first transistor and switches on a second transistor. This second switching transistor also connects the battery across the core winding, but with reversed polarity and in series with a second transducer. The core is now driven from $+B_r$ to $-B_s$, the time taken in this case being a measure of the resistance of the second transducer.

The above cycle may be repeated indefinitely so that across an output winding on the core a rectangular alternating voltage is generated, the duration of positive half-cycles measuring the first transducer signal and the duration of negative half-cycles measuring the second transducer signal.

In an actual device the half-cycle intervals vary between 0 to 30msec for transducer resistance changes of 0 to 5kΩ.

Variable Frequency Multivibrator

A magnetizing force is impressed on a core by applying a signal voltage or current to a control winding. This magnetizing force establishes a flux density B_M say in the core. (Compare the control action in an auto-self-excited transductor.) When a constant battery voltage is applied to a second winding so as to increase B from B_M then it can readily be shown from equation (2) that the time taken for B to rise from B_M to B_s is proportional to $(B_s - B_M)$. This time interval is therefore a measure of B_M and hence of the input signal.

By means of a pair of switching transistors two transductor elements with the above action and with a common control winding and hence the same value of B_M are connected alternately to the battery. While the battery voltage is taking one core from B_M to B_s the other core is reset from B_s to B_M by means of windings coupling the two cores. The output appears across a further two windings, one on each core, connected in series and is a rectangular alternating voltage whose frequency increases as B_M and therefore as the signal voltage or current increases.

In actual devices a d.c. control current change of 30 to 700μA or a d.c. control voltage change of 0 to 0·5V (both current and voltage output transducers are used) changes the output frequency 5 to 15kc/s.

Peak Memory with Non-Destructive Read-out

A winding on a toroidally wound tape core of rectangular *B-H* loop material whose flux density is initially set to the value $-B_r$, carries a signal current which may vary between 20 and 700μA. At any instant the flux density in the core, B_M say, is determined by the peak value up to that instant of the current in the signal winding. (See Fig. 3(d) and the last part of the section '*B-H* Loops'.)

A second aperture is formed in the core by a hole through the tape as shown in Fig. 25. The two limbs of this small aperture carry windings and are used as the two cores of a variable frequency multivibrator similar to the circuit outlined above. As in that circuit the output frequency is determined by B_M and this frequency is therefore in this case a measure of the peak input current.

The operation of the read-out variable frequency multivibrator which uses windings *a* and *b* in Fig. 25, induces a periodic flux around the small aperture only and does not alter the value of B_M impressed by the signal current.

Decimal Counter with Non-destructive Read-out

A magnetic pulse forming circuit using the property expressed by equation (8) generates a constant volt-second pulse (duration about 200μsec) from each of the series of input pulses which are to be counted. This series of constant volt-second pulses is applied to a winding on a rectangular *B-H* loop core which operates as shown in Fig. 3(d). The core is initially set to $-B_r$. Each constant volt-second pulse causes a core flux density increase of slightly less than $2B_r/9$ so that the tenth pulse takes the core into saturation. The onset of saturation is used to trigger a switching transistor which resets the core to $-B_r$ in readiness for the next count and is also used to generate an input pulse to the next counting stage.

There are three cores operating in the above manner storing unit digit, tens digit and hundreds digit; at any instant the flux levels in these three cores register the total count up to that instant.

Non-destructive read-out of a core is achieved by the method described above for the peak memory; again the cores are of the form shown in Fig. 25. The count is telemetered as three successive frequencies, these being the read-out frequencies of the three cores.

In construction the satellite telemetry equipment is an assembly of encapsulated modules. The components in a module are all mounted on a 5½in diameter printed plate and each module is ¾in high.

A complete counting module comprising a transducer with transistor amplifier, a pulse former and a three stage decimal counter weighs 5oz after potting and consumes an average power of less than 10mW.

The telemetry encoding module which contains the two multivibrators described above as well as transistor matrices and gating circuits weighs 3·8oz plus 2·8oz batteries and consumes less than 12mW.

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An Anti-Collision Light System for Aircraft

The use of fluorescent paints and normal navigation lights are generally considered inadequate to avoid the possibility of collision between high speed aircraft.

A new system, now being developed in this country by Honeywell Controls Ltd uses xenon-filled flash units, similar to those employed in stroboscopic equipment, to produce an intense flashing light, which is much more brilliant than that available from conventional navigation lights, and so timed as to give accurate and easily assimilated information on the position, attitude and bearing of the aircraft. The lights, which are mounted in groups at each wingtip, cover the forward, rear and beam zones. The forward-facing lamps are triggered at the rate of 160 flashes per minute, those to the rear at 40 per minute, and the beam lamps at 80 per minute; all three rates can be instantly distinguished by the observer.

The flashing lights have two advantages: their intermittent character attracts attention even at the peripheral limits of the field of view, while the flash rate gives immediate indication of whether the other aircraft is approaching, receding or on a more or less parallel course. Moreover, the intense blue-white flashes are easily seen against beacons, landing approach lights, etc, and the pilot can see within seconds if the relative bearing of another aircraft does not change, thus indicating that the two aircraft are on a collision course.

Another important advantage of the xenon lamp system is that, by compressing great intensity into a very brief period, great range is obtainable for a very modest power consumption. The peak intensity is about 5 000 000 lumens, and night observations have been reported at distances of over 70 miles. In daylight, the sighting range varies from 5 miles in bright sunlight up to 15 miles in conditions of poor general visibility. The flash duration, of about 0·001sec, is below the value at which a latent image is formed on the retina, so that the observer is not dazzled and there is no deterioration in night vision.

The equipment is mounted at each wingtip, either in a streamlined pod, or built into the wing structure. Only low-voltage supplies need be carried through the wing, a power convertor being used to provide the 450V d.c. required for operation. A constant-frequency transistorized pulse network operates a stepping relay whose output shaft carries switching cams to provide the appropriate flash rate for each location. The flash tubes are rated at 100W-sec, but are operated at only 12W-sec to ensure long life and reliability. The total power requirement of the complete system is less than 300W,

LETTERS TO THE EDITOR

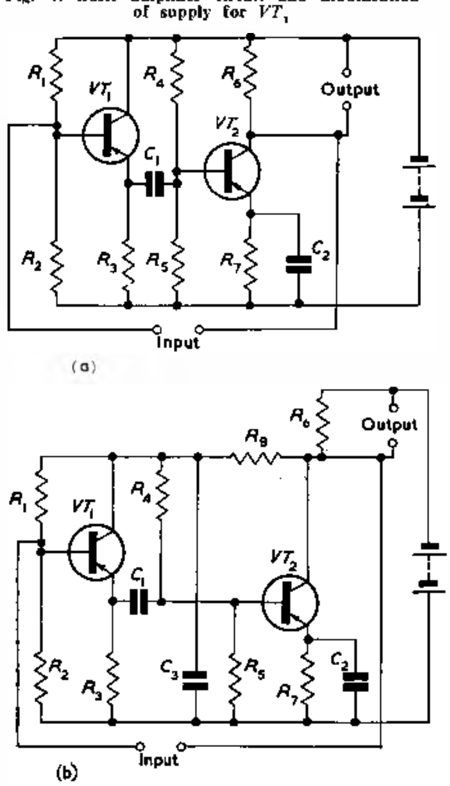
(We do not hold ourselves responsible for the opinions of our correspondents)

An A.C. Transistor Millivoltmeter with a High Input Impedance

DEAR SIR,—The input circuit described by Vierhout in his article 'An A.C. Transistor Millivoltmeter with a High Input Impedance' in your July issue represents an interesting solution to the problem of obtaining high input impedances with transistors. Amplifiers of this type[1,2], however, suffer from the disadvantage that neither side of the input is common with the power supply, a factor which sometimes precludes their use. A basically similar circuit in which this difficulty is overcome is described below[3].

Fig. 1(a) shows an amplifier similar to that described by Vierhout. The input signal is applied between the normal input and output connexions and the output appears across R_6. A circuit of this type gives a voltage transfer close to unity and has an input impedance approximately equal to the product R_6 and the overall current gain. The voltage supply for the transistor VT_1 and the bias resistor R_4 may be derived from the collector of transistor VT_2 through R_8 as shown in Fig. 1(b). Provided that resistor R_8 has negligible loading effect on R_6 and capacitor C_3 has a very small impedance to the signal frequency, the performance of the circuits in Fig. 1(a) and 1(b) will be identical.

Fig. 1. Basic amplifier circuit and modification of supply for VT_1



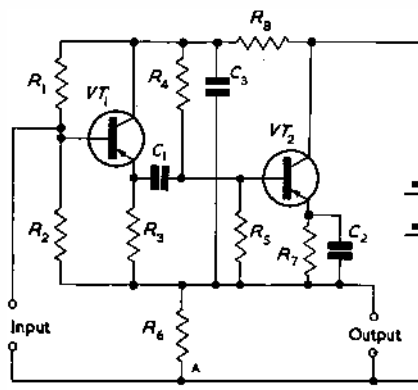


Fig. 2. Further modification making common point between input, output and supply

The positions of resistor R_6 and the supply may now be interchanged (Fig. 2). Assuming that the supply impedance is low there is again no change in performance and the point A is now common to input, output and the positive side of the supply. Circuits of this type provide input impedances in excess of 5MΩ and employed in conjunction with crystal microphones have proved very useful in sound level measuring equipment[4].

Yours faithfully,

B. J. WHITE,

Dawe Instruments Limited,

Ealing, London W.5.

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DEAR SIR,—We have read the article by R. R. Vierhout in the July issue, but have had some difficulty in interpreting the accuracy claim of 2 per cent of full scale.

The 2·5V range of the Model 8 AVO has a claimed accuracy of 2 per cent of indication between full scale and half scale deflexion, e.g. a possible inaccuracy of 2 per cent of full scale for a full scale indication.

To achieve, then, an accuracy of 2 per cent of full scale, the unit described would require to have negligible inaccuracy under this condition. This is possible under certain circumstances, for example, immediately after calibration, but one has difficulty in visualizing this claim as a long term accuracy. With the circuit shown in Fig. 2, a 20 per cent change of gain without feedback on the 10mV range due to battery ageing, etc., will result in a 1 per cent change of gain with feedback, i.e. a further inaccuracy of 1 per cent, and without doubt such changes can occur. There may also be components of inaccuracy over the frequency range and due to errors in the ranging resistors, etc.

We note also that the instrument appears to respond to the peak value of the input signal, and thus can have an additional error commensurate with the total harmonic distortion present.

With reference to calibration, we are unable to identify the 25kΩ potentiometer mentioned in the text and in the circuit diagram of Fig. 4.

Yours faithfully,

D. J. COLLINS and D. A. G. TAIT,

Dorking, Surrey.

The Author Replies:

DEAR SIR,—The comment by Mr. White is very valuable, the more so as the ways in which different input impedances with transistors can be obtained are not well known to a number of designers of transistor circuits.

I agree with Mr. White that the circuit of Fig. 2 has the advantage of having one side of the battery connected to the common input and output connexions. However, in this circuit the input impedance is about equal to the product of the current gain and the equivalent resistance of R_6 and R_8 in parallel. R_8 should be not more than several kilohms in order to avoid too large a voltage drop. The input resistance is, therefore, halved in comparison with my circuit. The circuit of Mr. White has a voltage amplification of nearly one, while my circuit has a voltage amplification of three. This could be of importance in the case of designing a transistor millivoltmeter with as few transistors as possible while a reasonable amplification stability is required. In a battery operated meter the disadvantage of separate batteries does not appear to be serious. Noteworthy is that both in my circuit and in that of Fig. 2 several emitter-followers preceding the transistor can be connected in series, all with a bypass capacitor C_3 to obtain maximum amplification. Thus an input resistance of 100MΩ or more can be obtained.

* * *

The 2 per cent accuracy claimed for the AVO 8 concerns the absolute accuracy. However, one particular instrument has a linearity better than 1 per cent and this only counts, since the full scale deflexion can be adjusted to the proper value by means of the 25kΩ potentiometer. Concerning the potentiometer I offer my apologies for the mistake in Fig. 4. The 25kΩ is wrongly shown as 2·5kΩ.

The transfer impedance of the last two stages for the OC71 and OC44 is 8MΩ and 24MΩ respectively. The gain with feedback is 170. Assuming the base-emitter resistance of the transistors about 1kΩ the stability factor is $8{\cdot}10^3/170$ and $24{\cdot}10^3/170$ respectively. A 20 per cent change of the gain without feedback will then result in only 0·4 per cent or 0·14 per cent change of gain with feedback. After a test of heating the instrument to 45°C and inserting exhausted batteries of 18V the reading did not change more than 2 per cent. Exact measurement of input voltage always needs a knowledge of the waveform, whatever the method of detection.

The detection of peak value instead of mean or effective value has been purposely chosen because for the various waveforms e.g. time wave, square wave, triangular wave the amplitude is the relevant quantity.

The indicated ranges in the text refer to effective voltages. This was done because it is customary to read effective values. The peak value can be obtained by multiplying the scale reading by $\sqrt{2}$, which conversion factor applies to all waveforms.

Yours faithfully,

R. R. Vierhout,
R.K. Universiteit,
Nijmegen, Holland.

Measurement of Transistor Switching Parameters

Dear Sir,—The purpose of this letter is to describe a method of measuring T_{co} and other transistor switching parameters by a pulse-testing technique.

T_{co} is the value of T_c when $V_{bo} = 0$, T_c being the collector time-constant as given by Beaufoy and Sparkes[1].

The test circuit is shown in Fig. 1 and its function is to inject a known charge into the base of the transistor under test, so that the collector voltage rises to the brink of saturation. If V' is the value of the voltage V which brings the collector to the brink of saturation, if Q_b is the base charge and if Q_v is the part of Q_b required by the charging of the base-collector capacitance and by the change of the base width, then it is:

$$V'C = Q_b = T_{co}(E_c/R_c) + Q_v \;\ldots\ldots\; (1)$$

on condition that E_c/R_c is much greater that the collector current a $I_b = 0$ and that E_c is much greater than the collector saturation voltage. Consequently T_{co} can be determined from two measurements with the same E_c but different values of R_c:

$$T_{co} = (R_c/E_c) \,.\, \Delta V'C$$

after which Q_v can be also calculated.

If C is kept low enough, the product $V'C$ is independent of C and of the resistance in the base.

Fig. 2(a) shows collector waveforms for various values of V for a medium-speed junction transistor. The fact that the waveform has reached the saturation level can either be detected with an oscilloscope or with a device described below under (d).

The method described is, of course, based on the same principles as all pulse-testing methods, but it has the following advantages.

(a) Only V has to be varied during the measurement and V can be varied and measured simply and very accurately. Parasitic reactances can be kept low. Knowledge of β_o is not required.

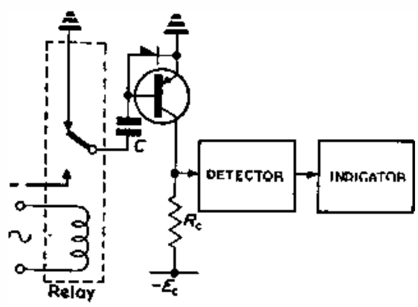


Fig. 1. The test circuit

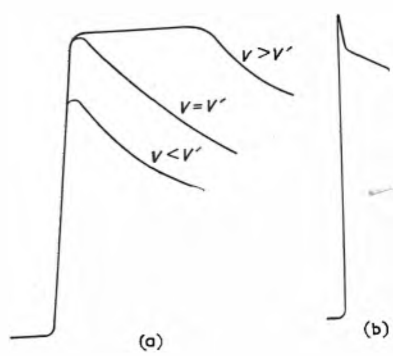


Fig. 2. Collector waveforms

(b) Since the pulse repetition rate can be as low as 50c/s a mercury wetted contact relay can be used and this is an inexpensixe way of making a square-wave generator accurately calibrated in amplitude and with rise- and fall-times to be measured in nanoseconds.

(c) Apart from stray capacitances between base and earth, the only discharge path for C is through the transistor base.

(d) Last, but most important, it is possible to avoid the use of an oscilloscope and of a skilled operator, using instead a detector circuit to detect that the collector voltage swing has reached a given level.

The detector output triggers a monostable device whose output is used to flash an indicator lamp. Therefore, given E_c and R_c, the operator has only to choose a value of C suitable to the transistor speed and then increase V until the indicator starts flashing.

This circuit, with a fixed V, can be used to check or select transistors for maximum Q_b, using an unskilled operator.

Substitution of C with a suitable resistor allows measurements of β_o (value of β at the brink of saturation).

Simple detectors can be built using circuits of the long-tailed pair type, with or without positive feedback.

A more sophisticated detector (or a fast-rise oscilloscope) has to be used when the collector waveform does not rise regularly (see Fig. 2(b)) displaying the wiggle-effect described by Sparkes.

This occurs with some types of transistors, especially at low collector currents. Wiggles can be also generated by some sort of parasitic effect, since the discharge of C is a matter of tens of nano-seconds and therefore there is a narrow voltage spike on the base (caused by the total base resistance) while the collector waveform rises sharply even with slow transistors.

But even if one has to use an oscilloscope the test circuit still retains its simplicity.

Spikes on the collector waveform can be generated also by the diode inserted between base and emitter to limit the positive voltage swing on the base.

In case I_c at $I_b = 0$ is too large, the base has to be given a small positive bias.

R. P. Nanavati[2] recently described a circuit for measuring T_s (the saturation base constant) using the discharge of a capacitor into the base of the transistor being tested to remove the excess charge stored in it until the transistor starts going out of saturation.

It has been found useful to use a detector also in a circuit of the type proposed by Nanavati for making a simple test instrument for measuring T_{co}, Q_v, T_s and β_o.

It is thought that, using the principles described, the measurement of transistor switching parameters can be easily made automatic.

It might be of interest to add that the expression of Q_b given by equation (1) is not only very useful for junction transistors, but also for the new faster transistors, which, however, show a much more marked dependence of T_{co} on I_c, especially at low values of I_c. This fact, though, is not very important from the point of view of many applications because for these transistors Q_v is an important part of Q_b.

In any case T_{co} is not more variable than β_o.

Yours faithfully,

Paolo Ercoli,
Consiglio Nazionale delle Ricerche,
Rome, Italy.

References

1. Beaufoy, R. Sparkes, J. The Junction Transistor as a Charge-Controlled Device. *A.T.E. J. 13*, 310 (1957).
2. Nanavati, R. P. Prediction of Storage Time in Junction Transistors. *I.R.E. Trans. ED-7* 9 (1960).

Short News Items

The Council of Industrial Design is arranging a course in design appreciation for apprentices and junior engineers from both light and heavy engineering industries. It will be held near London in November and December, and will be arranged in two residential periods, each of four days, separated by an individual study period of three weeks. The cost will be 35 guineas for each student. A detailed programme is now being prepared and will be available shortly and further particulars can be obtained from the Education Section of the Council of Industrial Design, 28 Haymarket, London, S.W.1.

Two British authorities on machine translation, Dr. Andrew Booth and Dr. John Cleave, have recently returned from a British Council sponsored visit to this year's Alpbach Forum in Austria. Every year since 1945 a group of eminent European scholars, artists and leading personalities in political and economic life have been invited to the Forum. In Alpbach they hear lectures, and take part in discussions and study groups dealing with one topic of prime importance to Europe. This year the subject 'Language and the World' was of great interest to workers in the field of translation by electronic computer, which involves wide research into the theory, structure and scope of language. Dr. A. D. Booth is Reader in Computer Design at the Department of Numerical Automation, Birkbeck College, London University. Dr. J. P. Cleave is Lecturer in Computation at the Department of Mathematics, Southampton University.

Communications and Space Research will be the subject of next year's Convention of the British Institution of Radio Engineers. In announcing this decision the Institution's Council has in mind the need for an open discussion on the enormous amount of work now being carried out in this country and elsewhere in developing space communication techniques. Recent articles in the Institution's Journal have referred to proposals for using satellites for relaying radio and television signals, and this will form the subject of an important session of the Convention. Associated techniques such as the role of electronics in the guidance and control of rockets and space vehicles, radio astronomy and radio measurements in the ionosphere will also be discussed. A further announcement will be made shortly regarding the date and place of the Convention. In accordance with the custom of the Institution, it will be held during the summer months at a British University and will be residential.

Telefunken G.m.b.H. of West Germany has recently obtained an order for the installation of a precision approach radar system for Shannon Airport. The installation will provide an approach control on five landing strips. Changeover to any of the various landing directions is performed automatically from the display unit of the equipment. No readjustments are required on the display unit or the antenna when changing from one runway to another. A similar installation, controlling three landing strips, has been ordered from Telefunken by the Polish Air Traffic Administration for the Warsaw Airport. The Telefunken Co. is also supplying a radio communication system for the Suez Canal comprising five fixed v.h.f. transmitting/receiving equipments to be installed along the 103-mile-long Canal between Port Said and Suez. This line of stations will be controlled over cables from the operational centre at Ismailia situated about midway between Port Said and Suez. This apparatus will be used for communication purposes by the Canal Administration and for reporting the actual position of convoys. The pilots on board of each ship will be provided with a portable 'Teleport' radiotelephone set which within the ranges of the relay stations will establish uninterrupted communications with the shore. This will permit the traffic control department to communicate with any ship at any time.

READER INFORMATION SERVICE

Readers may have noticed that the Reader Information Service cards in this issue carry the words "References apply to October 1960 issue only". All cards will in future carry this restriction to the month of issue.

The Publishers much regret the necessity to impose this limitation, but with enquiries being received at the rate of about 1 000 per week simplification of the internal system has become imperative if prompt dispatch of enquiries to manufacturers is to be achieved.

The National Research Council of Ottawa, Canada, has formed an Associate Committee to deal with problems of national scope in the field of automatic control. Chairman of the group is Dr. J. Ham, Professor of Electrical Engineering at the University of Toronto. The Committee will co-ordinate university, industrial and government interests in control theory and practice. It will recommend general areas for Canadian research in automatic control, and will encourage research investigations. The Committee will also represent Canada on the International Federation of Automatic Control.

A Conference on Electronic Telephone Exchanges is to be held at the Institution of Electrical Engineers, Savoy Place, London, W.C.2, on 22 to 24 November. The Conference is intended to provide an opportunity for the interchange of information and experience of the construction and operation of electronic exchanges of all kinds, both in the United Kingdom and overseas. Further details and registration forms for those wishing to attend the Conference may be obtained from the Secretary.

20th Century Electronics Ltd have recently completed the delivery of a large number of reactor control ionization chambers for incorporation in the control systems of 'Triga' reactors being built by General Atomics, California, U.S.A. The chambers include 20th Century's type RC6 which is a gamma compensated ionization chamber based on A.E.R.E. designs.

VASCA—the Electronic Valve and Semi-Conductor Manufacturers' Association which was formed last year has now taken over from B.V.A. (the British Radio Valve Manufacturers' Association) responsibilities for semiconductors and industrial valves and tubes, the B.V.A. continuing its separate interest in domestic valves and television tubes. Among the objects of VASCA are promotion of standardization, maintenance of quality of design and workmanship, encouragement of and participation in research and experimental engineering work and tests, co-operation with the Government, the Services, B.S.I., I.E.C., and I.E.E. and the promotion of exports.

The 1961 National Symposium of the Professional Group of Microwave Theory and Techniques will take place on 15 to 17 May at the Sheraton Park Hotel in Washington, D.C. The Technical Programme Committee for the Symposium is seeking original contributed papers in all fields of microwave research, development, and application, including especially the following:—

Precision Microwave Measurements—particularly involving plasmas, noise, parametric devices. Solid-State Microwave Devices, including active devices, such as amplifiers and frequency multipliers, and passive devices, such as switches and modulators. Sources and components at millimetre waves.

Five hundred word summaries of proposed papers should be submitted by 12 December 1960 to: Gustave Shapiro, Chairman, Technical Programme Committee, Engineering Electronics Section, National Bureau of Standards, Washington 25, D.C.

Radio Hong Kong's new v.h.f., f.m. broadcasting station, which went on the air last month, uses four Marconi 5kW f.m. transmitters in two parallel pairs to ensure the reliability required for unattended operation. The parallel pairs system was originally developed by Marconi's Wireless Telegraph Co. Ltd for use on remote transmitter stations, not easily accessible other than on foot. The station, which is situated at Mount Gough, was planned, built and installed, and will be serviced by Cable & Wireless Ltd on behalf of the Hong Kong Broadcasting Service. Four 5kW f.m. transmitters are used. The output of one of the English programme transmitters on 91Mc/s is combined with the output of one of the Chinese programme transmitters on 94Mc/s. This combined output is then fed through a 160ft length of 3½in diameter coaxial feeder to one half of the aerial. Similarly the other two transmitters are combined and fed to the other half of the aerial. In this way, should any one transmitter, combining unit, feeder or aerial-half develop trouble, then quarter power radiation is continued without interruption. The aerial is a Marconi Quadrant which is supported by a 135ft tower specially designed by British Insulated Callender's Construction Co. Ltd to withstand winds of up to about 160 miles an hour.

Johnson, Matthey & Co. Ltd announce that they are now producing very pure arsenic, antimony, tellurium and bismuth on a commercial scale. By means of newly developed techniques, arsenic is being produced with an impurity level of the order of 1 p.p.m., detected by use of present known and accepted spectrographic methods. The element is in the form of crystalline lumps and is packed in vacuum-sealed glass tubes. Antimony, with a maximum metallic impurity content of 5 p.p.m., and bismuth, with a maximum level of metallic impurities of 10 p.p.m., are being produced in ingot form. Zone-refined tellurium, with a metallic impurity content of the order of 1 p.p.m., is also available in bulk, in the forms of ingot or grain.

Lord Brabazon of Tara, who has been President of the Radio Industry Council since 1957, has agreed to serve for another year. E. E. Rosen and Hector V. Slade have agreed to remain chairman and vice-chairman respectively until the end of 1960. Following the sudden death of Air Marshal Sir Raymund Hart, Director, R.I.C., R. Kelf-Cohen, C.B., has been appointed Acting Director until such time as a permanent appointment has been made.

The Autonomics Division of the National Physical Laboratory announces the convening of an international conference on Machine Translation of Languages and Applied Language Analysis, to be held during 5 to 8 September 1961 at the NPL Conference Centre, Teddington. Written contributions to the conference are invited from workers engaged directly in research into the machine translation of natural languages and also from those who are concerned with the syntactic or semantic analysis of languages, where such analysis may be of help in achieving machine translation. Papers should be sent to the Chairman of the papers subcommittee of the appropriate area, depending on the country of origin of authors, to be received by him by 31 January 1961.

U.S.S.R., Eastern Europe: To be arranged. U.S.A.: Professor L. Dostert, Georgetown University, 1715 Massachusetts Avenue, Washington 6, D.C., U.S.A. All other countries: Dr. A. M. Uttley, Superintendent, Autonomics Division, National Physical Laboratory, Teddington, Middlesex, England.

Details of the Conference programme and of arrangements for registration of delegates will be announced in the Spring of 1961. The Autonomics Division will be pleased to accept requests for these details at any time.

The Institute of Physics and the Physical Society announces that it is arranging a Symposium on 'Electrical Contacts' in collaboration with the Institution of Electrical Engineers which will take place at the Brunel College of Technology, London, on 5 to 7 April 1961. The Symposium is intended to cover recent advances in the study of the phenomena occurring at mating surfaces carrying currents used in light electrical engineering. It will include electrical erosion and material transfer, mechanical wear, and the influence of surface films and contamination and will deal with make and break contacts, sliding contacts, semi-permanent contacts and connexions between metallic and non-metallic materials. All communications regarding the Symposium should be sent to the Secretary, The Institute of Physics, and The Physical Society, 47 Belgrave Square, London, S.W.1.

The British Electrical & Allied Manufacturers' Association has established a Semi-Conductor Devices Section in recognition of the rapid technical advance in semiconductors and their increasing application for power and industrial purposes. The formation of this Section will provide within the BEAMA an expert body to guide manufacturers of semiconductor devices on matters of industrial policy. This Section will co-operate closely with the Electronic Valve and Semi-Conductor Manufacturers' Association (VASCA), and among the important objectives will be the work of fostering standardization of semiconductor devices, both on a national and international basis. This Section will also co-operate with other associations and sections of the BEAMA concerned with the application of semiconductor devices. The Chairman of the new Section is L. E. Thomson, Rectifier Section, Westinghouse Brake & Signal Co. Ltd. The Secretary is C. Brooks, BEAMA, The Red House, Ascot, Berks, from whom further information can be obtained.

Mullard Ltd have obtained a contract worth 2 million dollars for the supply of Travelling Wave Tubes to the Radio Corporation of America. These tubes which are intended for use in a new R.C.A. multi-channel radio communication system were developed by Mullard Research Laboratories and will be manufactured at the Company's Transmitting and Microwave Valve Plant at Waddon, Surrey. First shipments are expected to be made in May 1961.

An apprenticeship scheme designed to produce a flow of graduate engineers, qualified technicians, and craftsmen suitable for employment in the Electronics Department has recently been introduced by Sir W. G. Armstrong Whitworth Aircraft Ltd, Baginton, Coventry. There are two levels of entry, one at 'O' level of the G.C.E. with four passes including Mathematics, and preferably Physics and English. The other is at 'A' level of the G.C.E. with three passes including Mathematics and Physics. This apprentice scheme has been approved by the Institution of Electrical Engineers, and is thought to be the first scheme run by an aircraft company with I.E.E. approval.

The Twelfth Annual Exhibition of Cardiological Apparatus organized by the Society of Cardiological Technicians of Great Britain is to be held at the Lowndes Hotel, Welbeck Street, London, W.1, on 14 to 15 October. Admission is by ticket which is obtainable from the Cardiological Department of St. Bartholomew's Hospital, London, E.C.1, and the University College Hospital, London, W.C.1.

A Marconi AD2300 Doppler Navigator has recently been flown at Mach 2 at high altitude in the Mirage IV, when its accuracy was shown to be well within its specification. The equipment has been undergoing comprehensive evaluation trials at the Centre d'Essais en Vol since September 1959, when a substantial order was received from Générale Aéronautique Marcel Dassault for AD2300 doppler navigation equipment and specially developed navigation computers for the Mirage IV.

L. Light & Co. of Colnbrook, Bucks, have developed a technique for the production of high purity phosphorus in either red or white forms with a minimum purity of 99·999 per cent.

Correction

Role of Space Charges Waves in Modern Microwave Devices by G. D. Sims and I. M. Stephenson (ELECTRONIC ENGINEERING 32 1960, pp. 408-413, 499-503, 567-571). The authors apologize for the omission of a factor $1/\omega_p$ on the r.h.s. of equation (13) (p. 410).

Equation (13) should read:

$$V_1 = (u_o/\omega)(\pm\, \omega_p/\rho_o\eta)\, J = \pm(u_o/\omega \,.\, \omega_p\epsilon_o)\, J_1$$

Also equation (33) p. 500 should read:

$$f_1(Tb) = -(Tb)\,\frac{J_1(Tb)}{J_o(Tb)}$$

$$= \tau b\,\frac{K_o(\tau a)I_1(\tau b) + I_o(\tau a)K_1(\tau b)}{K_o(\tau a)I_o(\tau b) - I_o(\tau a)K_o(\tau b)}$$

BOOK REVIEWS

Electromagnetic Fields, Energy and Forces

By Robert M. Fano, Lan Jen Chu and Richard B. Alder. 513 pp. 99 Figs. Medium 8vo. John Wiley & Sons, Inc, New York. Chapman & Hall Ltd, London. 1960. Price 116s.

THE interesting thing about the theory of electromagnetism is that there are as many interpretations of it as there are professors. The unique feature of this book is that it definitely rejects the traditional idea of circulating currents as the origin of the magnetic properties of matter, and postulates the existence of 'magnetic charges' which, however, may only occur in pairs so that dipole phenomena are observed but never the effects of single charges. It is argued that if a circulating current is placed in a steady electric field, there should be a transfer of energy from the 'uphill' to the 'downhill' side of the circuit, and the idea of energy transfer within a permanent magnet immersed in an electrostatic field is repugnant. (What would be meant by transfer of energy from one side to the other of a spinning electron?) One suspects that the principal motive for this stand is the greater symmetry of equations resulting from the introduction of magnetic charge and magnetic current to parallel electric charge and electric current, but unfortunately the phenomena of electromagnetism have some inherent asymmetry, as is explained on p. 215 of the book. It is, of course, pointed out throughout the book that for all practical purposes the hypothesis of magnetic charge leads to the same results as the hypothesis of circulating currents.

The application of Maxwell's equations to particular cases is notoriously difficult on account of boundary conditions. The need to solve for electric and magnetic components simultaneously is avoided by the authors by a technique of successive approximation, which uses the fact that a steady electric current produces a magnetic field but a steady magnetic field produces no electric effects. One may therefore calculate the zero order electric and magnetic fields E_o and B_o from the charge distributions; then use dB_odt to obtain a corrected electric field E_1 from which one derives corrected currents and magnetic induction B_1; use dB_1dt to obtain E_2 and so on. The result converges if the time of propagation across the system is small compared with the time required for fields to change.

Another interesting point is that the authors reject the concept of 'displacement current' in a vacuum admitting only polarization currents in a material medium. Since the medium of electromagnetic propagation is not nowadays considered to have material properties, this is intuitively very acceptable; but it carries with it the consequence that electric current is not always a continuous quantity. In fact electric current ceases to be a fundamental entity, being replaced by the circuital integral of magnetomotive force which is a constituent of the integral form of Maxwell's equations.

This book represents part of the M.I.T. programme of refreshing electrical engineering education by emphasizing fundamentals rather than techniques; and it is aimed at students who in Britain would be classed as 'Second Honours year.' Many teachers will doubt the wisdom of introducing the magnetic charge hypothesis to such students, but for the more mature student it is at least a valuable challenge to clarify the defence of whichever hypothesis one chooses. As a text book for a first serious course in electromagnetism, it has the merits of being very readable, of having numerous problems for solution, and most important, of having selected references to parts of other books. By this means the student may be introduced to more advanced books, Stratton's *Electromagnetic Theory*, Guillemin's *Mathematics of Circuit Analysis*, *etc.* and to the original work of such authors as Maxwell, Einstein, Sommerfeld. But one wishes it had also given a reference to Poynting's original paper, since the treatment of field energy is largely based on Poynting's theorem.

Appendix 1, 'Four-dimensional Formulation of Electrodynamics,' is at a more advanced level, but is included because it has some bearing on the interpretations which the authors have chosen for the ordinary three dimensional equations. Appendix 2 is a useful discussion of Units and Dimensions, with a table of mks units and their dimensions in M, L, T, Q; and appendices 3 and 4 serve as a glossary of vector differential operators and vector operations.

D. A. BELL

Fundamentals of Electronics

By E. N. Lurch. 601 pp. 494 Figs. Medium 8vo. John Wiley & Sons, Inc, Chapman & Hall Ltd, London. 1960. Price 66s.

TEXTBOOKS on electronics are becoming so numerous and so like each other that a formula should be devised to give a figure of merit by which a student can decide on a 'best buy.' This figure would include a factor to take account of the student's requirements and attainments and one reason why this book cannot be wholeheartedly recommended as a 'best buy' is that it is difficult, despite the statement of the author's aims, to discover the type of student for whom it is best suited.

It deals thoroughly, at a fairly high level, with thermionic vacuum tubes and transistors, giving their characteristics and applications, with graphical and mathematical analyses of many of the circuits in which they are employed. The mechanism of emission and semiconduction are treated in sufficient detail for the subsequent chapters to be readily understood. In particular, the four-terminal network, hybrid parameter treatment of transistor amplifiers is very carefully explained and illustrated by numerical examples, and the four chapters on oscillators of various kinds are good. But because of the rather arbitrary restrictions he has imposed, the author has often gone too far for the 'non-engineer' (to whom the book is directed) and by avoiding mathematical treatment of many interesting circuits when the algebra threatens to become fairly complicated, will disappoint any more enquiring reader.

One regrets the omission of some account of tubes for use at v.h.f., the c.r.t. other than as an electrostatically-controlled measuring instrument, and photo electric devices. And when, please, will authors writing about electronics in general include the more important types of television camera tube? Something of these subjects, it is felt, could have replaced the chapters headed 'Auxiliary components in electric circuits,' 'Decibels and sound' and 'Audio Elements' (a very superficial treatment), all of which would be more appropriate in a book on 'Communications'.

Each chapter is introduced by a synopsis and followed by a useful set of questions which emphasize the salient points and provide numerical exercises. Misprints are comparatively few, but there are a number of incorrect graphs which appear to have been drawn to fit a draughtsman's curves rather than the mathematical equation or oscillogram. An occasional attempt to give a simple explanation of a complicated phenomenon has led to a misleading statement and there is some looseness of expression which is undesirable in a technical book. The equal treatment of vacuum tubes and transistors in one volume is useful and the book bears comparison with others of about the same price.

A. W. HARRIS

Proceedings of the Symposium on Millimeter Waves

Edited by J. Fox. 656 pp. 408 Figs. Medium 8vo. Interscience Publishers Inc, New York. 1960. Price $8.00.

THIS is the ninth volume published in this series since 1952. The present volume could be regarded as a continuation of volume IV entitled 'Modern Advances in Microwave Techniques,' November 1954. It deals primarily with aspects of theory, generation, measurement and application of microwaves. The stress is on millimetric waves but in several cases reference is made to submillimetric spectrum.

The field of millimetric waves is a rapidly expanding one. It calls for cooperation of various specialists and a symposium is a good way of achieving this. The book is a collection of papers presented during the symposium held at Brooklyn Polytechnic in New York in the Spring of 1959. Altogether some 40 papers were presented by contributors from various parts of the world, including U.S.A., Japan, U.S.S.R., G.B., etc.

A large proportion of the book deals with various aspects of generation of short millimetric waves: a field hampered by numerous difficulties. The methods of generation are diverse. On one side there is the conventional klystron which for millimetric waves is being pushed to the limits of present technology. There is the much favoured Carcinotron. There are also a number of rather sophisticated and frequently inefficient methods of generation of millimetric waves such as Cerenkov radiation, generation of harmonics from lower frequencies, radiation from relativistic electron streams, etc. This is a wide field crowded with technological difficulties.

Millimetric waves is a fascinating and challenging field. But there are inherent difficulties in dealing with millimetric waves and various aspects of measurements, control and utilization form a proportion of the book. There are many fields of application of millimetric waves. To mention just two: millimetre wave spectroscopy in physics, and communications, in particular long distance communication by waveguide. These have been made possible through the rapid development in microwave techniques.

Transmission of millimetric waves is another aspect that makes extreme demands on human ingenuity. The waves are rather severely attenuated in free space and the conventional waveguides are lossy and inconveniently small. On the other hand transmission in multimode waveguides and quasi-optical methods are most promising: a number of papers are devoted to these aspects.

Being a collection of papers by specialists the book is not intended to be a balanced survey, but it does contain a great deal of material of interest to those engaged in the microwave field.

A. E. Karbowjak

Analogue and Digital Computers

Consulting Editor, M. G. Say. 303 pp. 223 Figs. Demy 8vo. George Newnes Ltd, London. 1960. Price 50s.

This book has been written by a panel of specialists each of whom has contributed material in his own field. It deals with computers in general and the principles of analogue and digital machines. Chapter 1 discusses the basic differences between the two types; the remaining chapters being divided into two sections dealing in detail with analogue and digital machines respectively. The book is intended primarily for newcomers.

The various aspects of analogue computing such as scaling, operation, design, and testing are covered adequately if somewhat illogically. For instance the high gain amplifier is introduced as a computing element at an early stage but the explanation of why it works is not given until later.

The chapter on design is too detailed for the newcomer and some of the space could have been more profitably used to give further illustrations of the ways in which typical problems are solved on analogue machines.

The section on digital machines is much the better and the reader is taken step by step from the first principles of number representation to operation, circuit elements, storage, input-output equipment and programming. The reader's attention is occasionally distracted by the introduction of number and logic tables occupying too large an area of the page and by the inclusion of detailed circuit diagrams. These, in fact, are not truly contemporary; only once in chapter 7 is a brief excursion made into transistor and core logic.

For newcomers the book is a mine of information, but it is felt that the reader would have benefited if in both sections much of the circuit detail had not been included.

P. L. Owen
T. R. H. Sizer

Automatic Translation

By D. Yu. Panov. Translated by R. Kisch & edited by A. J. Mitchell. 73 pp. 27 Figs. Demy 8vo...Pergamon Press Ltd, New York, London. 1960. Price 21s.

This book contains a record of Russian work on machine translation until 1956, with additional material added to the translation to bring it up to date.

It starts with a brief introduction and history of machine translation, and it is interesting to see how the Russians have reacted to Western experiments in the field, especially to the Georgetown experiment of 1954. From the Western point of view, the claim that machine translation was first pioneered by P. P. Troyansky in 1933 is hard to believe, especially since "automatic installations suitable for the purpose had not yet been created" (page 3).

This is followed by a chapter on the techniques used by a human translator and one on the way in which these can be simulated by a computing machine. Chapter 4 contains a detailed description of a computer. In chapters 5 and 6 the author studies the construction of the automatic dictionary and the encoding of words in numerical form for machine use. Chapter 7 gives in detail one of the Russian programmes for machine translation and this is followed by discussions of the problems encountered in translating such languages as Chinese and Japanese, the structural analysis of language, ambiguity, style and editing by machine, and the problems involved in multi-lingual translation and the use of an intermediary language. The book ends with a very brief conclusion and an appendix containing an analysis of an English sentence by machine.

The book is very clearly written and the translation and editing are equally good. It can be recommended to anyone who wishes to find out about machine translation.

A. D. Booth

Principles of Semiconductor Device Operation

By A. K. Jonscher. 158 pp. 58 Figs. Demy 8vo. G. Bell & Sons Ltd. 1960. Price 30s.

THE semiconductor field is now so vast, that for the author of a text book to do anything like justice to his subject matter, this must have a fairly limited scope. The topics presented in this book are the injection, transport and decay of excess carriers in semiconductors. As the book is only of moderate length the two introductory chapters, which set down the basic concepts associated with the determination of equilibrium and non-equilibrium carrier densities, contain much background material which has to be presented without proof. Subsequently, the theme of the text is developed in chapters entitled 'Transport of Excess Carrier Densities in a Homogeneous Medium,' 'Theory of p-n Junctions and Junction Diodes' and 'Theory of Multi-Junction Structures,' while there is a short final chapter on 'Carrier Flow in Inhomogeneous Media.'

The unified treatment of this basic section of semiconductor theory is very welcome and has been well presented. Emphasis has been placed on the underlying one-dimensional theory of carrier flow in filaments and devices having rectangular geometry. In the steady state analyses, due regard has been given to the effects of carrier injection level. Within its range the book is excellent, the author having taken pains to give clear descriptions of the physical processes associated with transport phenomena which have not been too intelligible in some of the early papers written on this topic. It cannot be said, however, that the treatment is as 'complete' as is suggested on the dust cover. It is noted for example that there is no treatment, nor indeed mention of the effects of injection level on transport phenomena in diodes and transistors at high frequencies, although several papers have been published on this topic. Nevertheless what is done is done well, and the book will be valuable to all who wish to understand the basic principles on which the operation of semiconductor devices depend.

F. J. HYDE

The Arc Discharge

By H. de B. Knight. 436 pp. 208 Figs. Demy 8vo. Chapman & Hall Ltd. 1960. Price 63s.

MR. H. de B. KNIGHT has devoted almost the whole of his industrial career to the study of arc discharges and he is probably more qualified than any other person in this country to write a book on the application of the discharge to power control.

The book is primarily concerned with hot cathode gas filled valves and mercury pool ignitrons and excitrons. Mr. Knight first describes the design of typical devices and then discusses the relevant gas discharge theory on which the design is based. Finally there is an applications section which gives details of typical circuits in which the devices are used and advice on how to use the valves in service.

Arc discharges are difficult to work with because although there is a considerable volume of physical theory on the subject it usually seems that the theory can explain a result only after it has been obtained, it cannot predict what is going to happen in advance. The author is therefore describing devices which have been evolved by taking due note of theory, by noting the materials available for construction and finally, more important, by observing how previous devices performed on test.

The main criticisms of the book would be that it is a little confusing to find the section on physical processes in the discharge placed after general principles, characteristics and construction; as a result of this approach there is some repetition.

On page 225 it is stated that deionization of a gas is assisted by negative bias; this is not completely in accord with most recent theory*.

The book is perhaps not entirely suitable for students; one would hope that they would concentrate more on the theory of the arc discharge so that future practice will be less the result of trial and error. It will, however, be extremely valuable to electronic valve designers and manufacturers and to application engineers and users of arc discharge control devices.

It was a pleasure to read a book in which there appear to be no obvious typographical errors, a tribute to the publishers and to Mrs. H. de B. Knight and Mr. L. Herbert who checked the proofs.

* *Studies of Thyratron Behaviour. L. Malter and E. O. Johnson. R.C.A. Review. June 1950. Vol. XI No. 2.*

K. G. COOK

Telemetering Systems

By P. A. Borden & W. J. Mayo-Wells. 330 pp. 291 Figs. Medium 8vo. Reinhold Publishing Corpn., N.Y. Chapman & Hall Ltd. London. 1960. Price 68s.

THE value of this book is largely as a review of telemetry systems and equipment, in which full importance has been given to a balanced presentation and grouping of the subject matter. These attributes are particularly noticeable in the introduction, which is excellent—seventeen pages are taken to survey and set in perspective the field covered by the authors without the reader being really conscious of the amount of compression that has been achieved. In the remainder of the book, however, these high standards are not uniformly maintained. Although very detailed descriptions are provided of equipment, largely American in origin, with clear diagrams and well chosen illustrations, virtually no mathematical treatment is attempted.

Thus, chapter 13—'Selection and Application of Telemetering Systems' gives a comprehensive account from a potential user's point of view, but would gain considerably if the information theory aspect had been brought in. This would be particularly true if the utmost benefit were to be derived by students and designers concerned with the fundamentals of telemetry.

There is no doubt that the whole field of telemetry application has been covered in the widest possible sense, especially in up-to-date uses, not only to the more obvious Guided Weapon and similar projects, but also to automation in all its relevant forms, such as digital systems for Public Utility and other industrial purposes. In this connexion it is noteworthy that closed-circuit television is only briefly mentioned (in a two-page chapter 'Remote Reading of Meters and Registers'), whereas television is regarded by most authorities as being a major sub-division of telemetry.

The book, however, gives evidence of very careful preparation, particularly with regard to choice of words and the realization of the value of exact definition. The whole attitude is well illustrated by the reference to (page 74) ' . . . misleading colloquialism "synchros" ', and by the considered use of 'intelligence' throughout as a generic term for that which is conveyed by and through the medium of telemetry.

As has been indicated, the attraction of this book will be greatest to those who wish to examine telemetry in the light of practical applications, and it could well become a standard reference book for this purpose.

R. E. YOUNG

Physique et technique des tubes électroniques

By R. Champeix. 428 pp. Crown 4to. Volume 2—Théorie et fabrication des tubes. Dunod, Paris. 1960. Price 58 NF.

R. CHAMPEIX has worked practically all his life in electronic tubes, and his wide experience is apparent in this book. Volume I deals with vacuum technique. The present volume II presents first the electron, its production and its behaviour in electrical and magnetic fields. Valves are then studied, starting with diodes and taking up in order triodes, cathode-ray tubes, photoelectric tubes, and gas tubes. The second part of the book is devoted to technical and technological considerations pertaining to the design and development of electronic tubes. A number of appendices study in detail particular points falling somewhat outside the general scope of the book, but relevant to the subject matter. Problems for each chapter are given at the end of the book, as well as a subject index.

The avowed aim of the book is to strike a happy balance between theory and practice. Only a long perusal could ascertain whether this ambition has been fulfilled. To this reviewer, it seems that the book could almost have been presented in two separate volumes with little extra material and perhaps better independence between theory and practice. As it stands, no technician in the field should be without it.

A. V. J. MARTIN

THE AIRCRAFT EXHIBITION

A description, compiled from information supplied by the manufacturers, of a few of the electronic exhibits shown at the recent exhibition of the Society of British Aircraft Constructors.

(Voir page 659 pour la traduction en français : Deutsche Übersetzung Seite 667)

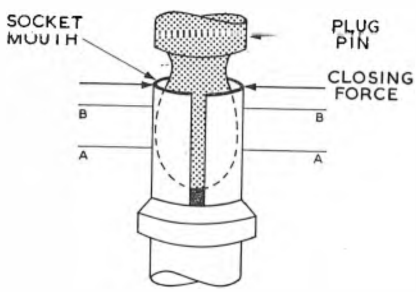
BELLING AND LEE LTD

Great Cambridge Road, Enfield, Middlesex

MULTI-PIN CONNECTORS

(Illustrated below)

The 'Camlock' and 'Autolock' series of plugs and sockets embody a form of construction in which every pin of a multi-connector is individually locked into its mating socket. This ensures positive connexion of all poles and a high degree of reliability under conditions of shock and vibration.



The principle of operation is illustrated in the accompanying diagram. The plug pin normally fits freely in the socket, which is divided axially by two or more slots. On the application of a compressive force to the mouth of the socket, as indicated by the arrows, the inside walls are brought to bear on the bulbous pin and, as the force is progressively increased, the socket walls take up a curved formation, with a rolling fulcrum. The mouth of the socket never actually meets the neck of the pin, final contact being made at some point between levels AA and BB, depending on individual tolerances which are therefore not critical

Two distinct types of connector employing this principle were shown, and they have been called the 'Camlock', and the 'Autolock'. The former has multiple contacts arranged in straight rows, the closing force being applied by a bar with a key-hole shaped slot surrounding the mouth of each socket, which is moved along the row of contacts by an eccentric shaft operated by a rotating key built into the free plug member. A feature of the 'Camlock' series is the provision of a simple polarizing device which makes it possible to set up 36 different, non-interchangeable mating arrangements, each distinctively numbered.

In the 'Autolock' type, the locking action is automatically achieved in the final stage of mating. Here, the outside of the socket mouth is bell-shaped, and is closed by the axial movement of a cylindrical sleeve. In a multi-pole connector a single locking plate is employed, having a hole pierced for each pole, instead of a multiplicity of individual sleeves. The contacts may be grouped in any desired pattern, and in one form exhibited, where a circular housing is used, engagement of the plug and socket and the subsequent locking of the poles is brought about by angular rotation of the plug housing; this type of 'Autolock' connector is fully sealed, and a choice of any one of six different mating arrangements can be selected by the user.

EE 26 751 *for further details*

S. G. BROWN LTD

Shakespeare Street, Watford, Herts

SERVO AMPLIFIER

Using npn silicon transistors this 6·5W servo amplifier is capable of giving its rated output at ambient temperatures up to +90°C without the use of any additional heat sink. The unit has been primarily designed to operate in conjunction with the type 15B servo motor. An overall power gain of 72dB is available from the amplifier when operating from a source impedance of not less than 250Ω. The amplifier, designed to operate from a carrier frequency of 400c/s, is supplied as a sealed unit having dimensions of 3¼in × 1¼in × 2in.

The transistor power supply unit is designed to operate from 400c/s, 115V, and is capable of delivering up to 30W d.c.

EE 26 752 *for further details*

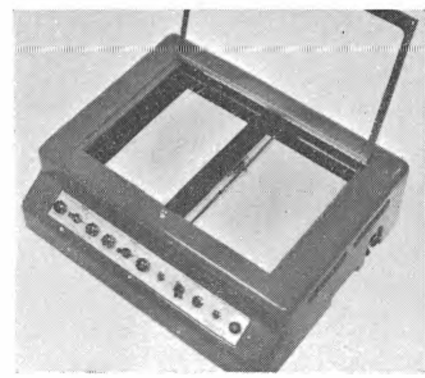
TUNING FORK OSCILLATOR AND DIVIDER UNIT

The tuning fork is a self-contained audio frequency source constructed from an extremely low temperature coefficient nickel steel and having an electromagnetic driving system of unique design. The nominal frequency is 2kc/s to better than 0·005 per cent at 20°C. Other frequencies within the 2kc/s to 2·4kc/s range may be supplied to order.

The transistorized oscillator utilizes a silicon transistor and will operate satisfactorily from dry cells of the 'hearing aid' type. It is fully operational over the temperature range −40°C to +70°C. The dimensions of the container, including the tuning fork, are 2½in × 2½in × 3in.

The frequency dividing unit provides a 5:1 division ratio and is primarily intended for use with the S. G. Brown 2kc/s tuning fork when it will provide a highly accurate 400c/s reference frequency. The dimensions of the container including the tuning fork and divider are 2¾in × 3¾in × 3½in.

EE 26 753 *for further details*



BRYANS AEROQUIPMENT LTD

1 and 15 Willow Lane, Mitcham, Surrey

CO-ORDINATE PLOTTING TABLE

(Illustrated above)

This is a self-contained and compactly designed instrument for use on a bench or desk. It will accept X and Y signals in the form of d.c. voltages and convert these to an appropriate pen position, thus drawing the graph of the X and Y relationship as these signals vary. The table is also fitted with a time-base which may be switched into the X axis, so enabling the Y voltage to be plotted against time.

The table has a Perspex lid to keep the writing area free from dust, and the graph paper is held in place by suction from a fan through the porous bed of the table. Graticules are provided for alignment of the paper.

The pen is of a capillary type with large ink reservoir and is lowered into the 'write' position by the operation of a switch on the front panel.

The table takes paper up to 17in × 11in giving a graphing area of 15in × 10in.

The pen is controlled in the two axes by a high-performance servo system, which gives both rapid dynamic response and great positional accuracy, the pen position being measured by precision potentiometers running the length and breadth of the table. Care has been taken in the design of the servo and ancillary circuits to ensure a minimum of drift, which has resulted in good long-term stability.

The controls of the table are all located on a sloping front panel. On the left-hand side are the Y axis controls, in the centre are the X axis controls including the time-base and write switch and on the right-hand side are the mains switch and pilot lamp.

The first Y axis control is called 'Y shift' and moves the pen anywhere along the Y axis. The complete Y traverse is obtained by ten turns of the Y shift knob, thus enabling the pen to be set accurately at any desired point along the Y axis.

The two remaining Y axis controls are marked sensitivity, fine and coarse. With these controls the sensitivity of the Y axis servo may be adjusted to any value between the limits of 0·07V/in and 7V/in of pen movement.

The X axis has similar pen shift and sensitivity controls to the Y axis which enables the pen to be positioned anywhere along the X axis. Thus, in conjunction with the Y shift control, one may establish a datum point for zero input signals anywhere over the writing area.

The plotting speed may be up to 20in/sec and the time-base speed is variable from 0·1in/sec to 10in/sec.

EE 26 754 *for further details*

COSSOR RADAR AND ELECTRONICS LTD

The Pinnacles, Harlow, Essex

AIRBORNE TRANSPONDER

(Illustrated above right)

A feature of the type 1251 secondary radar transponder is sidelobe suppression.

Although the sidelobes of an interrogator aerial are of much smaller amplitude than the narrow main beam they will provide sufficient signal strength to trigger transponders not equipped to discriminate against sidelobe interrogation. This would result in the replies from the aircraft being spread over a large area so that bearing information would be lost and other undesirable effects introduced such as interference with other ground stations and 'capture' of transponders by local stations, resulting in insensitivity to interrogation from distant stations.

Sidelobe suppression is effected by supplementing the directional interrogator transmission with an omnidirectional control transmission. Circuits embodied in the SSR.1251 transponder ensure that replies are made only to interrogations in which the amplitudes of the interrogation and control pulses appear in the relationship that can only exist in the direction of the main lobe. The sidelobe suppression system currently specified by I.C.A.O. is the 'two-pulse' system. An alternative 'three-pulse' system has been the subject of recent discussion and may also receive international approval. The Cossor ground equipment can be supplied to work with either system and the airborne equipment—currently supplied for use with the 'two-pulse' system—can be

modified for use also with the 'three-pulse' system.

The airborne transponder is suitable for unpressurized operation up to an altitude of 20 000ft and is designed to reply to interrogation signals consisting of pairs of 0·8μsec pulses either 8μsec (mode A) or 17μsec (mode B) apart. Provision is made for the future use of additional 21 and 25μsec modes (modes C and D).

EE 26 755 *for further details*

EKCO ELECTRONICS LTD

Southend-on-Sea, Essex

AIRBORNE WEATHER RADAR

(Illustrated below)

A lightweight 3cm weather radar, the Ekco type E190, weighs only 57lb and has a range of 150 miles. Comprising only three units, this transistorized equipment provides every facility expected from a modern weather radar system, including high-brightness display and fully-stabilized 24in antenna. It gives accurate range and azimuth information on cumulo-nimbus cloud formations as well as providing facilities for map-painting. A Doppler drift unit can be added as an optional extra.

The type E190 was also displayed as a dual transmitter-receiver and indicator system, in keeping with the current practise of duplicating essential services which are the subject of mandatory requirements. Using this system, full fail-safe conditions are provided as either indicator unit will operate with either transmitter-receiver unit. Performance

characteristics are similar to those of the standard Ekco equipment apart from some increase in power requirements. The illustration shows the scanner unit of the E.190 mounted in the nose of a Vickers Vanguard airliner.

EE 26 756 *for further details*

FERRANTI LTD

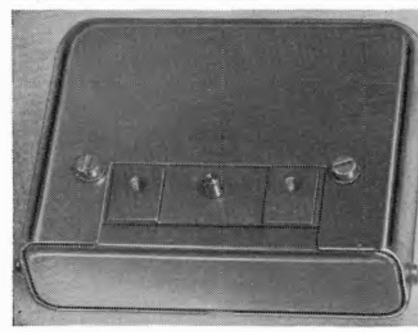
Hollinwood, Lancashire

DISPLACEMENT TRANSDUCER

(Illustrated below)

This transducer provides a sensitive measurement of angular displacement. A central primary coil is energized by a 20V, 2 400c/s supply, which sets up a flux linkage between the central primary coil and two outer secondary coils. The shaft whose displacement is to be measured is connected to a copper shorted turn which is moveable in an air-gap in the central limb.

With the shorted turn in the central position, the flux linkage between the primary and secondary coils is symmetrical and there is no output from the



secondary coils. Displacement of the shorted turn from the central position disturbs the symmetry of the flux linkage and gives rise to a voltage output from the secondary coils proportional to the displacement. Protection is provided by a mild steel case.

EE 26 757 *for further details*

FIRTH CLEVELAND INSTRUMENTS LTD

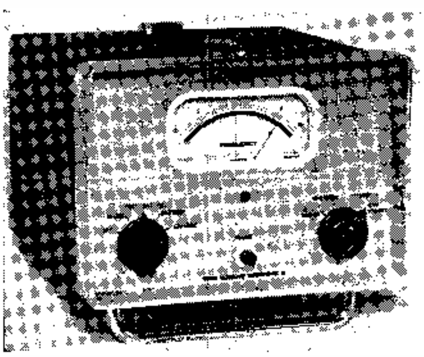
Treforest, Pontypridd, Glamorgan

PORTABLE FREQUENCY METER (TACHOMETER)

(Illustrated above right)

The frequency meter type FM1015 is a lightweight instrument, designed to measure the frequency of signals having a wide variation in both amplitude and waveform over the frequency range 10c/s to 200kc/s. The instrument may be operated from an internal battery or mains supplies, and over the frequency range stated, the accuracy of indication is within $\pm 2\frac{1}{2}$ per cent of f.s.d. when the input signals have an amplitude within 0·075 and 10V r.m.s. In addition to direct frequency measurement, the unit can be used for tachometry, when the necessary input signal can be generated via a magnetic pick-up coil associated with a ferrous toothed wheel, coupled to a revolving shaft. Alternatively the revolving shaft could be coupled to a contact-breaker, either mechanical or utilizing a photocell and light source. For the last case, a separate socket is fitted to the frequency meter for the purpose of energizing a phototransistor head and light source.

The signal to the frequency meter is fed via a medium impedance input stage to an amplifier which generates a waveform having a steep wave front for triggering a bistable circuit, whose function is to produce a square wave of equal mark-to-space ratio, irrespective of input waveform. The output of the bistable circuit is further amplified via a degenerative drive circuit, thereby producing a large amplitude square wave which drives the output transistor. The output from this latter stage is limited by a Zener reference diode which ensures that a constant amplitude square wave is applied across the calibration capacitors and rectifying diodes comprising the meter circuit. The resulting rectified capacitor current passes through the meter and is directly proportional to the pulse repetition rate and hence the input signal frequency or pulse rate. The



meter indication is unaffected by supply voltage variations and changes in input signal level. To ensure the maximum degree of portability a light-weight rechargeable Venner silver zinc battery is fitted in the unit along with an appropriate charging circuit. An additional feature of the self contained charging circuit is that charging ceases once the battery reaches a fully charged state.

EE 26 758 *for further details*

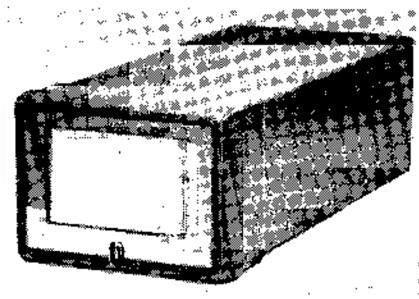
MINIATURE POTENTIOMETRIC RECORDER

(Illustrated above right)

This instrument has been produced to meet the industrial requirement for a precision recorder which occupies a minimum of panel space and yet still provides the features and accuracy of more conventional instruments.

The complete instrument requires a panel space of $7\frac{7}{8}$in × $5\frac{1}{2}$in and is $18\frac{1}{2}$in deep. The electronic units which are incorporated comprise an input unit with low noise mechanical chopper and precision balancing potentiometer; a transistorized temperature compensated high gain amplifier; a power unit and output stage and a highly stable temperature compensated Zener voltage reference source which obviates the need for a standard cell.

The maximum speed of pen deflexion



is 3in/sec and full scale sensitivities between 1mV and 100mV are available. Chart speeds between $\frac{1}{2}$in/h and 12in/h can be provided.

EE 26 759 *for further details*

THE GENERAL ELECTRIC CO. LTD

Magnet House, Kingsway, London, W.C.2

VIBRATOR DRIVE EQUIPMENT

(Illustrated below)

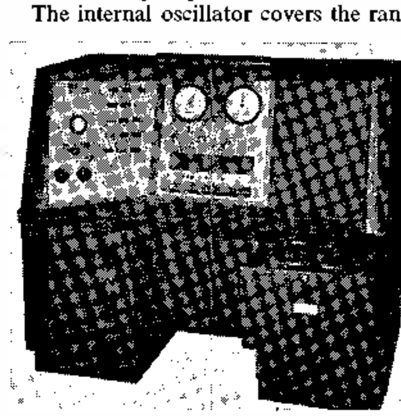
This equipment is a complete, self-contained vibration test control console, designed for use by a semi-skilled operator. It will perform the majority of the vibration tests required by a number of Government specifications. It requires no setting-up in normal everyday use, and can be arranged to perform repetitive tests unattended over periods of 0·1h to 1 000h.

The equipment comprises a power amplifier and d.c. supply to drive a vibrator such as the G.E.C. VEM 5 Mk. 2, an oscillator, a tape-deck, and a servo amplifier for constant acceleration control. All these are housed in a console, together with control monitoring, safety and protection, circuits, and timing switches. Only the vibrator itself, the cooling fans and accelerometer cathode follower unit are separate from the console.

Audio power output is of the order of 2·5kW with a total distortion of less than 2 per cent, in the frequency range 30c/s to 10kc/s. The amplifier will deliver a total of up to 3kW into alternative impedances of 10·15 or 20Ω, before the operation of its protection circuit. Input may be from an external source, from the built-in oscillator, or from the tape-deck in the console.

To supply the field coil of an electromagnetic type vibrator a d.c. power unit delivers 230V at 2A with a ripple level not exceeding 5 per cent.

The internal oscillator covers the range



30c/s to 10kc/s. Output frequency is indicated to an accuracy of ±5 per cent on a single-scale logarithmically-calibrated meter with a 240°, 10in scale. In addition to giving a fixed frequency output, the oscillator can be swept in frequency logarithmically with time. The limits of this sweep can be chosen from the complete oscillator range, and the sweep rate can be continuously varied between 4 and 140sec/octave.

A Simon SP4 automatic reversing twin-track tape recorder is mounted in a drawer in the console. This can be fitted with a tape record of any required test within the frequency ranges covered by the amplifier. It will then play back the record continuously, with breaks for tape reversal of less than 5sec.

Constant acceleration is achieved with the aid of *g*-level control unit, which can be fed with information from any one of three accelerometers. Acceleration can be held constant within ±1dB. The level is indicated on a meter logarithmically - calibrated between 2*g* and 100*g*.

To simplify day-to-day operation, all the controls for normal use are on the front panel. After initial setting for a known task, simple on-off switching is all that is required. All warm-up and safety circuits are entirely automatic, so that no technical knowledge is required to start up the equipment and a change of task can normally be achieved by operation of push-button controls on the front panel.

EE 26 760 *for further details*

COMMUNICATION RECEIVER

The BRT400D is a 14-valve superheterodyne receiver with a frequency range of 150 to 385kc/s and 0·51 to 30·0Mc/s, covered in six bands. Sensitivity, signal-to-noise ratio, frequency stability, etc., are of a high order, the provision of six-step variable selectivity and an extremely efficient crystal filter contributing to a performance specification which makes the receiver suitable for the most exacting service in almost any application. Facilities are included for diversity reception and, in conjunction with suitable terminal equipment, f.s.k. (frequency shift keying) telegraphy operation.

Normal operation of the receiver is from an a.c. mains supply but, in emergency or where no such supply exists, use of the BRT401 battery power unit makes it possible to operate from a 12V d.c. supply.

All components, materials and finishes used in the construction of the BRT400D series of receivers have been individually selected and tested for satisfactory performance and reliability under rigorous tropical conditions. They comply either with British Services Specifications or, where these are inappropriate, have been subjected to the standard K.110 tropical test.

For those applications where telegraphy is of minor or no importance and where, as for example, for relay installations, the reception of high quality telephony transmissions is the main concern, the 1kc/s a.f. acceptor filter may, if specially ordered, be replaced by a 9kc/s rejector filter.

EE 26 761 *for further details*

GENERAL PRECISION SYSTEMS LTD

Aylesbury, Buckinghamshire

AERONAUTICAL RESEARCH COMPUTER

This computer was designed by General Precision Systems Limited to provide a compact, flexible and versatile analogue computer for the solution of problems in dynamics in the aeronautical field. The basic unit which is capable of considerable expansion, should the need arise, comprises the following elements:

(a) 30 Amplifiers (high gain chopper stabilized)

(b) 20 Sum integrate computing networks

(c) 10 Sum computing networks

(d) 40 Precision 10-turn coefficient potentiometers

(e) 3 Velodyne-driven servo multipliers/function generators

(f) 5 Motor-driven servo multipliers/function generators

(g) 2 Electronic multipliers

(h) 4 Electronic function generators

(i) 5 Dead space and limiter simulation units

(j) Digital voltmeter with selector panel to give direct access to computing elements

(k) Double beam oscilloscope with similar panel

(l) Forcing function generator

(m) Central control and overload unit

The amplifiers used in the computer have been specially designed to provide highly reliable yet economical units to be used with two types of computing network boxes for summation and integration. In the case of the sum/integrate network the initial condition of the integration is set by a 10-turn precision Helipot fitted to the unit. All networks are provided with 0·1 per cent precision components. In many cases the resultant computational accuracy may be better than the primary data, but reliability of results is enhanced by the use of these components.

In the computer, equation coefficients or parameters under investigation are set and adjusted by 10-turn potentiometers of which 40 are provided. These are fused to guard against accidental damage, and may be set up or scanned very accurately by the use of the internal reference source and the digital voltmeter provided.

Two types of servo multipliers have been provided in order to cater for a wide range of problems. The velodyne-driven type has limitations on the frequencies which it is able to handle, but the advantage that it may be used for integration, depending on the gear box fitted, over periods of hours. The potentiometer cards in this unit are 4in long strip windings, and their design permits interchange of cards to simulate various functions. The iron free motor driven type of servo is ideal for operation in real time, since the upper limit of usable frequency response is 10c/s. In both types of servos certain of the gangs are provided with tappings on the potentiometer cards to permit off loading by adjustable resistors to give mathematical laws. The function required may be set up using the digital voltmeter.

Adequate provision of electronic multipliers and function generators ensures that problems in which comparatively high frequencies may be encountered can also be handled. The multiplier is of the mark-space variety and can be used to give up to four products. The 10-segment biased diode function generators can be used to approximate any single valued function of an input variable. The digital voltmeter is used to set up the required values of break points of the 10 straight line segments most closely representing the function.

The various elements are interconnected on a removable patch panel by means of single conductor cords.

EE 26 762 *for further details*

GOODMANS INDUSTRIES LTD

Axiom Works, Wembley, Middlesex

AUTOMATIC SWEEP OSCILLATOR

The E.502 sweep oscillator has been designed to provide an accurate and convenient source of sinusoidal oscillation, frequency varying to a predetermined law. The standard model is arranged to sweep to the law specified in many guided weapons test specifications, that is, the law

$$(df/dt) = (1/70)\ f^{4/3}$$

It is however possible (to special order) to provide any law, the rate of change of frequency at the extreme limits of any particular band for which does not exceed a ratio of 100 to 1.

Two frequency ranges are provided, 5c/s to 500c/s and 30c/s to 3kc/s. A high quality Wien bridge oscillator is employed, followed by a cathode-follower resulting in very stable frequencies and low distortion levels, also a very high degree of amplitude stability. At a given setting of the gain control amplitude variations between the two ranges or from one extreme to the other of either range are less than 1dB and distortion levels are less than 2 per cent. Automatic sweep operation is obtained from a direct current motor, controlled by a relay circuit and magnetic clutch coupled to the frequency determining potentiometer. Adjustable limit switches preset the positions at which the motor reverses direction. Manual or single sweep operation facilities are provided. A microswitch adjustable to anywhere within the preset limits of the dial is provided. This operates a relay to enable change-over from constant acceleration to constant velocity measurements, where made in conjunction with a *g* control amplifier.

Two outputs are provided, one via an attenuator and cathode-follower and one at high level for synchronizing a stroboscope.

Equipment is supplied as an individual unit in a case, or is available on a standard rack panel for fitting into rack or console as required.

The maximum output is 5V into 20kΩ or 0·5V into 600Ω.

EE 26 763 *for further details*

SEVEN-CHANNEL CATHODE-FOLLOWER

(Illustrated below)

The model E.506 7-channel cathode-follower unit has been designed to enable barium titanate accelerometers to be cabled to the main measurement position of a vibration test system by relatively long cable runs.

The input impedance is 100MΩ and the output impedance 800Ω in series with a 0·5μF capacitor. The frequency response is 5c/s to 20kc/s ±1dB; with 30ft of

double screened cable attached, the response to the same degree of consistency is from 5c/s to 2kc/s. Lengths of cable of the order of 30ft may be used between the accelerometer and the cathode-follower input without reduction of effective accelerometer sensitivity below the value normally found in practice. This is achieved by the use of double screened cable the inner conductor of which is connected between the active element of the accelerometer and the grid of the input valve, the inner screen of the cable being connected to the cathode of the input valve at one end and insulated at the other end. The outer screen is earthed at one end and connected at the other end to the earth electrode of the accelerometer. This results in a reduction of the effective cable capacitance by a factor of approximately 30.

This unit can be supplied either in a case or for rack mounting.

EE 26 764 *for further details*

HONEYWELL CONTROLS LTD

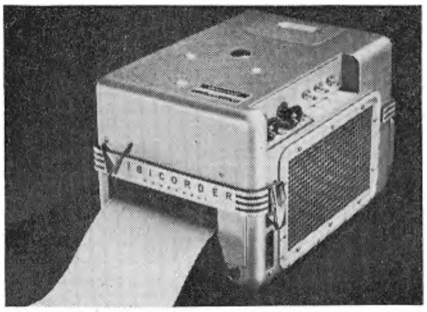
Ruislip Road East, Greenford, Middlesex

DIRECT READING OSCILLOGRAPH

(Illustrated above right)

Following the lifting of import restrictions on oscillographs from the United States, Honeywell Controls Limited have arranged with their U.S. associates to market a 14-channel direct reading oscillograph known as the Visicorder.

Known fields of application for this instrument include weather and earthquake studies, space vehicle tracking, air flow and wind tunnel research, etc.



The Visicorder resembles a conventional oscillograph with its light source, mirror galvanometers, optical system and paper transport system. But no chemical means are used to obtain a permanent record. There is no ink, electrostatic charge, electric arc, chemical vapour or heat.

Using six-inch wide paper, frequencies up to 5kc/s can be recorded on 12 channels, with two reference or timing traces. Intensity control, grid line system and trace identification are provided. The instrument lends itself to remote control as it contains a self-starting recording lamp. There is a built-in power pack.

EE 26 765 *for further details*

McMICHAEL RADIO LTD

Wexham Road, Slough, Buckinghamshire

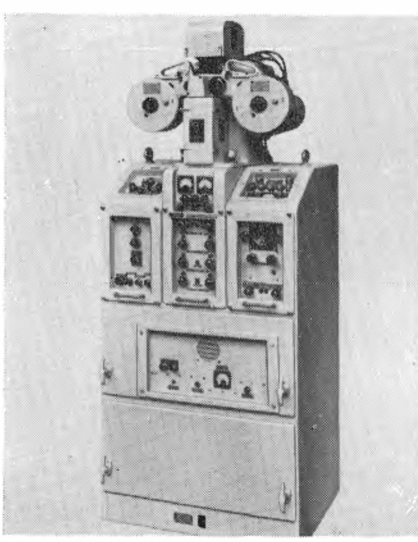
RADAR RECORDER

(Illustrated below)

This is standard naval equipment and is used for training radar operators. It can also be used for logging radar information where a permanent record is required.

Outfit REJ uses 35mm film on which it can record and play back video signals from radar equipments which employ a p.p.i. information display unit and which have a continuously rotating aerial. It can operate in any selected range between ten and 160 miles with equipments which have a data rate of up to 100rev/min. A north marker line can also be recorded.

Three speeds of recording and playback are provided and the basic master drive unit can be adapted to suit either Magslip and/or 'M' type transmission.



A tape recorder is incorporated in order to enable commentaries to be recorded and played back in synchronism with the film.

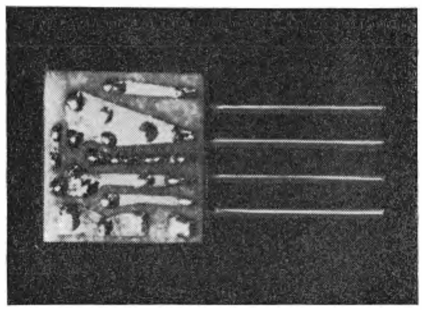
Provision is also made to enable the recorder to be controlled from a separate remote control unit.

EE 26 766 *for further details*

BINARY ELEMENT

(Illustrated below)

This special 'divide by two' binary element is an application of McMichael subminiature circuits. It is designed to be a versatile building block for use in compact computer development, aircraft and outer space research. It consists of a two transistor bistable circuit with provisions for inputs, outputs, and feedback for decade counting. Designed to work from 5 to 7V it takes a current of 4mA. It will operate at speeds up to 100 000 counts per second from pulses as short as 2μsec. Temperature range is 0 to 60°C.



The size of this unit is 0·5in^3 and the weight $\frac{1}{4}$oz. It includes two germanium transistors, two germanium diodes, four ceramic capacitors and eight resistors; the component density being 221 000/ft^3.

EE 26 767 *for further details*

MARCONI INSTRUMENTS LTD

St. Albans, Hertfordshire

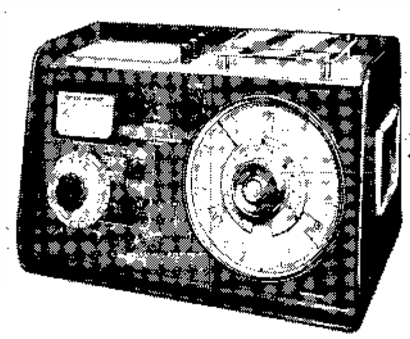
PRECISION UNIVERSAL BRIDGE

(Illustrated above right)

The TF1313 is a new general purpose impedance bridge with 0·25 per cent accuracy. It uses a single dial for *L*, *C*, and *R* measurements, but with coarse and fine concentric controls; the coarse one moves in 1 per cent steps and the fine interpolates 50 divisions per step. Its meter gives a clear indication of the direction of the balance point even when far off-balance, bringing speed and simplicity to measurements of completely unknown components. An external audio oscillator can be plugged in where L and C measurements are required at frequencies other than the internal 1 and 10kc/s; and the detector output is available externally to allow an oscilloscope or headphones to be used for balance indication.

The ranges covered are: inductance, 0·1μH to 110H at 1 and 10kc/s; capacitance, 0·1pF to 110μF at 1 and 10kc/s; resistance, 0·01Ω to 110MΩ at d.c.

EE 26 768 *for further details*



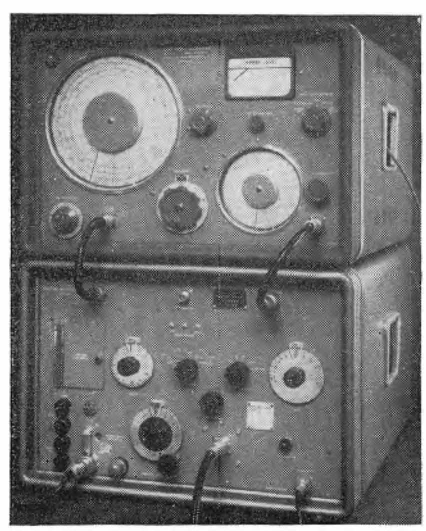
TRANSPONDER TEST SET

(Illustrated below)

Test set type 506, a differential pulsed attenuator, has been developed by Marconi Instruments Ltd in conjunction with the Ministry of Aviation as part of their Civil Secondary Surveillance Radar Programme. When operated with the Marconi u.h.f. signal generator TF1060, it is suitable for testing the receiver section of a transponder, and in particular the side lobe suppression characteristics as standardized by I.C.A.O.

The test set generates video pulse trains, consisting of two or three pulses, at a repetition frequency which is continuously variable in one range from 250 to 2 000 per second. Individual pulse widths can be varied from 0·5 to 2·0μsec, the spacing being selected by a switch, either to give preset intervals corresponding to Civil Modes A, B, C and D or continuously variable up to 30μsec. These pulse trains modulate the u.h.f. signal generator, which is set to the required r.f. frequency, and the resultant pulse modulated r.f. signal is fed back to the Test Set and passed through the differential attenuator. This enables the relative amplitude of one pulse in a double pulse train, or one or two pulses in a treble pulse train, to be varied by plus or minus 10dB with respect to the other. By suitable selection with the 'function' switch the variable pulses can be either the control or the interrogate pulses as desired.

The resultant r.f. signal obtained at the output socket of the Test Set can, if required, be monitored, by feeding the output into the built-in crystal detector with



its following video amplifier. The output from the amplifier can be observed with a suitable oscilloscope such as the Marconi type TF 1330. A trigger pulse for the oscilloscope is provided at the 'sync out' socket and occurs 5μsec prior to the first r.f. pulse.

This instrument has been designed so that the signal generator can be mounted above it as shown in the illustration.

EE 26 769 *for further details*

MARCONI'S WIRELESS TELEGRAPH CO. LTD

Chelmsford, Essex

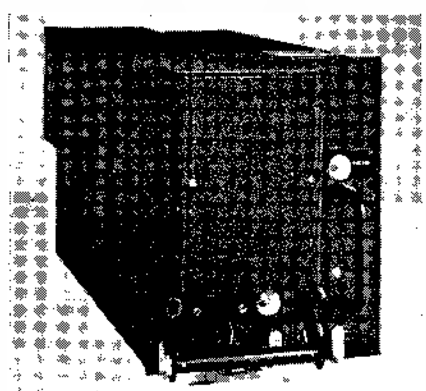
V.H.F. Communication Equipment

(Illustrated below)

This comprises a v.h.f. transmitter type 6400 and a v.h.f. receiver type 6401.

V.H.F. Transmitter

This provides 360 crystal-controlled channels (with 50kc/s spacing) between 118·0Mc/s and 135·95Mc/s. The transmitter has an output of 25W. It weighs 14lb and is housed in a short 3/8 ATR case. Used with the 6401 receiver it provides a v.h.f. communication equipment of small size weighing only 23lb.



The equipment meets all the electrical requirements of ARINC characteristic 520A, but includes a number of additional features. Principal among these is the incorporation of automatic modulation control and 12dB of speech clipping, which ensures maximum intelligibility under all conditions.

Maximum use is made of transistors, the modulator and crystal drive stages being fully transistorized. The use of recently developed sub-miniature overtone crystals reduces the number of stages required and gives increased protection against spurious radiations. The transmitter can be used with either electromagnetic microphones (including noise-cancelling types) or carbon microphones, so that is is compatible with British and American intercommunication systems without modification.

The type 6400 is designed for either single channel or double channel simplex operation, and provision is made in the modulator circuits for future automatic data transmission systems.

V.H.F. Receiver

The 6401 receiver is designed for use with the 6400 transmitter and in addition, for use with other units to form a fully transistorized v.h.f. navigation and approach guidance system.

The 6401 receiver covers the band 118·0 to 135·95Mc/s, and provides 560 channels in that band. It is fully transistorized, enabling it to be housed in a short 1/4 ATR case with a weight of only 8lb; its power consumption is only 10W.

It is a multiple superheterodyne with a final intermediate frequency of 500kc/s giving the main selectivity characteristic. The components in the detector circuits are designed to give satisfactory operation 'climax' transmissions and the speech is fed through signal-to-noise operated 'squelch' circuits to the audio output stages.

EE 26 770 *for further details*

PYE TELECOMMUNICATIONS LTD

Newmarket Road, Cambridge

Radio Directed Television

This radio directed television system is completely transportable and is independent of cables.

This system permits control tower staff observation of areas they cannot see and all assembly areas, taxi ways, and runways, especially during operation periods of low visibility. It can also give close observation of aircraft take off and landing performance at test and experimental airfields.

The use of a radio remote control link makes for a system of considerable flexibility, the distance between the control point and the camera being almost unlimited for most practical purposes.

The equipment was demonstrated on the Pye Telecommunications indoor stand where an operator, using a joystick, directed a remote camera by radio at any point on the airfield. The control system is achieved over a 450Mc/s u.h.f. link and the pictures are fed back along a microwave link. The remote television camera is unattended and completely automatic, all its functions being controlled over the radio link.

EE 26 771 *for further details*

W. H. SANDERS (ELECTRONICS) LTD

Gunnels Wood Road, Stevenage, Hertfordshire

Microwave Calibration Receiver

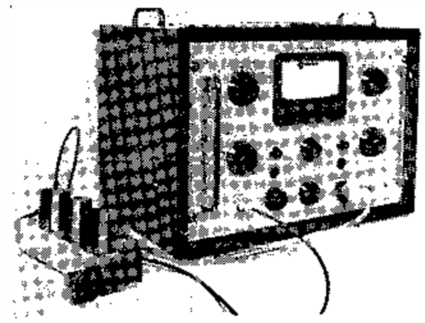
(Illustrated above right)

An improved version of the 45Mc/s calibration receiver is now available and improvements to the existing unit include the following.

Noise factor	1·8 to 2·5dB.
I.F. frequency	45Mc/s.
Bandwidth	±2·5Mc/s.

A dual movement meter is incorporated allowing monitoring of the currents in the first and second stage detectors, and dual sensitivity positions for these meters gives a full-scale deflexion of either 1mA or 100μA.

A switched turret attenuator is incorporated, having a range of 0 to 100dB in coarse control steps of 20dB and fine control steps of 1dB from 0 to 20dB. The head amplifier is a separate unit



designed for ease of serviceability and replacement of component parts. An h.t. check point is provided on the unit. A redesigned case houses the complete assembly which is mounted on a standard rack.

The head amplifier will accommodate any of the standard range of crystal mixers between waveguide sizes 10 to 22 (2·60 to 40·00kMc/s).

EE 26 772 *for further details*

THE SOLARTRON ELECTRONIC GROUP LTD

45 Thames Street, Kingston-on-Thames, Surrey

Digital Data Recorder

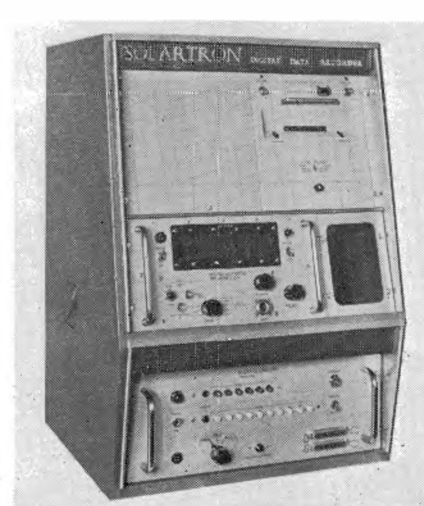
(Illustrated below)

This unit accepts analogue signals of either positive or negative polarity from up to 50 channels and converts these signals into digital form for driving an integral printer. The scan rate is two channels per second with an analogue-to-digital conversion accuracy of 0·1 per cent. The printer output data gives channel identity, measured signal value and polarity on a continuous 3in wide paper strip.

The equipment consists of the following units: a fifty-channel commutator, an analogue-to-digital convertor with associated display, and a printer.

The commutator unit employs sealed relays with gold-plated contacts for low noise and long life. It acts as a 50-way, 2-pole switch to connect each of the 50 inputs in turn to the convertor.

Any one of three modes of operation, viz.: continuous automatic sampling, single scan by external command, or



manual selection, can be selected by a switch on the commutator unit. The commutator unit is permanently connected to the analogue-to-digital convertor, the output of the latter being in appropriate coded decimal form for direct operation of the printer.

EE 26 773 *for further details*

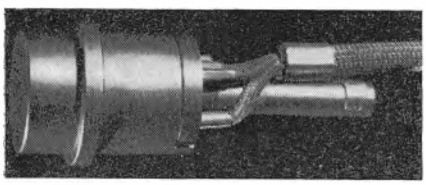
PRESSURE TRANSDUCERS

(Illustrated below)

The NT 4-313 is a general-purpose pressure transducer for applications involving medium and high pressure measurement. Incorporating a miniaturized, unbonded strain gauge sensing element, it achieves reliability and repeatability of results even under extreme conditions of vibration and temperature.

The flush diaphragm of the transducer enables it to be mounted into the wall of a pressure vessel without altering the volume of the container or introducing turbulence into the flow of the pressure medium.

Hermetically sealed absolute versions of the NT 4-313 are suitable for measurements in corrosive atmospheres, the clean design and inherent corrosion resistance of the stainless steel used



permitting satisfactory operation of the transducer when it is in contact with liquids such as red or white fuming nitric acid, 100 per cent hydrogen peroxide or uranium hexafluoride.

These gauges are available for pressure ranges between 100 and 5 000lb/in^2.

A special version of this gauge, the type NT 4-317 will operate continuously at temperatures up to 600°F or up to 2 000°F using a cooling adaptor.

EE 26 774 *for further details*

SOUTHERN INSTRUMENTS LTD

Frimley Road, Camberley, Surrey

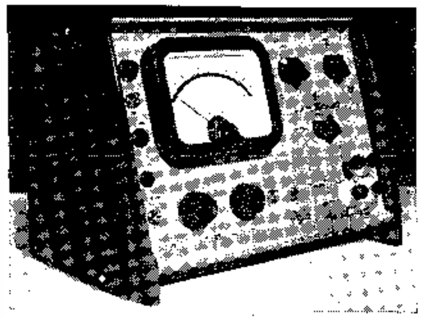
'MEMORY' MULTIMETER

(Illustrated above right)

With the E.R.I.C. universal electronic memory multimeter a wide range of measurements is made possible by the use of a 'tripole' circuit. The tripole is a balanced d.c. amplifier with three terminals, the characteristics, of any pair of terminals being vastly different from any other pair. One pair designated terminals 1, 2 has virtually infinite input impedance. The second pair 1, 3 has very low input impedance while terminals 2, 3 exhibit very low output impedance.

The latter property is required for driving a low impedance meter and terminals 2, 3 are used in this way.

It is the high impedance across terminals 1, 2 which gives the E.R.I.C. many of its interesting features. The value is so high that a charged high insulation capacitor may be connected



across these terminals with no appreciable charge loss occurring over periods of several hours. Such a capacitor internally connected in the instrument thus provides it with the feature of a memory. As there is unit voltage gain between these terminals and the output terminals, the meter will retain the reading of the input voltage as long as the capacitor holds its charge. An 'erase button' enables this charge to be removed at will.

The E.R.I.C. also makes possible the measurement of a wide range of resistance values up to many hundreds of megohms.

EE 26 775 *for further details*

STANDARD TELEPHONES AND CABLES LTD

Connaught House, Aldwych, London, W.C.2

AUTOMATIC D.F. TRIANGULATION EQUIPMENT

In association with networks of automatic ground-based wide-aperture direction finding stations, this new triangulation display provides an accurate and convenient aircraft position finder for use in air traffic control. Its main function is to identify and locate aircraft entering or over-flying controlled airspace, using only the signals radiated by the aircraft in the course of ordinary communication with the control centre. Although particularly intended for use with the STC wide-aperture CADF system, the display is readily adaptable to other direction finders.

The display equipment for the new PVT-2 system employs closed-circuit television and represents a further stage in the development of the established PVT-1 triangulation system. This is a ground-based aircraft position finder which has been in use in Britain and elsewhere in Europe for several years.

The equipment at Farnborough was fed with 'artificial' signals from a simulator or 'live' signals from two direction finders tuned to one of the civil air traffic control frequencies. One of the live signals was fed from a CADF equipment at Bovingdon and the other will be fed from a CADF equipment which was exhibited by Airtech Ltd.

EE 26 776 *for further details*

ULTRA ELECTRONICS LTD

Western Avenue, Acton, London, W.3

COMMUNICATION CONTROL SYSTEM

This equipment provides a push-button selection system, which contributes to an advance in miniaturization of this type of equipment.

The basic station box (type UA6010) incorporates 15 push-buttons for the selection of communications (transmitters and receivers), inter-communication and cabin address facilities, yet the front panel is only 5¾in × 3in (14·7cm × 7·6cm). The weight of the unit is 3lb (1·4kg).

The UA60 is a de-centralized system with local amplifiers in each station box and the addition of a central junction box provides a comprehensive communication control system.

The range of equipment includes all the necessary associated items, such as junction box, ground crew amplifier, ground crew jack boxes and steward's station boxes.

The main features of the UA60 in addition to the small size and light weight made possible by the modern transistor and printed circuit techniques employed, are push-button selection for 15, 25, or 35 services, volume control incorporated with the push-buttons for all receiver channels and an edge-lit panel.

The system is designed to current U.S. installation standards and is equally suitable for British or American radio equipment. It can be tailored to system specification.

EE 26 777 *for further details*

VACTRIC (Control Equipment) LTD

Vactric House, Sloane Street, London S.W.1

SERVO COMPONENTS

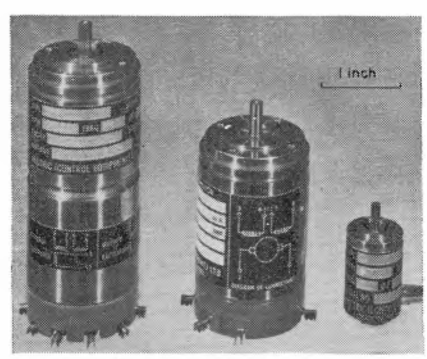
(Illustrated below)

Included in a wide range of international frame size precision servo components were three new units. These are a size 15 a.c. motor tachogenerator, a size 15 split-field d.c. motor and a size 08 a.c. motor.

The size 15 a.c. motor tachogenerator has a two-phase 400c/s motor and a tachogenerator output of 3·0V/1 000 rev/min with a linearity of ±0·5 per cent.

The stalled torque of the split-field motor is 160g. cm at maximum excitation. The maximum external series resistance is 18Ω and the maximum armature current 1A. The armature inertia is 13g. cm^2, the field current 40-0-40mA and the field resistance 800Ω per winding.

The size 08 a.c. motor is a two-phase 400c/s unit having a minimum stalled torque of 219g. cm and a no-load speed of 6 200rev/min. The motor weighs 48g.



EE 26 778 *for further details*

Meetings this Month

THE BRITISH INSTITUTION OF RADIO ENGINEERS

Date: 12 October. Time: 6.30 p.m.
Held at: The London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London W.C.1.
Lecture: Electro-Acoustics for Human Listeners.
By: Professor Colin Cherry.
Date: 26 October. Time: 10.45 a.m. to 12.30 p.m. and 2.30 p.m. to 5.15 p.m. and
Date: 27 October. Time: 10 a.m. to 12.15 p.m. and 2.30 p.m. to 5.15 p.m.
Held at: The School of Pharmacy, Brunswick Square, London W.C.1.
Two Day Symposium on New Components comprising over 20 papers to be read in the morning and afternoon sessions.
Papers will be pre-printed and advance registration will be necessary. Details may be obtained from the Brit.I.R.E., 9 Bedford Square, London W.C.1.

Birmingham—West Midlands Section

Date: 26 October. Time: 7.15 p.m.
Held at: The Department of Electrical Engineering, University of Birmingham, Edgbaston.
Lecture: Industrial Applications of Automatic Control Using Electronic Techniques.
By: R. J. F. Howard.

Bristol—South Western Section

Date: 6 to 7 October.
Held at: The College of Science and Technology, Ashley Down Road.
A Convention on Aviation Electronics and its Industrial Applications.
Details and Registration Forms may be obtained from W. C. Henshaw, Hon. Secretary, Brit. I.R.E., South Western Section, c/o School of Management Studies, Unity Street, Bristol 1.
Date: 26 October. Time: 7 p.m.
Held at: The School of Management Studies, Unity Street.
Lecture: Radio Aids for Automatic Landing developed by the Blind Landing Experimental Unit.
By: J. S. Shayler.

Cardiff—South Wales Section

Date: 19 October. Time: 6.30 p.m.
Held at: The Welsh College of Advanced Technology.
Lecture: The Use of Transistors in Pulse Circuitry.
By: A. R. Owens.

Edinburgh—Scottish Section

Date: 5 October. Time: 7 p.m.
Held at: The Department of Natural Philosophy, The University, Drummond Street.
Lecture: Technical Education for the Radio and Television Industry.
By: J. B. Rimmer.

Glasgow—Scottish Section

Date: 6 October. Time: 7 p.m.
Held at: The Institution of Engineers and Shipbuilders, 39 Elmbank Crescent.
Lecture: Technical Education for the Radio and Television Industry.
By: J. B. Rimmer.

Manchester—North Western Section

Date: 6 October. Time: 7 p.m.
Held at: Reynolds Hall, Manchester College of Science and Technology, Sackville Street.
Lecture: v.h.f. fm/am Transistor Receivers.
By: L. E. Jansson.

Newcastle-upon-Tyne—North Eastern Section

Date: 12 October. Time 6 p.m.
Held at: The Institution of Mining and Mechanical Engineers, Neville Hall, Westgate Road.
A Film Evening including 'This is the BBC'.

Wolverhampton—West Midlands Section

Date: 12 October. Time: 7.15 p.m.
Held at: The College of Technology, Wulfruna Street.
Lecture: Electrical Synthesis of Music.
By: Alan Douglas.

THE INSTITUTION OF ELECTRICAL ENGINEERS

Ordinary Meeting

Date: 6 October. Time: 5.30 p.m.
Held at: Savoy Place, London W.C.2.
Inaugural Address as President—
By: Sir Hamish D. Maclaren.

Medical Electronics Discussion Group

Date: 7 October. Time: 6 p.m.
Held at: Savoy Place, London W.C.2.
Discussion on Nerve Endings.
Opened by: Dr. O. C. J. Lippold and Dr. D. R. Wilkie.

Measurement and Control Section

Date: 11 October. Time: 5.30 p.m.
Held at: Savoy Place, London W.C.2.
Chairman's Address—C. G. Garton.

Education Discussion Circle

Date: 12 October. Time: 6 p.m.
Held at: Savoy Place, London W.C.2.
Discussion on Laboratory Work for the Part 3 Examination.
Opened by: P. F. Soper.

Measurement and Control Section

Date: 25 October. Time: 5.30 p.m.
Held at: Savoy Place, London W.C.2.
Lecture: Rapid Methods for Ascertaining whether the Activity of a Weak Radioactive Sample Exceeds a Predetermined Level
By: E. H. Cooke-Yarborough.

Electronics and Communications Section

Date: 26 October. Time: 5.30 p.m.
Held at: Savoy Place, London W.C.2.
Chairman's Address—T. B. D. Terroni.

Ordinary Meeting

Date: 27 October. Time: 5.30 p.m.
Held at: Savoy Place, London W.C.2.
Lecture: The Principles and Operation of Large Radio Telescopes.
By: A. Hewish.

THE INSTITUTE OF NAVIGATION

Date: 19 October. Time: 2.30 p.m.
Held at: The Royal Geographical Society, 1 Kensington Gore, London S.W.7.
Lecture: Navigation in Sport.
For this year's annual meeting for Nautical School Cadets.
Date: 26 October. Time 3 p.m.
Held at: The Royal Geographical Society, 1 Kensington Gore, London S.W.7.
Annual General Meeting
Presidential Address
Lecture: The Philosophy of Navigation Today.
By: Wing-Commander E. W. Anderson.

THE SOCIETY OF INSTRUMENT TECHNOLOGY

Date: 13 October. Time: 7 p.m.
Held at: Manson House, 26 Portland Place, London W.1.
Lecture: Transistor Switches in Monitor and Control Systems.
By: W. A. Ross.

Chester Section

Date: 27 October. Time: 7 p.m.
Held at: Lecture Theatre, Administration Building, The Associated Ethyl Co Ltd, Oil Sites Road, Ellesmere Port, Wirral.
Lecture: Analogue Computers.
By: W. E. Willison.

Fawley Section

Date: 7 October. Time: 5.30 p.m.
Held at: Administration building, Esso Refinery, Fawley.
Lecture: The Basic Principles of Digital Instrumentation.
By: D. S. Evans.

Manchester Section

Date: 12 October. Time: 6.45 p.m.
Held at: College of Science and Technology, Sackville Street, Manchester.
Lecture: Data Handling and Processing.
By: E. K. Robertson.

THE TELEVISION SOCIETY

Date: 13 October. Time: 7 p.m.
Held at: Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue W.C.2.
Lecture: Automation in Television Presentation.
By: T. A. H. Marshall.
Date: 27 October. Time: 7 p.m.
Held at: Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue W.C.2.
Discussion on New Standards and the Problem of Colour Television.

PUBLICATIONS RECEIVED

LIST OF PUBLICATIONS AVAILABLE TO THE PUBLIC. Cumulation No. 4. January-December 1959 is published by the Atomic Energy Research Establishment Library, Harwell, Berkshire, and is available from H.M.S.O. Price 23s.

NEW RCA RECEIVING TUBE MANUAL. Technical Series RC-20 published by the Electron Tube Division of the Radio Corporation of America is a new edition containing technical data for more than 760 receiving tubes, including types for black-and-white and colour television, series-string applications, ac/dc equipment, 12-volt car radio receivers, and high-fidelity audio applications both monophonic and stereophonic. Copies of this manual may be obtained from Commercial Engineering, Electron Tube Division, Harrison, New Jersey, U.S.A. Price $1.00.

APPLICATION REPORT D.C. TO D.C. TRANSISTORISED CONVERTORS, MK/143, Ed. 1., by R. A. Holme, published by the Transistor Division of Standards Telephones & Cables Ltd., Footscray, Kent. Available free of charge on application.

UNITED KINGDOM ATOMIC ENERGY AUTHORITY. Sixth Annual Report for the period 1 April-31 March 1960. Published by H.M.S.O. Price 5s.

TRANSISTORS AND GERMANIUM DIODES is published by the Components Group of Standard Telephones & Cables Ltd., Footscray, Kent. Available free of charge on application.

KNITMESH ELECTRONIC PRODUCTS, including Radio Frequency Shields is the title of a brochure giving full details of equipment manufactured by Knitmesh Ltd, 36 Victoria Street, London S.W.1. Available free of charge on application to the above address.

BRITISH STANDARDS INSTITUTION Annual Report 1959-60 covers the Institution's year 1959-60 (i.e. the period from 1 April, 1959, to 31 March 1960). Available on application to the British Standards Institution, British Standards House, 2 Park Street, London W.1. Price 7s. 6d.

PRINTED CIRCUITS Manufactured by Line Production Methods is the title of a booklet published by Bribond Ltd, Burgess Hill, Sussex. Available free of charge upon application to the above address.

INSTRUCTIONAL SERVO SYSTEM—ESIA is a leaflet giving an illustrated description and specification of the system and describing its experimental uses. Manufactured by Feedback Ltd, Crowborough, Sussex, this leaflet and further information can be obtained from Miss Alison Lang, Public Relations Consultants Ltd, 4 Great Queen Street, London W.C.2.

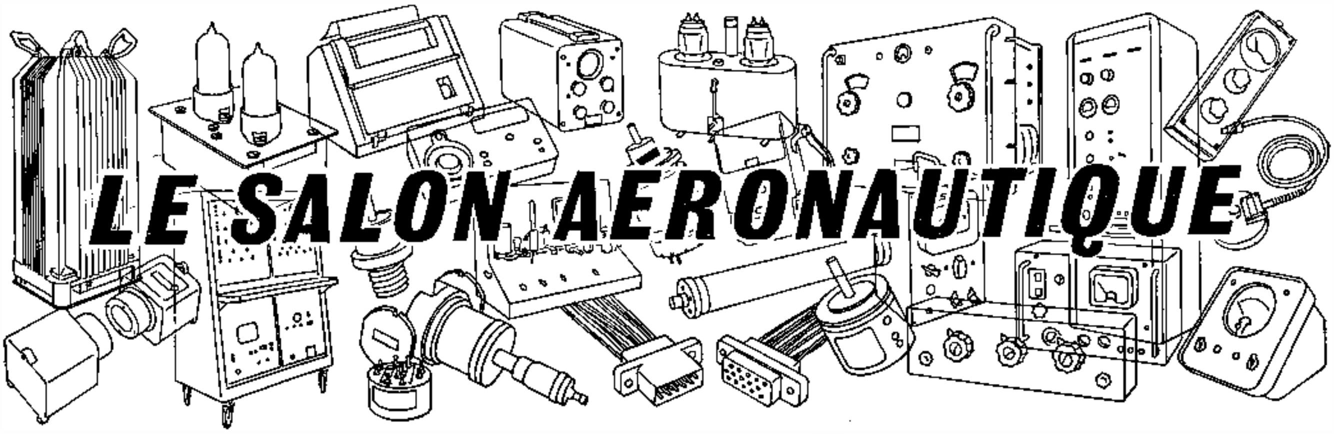
TRANSMISSION TESTING APPARATUS CATALOGUE C/TT-11 Ed. 3/1 is published by the Transmission Division of Standard Telephones & Cables Ltd, North Woolwich, London E.16. The apparatus described in this catalogue has been developed mainly for the installation and maintenance of a wide variety of carrier telephone and other systems. Further details can be obtained from the address given above.

LIGHT SOLDERING DEVELOPMENTS LTD, 28 Sydenham Road, Croydon, Surrey, have published two brochures on their Litesold and Adamin soldering equipment. Their soldering instrument range now includes 33 different models. The Adamin low-voltage range is an entirely new product which has been introduced to supplement the Litesold type where minimum size and exceptional performance is essential. It is made on a completely different principle with the element inside the bit. Both brochures and further information can be obtained direct from the manufacturer.

THE NATIONAL COUNCIL FOR TECHNOLOGICAL AWARDS Report for the period April 1959 to March 1960 is now available on application to The Secretary, National Council for Technological Awards, 9 Cavendish Square, London W.1.

COMMUNICATIONS MEASURING EQUIPMENT is a new catalogue dealing with Siemens & Halske test gear for laboratory and production measurements on communication equipment and components. This catalogue was released by R. H. Cole (Overseas) Ltd, 2 Caxton Street, Westminster, London S.W.1, on the occasion of the recent I.E.A. Exhibition held in London, where a range of microwave sweep measuring equipment was on display. A description is also given of the complex coupling ratio tracer and equipments for level measurement and display.

(Pages 659 to 674 French and German Section)



LE SALON AÉRONAUTIQUE

Une description, basée sur des renseignements fournis par les fabricants, de certains des appareils électroniques exposés au dernier salon de la Société des Constructeurs d'Avions Britanniques.

Traduction des pages 651 à 657

BELLING AND LEE LIMITED
Great Cambridge Road, Enfield, Middlesex

CONNECTEURS À BROCHES MULTIPLES

(Illustration à la page 651)

La série des fiches et prises CAMLOCK et AUTOLOCK présente une forme de construction où chaque broche de connecteur s'enclenche individuellement dans sa prise d'accouplement. Ceci a pour effet d'assurer la connexion positive de tous les pôles ainsi qu'un degré élevé de sécurité dans des conditions de chocs et de vibrations.

Le principle de fonctionnement est expliqué dans la figure c-après. Normalement, la broche de la fiche s'emboîte librement dans la prise, qui est divisée axialement par une ou plusieurs encoches. Lorsqu'on applique une force de compression à l'ouverture de la prise, ainsi qu'indiqué par les flèches, les parois intérieures pèsent sur la broche bulbeuse et, à mesure que la force augmente, les parois de la prise assument une forme courbe, avec un axe roulant. L'ouverture de la prise ne rencontre effectivement jamais le cou de la broche, le contact final se faisant à un certain point entre les niveaux AA et BB, selon les tolérances individuelles qui ne sont donc pas critiques.

Deux types distincts de connecteur appliquant ce principe furent exposés, l'un désigné par le nom de CAMLOCK et l'autre par celui de AUTOLOCK. Le premier est muni de contacts multiples disposés en rangées droites, la force de fermeture étant appliquée par une barre avec encoche en forme de trou de serrure entourant l'ouverture de chaque prise. Cette barre est déplacée le long de la rangée des contacts par un axe excentrique actionné par une clef rotative incorporée à l'organe à fiche libre. La série CAMLOCK se distingue par un dispositif polarisant simple, qui permet de caler jusqu'à 36 montages d'accouplement différents et non-interchangeables, chacun d'eux étant numéroté de façon distincte.

Pour le type AUTOLOCK, l'action de verrouillage se fait automatiquement au stade final de l'accouplement. La partie extérieure de l'ouverture de la prise est, chez ce type, en forme de cloche et elle est fermée par le mouvement axial d'un manchon cylindrique. Le connecteur à pôles multiples n'est muni que d'une seule plaque de verrouillage. Un trou est percé dans cette dernière pour chaque pôle, au lieu d'une multiplicité de manchons individuels. Les contacts peuvent être groupés en n'importe quel dessin voulu. Dans l'une des formes de groupage exposées, utilisant un logement circulaire, l'accouplement de la fiche et de la prise, ainsi que le verrouillage ultérieur des pôles, se fait par la rotation angulaire du logement de la fiche. Ce type de connecteur AUTOLOCK est complètement scellé et l'utilisateur a un choix de six montages d'accouplement différents.

EE 26 751 *pour plus amples renseignements*

S. G. BROWN LTD
Shakespeare Street, Watford, Herts

AMPLIFICATEUR ASSERVI

Cet amplificateur de 6,5 W à transistors npn au silicium peut fournir sa puissance de sortie nominale à des températures ambiantes atteignant +90°C sans l'emploi d'aucune source froide supplémentaire. Il a été conçu principalement pour être utilisé en liaison avec le moteur asservi type 15B. Il produit un gain global de puissance de 72 dB lorsqu'il fonctionne à partir d'une impédance de source non inférieure à 250 ohms. Prévu pour fonctionner sur fréquence porteuse de 400 Hz, l'amplificateur asservi est livré sous forme d'appareil scellé aux dimensions de 8,25 cm × 3,17 cm × 5,08 cm.

Le bloc d'alimentation transistorisé fonctionne sur 400 Hz, 115 V, et peut fournir un courant continu allant jusqu'à 30 W

EE 26 752 *pour plus amples renseignements*

OSCILLATEUR À DIAPASON ET BLOC DIVISEUR

L'oscillateur à diapason est une source autonome de fréquence acoustique, construite en acier au nickel à coefficient de température extrêmement bas et ayant un mécanisme d'entraînement électromagnétique de conception originale. La fréquence nominale est de 2 kHz à plus de 0,005% à 20°C. D'autres fréquences, dans la gamme de 2 kHz à 2,4 kHz, peuvent être fournies sur demande.

Cet oscillateur transistorisé utilise un transistor au silicium et fonctionne convenablement sur piles sèches du type pour appareils de surdité. Sa gamme de températures de fonctionnement va de −40°C à +70°C. Les dimensions du boîtier contenant l'oscillateur à diapason sont de 6,35 cm × 6,35 cm × 7,62 cm.

Le diviseur de fréquences fournit un rapport de division de 5:1 et il a été essentiellement étudié pour être employé avec l'oscillateur à diapason de 2 kHz S. G. Brown, afin de donner une fréquence de référence de 400 Hz des plus précises. Les dimensions du boîtier contenant tant l'oscillateur à diapason que le diviseur sont de 6,98 cm × 9,52 cm × 8,89 cm.

EE 26 753 *pour plus amples renseignements*

BRYANS AEROQUIPMENT LTD

1 and 15 Willow Lane, Mitcham, Surrey

TABLE POUR RELEVÉS EN COORDONNÉES

(Illustration à la page 651)

Cet instrument autonome et de construction compacte peut être utilisé sur établi ou sur pupitre. Il reçoit des signaux X et Y, sous forme de tensions continues et les convertit en positions de plume appropriées, traçant ainsi le graphique des rapports X/Y à mesure que ces signaux varient. Il est également pourvu d'une base de temps qui peut être commutée sur l'axe X, permettant ainsi de reporter la tension Y par rapport au temps.

La table a un couvercle en perspex afin de proteger la surface de report contre la poussière, le papier graphique étant tenu en place par l'aspiration d'un ventilateur à travers le lit poreux de la table. L'alignement du papier est assuré par des micromètres.

La plume est du type capillaire et à grand réservoir d'encre. Elle est abaissée à la position d'écriture par l'action d'un commutateur sur le panneau frontal.

La table peut guiper du papier dont les dimensions peuvent aller jusqu'à 43,2 × 27,9 cm, donnant une surface de 37,1 × 25,4 cm.

La plume est commandée par les deux axes d'un mécanisme d'asservissement des plus perfectionnés, assurant une réponse dynamique rapide et une grande précision de position. La position de la plume est mesurée par les potentiomètres de précision parcourant la table en long et en large. Le plus grand soin a été apporté à l'étude des circuits auxiliaires et d'asservissement, afin d'assurer le minimum de dérive. Le résultat en a été une excellente stabilité à long terme.

Les commandes de la table sont toutes logées dans le panneau frontal qui est de forme inclinée. A gauche, se trouvent les commandes d'axe Y, au centre il y a celles d'axe X, ainsi que le commutateur de secteur et la lampe pilote.

Les deux autres commandes d'axe Y sont marquées "SENSITIVITY", "FINE" et "COARSE" (soit: sensibilité, réglage précis et réglage approximatif). A l'aide de ces commandes, on peut ajuster la sensibilité de l'asservissement de l'axe Y à n'importe quelle valeur entre les limites de 0,07 V/pouce et 7 V/pouce de mouvement de plume.

L'axe X a les mêmes commandes de déplacement de la plume et de réglage de la sensibilité que celles de l'axe Y, ce qui permet de placer la plume en n'importe quel point de l'axe X. On peut ainsi, en liaison avec la commande de déplacement Y, établir un point de repère pour les signaux d'entrée zéro, à n'importe quel point de l'ensemble de la surface de report.

La base de temps a une gamme de vitesses de 100/1, ce qui est fort étendu pour un système entraîné par moteur et peut donner lieu à un léger "cahotement" aux vitesses réduites lorsque le moteur passe par saccades d'un segment de commutateur à l'autre, mais cela n'est d'aucun inconvénient dans la plupart des cas.

La base de temps est déclenchée par le bouton marqué "trigger" (déclenchement) sur le panneau frontal, mais elle peut être déclenchée par un circuit amené jusqu'à la prise de signal d'où l'on pourrait vouloir déclencher son balayage par un signal extérieur quelconque. La base de temps est munie d'un dispositif automatique de retour au cours duquel la plume est soulevée afin de ne pas laisser une trace de retour sur le papier pouvant induire en erreur. Si le commutateur d'écriture est dans la position "lift" (levée), la plume ne sera pas abaissée durant le balayage de la base de temps, de sorte que le balayage pourra être ajusté sans marquer le papier.

La vitesse de traçage peut atteindre 50,8 cm/sec. et la vitesse de la base de temps est variable de 0,3 cm à 25,4 cm/sec.

EE 26 754 *pour plus amples renseignements*

COSSOR RADAR AND ELECTRONICS LTD

The Pinnacles, Harlow, Essex

RÉPONDEUR DE BORD

(Illustration à la page 652)

Le répondeur de radar secondaire, type 1251, se caractérise par le fait qu'il supprime les lobes latéraux.

Quoique les lobes latéraux de l'antenne d'un émetteur pilote d'impulsions ou "interrogateur" soient d'une amplitude beaucoup plus réduite que l'étroit faisceau principal, ils fournissent une intensité de signal suffisante pour déclencher des répondeurs qui ne sont pas en mesure de discriminer contre l'interrogation de lobes latéraux. Ceci aurait pour résultat de diffuser les réponses de l'avion sur une surface étendue, de sorte que les informations de gisement se perdraient et que d'autres effets indésirables se produiraient tels que le brouillage d'autres stations terrestres et le captage des répondeurs par des stations locales, rendant ainsi ces stations éloignées insensibles à l'interrogation.

La suppression des lobes latéraux se fait en ajoutant à l'emission d'interrogation directionnelle, une émission de contrôle omnidirectionnelle. Grâce aux circuits incorporés dans le répondeur SSR.1251, les réponses ne sont données qu'aux interrogations dont l'amplitude et les impulsions de commande se présentent dans un rapport qui ne peut exister que dans la direction du lobe principal. Le système de suppression du lobe latéral, tel qu'il est actuellement spécifié par l'I.C.A.O. (Organisation Internationale d'Aviation Civile) est le système dit à deux impulsions. En variante, un système à trois impulsions est en cours d'étude et pourrait également être soumis à l'approbation des comités internationaux. Le matériel de sol Cossor peut être fourni pour fonctionner avec l'un ou l'autre de ces systèmes, cependant que le matériel de bord—actuellement fourni pour être utilisé avec le système à deux impulsions —peut être adapté à l'emploi du système à trois impulsions.

Le répondeur de bord se prête au fonctionnement non-pressurisé jusqu'à une altitude de 20 000 pieds et il est prévu pour répondre à des signaux d'interrogation formés de paires d'impulsions de 0,8 μsec, à intervalles de 8 μsec (mode A) ou 17 μsec (mode B). Enfin, l'appareil a été réalisé en prévision d'une utilisation future de modes supplémentaires de 21 et de 25 μsec (modes C et D).

EE 26 755 *pour plus amples renseignements*

EKCO ELECTRONICS LTD

Southend-on-Sea, Essex

RADAR MÉTÉOROLOGIQUE DE BORD

(Illustration à la page 652)

Le radar météorologique poids léger 3 cm, Ekco type E190, ne pèse que 26 kg et sa portée est de 241,4 km. Se composant de trois éléments seulement, cet appareil transistorisé offre tous les avantages qu'on est en droit d'attendre d'un radar météorologique moderne, y compris une image d'une grande brillance et une antenne de 61 cm, pleinement stabilisée. Il fournit des indications précises de distance et d'azimut sur les formations de nuages cumulo-nimbus et permet des représentations topographiques du terrain survolé.

Un dérivomètre Doppler peut être ajouté comme auxiliaire facultatif.

Le radar E190 fut également exposé comme double système émetteur-récepteur et indicateur, en accord avec la pratique habituelle de produire en double certains dispositifs essentiels et répondant à des réglements obligatoires. A l'aide de ce système, des conditions de sécurité absolue sont, en effet, assurées car l'un ou l'autre des deux indicateurs fonctionne avec l'un ou l'autre des émetteurs-récepteurs. Les caractéristiques de comportement sont semblables à celles de l'appareil Ekco standard, en dehors de la consommation électrique accrue. Notre gravure montre l'ensemble d'exploration du radar type E190 monté sur le nez de fuselage d'un avion Vickers Vanguard.

EE 26 756 *pour plus amples renseignements*

FERRANTI LTD

Hollinwood, Lancashire

TRANSDUCTEUR DE DÉPLACEMENT

(Illustration à la page 652)

Ce transducteur permet de mesurer avec précision le déplacement angulaire. Une bobine primaire centrale est excitée par un courant de 20 volts, 2400 Hz, établissant un couplage inductif entre la bobine primaire centrale et deux bobines secondaires extérieures. L'arbre, dont on veut mesurer le déplacement, est relié à une spire de cuivre en court-circuit, qui est mobile dans un entrefer de l'organe central.

La spire court-circuitée étant dans la position centrale, le couplage inductif entre la bobine primaire et les bobines secondaires est symétrique et il n'y a pas de sortie de puissance des bobines secondaires. Le déplacement de la spire court-circuitée de la position centrale dérange la symétrie du couplage inductif et donne lieu à une sortie de tension des bobines secondaires, proportionnelle au déplacement. Un carter en acier doux protège le transducteur.

EE 26 757 *pour plus amples renseignements*

FIRTH CLEVELAND INSTRUMENTS LTD

Treforest, Pontypridd, Glamorgan

FRÉQUENCEMETRE PORTATIF (TACHYMÈTRE)

(Illustration à la page 653)

Le fréquencemètre type FM1015 est un instrument poids léger pour mesurer la fréquence de signaux à variation étendue, tant d'amplitude que de forme d'onde, dans la gamme de fréquences de 10 Hz à 200 kHz. L'instrument fonctionne sur batterie intérieure ou sur secteur. Dans la gamme de fréquences précitées, la précision des indications est de $\pm 2\frac{1}{2}$% de l'échelle totale lorsque les signaux d'entrée ont une amplitude allant de 0,075 à 10V efficaces. En plus de la mesure de fréquence directe, l'instrument peut être employé pour la tachymétrie où le signal d'entrée nécessaire peut être produit au moyen d'une bobine exploratrice magnétique, reliée à une roue dentée ferreuse et accouplée à un arbre rotatif. En variante, l'arbre rotatif peut être accouplé à un rupteur, soit mécanique soit à cellule photoélectrique et source lumineuse. Dans ce dernier cas, une prise à part est ajoutée au fréquencemètre afin d'exciter une tête de phototransistor et une source lumineuse.

Le signal donné au fréquencemètre est injecté, à travers un étage d'entrée d'impédance moyenne, à un amplificateur produisant une forme d'onde à front raide pour déclencher un circuit bistable dont la fonction est de produire une onde carrée d'un rapport repère/espace égal, quelle que soit l'onde d'entrée. La puissance de sortie du circuit bistable est encore amplifiée par un contre-circuit de commande, produisant ainsi une onde carrée à grande amplitude qui actionne le transistor de sortie. La sortie de ce dernier est limitée par une diode de référence Zéner, qui assure l'application d'une onde carrée d'amplitude constante à travers les condensateurs d'étalonage et les diodes redresseuses formant le circuit de mesure. Le courant de condensateur redressé qui en résulte, passe par le fréquencemètre et il est directement proportionnel au taux de répétition des impulsions et, par conséquent, à la fréquence des signaux d'entrée ou cadence d'impulsions. Les indications de l'instrument ne sont pas affectées par les variations de tension d'alimentation ou par les changements de niveau du signal d'entrée. Afin de lui assurer le degré maximum de portabilité, l'instrument est pourvu d'une batterie rechargeable poids léger Venner, en zinc argenté, de même que d'un circuit de charge approprié. Ce circuit de charge autonome se caractérise par le fait que la charge cesse aussitôt que la batterie atteint son état de pleine charge.

EE 26 758 *pour plus amples renseignements*

ENREGISTREUR POTENTIOMÉTRIQUE MINIATURE

(Illustration à la page 653)

Cet appareil a été réalisé afin de répondre à la demande industrielle d'un enregistreur de précision, occupant un minimum d'espace de panneau tout en offrant les mêmes avantages et le même degré de précision que les instruments de type plus classique.

L'instrument complet n'exige qu'un espace de tableau de 19,80cm × 13,75 cm et sa profondeur n'est que de 46,25 cm. Les éléments électroniques qu'il englobe comprennent: un élément d'entrée à obturateur rupteur mécanique à bruit réduit et potentiomètre d'équilibrage de précision; un amplificateur transistorisé à grand gain et compensation thermique; un bloc d'alimentation et son étage de sortie et, enfin, une source de référence de tension Zéner à compensation thermique et à grande stabilité, rendant inutile l'emploi d'une pile étalon.

La vitesse maxima de déviation de la plume est de 7,5 cm/seconde et des sensibilités totales, allant de 1mV à 100mV, peuvent être obtenues. Des vitesses d'avance de diagramme de 1,25cm/h et de 30cm/h peuvent être effectuées.

EE 26 759 *pour plus amples renseignements*

THE GENERAL ELECTRIC CO LTD

Magnet House, Kingsway, London, W.C.2

EQUIPEMENT D'ESSAI DE VIBRATION

(Illustration à la page 653)

Ce matériel constitue un ensemble d'essai de vibration, autonome et complet, pouvant être utilisé par un opérateur semi-qualifié. Il effectue la plupart des essais de vibration exigés par bon nombre de spécifications gouvernementales. Nul montage n'est nécessaire pour son utilisation quotidienne normale et il peut être réglé pour effectuer des essais à répétition sans surveillance pendant des périodes allant de 0,1 h à 1000 h.

L'équipement comprend un amplificateur de puissance et une alimentation en courant continu entraînant un vibreur, tel que le vibreur G.E.C. VEM 5 MK 2, un oscillateur, un pont à bande magnétique et un amplificateur asservi pour la commande constante d'accélération. Tous ces éléments sont logés dans un pupitre contenant également les circuits de contrôle, de sécurité et de protection, ainsi que les circuits de minutage. Seuls le vibreur, les ventilateurs de refroidissement et le bloc à cathode asservie accélérométrique ne sont pas contenus dans le pupitre.

La sortie de puissance acoustique est de l'ordre de 2,5 kW avec une distorsion totale de moins de 2% dans la gamme de fréquences de 30 Hz à 10 kHz. L'amplificateur fournit une tension totale pouvant atteindre 3 kW en impédances de 10,15 ou de 20 ohms, avant la mise en oeuvre de son circuit de protection. La puissance d'entrée peut venir d'une source extérieure, de l'oscillateur incorporé ou du pont à bande dans la console.

Pour alimenter la bobine de champ d'un vibreur de type électromagnétique, un bloc d'alimentation en courant continu fournit 230 V à 2 A avec un niveau d'ondulation ne dépassant pas 5%.

L'oscillateur intérieur couvre la gamme de 30 Hz à 10 kHz. La fréquence de sortie est indiquée, à un degré de précision de ± 5% sur un enregistreur étalonné logarithmiquement à échelle de 25,4 cm graduée en 240°. L'oscillateur donne non seulement une sortie de fréquence fixe, mais il peut aussi être balayé en fréquence logarithmiquement, en fonction de la durée. Les limites de ce balayage peuvent être choisies de la gamme complète d'oscillation, la vitesse de balayage pouvant être soumise à une variation continue de 4 à 140 sec./octave.

Un magnétophone à double piste SIMON SP4 à inversion de marche automatique est fixé dans un tiroir du pupitre. Il peut effectuer un enregistrement sur bande de n'importe quel essai voulu, dans la gamme de fréquences couverte par l'amplificateur. Cet enregistrement pourra ensuite être reproduit de façon continue, avec des interruptions de moins de 5 sec. pour l'inversion de la bande.

L'accélération constante est réalisée à l'aide d'un élément de commande du niveau-*g*, qui peut recevoir des informations de n'importe lequel des trois accéléromètres. La constance de l'accélération peut être maintenue à $+1$ dB près. Le niveau est indiqué sur un compteur étalonné logarithmiquement de 2 *g* à 100 *g*.

Afin de simplifier la mise en service quotidienne de l'équipement, toutes les commandes d'usage courant ont été placées sur le panneau frontal. Après un réglage initial pour une opération connue, le fonctionnement n'aura plus qu'à se faire par simple commutation d'arrêt-marche. Tous les circuits de chauffage et de protection sont entièrement automatiques, de sorte que nulle connaissance technique n'est nécessaire pour la mise en marche de l'équipement et qu'un changement d'opération peut se faire normalement en actionnant les boutons-poussoirs sur le panneau frontal.

EE 26 760 *pour plus amples renseignements*

RÉCEPTEUR DE COMMUNICATIONS

Le récepteur superhétérodyne à 14 lampes BRT 400D a une gamme de fréquences de 150 à 385 kHz et de 0,51 à 30 MHz, s'étendant sur six bandes. La sensibilité, le rapport signal/bruit, la stabilité de fréquence, etc, sont remarquables. En outre, une sélectivité variable à six échelons et un filtre à cristal extrêmement efficace contribuent à rendre ce récepteur propre au service le plus astreignant dans presque toutes les applications. Il permet également la réception en diversité, de même que la télégraphie par déplacement de fréquence, en liaison avec un appareil terminal approprié.

Le récepteur BRT 400D fonctionne habituellement sur alimentation secteur en courant alternatif, mais en cas de sinistre ou à défaut de courant alternatif, il fonctionnera également à partir d'une alimentation en courant continu de 12 V, grâce au bloc à batterie BRT 401.

Toutes les pièces constitutives et les matériaux employés dans la fabrication de la série des récepteurs BRT 400D ont été choisis individuellement et mis à l'épreuve de conditions tropicales rigoureuses, en ce qui à trait à la sûreté de leur comportement. Il se conforment aux spécifications militaires britanniques ou bien, lorsque ces dernières sont inappropriées, ils sont soumis à l'essai tropical standard K.110.

Dans le cas des applications où la télégraphie est de peu ou sans importance et où, par contre, comme par exemple dans les installations de relais, la réception de transmissions par téléphonie de haute qualité est l'objectif principal, le filtre accepteur à fréquence acoustique de 1 kHz pourra, sur commande spéciale, être remplacé par un filtre réjecteur de 9 kHz.

EE 26 761 *pour plus amples renseignements*

GENERAL PRECISION SYSTEMS LTD

Aylesbury, Buckinghamshire

CALCULATEUR DE RECHERCHE AÉRONAUTIQUE

Ce calculateur, conçu par la société General Precision Systems Ltd., constitue un calculateur analogique des plus adaptables pour résoudre les problèmes de dynamique dans le domaine aéronautique. L'appareil de base, qui peut être considérablement accru au besoin, comprend les éléments suivants:

(a) 30 amplificateurs (stabilisés par chopper à grand gain).
(b) 20 réseaux calculateurs intégrateurs de sommes.
(c) 10 réseaux calculateurs de sommes.
(d) 40 potentiomètres de précision à coefficient de 10 tours.
(e) 3 servo - multiplicateurs/générateurs de fonctions, actionnés par moteur Vélodyne (à réglage de vitesse).
(f) 5 servo - multiplicateurs/générateurs de fonctions, actionnés par moteur.
(g) 2 multiplicateurs électroniques.
(h) 4 générateurs de fonctions électroniques.
(i) 5 éléments de simulation de secteur mort et de limiteur.
(j) 1 voltmètre numérique avec tableau de sélecteurs.
(k) 1 oscilloscope à double faisceau avec tableau de sélecteurs similaire.
(l) 1 générateur de fonctions de pression.
(m) 1 élément de surcharge et de commande centrale.

Les amplificateurs employés dans le calculateur ont été spécialement étudiés pour en faire des éléments à la fois sûrs et économiques, pouvant être employés avec deux types de boîtes de réseaux de calcul pour la sommation et l'intégration. Dans le cas du réseau de sommation/intégration, le réglage initial d'intégration se fait par une résistance HELIPOT à variation continue de précision à 10 tours, fixée sur l'élément. Tous les réseaux sont dotés de pièces d'une précision de 0,1%. Dans de nombreux cas, l'exactitude du calcul qui en résulte peut être supérieure aux données primaires, mais la sûreté des résultats est garantie par l'emploi de ces pièces.

Avec ce calculateur, les coefficients ou paramètres d'équations soumis à l'examen sont fixés ou ajustés par des potentiomètres 10-tours, dont quarante sont inclus. Ces potentiomètres sont à fusibles, pour les protéger contre l'endommagement accidentel, et ils peuvent être réglés ou balayés avec grande précision par l'emploi de la source de référence interne et du voltmètre numérique prévus à cet effet.

L'appareil est doté de deux types de servomultiplicateurs pour répondre à une grande variété de problèmes. Le type actionné par moteur Vélodyne est limité dans le nombre des fréquences qu'il peut traiter, mais il a l'avantage de pouvoir être employé pour l'intégration, selon la boîte d'engrenages utilisée, pendant de longues heures. Les cartes potentiométriques de cet élément sont des bobines de ruban de 10 cm de longueur, et leur dessin particulier permet l'échange de cartes simulant diverses fonctions. Le type de servomultiplicateur actionné par moteur classique et exempt de fer, est idéal pour le fonctionnement dans le temps réel, puisque la limite supérieure de réponse de fréquence utilisable est de 10 Hz. Dans les deux types de servomultiplicateurs, certains des jumelages sont munis de prises sur les cartes de potentiomètre afin de permettre les temps de repos par résistances réglables pour donner des lois mathématiques. La fonction requise peut être établie par l'emploi du voltmètre numérique.

Les multiplicateurs électroniques et les générateurs de fonctions dont ce calculateur est doté en nombre adéquat, assurent également la solution de problèmes où des fréquences relativement élevées peuvent être rencontrées. Les multiplicateurs sont du genre "repère-espace" et ils peuvent être utilisés pour donner jusqu'à quatre produits. Les générateurs de fonctions à diodes de polarisation à 10 segments peuvent être utilisés pour approcher n'importe quelle fonction à valeur unique d'une variable de puissance d'entrée. Quant au voltmètre numérique, il sert à établir les valeurs requises des points de rupture des 10 segments rectilinéaires représentant la fonction de la façon la plus proche.

Ces divers éléments sont reliés entre eux sur un panneau amovible de préaffichage, au moyen de cordons à conducteur unique.

EE 26 762 *pour plus amples renseignements*

GOODMANS INDUSTRIES LTD

Axiom Works, Wembley, Middlesex

OSCILLATEUR DE BALAYAGE AUTOMATIQUE

L'oscillateur de balayage E.502 représente une source précise et commode d'oscillations sinusoïdales, dont la fréquence varie selon une loi prédéterminée. Le modèle standard est conçu de manière à osciller selon les conditions stipulées dans de nombreuses spécifications de contrôle d'engins téléguidés, c'est à dire selon la loi suivante:

$$\frac{df}{dt} = \frac{1}{70}f^{4/3}$$

Il est, cependant, possible d'appliquer (sur commande spéciale) n'importe quelle loi dont la vitesse de changement de fréquence, aux limites extrêmes d'une bande quelconque, ne dépasse pas le rapport de 100 à 1.

Deux gammes de fréquences sont prévues, soit 5 Hz à 500 Hz et 30 Hz à 3 kHz. Un oscillateur à pont de Wien de haute qualité est utilisé. Il est suivi d'un dispositif à cathode asservie, donnant ainsi des fréquences très stables, de faibles niveaux de distorsion ainsi qu'un degré très élevé de stabilité d'amplitude. A un réglage donné de la commande de gain, les variations d'amplitude entre les deux gammes ou entre les deux extrémités de chacune des gammes sont inférieures à 1dB et les niveaux de distorsion sont inférieurs à 2%. Le balayage automatique s'effectue au moyen d'un moteur à courant continu, commandé par un circuit de relais et un embrayage magnétique accouplé au potentiomètre déterminant la fréquence. Des disjoncteurs réglables de sécurité prérèglent les positions à inversion de marche du moteur. Le balayage peut se faire à la main ou par préréglage d'unibalayage. L'oscillateur est pourvu d'un micro-rupteur pouvant être ajusté à n'importe quelle position dans les limites préréglées du cadran. Ce micro-rupteur met en oeuvre un relais permettant de passer des mesures d'accélération constante à celles de vitesse constante lorsqu'elles sont effectuées à l'aide d'un amplificateur de commande *g*.

Deux sorties sont prévues, l'une à travers un atténuateur et une cathode asservie, et l'autre à un niveau élevé pour synchroniser un stroboscope.

L'appareil est livrable sous forme d'élément individuel dans un coffret ou sur bâti standard pour montage dans une baie ou sur pupitre de commande.

EE 26 763 *pour plus amples renseignements*

Cathode asservie à sept voies

(Illustration à la page 654)

La cathode suiveuse à sept voies, modèle E506, a été étudiée en vue du câblage d'accéléromètres au titanate de baryum à la principale position de mesure d'un système de contrôle de vibrations, au moyen de câbles relativement longs.

L'impédance d'entrée est de 100 Mégohms et celle de sortie est de 800 ohms en série avec un condensateur de 0,5μF. La réponse de fréquence est de 5 Hz à 20 kHz $\pm$ 1dB. En ajoutant 9m de câble à double blindage, la réponse, au même degré d'uniformité, est de 5 Hz à 2 kHz. Des longueurs de câble de l'ordre de 9m peuvent être utilisées entre l'accéléromètre et l'entrée de la cathode asservie sans réduire la sensibilité accélérométrique efficace au-dessous de la valeur normalement trouvée dans les conditions pratiques. Ceci est réalisé par l'emploi d'un câble à double blindage, dont le conducteur intérieur relie l'élément actif de l'accéléromètre à la grille du tube d'entrée, le blindage intérieur du câble étant relié à la cathode du tube d'entrée à l'une des extrémités et isolé à l'autre. Le blindage extérieur est à la masse, à l'une des extrémités et relié, à l'autre extrémité, à l'électrode de terre de l'accéléromètre. Ceci amène une réduction de la capacité de câble efficace par un facteur de 30 environ.

L'appareil est livrable en coffret ou pour montage sur bâti.

EE 26 764 *pour plus amples renseignements*

HONEYWELL CONTROLS LTD

Ruislip Road East, Greenford, Middlesex

Oscillographe à lecture directe

(Illustration à la page 655)

A la suite de la levée des restrictions sur l'importation des oscillographes des Etats-Unis, la société Honeywell Controls Ltd s'est mise d'accord avec ses associés américains pour la vente au Royaume-Uni d'un oscillographe à lecture directe de 14 voies portant le nom de Visicorder.

Les applications connues de cet instrument comprennent les études météorologiques et sismologiques, le repérage d'engins spatiaux, les recherches se rapportant au débit d'air et à la soufflerie aérodynamique, etc.

Le Visicorder ressemble à un oscillographe ordinaire avec sa source lumineuse, ses galvanomètres à miroir, son système d'optique et son système de transport de papier, mais aucun procédé chimique n'est employé pour obtenir un enregistrement permanent. Il n'utilise ni encre, ni charge électrostatique, ni arc électrique, ni vapeur chimique ou chaleur.

Grace à l'emploi de papier de 15 cm de largeur, des fréquences allant jusqu'à 5 kHz peuvent être enregistrées sur 12 voies, avec deux repères de référence ou de minutage. Une commande d'intensité, ainsi qu'un système de ligne de grille et d'identification de trace sont également inclus. Enfin, l'appareil se prête à la télécommande car il comporte une lampe d'enregistrement à auto-démarrage et un bloc d'alimentation incorporé.

EE 26 765 *pour plus amples renseignements*

McMICHAEL RADIO LTD

Wexham Road, Slough, Buckinghamshire

Enregistreur de Radar

(Illustration à la page 655)

Il s'agit ici d'un appareil naval de type classique, employé pour l'instruction des opérateurs de radar. Il peut également être utilisé pour la concentration des indications de radar lorsqu'un enregistrement permanent est nécessaire.

L'enregistreur REJ utilise un film de 35mm sur lequel il enregistre et réenregistre les signaux vidéo émanant de l'indicateur de gisement (P.P.I.) d'un radar panoramique à antenne à rotation continue. Il fonctionne sur n'importe quelle gamme choisie entre 10 et 160 milles avec des radars ayant une vitesse de rotation pouvant aller jusqu'à 100 tours/minute. Une ligne repère du nord peut aussi être enregistrée.

Trois vitesses d'enregistrement et de réenregistrement sont prévues et l'élément d'entrainement pilote de base peut être adapté soit au type d'émission magslip, soit au type M, soit à tous deux.

Un magnétophone est incorporé à l'appareil afin de permettre l'enregistrement de commentaires et leur réenregistrement synchronisé avec le film.

On peut également commander l'enregistreur à partir d'un élément de télécommande à part.

EE 26 766 *pour plus amples renseignements*

Élément binaire

(Illustration à la page 655)

Cet élément binaire spécial de "division par deux" représente une application nouvelle des circuits subminiature McMichael. C'est un élément constitutif compact de calculateur pour avions d'études et de recherches extra-atmosphériques. Il se compose d'un circuit bistable à deux transistors, prévu pour des entrées, des sorties et le réenregistrement pour comptage de décades. Conçu pour une puissance de 5 à 7V, sa consommation de courant est de 4mA. Il fonctionne à des vitesses allant jusqu'à 100,000 coups par seconde, à partir d'impulsions d'une durée ne dépassant pas 2μsec. La gamme de témperatures va de 0 à 60°C.

L'élément binaire est d'un volume de 8cm et son poids est de 3,5 grammes. Il comprend deux transistors au germanium, deux diodes au germanium, quatre condensateurs en céramique et huit résistances. Sa densité constitutive est de 221000/28,3 dm³.

EE 26 767 *pour plus amples renseignements*

MARCONI INSTRUMENTS LTD

St. Albans, Hertfordshire

Pont universel de précision

(Illustration à la page 655)

Le pont universel à impédance TF 1313, est d'une précision de 0,25%. Il ne comporte qu'un seul cadran pour les mesures d'inductance, de capacité et de résistance, mais ce cadran est pourvu de réglages approximatifs et précis. Le réglage approximatif se fait par plots de 1%, tandis que le réglage précis comporte 50 divisions par plot. Son instrument de lecture donne une indication claire de la direction du point d'équilibrage, même lorsqu'il est nettement déséquilibré, contribuant ainsi à l'accélération et à la simplification des mesures de composantes complètement inconnues. Un générateur extérieur de basse-fréquence peut être branché à l'appareil lorsque des mesures d'inductance et de capacité doivent être prises à des fréquences autres que les fréquences intérieures de 1 et de 10 kHz. La sortie de puissance du détecteur est fournie extérieurement pour permettre l'emploi d'un oscilloscope ou d'un casque pour les indications d'équilibrage.

Les gammes couvertes sont: inductance-de 0,1μH à 110H, à 1 et 10 kHz; capacité—de 0,1 pF à 110 μF, à 1 et 10 kHz; résistance—de 0,01 ohms à 110 Mégohms, au courant continu.

EE 26 768 *pour plus amples renseignements*

Appareil de contrôle de répondeurs

(Illustration à la page 655)

L'appareil de contrôle type 506 est un affaiblisseur à impulsions différentielles, réalisé par la société Marconi Instruments Ltd. en collaboration avec le Ministère de l'Aviation, dans le cadre de son Programme de Radar de Surveillance Secondaire Civil. Lorsque cet appareil est utilisé avec le générateur de signaux UHF Marconi TF 1060, il permet de contrôler la partie récepteur d'un émetteur-récepteur asservi par impulsions ou "répondeur," et en particulier les caractéristiques de suppression des lobes latéraux, telles que normalisées par l'I.C.A.O. (Organisation Internationale d'Aviation Civile).

Le contrôleur type 506 produit des trains d'impulsions vidéo, formés de deux ou trois impulsions, à une fréquence de répétition à variation continue dans une gamme de 250 à 2 000 par seconde. On peut faire varier les largeurs d'impulsions individuelles de 0,5 à 2,0 μsec, l'espacement pouvant être effectué par commutateur pour donner des intervalles préréglés, correspondant aux Modes Civils A,B,C, et D, ou pour des intervalles à variation continue jusqu'à 30 μsec. Ces trains d'impulsions modulent le générateur de signaux UHF, réglé à la haute fréquence voulue, et le signal HF modulé par impulsions qui en résulte est injecté à l'appareil de contrôle et conduit à travers l'atténuateur différentiel. Ceci permet de faire varier l'amplitude relative d'une impulsion dans un train à double impulsion, ou encore d'une ou de deux impulsions dans un train à triple impulsion, par plus ou moins de 10dB, par rapport à l'autre impulsion. A l'aide du commutateur de " fonction," on choisit les impulsions variables qui peuvent être soit de commande soit d'interrogation, selon les besoins.

La signal HF obtenu ainsi à la prise de sortie de l'appareil peut être contrôlé si nécessaire, en l'injectant dans le détecteur pézoélectrique incorporé dans son amplificateur vidéo. Le signal de sortie de l'amplificateur peut être observé au moyen d'un oscilloscope approprié, tel que le type Marconi TF 1330. Une impulsion de déclenchement de l'oscilloscope est fournie à la prise "SYNC OUT" et elle se produit 5 μsec avant la première impulsion HF.

Enfin, l'appareil a été conçu de manière à ce que le générateur de signaux puisse être monté au-dessus, ainsi que le montre notre gravure.

EE 26 769 *pour plus amples renseignements*

MARCONI'S WIRELESS TELEGRAPH CO LTD

Chelmsford, Essex

MATÉRIEL DE COMMUNICATION POUR HYPER-FRÉQUENCES

(Illustration à la page 656)

Ce materiel comprend un émetteur VHF type 6400 et un récepteur VHF type 6401.

Emetteur VHF

Cet émetteur, qui a une puissance de sortie de 25W, fournit 360 voies pilotées par quartz (avec espacement de 50 kHz) de 118,0 MHz à 135,95 MHz. Il pèse 6,3 kg et il est logé dans un petit coffret format 3/8 ATR. Employé en liaison avec le récepteur 6401, il forme avec ce dernier un appareil de communication VHF de petit format ne pesant en tout que 10,4 kg.

Il répond à toutes les conditions de la spécification 520A de l'A.R.I.N.C. (organe de centralisation de caractéristiques d'appareils électroniques), mais comprend un nombre de dispositifs supplémentaires. Parmi ces derniers, il convient de citer principalement la commande de modulation automatique et l'écrêteur de parole de 12 dB, qui assurent la plus grande intelligibilité possible en toutes circonstances.

Un emploi maximum a été fait des transistors, les étages quartz et modulateurs étant entièrement transistorisés. L'application du quartz sur partiel inframiniature, récemment mis au point, réduit le nombre d'étages nécessaires et augmente la protection contre les rayonnements parasites. L'émetteur peut être utilisé avec des microphones électromagnétiques (comprenant également les types éliminateurs de bruit) ou des microphones au carbone, de sorte qu'il se conforme aux systèmes d'intercommunications britannique et américain sans modification aucune.

Le type 6400 a été étudié pour le fonctionnement simplex sur voie unique ou sur double voie, des circuits modulateurs étant, en outre, prévus pour des systèmes futurs de transmission automatique de données.

Récepteur VHF

Le récepteur type 6401 doit être utilisé avec l'émetteur 6400, ainsi qu'avec d'autres appareils, afin de former un système de guidage d'approche et de navigation VHF entièrement transistorisé.

Il couvre la bande de 108 à 135,95 MHz et fournit 560 voies dans cette bande. Il est entièrement transitorisé, ce qui permet de le loger dans un petit coffret format 1/4 ATR. Il ne pèse que 3,6 kg et sa consommation électrique n'est que de 10W.

Le récepteur 6401 est, effectivement, une superhétérodyne multiple avec une fréquence intermédiaire finale de 500 kHz, donnant la caractéristique de sélectivité principale. Les pièces des circuits détecteurs ont été étudiées pour un fonctionnement satisfaisant dans les transmissions dites "climax" et la parole est introduite dans les étages de sortie basse-fréquence à travers des circuits "à réglage silencieux" et fonctionnement signal/bruit.

EE 26 770 *pour plus amples renseignements*

PYE TELECOMMUNICATIONS LTD

Newmarket Road, Cambridge

TÉLÉVISION DIRIGÉE PAR RADIO

Ce système de télévision dirigé par radio est entièrement transportable et indépendant de câbles.

Il permet au personnel des tours de contrôle d'observer des zones qui leur sont invisibles, ainsi que toutes les zones de rassemblement et pistes de décollage, particulièrement durant les périodes opérationnelles de visibilité réduite. Il permet, en outre, l'observation serrée du décollage et de l'atterrissage d'avions aux aérodromes d'essais et expérimentaux.

L'emploi de la télécommande radio assure un système d'une souplesse considérable, la distance entre le point de contrôle et la caméra étant presque illimitée pour la plupart des besoins pratiques.

Une démonstration de l'appareil fut donnée au stand intérieur de la Sté. Pye Telecommunications où un opérateur, à l'aide d'un levier de commande de profondeur, dirigeait par radio une caméra éloignée sur n'importe quel point voulu de l'aérodrome. Le système de commande s'effectue par liaison radioélectrique UHF de 450 MHz, les images étant renvoyées à travers une liaison par microondes. La caméra de télévision éloignée est entièrement automatique et ne nécessite aucune attention, toutes ses fonctions étant commandées au moyen de la liaison par microondes.

EE 26 771 *pour plus amples renseignements*

W. H. SANDERS (ELECTRONICS) LTD

Gunnels Wood Road, Stevenage, Hertfordshire

RÉCEPTEUR D'ETALONNAGE POUR MICROONDES

(Illustration à la page 656)

Une version améliorée du récepteur d'étalonnage de 45 MHz vient d'être réalisée, qui comporte les perfectionnements suivants:

Facteur de bruit: 1,8 à 2,5 dB
Fréquence intermédiaire: 45 MHz
Largeur de bande: ±2,5 MHz.

Le nouveau récepteur comprend un appareil de mesure à double mouvement, permettant de contrôler les courants dans les détecteurs de premier et de second étage. D'autre part, les positions à double sensibilité de cet appareil de mesure donnent une déviation totale de 1 mA ou de 100 μA.

En outre, un atténuateur à barillet de commutation est incorporé au récepteur. Il couvre une gamme de 0 à 100 dB, par plots de commande approximative de 20 dB ou par plots de commande précise de 1 dB, de 0 à 20 dB. Le préamplificateur est un élément à part, afin d'en faciliter l'entretien et le remplacement éventuel des pièces. Il est muni d'une prise de contrôle de haute tension. Un boîtier de conception nouvelle renferme l'ensemble complet qui est monté sur châssis normal.

Le préamplificateur peut loger n'importe laquelle des gammes normales de mélangeurs à cristal entre les dimensions de guide d'ondes 10 et 22 (2,60 à 40 kMHz).

EE 26 772 *pour plus amples renseignements*

THE SOLARTRON ELECTRONIC GROUP LTD

45 Thames Street, Kingston-on-Thames, Surrey

ENREGISTREUR DE DONNÉES NUMÉRIQUES

(Illustration à la page 656)

Cet appareil accepte des signaux analogiques, de polarité positive ou négative, d'un nombre de voies allant jusqu'à 50, et les convertit en signaux analogiques pour actionner un imprimeur intégral. La vitesse d'exploration est de deux voies par seconde et la précision de conversion analogique/numérique est de 0,1%. Les données de sortie de l'imprimeur indiquent l'identité des voies, la valeur du signal mesuré et la polarité, sur une bande continue de papier de 7,5 cm de large.

L'appareil se compose de éléments suivants: un commutateur à 50 voies, un convertisseur analogique/numérique et son indicateur, et un imprimeur.

L'élément de commutation est à relais scellés avec contacts dorés, afin de leur assurer une plus longue durée et d'en réduire le bruit. Ses fonctions sont celles d'un commutateur bipolaire à 50 voies, reliant, tour à tour, chacune des 50 entrées au convertisseur. Un interrupteur, monté sur cet élément, offre un choix de trois modes de fonctionnement, à savoir l'échantillonnage automatique continu, l'exploration unique par commande extérieure ou le choix manuel. L'élément de commutation est relié de façon permanente au convertisseur analogique/numérique, le débit de ce dernier étant sous forme décimale codée, appropriée au fonctionnement direct de l'imprimeur.

EE 26 773 *pour plus amples renseignements.*

TRANSDUCTEURS DE PRESSION

(Illustration à la page 657)

Le transducteur de pression universel, type NT 4-313, sert à mesurer des pressions moyennes et élevées. Comportant un élément sensible à jauge de contrainte miniaturisé, ses indications sont des plus sûres et peuvent être répétées même dans des conditions extrêmes de vibration et de température.

Le diaphragme affleurant du transducteur permet de monter ce dernier dans la paroi d'un bac à pression sans en modifier le volume et sans déranger le flot de la substance de pression.

Il existe des versions absolument identiques au type NT 4-313, mais fermées hermétiquement, pour les mesures effectuées dans des atmosphères corrosives. Les propriétés de l'acier inoxydable utilisé pour ces versions, notamment sa résistance spécifique à la corrosion, permettent l'emploi du transducteur lorsqu'il est en contact avec des liquides tels que l'acide azotique fumant, rouge ou blanc, le bioxyde d'hydrogène à 100% ou l'hexafluorure d'uranium. Ces jauges sont livrables pour des gammes de pression allant de 7,030 à 351,5 kg/cm².

Un modèle spécial de ce transducteur, à savoir le type NT 4-317, fonctionne continûment à des températures allant jusqu'à 600°F, ou même jusqu'à 2000°F, si l'on utilise un raccord de refroidissement.

EE 26 774 *pour plus amples renseignements*

SOUTHERN INSTRUMENTS LTD

Frimley Road, Camberley, Surrey

MULTIMÈTRE À MÉMOIRE

(Illustration à la page 657)

Le multimètre à mémoire électronique universel E.R.I.C. offre la possibilité d'effectuer une gamme étendue de mesures, grâce à son utilisation d'un circuit "TRIPÔLE." Le "TRIPÔLE" est un amplificateur c.c. équilibré à trois bornes, les caractéristiques de n'importe quelle paire de bornes étant fort différentes de celles d'une quelconque autre paire. Une de ces paires de bornes, désignées par 1-2, a une impédance d'entrée virtuellement infinie. La seconde paire, 1-3, a une très faible impédance d'entrée tandis que la paire 2-3 manifeste une très faible impédance de sortie.

Cette dernière propriété sert à actionner un appareil de mesure à faible impédance et les bornes 2-3 sont utilisées à cette fin.

L'impédance élevée à travers les bornes 1-2 donne au multimètre E.R.I.C. la plupart de ses particularités intéressantes. La valeur est tellement élevée qu'un condensateur chargé à grande isolation peut être relié à travers ces bornes sans qu'il se produise de perte appréciable de charge pendant des périodes de plusieurs heures. Ce condensateur, relié au sein de l'instrument, lui donne l'avantage d'une mémoire. En raison du gain de tension unité entre ces bornes et celles de sortie, le multimètre gardera la lecture de la tension d'entrée tant que le condensateur garde sa charge. Un bouton "d'effacement" permet d'écarter cette charge à volonté.

Le multimètre E.R.I.C. permet aussi de mesurer une gamme étendue de valeurs de résistance, jusqu'à plusieurs centaines de mégohms.

EE 26 775 *pour plus amples renseignements*

STANDARD TELEPHONES AND CABLES LTD

Connaught House, Aldwych, London, W.C.2

INDICATEUR DE TRIANGULATION RADIOGONIOMÉTRIQUE AUTOMATIQUE

Ce nouvel indicateur de triangulation constitue, en liaison avec les réseaux de stations radiogoniométriques automatiques terrestres dites à grande ouverture, un radiogoniomètre d'aérodrome précis et pratique pour le contrôle du trafic aérien. Sa fonction principale est d'identifier et de localiser les avions pénétrant ou survolant des espaces aériens contrôlés, en n'employant que des signaux émis par l'avion pour communiquer de manière ordinaire avec le centre de contrôle. Quoique particulièrement destiné à être utilisé avec le système CADF (radiogoniométrie par commutation successive sur une série d'antennes) à grande ouverture de la Standard Telephones and Cables Ltd, cet indicateur peut être adapté facilement à d'autres radiogoniomètres.

L'indicateur du nouveau système PVT-2 utilise la télévision en circuit fermé et représente une nouvelle étape de perfectionnement du système actuel de triangulation PVT-1. Ce dernier est constitué par un radiogoniomètre d'aérodrome employé depuis de longues années en Grande-Bretagne et dans d'autres pays d'Europe.

L'indicateur qu'on a pu voir à Farnborough recevait des signaux "artificiels" d'un simulateur ou des signaux "en direct" de deux radiogoniomètres accordés à l'une des fréquences du contrôle du trafic aérien civil. L'un des signaux en direct fut émis d'un appareil CADF à Bovingdon et l'autre d'un appareil CADF exposé par Airtech Ltd.

EE 26 776 *pour plus amples renseignements*

ULTRA ELECTRONICS LTD

Western Avenue, Acton, London, W.3

SYSTÈME DR CONTRÔLE DE COMMUNNICATIONS

Cet appareil représente un système de sélection par boutons-poussoirs, constituant un nouveau progrès dans la miniaturisation de ce genre de matériel.

Le poste de base (type UA.6010) comporte 15 boutons-poussoirs pour la sélection des communications (émetteurs et récepteurs), les intercommunications et les télécommunications par cabine. Ses dimensions ne sont, cependant, que de 14,7 cm × 7,6 cm et il ne pèse que 1,4 Kg.

Le poste de base UA.60 est un système décentralisé à amplificateurs locaux dans chacun des postes. Une boîte de jonction centrale supplémentaire assure un système complet de contrôle de communications.

L'assortiment d'accessoires comprend tous les éléments nécessaires, tels que boîtes de jonction, amplificateurs pour le personnel non-navigant, boîtes de jacks pour le personnel non-navigant et postes pour steward.

Les principales caractéristiques de l'UA.60, en dehors de son encombrement et de son poids réduits, rendus possibles par l'application des méthodes modernes à transistors et circuits imprimés, sont la sélection par boutons poussoirs de 15, 25 ou 35 services, la commande d'intensité incorporée aux boutons-poussoirs pour toutes les voies de réception et, enfin, un panneau à éclairage sur les bords.

Ce système est conforme aux normes d'installation américaines actuelles et convient également au matériel de radio britannique ou américain. Il peut être construit pour s'adapter aux spécifications de tout système.

EE 26 777 *pour plus amples renseignements*

VACTRIC (Control Equipment) LTD

Vactric House, Sloane Street, London S.W.1

ORGANES D'ASSERVISSEMENT

(Illustration à la page 657)

Trois nouveaux éléments figuraient dans la gamme étendue d'organes asservis de précision à carcasse de format international, à savoir: une génératrice tachymétrique à moteur c.a. format 15, un moteur c.c. à répulsion à enroulement auxiliaire format 15, et un moteur c.a. format 08.

Le moteur de tension alternative format 15 de la tachy-génératrice est à deux phases, 400 Hz, et sa puissance de sortie tachy-génératrice est de 3,0 V/1000 tours/minute, avec une linéarité de ±0,5%.

Le couple de décrochage du moteur à répulsion à enroulement auxiliaire est de 160 cm à l'excitation maximum. La résistance série extérieure maximum est de 18 ohms et le courant d'induit maximum est de 1 A. L'inertie d'induit est de 13 g.cm², le courant de champ est de 40-0-40 mA et la résistance de champ est de 800 ohms par bobinage.

Le moteur c.a. format 08 est à deux phases et 400 Hz, et son couple décrochage minimum est de 219 g.cm. Sa vitesse à vide est de 6200 tours/minute et il pèse 48 g.

EE 26 778 *pour plus amples renseignements*

Résumés des Principaux Articles

Un convertisseur analogique/numérique à usage spécial par G. C. Henderson

Résumé de l'article aux pages 602 à 608

Le convertisseur analogique/numérique décrit ici a été réalisé pour être utilisé dans un système de traitement des données pour l'analyse d'enregistrements télémétriques à transmission successive de signaux. A partir d'entrées comportant une tension non-linéaire analogue au paramètre mesuré, ainsi que d'un nombre de tensions d'étalonnage et d'un train d'impulsions de fixation, le convertisseur obtient une sortie numérique binaire et une sortie analogue, toutes deux en rapport linéaire avec la valeur, dans les élément requis, du paramètre, avec correction automatique du gain global et des dérives de niveau.

Commutation statique par G. H. Ohlsen

Résumé de l'article aux pages 609 à 613

Les usages et les avantages de la commutation statique, dérivant des méthodes de calcul numérique, sont examinés par l'auteur. Il compare ensuite les techniques existantes et décrit un système complet utilisant des dispositifs 'NI' comme élément logique, ainsi que l'analyse et la solution d'un problème simple.

L'Analyseur différentiel et sa réalisation sous forme numérique par P. L. Owen, M. F. Partridge et T. R. H. Sizer

Résumé de l'article aux pages 614 à 616

Cet article décrit l'analyseur différentiel, tant sous sa forme mécanique originale que sous sa forme numérique ultérieure. En gros, les calculateurs correspondant à cette désignation générique traitent des données continûment variables, comme dans la solution des équations différentielles.

L'intérêt suscité par cet analyseur différentiel s'est récemment accru du fait de l'application des techniques numériques, ayant eu pour résultat la réalisation de l'analyseur différentiel numérique (abrégé en A.D.N.). Ce type de machine est d'une grande souplesse de fonctionnement et d'une précision inhérente au système numérique.

Une fermeture automatique codée par J. D. Storer

Résumé de l'article aux pages 617 à 619

L'auteur décrit une fermeture à combinaison simple qui est actionnée par boutons-poussoirs portant les lettres de l'alphabet, soit quatre lettres devant être choisies dans l'ordre correct. Le circuit comporte des unisélecteurs et des relais.

Un circuit de déclenchement cascode utilisant un transistor PNP et un transistor NPN. par P. Arnoldt

Résumé de l'article aux pages 620 à 623

Un circuit de déclenchement monostable utilisant un transistor NPN dans un dispositif cascode est décrit dans cet atricle. Ce circuit, lorsqu'il est précédé d'un intégrateur à diode, forme un étage diviseur de fréquences. On obtient ainsi des conditions optima pour assurer une parfaite sécurité de fonctionnement avec les variations de température. Des valeurs pratiques sont indiquées pour une sécurité d'étage, divisant par 10 dans une gamme de températures de 50° à 50°C., avec des impulsions d'entrée de 100kHz. L'impulsion de sortie d'un tel étage permet de mettre en oeuvre la puissance d'entrée d'un étage suivant.

Le circuit de déclenchement peut aussi être utilisé pour produire des formes d'ondes en dents de scie ou pour faire fonction de modulateur de temps.

L'utilisation de la résistance au silicium pour la stabilisation de tension continue des circuits à transistors. par D. H. Mehrtens et J. T. Zakrewski

Résumé de l'article aux pages 624 à 629

Les auteurs présentent une nouvelle méthode pour stabiliser le point de fonctionnement en continu des transistors à l'aide de résistances au silicium, et donnent un exposé de son application tant pour les transistors de puissance que pour ceux à signaux faibles. Ils démontrent la possibilité d'obtenir, grâce à cette méthode, un courant au collecteur constant sur toute la gamme de températures de fonctionnement des transistors dans la plupart des cas.

"ISABEL" Binaires d'accumulation à isostatut utilisant une logique extraordinaire. par J. A. Goss

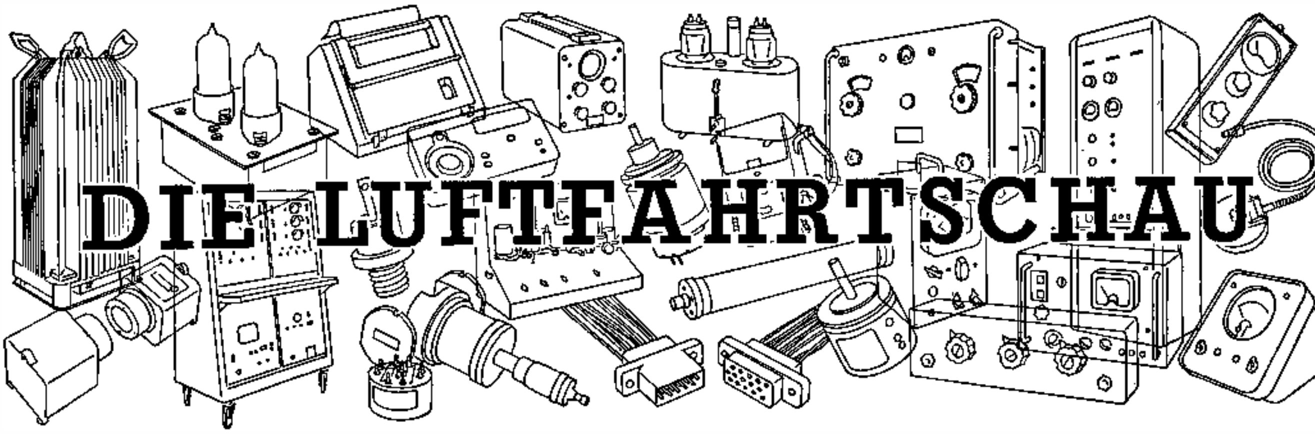
Résumé de l'article aux pages 630 à 634

Un dispositif logique perfectionné de compteur décimal, basé sur des éléments bistables, est étudié par l'auteur qui décrit également le comportement de divers circuits utilisant cette méthode.

Une méthode automatique perfectionnée pour mesurer l'absorption ionosphérique. par L. Thomas

Résumé de l'article aux pages 635 à 639

L'absorption ionosphérique a été mesurée à University College, Swansea, par une méthode automatique pendant l'Année Géophysique Internationale. L'appareil décrit dans cet article constitue un perfectionnement d'un modèle précédent, enregistrant l'amplitude d'écho moyenne pendant un intervalle de temps d'une minute environ. Le système entier est synchronisé à des tensions de déclenchement d'une impulsion par seconde, assurant ainsi une compensation améliorée pour des signaux de bruit de fond et un minimum de brouillages d'autres services. L'auteur décrit le fonctionnement général de l'appareil et compare les mesures automatiques à celles effectuées par la méthode manuelle courante.



DIE LUFTFAHRTSCHAU

Beschreibung einiger auf der Luftfahrtschau des Vereins Britischer Flugzeugkonstrukteure (SBAC) gezeigten elektronischen Geräte, die nach Angaben der Hersteller zusammengestellt wurde.

(Übersetzung der Seiten 651 bis 657)

BELLING AND LEE LTD

Great Cambridge Road, Enfield, Middlesex

MEHRFACH-STECKVORRICHTUNGEN

(Abbildung Seite 651)

In den Steckern und Buchsen Baumuster "Camlock" und "Autolock" wurde eine Konstruktion geschaffen, in der jeder Steckerpol mit der entsprechenden Buchse einzeln verriegelt ist. Dadurch ergibt sich zwangsläufig guter Kontakt aller Pole und hohe Betriebssicherheit, wo sie Stössen und Erschütterungen ausgesetzt sind.

Die Abbildung illustriert das Arbeitsprinzip. Normalerweise passt der Steckerpol gleitend in die Buchse, die axial durch zwei oder mehr Schlitze unterteilt ist. Durch Einwirkung einer Druckkraft auf den Buchsenmund in Pfeilrichtung werden die Innenwände gegen den wulstförmigen Stecker gedrückt, und mit ansteigendem Druck nehmen die Buchsenwände eine kurvenförmige Gestalt mit einem rollenden Drehpunkt an. Der Buchsenmund berührt den Steckerhals überhaupt nicht, und der endgültige Kontakt liegt zwischen den Ebenen AA und BB, wodurch die einzelnen Toleranzen nicht kritisch sind.

Zwei verschiedene Baumuster dieses Konstruktionsprinzips werden als "Camlock" und "Autolock" bezeichnet. Bei ersterem sind die Kontakte leistenförmig angeordnet, und die Verriegelung erfolgt mittels einer Stange mit schlüssellochartigen Schlitzen, die um den Mund jeder einzelnen Buchse liegen. Diese Stange wird durch einen exzentrischen Schaft mittels eines in der freien Steckerleiste eingebauten Drehelementes längsweise gegen die Buchsen verschoben. Im Baumuster "Camlock" ist eine einfache Vorrichtung vorgesehen, die Einstellung von 36 verschieden gepolten, unverwechselbaren und eindeutig numerierten Eingriffstellungen ermöglicht.

In der "Autolock" Baureihe findet die Verriegelung automatisch im letzten Stadium des Einschiebens statt. In diesem Fall ist die Aussenseite des Buchsenmundes glockenförmig gestaltet und wird durch axiale Bewegung einer zylindrischen Hülse zusammengedrückt. In Mehrfachsteckern wird statt der einzelnen Hülsen für jeden Pol eine einzige Verriegelungsplatte mit einem Loch für jeden Pol benutzt. Die Polanordnung kann nach jedem gewünschten Muster erfolgen, und in einer ausgestellten Konstruktion wird ein rundes Gehäuse benutzt; in diesem Falle werden Pole und Buchsen durch eine Winkeldrehbewegung des Steckergehäuses zum Eingriff gebracht und verriegelt. Diese "Autolock" Steckerverbindung ist vollständig dicht, und der Benutzer kann jede von sechs vorhandenen Kontaktanordnungen wählen.

EE 26 751 *für weitere Einzelheiten*

G. BROWN LTD

Shakespeare Street, Watford, Hertfordshire

SERVOVERSTÄRKER

Dieser 6,5 W-Verstärker ist mit npn-Siliziumtransistoren bestückt und kann diese Nennleistung bei Umgebungstemperaturen bis zu $+90°C$ ohne zusätzliche Wärmeabfuhr abgeben. Das Gerät wurde hauptsächlich für Betrieb mit dem Servomotor Type 15B entwickelt. Durch den Verstärker steht bei einem Quellenwiderstand von nicht weniger als 250Ω eine Gesamtleistungsverstärkung von 72 dB zur Verfügung. Der für eine Trägerfrequenz von 400 Hz ausgelegte Verstärker wird in einem abgedichteten Gehäuse von nur $82{,}5 \times 31{,}75 \times 50{,}8$ mm Abmessungen geliefert.

Der Transistor-Netzanschluss ist für 115 V, 400 Hz und kann Gleichstrom bis zu 30 W abgeben.

EE 26 752 *für weitere Einzelheiten*

STIMMGABELGENERATOR UND FREQUENZTEILER

Die Stimmgabel ist eine in sich geschlossene Tonquelle, die aus Nickeleisen mit geringem Temperaturkoeffizienten konstruiert ist und ein einzigartiges elektromagnetisches Antriebssystem besitzt. Die Nennfrequenz ist 2 kHz und die Toleranz bei 20°C besser als 0,005%. Gegen Sonderauftrag können andere Frequenzen im Bereich 2 ... 2,4 kHz geliefert werden.

Der transistorisierte Oszillator ist mit einem Si-Transistor bestückt und arbeitet zufriedenstellend mit Trockenbatterien, die für Hörhilfen benutzt werden. Er ist über den Temperaturbereich $-40°C \ldots +70°C$ voll betriebsfähig. Die Abmessungen des Gehäuses einschliesslich Stimmgabel sind $63{,}5 \times 63{,}5 \times 76{,}2$ mm.

Der Frequenzteiler gibt ein Abbauverhältnis von 5:1 und ist in erster Linie für Verwendung mit der S. G. Brown 2 kHz-Stimmgabel bestimmt, mit der zusammen er eine sehr genaue 400 Hz Bezugsfrequenz abgibt. Die Gehäuseabmessungen des Teilers sind $70 \times 95{,}25 \times 89$ mm.

EE 26 753 *für weitere Einzelheiten*

BRYANS AEROQUIPMENT LTD

1 and 15 Willow Lane, Mitcham, Surrey

KOORDINATEN-AUSWERTTISCH

(Abbildung Seite 651)

Dies ist ein in sich geschlossenes und kompakt konstruiertes Gerät für Werkbank oder Schreibtisch. X- und Y-Signale werden als Gleichspannungen aufgenommen und in die entsprechenden Stylusstellungen umgesetzt, wodurch ein Diagramm der X und Y Beziehungen gezeichnet wird, das den Änderungen dieser Signale entspricht. Ein Zeitablenkgerät ist eingebaut, das ermöglicht, Y-Signale als Funktion der Zeit auf der X-Achse auszuwerten.

Die Aufzeichnung wird durch einen Plexiglasdeckel staubfrei gehalten. Durch ein poröses Bett saugt ein Gebläse das Papier an, um es festzulegen. Zum genauen Ausrichten des Papiers sind Raster vorgesehen.

Der Stylus ist in Kapillarausführung mit grossem Farbbehälter und wird durch Betätigung eines Schalters auf der Frontplatte in die Schreibstellung gebracht.

Die maximale Blattgrösse ist 43 × 28 cm mit einer Diagrammfläche von 38 × 25½ cm.

Steuerung des Stylus in beiden Achsen erfolgt durch Hochleistungs-Servosysteme, die sowohl schnelles dynamisches Ansprechen als auch genaue Positionseinstellung gewährleisten. Die Stylusstellung wird durch Präzisionsschleifdrähte gemessen, die über die Länge und Breite des Gerätes laufen. Die Servo- und Hilfsschaltungen wurden besonders sorgfältig für geringe Drift ausgelegt, um gute Langzeitstabilität zu erreichen.

Die Bedienungselemente des Gerätes sind auf einer schräggestellten Frontplatte angeordnet: links für die Y-Achse, in der Mitte für X-Achse, Zeitablenkung und „Schreibschalter" und rechts der Hauptschalter mit Signallampe.

Der mit „Y-Verstellung" bezeichnete Knopf verschiebt den Stylus entlang der Y-Achse, wobei mit zehn Umdrehungen des Knopfes die ganze Y-Achsenlänge überstrichen wird. So kann der Stylus genau auf jeden gewünschten Punkt der Y-Achse eingestellt werden.

Die beiden anderen Y-Achsen-Knöpfe sind für Grob- und Feineinstellung der Empfindlichkeit. Mittels dieser Bedienungselemente kann die Empfindlichkeit des Y-Achsen-Servos auf jeden Wert zwischen 0,028 ... 2,8 V/cm Stylusbewegung eingeregelt werden.

Die Bedienungselemente für Stylusverschiebung und Empfindlichkeit der X-Achse entsprechen denen der Y-Achse. Durch Zusammenwirken der X und Y Regler kann daher überall auf der Schreibfläche ein Bezugspunkt für Nullsignal eingestellt werden.

Die Zeitablenkung hat einen Geschwindigkeitsbereich von 100:1, was für motorgetriebene Systeme sehr gross ist und bei niedrigeren Geschwindigkeiten minimale Sprunghaftigkeit hervorrufen kann, wenn der Motor sehr langsam von einer Lamelle auf die andere übergeht. In den meisten Fällen verursacht das jedoch keinerlei Unannehmlichkeiten.

Die Zeitablenkung wird durch den mit „Trigger" bezeichneten Druckknopf auf der Frontplatte ausgelöst, kann aber auch mittels einer zum Signalstecker herausgeführten Schaltung durch Fremdsignal betätigt werden, wo das wünschenswert ist. Die Zeitablenkung hat automatische Rückführung mit Stylusanhebung, um verwirrende Rücklaufspuren auf dem Papier zu vermeiden. Ist der Schreibschalter in der Stellung für Stylusanhebung, so wird der Stylus während des Zeitablenkungslaufes nicht auf das Papier heruntergebracht, und somit kann die Ablenkung ohne Schreiben eingeregelt werden.

Die Schreibgeschwindigkeit geht bis zu 50 cm/s, und die Zeitablenkgeschwindigkeit ist von 0,254 ... 25,4 cm/s einregelbar.

EE 26 754 *für weitere Einzelheiten*

COSSOR RADAR AND ELECTRONICS LTD

The Pinnacles, Harlow, Essex

BORD-TRANSPONDER

(Abbildung Seite 652)

Eine Eigenschaft des sekundären Radar-Transponders Type 1251 ist die Unterdrückung der Seitenlappen.

Trotzdem die Seitenlappen des Abfragesenders viel kleinere Amplituden haben als die stark gebündelte Hauptkeule, strahlen sie ausreichend starke Signale ab, um Antwortgeräte zu triggern, die nicht für Unterscheidung der Seitenlappenstrahlung ausgerüstet sind. In diesem Fall würden sich die Antworten vom Flugzeug über ein weites Gebiet erstrecken, so dass Peilinformation verloren geht und unerwünschte Erscheinungen wie z.B. Störung anderer Bodenstationen und "Fangen" der Transponder durch Ortsstationen auftreten und Unempfindlichkeit gegen Abfragen durch diese entfernten Stationen hervorgerufen wird.

Seitenlappenunterdrückung wird durch Ergänzung der Richtungsausstrahlung des Abfragegerätes mit einer Kontroll-Rundstrahlung erreicht. Die im Transponder SSR 1251 verwendeten Schaltungen gewährleisten, dass nur die Abfragen beantwortet werden, in denen die Amplituden der Abfrage und Kontrollimpulse in einem bestimmten Verhältnis stehen, was nur in der Richtung der Hauptkeule möglich ist. Das z.Z. von I.C.A.O. vorgeschriebene System mit Seitenlappenunterdrückung ist das "Zwei-Impuls"-System. Ein alternatives "Drei-Impuls"-System wird neuerdings erörtert und vielleicht auch zugelassen werden. Die Cossor-Bodenanlage ist für jedes der beiden Systeme lieferbar, und die z.Z. für das "Zwei-Impuls"-System gelieferte Bordstation kann für das "Drei-Impuls"-System umgeändert werden.

Der Bord-Transponder ist für Betrieb ohne Druckkabine bis zu 6100 m und für Antwort auf Abfragesignale geeignet, die aus Paaren von 0,8 μs Impulsen mit entweder 8 μs (Verfahren A) oder 17 μs (Verfahren B) Abstand bestehen. Für späteres zusätzliches Arbeiten mit 21 und 25 μs Abstand (Verfahren C und D) ist Vorsorge getroffen.

EE 26 755 *für weitere Einzelheiten*

EKCO ELECTRONICS LTD

Southend-on-Sea, Essex

BORDWETTERRADAR

(Abbildung Seite 652)

Das 3cm-Wetterradargerät EKCO E 190 wiegt nur 26 kg und hat eine Reichweite von 240 km. Diese transistorisierte Anlage besteht nur aus drei Bausteinen und hat alle Eigenschaften, die von einem modernen Wetterradarsystem erwartet werden, einschliesslich sehr heller Sichtanzeige und vollstabilisierter 61 cm Antenne. Es gibt die genaue Entfernung und Azimutangaben für Kumulonimbuswolken und hat eine Vorrichtung für Kartierung. Ein Dopplerabtriftgerät kann gegen Sonderpreis mitgeliefert werden.

Die Type E 190 wurde auch als doppeltes Funkgerät und Sichtanzeigesystem ausgestellt. Dieses Gerät entspricht der gängigen Praxis, alle notwendigen Dienste, soweit sie vorgeschrieben sind, in doppelter Ausführung einzubauen. Mit diesem System werden alle Sicherheitsbedingungen erfüllt, da jedes einzelne der Funkgeräte mit jedem der Sichtgeräte arbeiten kann. Das Pflichtblatt ist dem des Ekco-Standardgerätes ähnlich, jedoch ist die Stromaufnahme etwas höher. Die Abbildung zeigt die Abtasteinheit des E 190 im Bug eines Vickers Vanguard Verkehrsflugzeuges.

EE 26 756 *für weitere Einzelheiten*

FERRANTI LTD

Hollinwood, Lancashire

VERSCHIEBUNGSGEBER

(Abbildung Seite 652)

Dieser Geber ist ein empfindliches Messgerät für Winkelverschiebung. Eine in der Mitte liegende Primärspule wird durch 20 V 2400 Hz erregt. Dadurch entsteht eine induktive Kopplung zwischen der Primärspule und zwei äusseren Sekundärspulen. Der Schaft, dessen Verschiebung gemessen werden soll, wird mit einer Kupferkurzschlusswindung verbunden, die in einem Luftspalt des Kernsteges beweglich ist.

Wenn sich die Kurzschlusswindung in der Mittellage befindet, ist die Flussverkettung zwischen der primären und den sekundären Spulen symmetrisch, und die Sekundärspulen geben keine Spannung ab. Die Symmetrie der Kopplung wird durch Verschiebung der Kurzschlusswindung von der Mittellage gestört, und an den Sekundärspulen erscheint eine der Verschiebung proportionale Spannung. Zum Schutz ist ein Metallgehäuse vorgesehen.

EE 26 757 *für weitere Einzelheiten*

FIRTH CLEVELAND INSTRUMENTS LTD

Treforest, Pontypridd, Glamorgan

TRAGBARER FREQUENZMESSER (TACHOMETER)

(Abbildung Seite 653)

Der sehr leichte Frequenzmesser FM

1015 ist für Messungen von Signalen im Bereich von 10 Hz...200 kHz ausgelegt, deren Amplitude sowie Wellenform sehr schwanken. Das Gerät kann von eingebauten Batterien oder dem Netz betrieben werden und hat über den angegebenen Frequenzbereich für Eingangssignale mit Amplituden zwischen 0,075 und 10 V_{eff} eine Anzeigegenauigkeit von $\pm 2\frac{1}{2}\%$ des Vollausschlags. Das Gerät kann ausser für direkte Frequenzmessungen auch für Tachometrie benutzt werden. In diesem Fall kann das erforderliche Signal durch eine magnetische Abtastspule und ein mit dem laufenden Schaft gekuppeltes eisernes Zahnrad erzeugt werden. Andererseits kann der laufende Schaft auch mit einem Kontaktunterbrecher gekuppelt werden, der entweder mechanisch arbeitet oder eine Fotozelle und Lichtquelle benutzt. Für die letztere Ausführung hat der Frequenzmesser eine getrennte Buchse zum Betreiben eines Fototransistorkopfes und einer Lichtquelle.

Das Signal wird über eine Eingangsstufe mittlerer Impedanz einem Verstärker zugeführt, der eine Wellenform mit steiler Vorderflanke erzeugt, die eine bistabile Schaltung triggert. Die Funktion dieser Schaltung ist, unabhängig von der Eingangswellenform eine Rechteckwelle mit gleicher Impulsbreitenmodulation abzugeben. Der Ausgang dieser bistabilen Schaltung wird weiter in einer gegengekoppelten Treiberschaltung verstärkt und ruft eine Rechteckwelle grosser Amplitude hervor, die den Ausgangstransistor treibt. Der Ausgang der letzteren Stufe wird durch eine Zener-Bezugsdiode begrenzt, wodurch eine konstante Amplitude der Rechteckwelle gewährleistet wird, die an den aus Eichkondensatoren und Gleichrichterdioden bestehenden Messkreis angelegt wird. Der entstehende gleichgerichtete Kondensatorstrom geht durch das Instrument und ist der Impulsfolgefrequenz und daher der Eingangssignalfrequenz oder -impulsfrequenz direkt proportional. Die Instrumentanzeige wird weder durch Netzschwankungen noch durch den Pegel des Eingangssignals beeinflusst. Um das Gerät besonders leicht tragbar zu machen, ist eine aufladbare Venner Silber-Zinkbatterie mit der zugehörigen Ladeschaltung eingebaut. Die Ladung wird automatisch unterbrochen sowie die Batterie voll aufgeladen ist.

EE 26 758 *für weitere Einzelheiten*

MINIATUR-KOMPENSATIONSSCHREIBER

(*Abbildung Seite 653*)

Dieses Instrument entspricht den industriellen Forderungen nach einem Präzisionsschreiber, der die kleinstmögliche Fläche auf der Messtafel einnimmt und doch Eigenschaften und Genauigkeit eines traditionelleren Gerätes aufweist.

Das komplette Instrument nimmt einen Raum von 200 × 140 mm auf der Tafel ein und ist 470 mm tief. Die eingebauten elektronischen Bausteine bestehen aus einer Eingangsschaltung mit geräuscharmem mechanischem Zerhacker und Präzisions-Ausgleichspotentiometer, einem transistorisierten, temperaturkompensierten Hochleistungsverstärker, Netzteil, Ausgangsstufe und einer hochkonstanten Zenerspannung-Bezugsquelle, die eine Normalzelle überflüssig macht.

Die Höchstgeschwindigkeit der Stylusablenkung ist 76,2 mm/s, und Vollausschlagsempfindlichkeiten zwischen 1 mV und 100 mV sind lieferbar. Papiervorschübe zwischen 12,7 mm/h bis 305 mm/h können vorgesehen werden.

EE 26 759 *für weitere Einzelheiten*

THE GENERAL ELECTRIC CO LTD

Magnet House, Kingsway, London, W.C.2

SCHWINGUNGSERREGER-TREIBER

(*Abbildung Seite 653*)

Diese in einem kompletten, in sich geschlossenen Steuerpult untergebrachte Anlage kann von einem angelernten Arbeiter bedient werden. Sie kann die meisten von Regierungsbehörden vorgeschriebenen Schwingungstests ausführen und braucht zum täglichen Gebrauch nicht besonders eingerichtet zu werden. Dauerversuche können ohne Wartung über Zeitspannen von 0,1 ... 1 000 h vorgenommen werden.

Die Anlage besteht aus einem Leistungsverstärker und einer Gleichspannungsquelle für den Betrieb eines Schwingungserzeugers wie z.B. den G.E.C. VEM 5 Baumuster 2, einem Oszillator, Magnetband-Laufwerk und einem Servoverstärker zur Regelung der konstanten Beschleunigung. Alle diese Geräte sind im Pult untergebracht, zusammen mit allen Regler-, Monitor- und Schutzschaltungen und Zeitschalter. Nur der Schwingungserreger, die Kühlventilatoren und der Kathodenverstärker des Beschleunigungsmessers sind getrennt ausgeführt.

Die NF-Ausgangsleistung ist in der Grössenordnung von 2,5 kW mit einer Gesamtverzerrung unter 2% im Frequenzbereich 30 Hz ... 10 kHz. Der Verstärker liefert insgesamt 3 kW in Impedanzen von 10, 15 oder 20Ω, bevor die Schützen ansprechen. Der Eingang kann von einer externen Quelle, dem eingebauten Oszillator oder dem Magnetbandgerät im Pult zugeführt werden.

Eine Gleichspannungsquelle liefert 230 V 2 A mit einer Restwelligkeit unter 5% für die Feldspule des elektromagnetischen Schwingungserregers.

Der eingebaute Oszillator überstreicht den Bereich von 30 Hz ... 10 kHz. Die Ausgangsfrequenz wird mit ±5% Genauigkeit auf einer 25,4 cm langen 240° Skala mit logarithmischer Eichung angezeigt. Ausser der abgegebenen Festfrequenz kann die Oszillatorfrequenz auch mit logarithmischer Ablenkung als Funktion der Zeit gesteuert werden. Die Begrenzung dieser Überstreichung kann vom gesamten Frequenzbereich gewählt werden, und die Ablenkgeschwindigkeit kann stufenlos zwischen 4 und 140 Sekunden/Oktave eingeregelt werden.

Ein Simon-Magnetbandgerät SP4 mit Doppelspur und automatischer Umkehr ist in eine Schublade des Pultes eingebaut und kann mit einem Bandprogramm jedes gewünschten Tests innerhalb des Verstärker-Frequenzbandes benutzt werden. Das Programm wird dann laufend mit 5 s Unterbrechungen für Magnetbandumkehr wiedergegeben.

Konstante Beschleunigung wird mit Hilfe eines g-Niveau-Reglers erreicht, der von einem der drei Beschleunigungsmesser mit Daten gespeist wird. Die Beschleunigung kann innerhalb ±1 dB konstant gehalten werden. Der g-Wert wird auf einem zwischen 2 ... 100 g logarithmisch geeichten Instrument angezeigt.

Um den täglichen Gebrauch zu vereinfachen, sind alle Bedienungselemente auf der Frontplatte angeordnet. Nach Einstellung für eine bekannte Aufgabe braucht nur ein- und ausgeschaltet zu werden. Alle Aufwärm- und Schutzschaltungen arbeiten automatisch, so dass zur Inbetriebnahme des Gerätes keinerlei technische Kenntnisse erforderlich sind. Umschalten auf neue Aufgaben kann im allgemeinen durch Bedienung von Drucktasten auf der Frontplatte erfolgen.

EE 26 760 *für weitere Einzelheiten*

VERKEHRSEMPFÄNGER

Der BRT 400D ist ein 14-Röhren-Überlagerungsempfänger mit einem Frequenzbereich von 150 ... 385 kHz und 0,51 ...30,0 MHz in sechs Bändern. Empfindlichkeit, Geräuschabstand und Frequenzstabilität sind hochgradig. Einbau einer sechsstufigen Selektivitätswahl und eines äusserst wirksamen Quarzfilters tragen zu einer Leistung bei, die den Empfänger für den anspruchsvollsten Dienst auf fast allen Verwendungsgebieten geeignet machen. Das Gerät ist für Diversity-Empfang und, zusammen mit geeignetem Überführungsgerät, für F 1-Tastung im Funktelegraphiedienst ausgelegt.

Im normalen Betrieb wird der Empfänger an das Wechselstromnetz angeschlossen. Im Notfall, oder wo kein solches Netz zur Verfügung steht, kann das Batterieanschlussgerät BRT 401 eingesetzt und mit 12 V Gleichspannung gespeist werden.

Alle Bauelemente, Werkstoffe und Oberflächenbehandlung für die Konstruktion der BRT 400 Serie wurden besonders für schwierigste tropische Klimabedingungen ausgesucht und geprüft. Sie entsprechen entweder den Britischen Waffennormen oder wurden, wo diese nicht zutreffen, dem tropischen Standardklimatest K 110 unterworfen.

Wo Telegraphie nur geringe oder gar keine Bedeutung hat und die Hauptaufgabe Empfang hochwertiger Telephoniesendungen ist, wie z.B. für Ballempfänger, kann der 1 kHz-NF-Saugkreis durch ein 9 kHz-Sperrfilter ersetzt werden.

EE 26 761 *für weitere Einzelheiten*

GENERAL PRECISION SYSTEMS LTD

Aylesbury, Buckinghamshire

RECHNER FÜR LUFTFAHRTFORSCHUNG

Dieser elektronische Rechner wurde von General Precision Systems Ltd als kompakter, anpassungsfähiger und vielseitiger Analogrechner für Lösung dynamischer Probleme auf dem Luftfahrtgebiet entwickelt. In seiner Grundform, die im Bedarfsfall wesentlich erweitert werden kann, besteht er aus folgenden Bausteinen: —

(a) 30 Hochleistungsverstärker mit Chopperstabilisierung

(b) 20 Rechnernetzwerke für Summation and Integration

(c) 10 Rechnernetzwerke für Summation

(d) 40 Präzisions-Koeffizientenpotentiometer (10-Gang-Wendel)

(e) 3 Velodyne-getriebene Servomultiplikatoren/Funktionsgeber

(f) 5 Motorgetriebene Servomultiplikatoren/Funktionsgeber

(g) 2 Elektronische Multiplikatoren

(h) 2 Elektronische Funktionsgeber

(i) 5 Bausteine für "Tote Zone"- und "Begrenzung"-Nachbildung

(j) Digital-Voltmeter, das über Wählschalter direkt an die Rechenelemente angelegt werden kann

(k) Zweistrahl-Oszillograph mit ähnlichem Wählschalter

(l) Spezieller Funktionsgeber

(m) Zentrales Steuer- und Überlastungsschutzgerät.

Die im Rechner benutzten Verstärker wurden als besonders zuverlässige und trotzdem wirtschaftliche Geräte entwickelt, die mit zwei Modellen der Rechnernetzwerk-Bausteine für Summation und Integration eingesetzt werden. Die Anfangsbedingungen der Integration werden mittels eines in den Baustein eingebauten 10-gängigen Präzisions- Wendelpotentiometers eingestellt. Die in den Netzwerken verwendeten Präzisions-Bauelemente haben alle 0,1% Toleranz. In vielen Fällen wird dadurch die Rechengenauigkeit grösser als die der Primärdaten; die Zuverlässigkeit der Resultate wird jedoch durch Einsatz dieser Bauelemente erhöht.

Die Gleichungskoeffizienten oder die zu untersuchenden Parameter werden im Rechner mittels 10-gängiger Potentiometer eingestellt und nachgeregelt, wofür 40 Potentiometer vorgesehen sind, die gegen unbeabsichtigte Überlastung gesichert sind. Für sehr genaue Einstellung oder Abtastung stehen eine interne Bezugsquelle und ein Digitalvoltmeter zur Verfügung.

Die zwei Servomultiplikatoren-Typen ermöglichen Bearbeitung eines umfangreichen Problembereiches. Das Velodyne-getriebene Modell ist in Bezug auf die zu verarbeitenden Frequenzen begrenzt, hat aber den Vorteil, dass es mit dem richtigen Getriebe über mehrere Stunden integrieren kann. Als Potentiometerkarten werden 4 Zoll (101,6 mm) lange Streifenwicklungen benutzt, deren Konstruktion schnelles Auswechseln der Karten zur Nachbildung verschiedener Funktionen erlaubt. Die eisenfreie, motorgetriebene Servotype ist für Betrieb in Istzeit ideal, da die obere Grenze des nutzbaren Frequenzganges 10 Hz ist. Für beide Servotypen werden bestimmte Potentiometer mit Anzapfungen versehen, um mittels einstellbarer Widerstände mathematische Gesetze zu ergeben. Die gewünschte Funktion kann mit Hilfe des Digitalvoltmeters eingestellt werden.

Ausreichende Bereitstellung von elektronischen Multiplikatoren und Funktionsgebern ermöglicht auch Lösung von Problemen, in denen verhältnismässig hohe Frequenzen auftreten. Der Multiplikator hat Impulsbreitenmodulation und kann so eingesetzt werden, dass er bis zu vier Produkte abgibt. Der Funktionsgeber benutzt 10 mittels vorgespannter Dioden erzeugte Streckenabschnitte zur Approximierung jeder beliebigen einwertigen Funktion einer Eingangsvariablen. Für die 10 geradlinigen Streckenabschnitte können mit Hilfe des Digitalvoltmeters die erforderlichen Knickpunktwerte eingestellt werden, die die Funktion am besten wiedergeben.

Die verschiedenen Elemente werden mittels einadriger Steckerschnüre auf einem auswechselbaren Schalttafelfeld zusammengeschaltet.

EE 26 762 *für weitere Einzelheiten*

GOODMANS INDUSTRIES LTD

Axiom Works, Wembley, Middlesex

AUTOMATISCHER ABLENKOSZILLATOR

Der Ablenkoszillator E.502 wurde als genaue und bequeme Quelle sinusförmiger Schwingungen entwickelt, deren Frequenz sich nach einem vorgegebenen Gesetz ändert. Das Standardmodell folgt dem in Pflichtblättern für viele Fernwaffentests festgelegten Gesetz

$$(df/dt) = (1/70)\, f^{4/3}$$

Es ist jedoch möglich, im Sonderauftrag jedes beliebige Gesetz zu erfüllen, dessen Frequenzgeschwindigkeit an den äussersten Grenzen des jeweiligen Bandes das Verhältnis 100:1 nicht überschreitet.

Zwei Frequenzbereiche von 5...500 Hz und 30 Hz...3 kHz sind vorgesehen. Ein hochwertiger Wien-Brücken-Oszillator mit folgendem Kathodenverstärker findet Verwendung, wodurch sehr stabile Frequenzen und geringe Verzerrungen sowie konstante Amplituden erzielt werden. Mit gegebener Einstellung der Verstärkung sind Amplitudenschwankungen zwischen den beiden Bereichen oder von einem äussersten Ende jedes Bereiches zum anderen geringer als 1 dB und die Verzerrungen geringer als 2%. Automatisches Überstreichen wird durch einen Gleichstrommotor erzielt, dessen Steuerung durch ein Relais und magnetische Kupplung mit dem das Gesetz bestimmenden Potentiometer erfolgt. Einstellbare Grenzschalter bestimmen die Stellungen, in denen der Motor umgekehrt wird. Vorgesehene Einrichtungen ermöglichen Überstreichung bei Hand oder einen Ablenkablauf. Für jede Stellung innerhalb der vorgewählten Grenzen der Skala kann ein Mikroschalter eingestellt werden und die Umstellung von Messungen mit konstanter Beschleunigung zu konstanter Geschwindigkeit betätigen, wo sie in Zusammenhang mit einem g-gesteuerten Verstärker ausgeführt werden.

Zwei Ausgänge sind vorgesehen: über ein Dämpfungsglied mit Kathodenverstärker und bei hohem Pegel zur Synchronisierung eines Stroboskops.

Das Gerät wird entweder im Einzelgehäuse oder mit Frontplatte zum Einbau in Gestelle oder Pulte geliefert.

Die abgegebene Höchstspannung ist entweder 5 V in einen 20 kΩ Widerstand oder 0,5 V in 600 Ω.

EE 26 763 *für weitere Einzelheiten*

SIEBENKANAL-KATHODENVERSTÄRKER

(Abbildung Seite 654)

Der Siebenkanal-Kathodenverstärker Modell E.506 wurde entwickelt, um Bariumtitanat - Beschleunigungsmesser über verhältnismässig lange Kabel mit der Hauptmessstelle eines Schwingungstestsystems verbinden zu können.

Der Eingangswiderstand ist 100 MΩ und der Ausgangswiderstand 800 Ω in Serie mit einem 0,5 μF Kondensator. Der Frequenzgang von 5 Hz...20 kHz ist ±1 dB; mit einem doppelt abgeschirmten 9,5 m Kabel ist der Frequenzgang bei derselben Reproduzierbarkeit 5 Hz... 2 kHz. Zwischen Beschleunigungsmesser und Kathodenverstärkereingang können Kabellängen bis zu 9,15 m benutzt werden, ohne dass die effektive Empfindlichkeit des Beschleunigungsmessers unter die in normaler Praxis vorkommenden Werte absinkt. Das wird durch Verwendung doppelt abgeschirmter Kabel erreicht, deren innerer Leiter zwischen dem aktiven Element und dem Gitter der Eingangsröhre liegt, während die innere Abschirmung des Kabels an einem Ende an der Kathode der Eingangsröhre liegt, das andere Ende jedoch isoliert ist. Die äussere Abschirmung ist an einem Ende geerdet und am anderen an die Erdelektrode des Beschleunigungsmessers geschaltet. Dadurch wird die Kabelkapazität um einen Faktor von ungefähr 30 herabgesetzt.

Das Gerät wird entweder im Gehäse oder für Gestelleinbau geliefert.

EE 26 764 *für weitere Einzelheiten*

HONEYWELL CONTROLS LTD

Ruislip Road East, Greenford, Middlesex

DIREKTSCHREIBENDER OSZILLOGRAPH

(Abbildung Seite 655)

Nach Aufhebung der Einfuhrbeschränkung für Oszillographen aus USA hat Honeywell Controls für ihre amerikanischen Mitarbeiter den Vertrieb eines direktschreibenden 14-Kanal-Oszillographen unter dem Namen Visicorder übernommen.

Dieses Gerät wird bereits auf vielen Gebieten einschliesslich Wetter- und Erdbebenforschung, Verfolgung von Flugkörpern, Windströmungs- und Windkanalversuche eingesetzt.

Der Visicorder ähnelt bezüglich Lichtquelle, Spiegelgalvanometern, optischem System und Papiervorschub traditionellen Oszillographen. Es werden jedoch keine chemischen Mittel wie z.B. Tinte, elektrostatische Ladung, Lichtbogen, chemische Dämpfe oder Wärme für die Daueraufzeichnung benutzt.

Auf 15,25 cm breitem Registrierpapier können durch 12 Kanäle Frequenzen bis zu 5 kHz sowie zwei Bezugs- oder Zeitspuren aufgezeichnet werden. Helligkeitsregelung, Rastersysteme und Spurkennzeichnung sind vorgesehen. Das Gerät eignet sich für Fernsteuerung und ist mit einer selbstgehenden Registrierlampe ausgerüstet. Ein Netzgerät ist eingebaut.

EE 26 765 *für weitere Einzelheiten*

McMICHAEL RADIO LTD

Wexham Road, Slough, Buckinghamshire

RADAR-AUFZEICHNUNG

(Abbildung Seite 655)

Die Anlage ist ein Marine-Standardgerät, das zur Ausbildung von Radarpersonal benutzt wird. Wo eine Daueraufzeichnung benötigt wird, kann es auch der Radarinformationserfassung dienen.

Das Gerät REJ benutzt 35mm Film zur Aufzeichnung und Wiedergabe der Video-Signale von Radargeräten mit Sternschreibern und sich kontinuierlich drehender Antenne. Es kann in jedem eingestellten Bereich zwischen 10 und 160 Meilen (16...257 km) mit Anlagen bis zu 100 UPM Datengeschwindigkeit betrieben werden. Eine Nordanzeige kann auch aufgezeichnet werden.

Drei Aufzeichnungs- und Wiedergabegeschwindigkeiten sind vorgesehen, und der Hauptantrieb kann entweder Magslip- oder M-Ausstrahlung angepasst werden.

Ein Magnetband ist eingebaut, so dass mit dem Film synchronisierte Kommentare aufgenommen und wiedergegeben werden können.

Die Anlage kann auch mittels eines Fernsteuerungsgerätes bedient werden.

EE 26 766 *für weitere Einzelheiten*

BINÄRES ELEMENT

(Abbildung Seite 655)

Für dieses Spezial-Binärelement „dividiere durch 2" werden McMichael Kleinstschaltungen benutzt. Es wurde als vielseitiger Baustein für die Entwicklung kompakter Rechner im Flugzeug- und Weltraumforschungsprogramm konstruiert. Der Baustein besteht aus einer bistabilen Schaltung mit 2 Transistoren mit den erforderlichen Eingängen, Ausgängen und Rückkopplung zum Dekadenzählen. Er ist für Betrieb von 5...7 V ausgelegt, hat eine Stromaufnahme von 4 mA und arbeitet mit Taktfrequenzen bis zu 100 kHz von Impulsen, die mindestens 2 μs lang sind. Der Temperaturbereich ist von 0...60°C.

Der Kubikinhalt des Elementes ist 8,25 cm³; es wiegt 3,5 g und umfasst 2 Ge-Transistoren, 2 Ge-Dioden, 4 keramische Kondensatoren und 8 Widerstände. Die Bauelementdichte entspricht 8/cm³.

EE 26 767 *für weitere Einzelheiten*

MARCONI INSTRUMENTS LTD

St. Albans, Hertfordshire

UNIVERSAL-PRÄZISIONSMESSBRÜCKE

(Abbildung Seite 655)

Die TF 1313 ist eine neue Mehrzweck-Impedanzmessbrücke mit 0,25% Genauigkeit. Alle L, C und R Messungen werden auf einer Skala mit Grob- und Feineinstellung abgelesen; die Grobabstimmung erfolgt in 1%-Stufen, und die Feinabstimmung interpoliert 50 Teilstriche pro Stufe. Das Messgerät zeigt deutlich, in welcher Richtung der Abgleichpunkt liegt, selbst wenn die Brücke sehr unausgeglichen ist; dadurch wird das Messen völlig unbekannter Bauelemente beschleunigt und vereinfacht. Ein externer NF-Oszillator kann angeschlossen werden, wenn für L und C Messungen andere Frequenzen als die internen 1 und 10 kHz erforderlich sind. Der Detektor-Ausgang kann auch für Nullanzeige mittels eines externen Oszillographen oder Kopfhörers abgenommen werden.

Folgende Bereiche werden überstrichen: Induktivität 0,1 μH ... 110 H bei 1 und 10 kHz; Kapazität 0,1 pF ... 110 μF bei 1 und 10 kHz; Widerstand 0,01 Ω ... 110 MΩ bei Gleichstrom.

EE 26 768 *für weitere Einzelheiten*

TRANSPONDER-PRÜFGERÄT

(Abbildung Seite 655)

Prüfgerät Type 506 ist ein Differential-Impulsdämpfungsglied, das von Marconi Instruments gemeinsam mit dem Luftfahrtministerium als Teil ihres Zivil-Sekundär - Rundsicht - Radarprogramms entwickelt wurde. Zusammen mit dem Marconi UHf-Messender TF 1060 ist es zur Prüfung des Empfängerteils eines Transponders und besonders dessen Seitenlappenunterdrückung nach den von der I.C.A.O. festgelegten Normen geeignet.

Das Prüfgerät erzeugt eine aus zwei oder drei Impulsen bestehende Video-Impulsreihe mit einer stufenlos über den Bereich von 250 ... 2000 pro Sekunde variablen Folgefrequenz. Die Breite der einzelnen Impulse ist zwischen 0,5 und 2 μs einregelbar, und der Abstand kann durch einen Schalter auf das vorgegebene Zeitintervall für Zivilverfahren A, B, C und D oder kontinuierliche Regelung bis zu 30 μs eingestellt werden. Diese Impulsreihen modulieren den UHf-Messender, der auf die gewünschte HF-Frequenz eingestellt ist.

Das entstehende modulierte HF-Signal wird in das Prüfgerät zurückgespeist und geht durch das Differential-Dämpfungsglied. Hierdurch kann die relative Amplitude von einem Impuls in der Zwei-Impulsreihe und von einem oder zwei Impulsen in der Drei-Impulsreihe um plus oder minus 10 dB gegenüber der anderen verändert werden. Durch einen Funktionsschalter können entweder die Kontroll- oder Abtastimpulse wunschgemäss als variable Impulse eingestellt werden.

Das an der Ausgangsbuchse des Prüfgerätes erscheinende HF-Signal kann auf Wunsch dem eingebauten Kristalldetektor und nachfolgenden Video-Verstärker zwecks Überwachung zugeführt werden. Der Verstärkerausgang kann in einem geeigneten Oszillographen, z.B. dem Marconi TF 1330, beobachtet werden. Der mit "Synchronisierung Ausgang" bezeichneten Buchse kann ein Triggerimpuls für den Oszillographen entnommen werden, der 5 μs vor dem ersten HF-Impuls auftritt.

Durch die Konstruktion kann der Messender, wie im Bild gezeigt, über dem Prüfgerät aufgestellt werden.

EE 26 769 *für weitere Einzelheiten*

MARCONI'S WIRELESS TELEGRAPH CO. LTD

Chelmsford, Essex

KOMMERZIELLE UKW-ANLAGE

(Abbildung Seite 656)

Die Anlage besteht aus einem UKW-Sender Type 6400 und einem UKW-Empfänger 6401.

UKW-Sender

Der Sender hat im Frequenzbereich 118,0 . . . 135,95 MHz 360 quarzgesteuerte Kanäle mit 50 kHz Abstand zwischen den Kanälen und einer Leistung von 25 W. In einem kurzen 3/8 ATR Gehäuse eingebaut wiegt er nur 6,35 kg und stellt mit dem Empfänger 6401 eine kommerzielle UKW-Anlage kleiner Abmessungen dar, die nur 10,5 kg wiegt.

Die Anlage entspricht allen elektrischen Anforderungen der ARINC-Norm 520 A, hat jedoch eine Anzahl zusätzlicher Merkmale, unter denen als wichtigste Einbau einer automatischen Modulationssteuerung und 12 dB Sprachabkappung, um unter allen Umständen höchste Verständlichkeit zu gewährleisten, hervorzuheben ist.

Wo immer möglich, werden Transistoren verwendet; Modulator und Quarztreiberstufen sind volltransistorisiert. Verwendung der vor kurzem entwickelten Oberschwingungsquarze verringert die Anzahl der erforderlichen Stufen und gibt erhöhten Schutz gegen Nebenausstrahlungen. Der Sender kann mit elektromagnetischen Mikrofonen (einschliesslich geräuscharmen Typen) und Kohlemikrofonen betrieben werden, so dass er ohne Änderung mit britischen und amerikanischen Eigenverständigungsanlagen vereinbar ist.

Type 6400 ist für Ein- oder Zweikanal-Simplexbetrieb eingerichtet, und die Modulatorschaltung ist für künftige automatische Datenübertragungssysteme ausgelegt.

UKW-Empfänger

Der Empfänger 6401 ist für Einsatz mit Sender 6400 entwickelt und bildet ausserdem bei Verwendung mit anderen Geräten ein volltransistorisiertes UKW-Navigations- und Anflugleitsystem.

Empfänger 6401 überstreicht das Band 108,0 ... 139,95 MHz und sieht in diesem Band 650 Kanäle vor. Er ist volltransistorisiert und wiegt in einem kurzen ATR Gehäuse nur ungefähr 3,6 kg.

Es ist ein Mehrfach-Überlagerungsempfänger mit einer letzten Zwischenfrequenz von 500 kHz, die die Haupt-Selektionscharakteristik ergibt. Die Bauelemente in der Detektorschaltung sind für zufriedenstellenden Betrieb in "Höhepunkt"-Ausstrahlung bemessen, und die Sprache geht durch vom Geräuschabstand gesteuerte Schaltung zu den NF-Ausgangsstufen.

EE 26 770 *für weitere Einzelheiten*

PYE TELECOMMUNICATIONS LTD

Newmarket Road, Cambridge

RADIOGESTEUERTES FERNSEHEN

Dieses radiogesteuerte Fernsehsystem ist völlig beweglich und unabhängig von Kabeln.

Das System erlaubt dem Kontrollturmpersonal, Gelände zu beobachten, das sie sonst nicht sehen können, vor allem Bereitstellungsräume, Rollbahnen, Start- und Landebahnen, besonders in Betriebszeiten mit geringer Sichtbarkeit. Auf Test- und Versuchsflugplätzen kann die Ausführung von Start und Landung genau beobachtet werden.

Die Verwendung von Radio-Fernsteuerungsverbindungen gibt dem System eine ausserordentliche Anpassungsfähigkeit; für praktische Zwecke ist die Entfernung zwischen Bedienung und Kamera fast unbegrenzt.

Die Anlage wurde auf dem Pye Telecommunications Stand im Ausstellungsgebäude vorgeführt, von wo mittels eines kleinen Steuerknüppels eine entfernte Kamera auf einer beliebigen Stelle des Flugfeldes durch Radio bedient wurde. Das Steuersystem arbeitet über eine 450 MHz UHf-Verbindung, und die Bilder werden über eine Mikrowellenbrücke zurückgespeist. Die entfernte Kamera hat keinerlei Bedienungspersonal und arbeitet völlig automatisch, da alle Funktionen über die Radioverbindung gesteuert werden.

EE 26 771 *für weitere Einzelheiten*

W. H. SANDERS (ELECTRONICS) LTD

Gunnels Wood Road, Stevenage, Hertfordshire

MIKROWELLEN-EICHEMPFÄNGER

(*Abbildung Seite 656*)

Eine neue Ausführung des 45 MHz-Eichempfängers ist jetzt lieferbar. Die Verbesserung gegenüber dem bestehenden Modell umfasst:

Rauschfaktor	1,8 ... 2,5 dB
Zwischenfrequenz	45 MHz
Bandbreite	±2,5 MHz

Ein eingebautes Instrument mit Doppelmesswerk ermöglicht Überwachung der Ströme in den ersten und zweiten Detektorstufen; eine wahlweise Empfindlichkeitseinstellung gibt entweder 1 mA oder 100 μA Vollausschlag.

Das Trommelschalter-Dämpfungsglied hat einen Bereich von 0 ... 100 dB mit Grobregelung in 20 dB Stufen und 1 dB Feinregelungsstufen von 0 ... 20 dB. Der Mischkopf ist als getrennte Einheit ausgeführt, in der leichte Wartung und Bauelementaustausch besonders berücksichtigt wurden. Ein Messpunkt für Anodenspannung ist in diesem Baustein vorgesehen, und die gesamte Anlage ist in ein neues Gehäuse für Gestellmontage eingebaut.

Im Mischkopf kann jeder Quarzmischer aus dem Standardprogramm für Hohlleitergrössen 10 ... 22 eingesetzt werden.

EE 26 772 *für weitere Einzelheiten*

THE SOLARTRON ELECTRONIC GROUP LTD

45 Thames Street, Kingston-on-Thames, Surrey

DIGITALDATENDRUCKER

(*Abbildung Seite 656*)

Analogsignale positiver oder negativer Polarität können diesem Gerät von bis zu 50 Kanälen zur Umwandlung in Digitalsignale zugeführt werden, die einen eingebauten Drucker treiben. Die Abfrage erfolgt mit einer Geschwindigkeit von zwei Kanälen pro Sekunde mit einer Analog-Digital-Umsetzgenauigkeit von 0,1%. Die gedruckten Daten geben auf einem laufenden 76 mm breiten Papierstreifen das Kanalkennzeichen, den gemessenen Wert und die Polarität.

Das Gerät besteht aus folgenden Bausteinen: einem 50-Kanal-Kollektor, einem Analog-Digitalumsetzer mit Sichtanzeige und einem Drucker.

Der Kollektor verwendet abgedichtete Relais, die für lange Lebensdauer und Geräuscharmut mit vergoldeten Kontakten ausgerüstet sind. Er wirkt als zweipoliger Schalter mit 50 Stufen, der nacheinander die 50 Eingänge an den Umsetzer legt.

Durch einen Schalter im Kollektorgerät kann jede der drei Arbeitsmethoden eingestellt werden: fortlaufendes automatisches Abfragen, Einzelabfrage auf externen Befehl oder Handbedienung. Das Kollektorgerät ist fest mit dem Analog-Digitalumsetzer verschaltet, dessen Ausgang in geeigneter Dezimalverschlüsselung den Drucker direkt steuert.

EE 26 773 *für weitere Einzelheiten*

DRUCKGEBER

(*Abbildung Seite 657*)

Der NT 4-314 ist ein Universaldruckgeber, der zur Messung mittlerer und hoher Drücke eingesetzt wird. Als Abtastelement wird ein nicht verbundener Miniaturmessstreifen benutzt, und Betriebssicherheit sowie Reproduzierbarkeit der Ergebnisse sind selbst bei ausserordentlichen Schwingungs- und Temperaturzuständen gewährleistet. Die bündige Membran des Gebers ermöglicht Einbau in die Wand eines Druckbehälters ohne Änderung des Rauminhalts oder Einführung von Wirbeln in den Durchfluss des Druckmittels.

Hermetisch abgedichtete Ausführungen des NT 4-313 sind für Messungen in korrodierender Atmosphäre geeignet. Durch die saubere Konstruktion und den dem verwendeten rostfreien Stahl eigenen Korrosionswiderstand kann der Druckgeber selbst in Berührung mit kochender roter oder weisser Salpetersäure, 100%-igem Wasserstoffsuperoxyd oder Uranhexafluorid zufriedenstellend arbeiten.

Die Geber sind für Druckbereiche zwischen 7...352 kg/cm² lieferbar.

Type NT 4-317 ist eine Sonderausführung dieses Gebers, die dauernd in Temperaturen bis zu 315°C und mit Kühlzusatz bis zu 1100°C arbeiten kann.

EE 26 774 *für weitere Einzelheiten*

SOUTHERN INSTRUMENTS LTD

Frimley Road, Camberley, Surrey

UNIVERSALPRÜFER MIT "SPEICHER"

(*Abbildung Seite 657*)

Durch Benutzung einer „Dreipol"-Schaltung können mit dem E.R.I.C. Elektronischen Universalprüfer mit Speicher Messungen über einen umfangreichen Bereich ausgeführt werden. Der Dreipol besteht aus einem ausgeglichenen Gleichspannungsverstärker mit drei Klemmen, deren Charakteristik zwischen jedem beliebigen Klemmenpaar von allen anderen Paaren weitgehend verschieden ist. Das mit 1 und 2 bezeichnete Klemmenpaar hat praktisch unendlichen Eingangswiderstand. Das zweite Paar 1, 3 hat einen sehr niedrigen Eingangswiderstand, während das Paar 2, 3 einen sehr niedrigen Ausgangswiderstand zeigt.

Die letzte Eigenschaft wird zum Treiben eines Messgerätes niedriger Impedanz benötigt, wofür die Klemmen 2 und 3 Verwendung finden.

Der hohe Eingangswiderstand zwischen den Klemmen 1 und 2 gibt dem E.R.I.C. viele seiner interessantesten Eigenschaften. Der Widerstand ist so hoch, dass ein geladener Kondensator mit hoher Isolation an die Klemmen gelegt werden kann, ohne über eine Zeitspanne von mehreren Stunden einen nennenswerten Ladungsverlust zu erleiden. Die „Speicher"-Eigenschaft des Gerätes wird durch Einbau eines Kondensators auf diese Weise erzielt. Da die Spannungsverstärkung zwischen diesen Klemmen und den Ausgangsklemmen eins ist, zeigt das Instrument die Eingangsspannung so lange an wie der Kondensator seine Ladung hält, die jederzeit durch einen Druckknopf gelöscht werden kann.

Mit dem E.R.I.C. können auch Widerstandsmessungen über einen grossen Bereich bis zu mehreren hundert Megohm vorgenommen werden.

EE 26 775 *für weitere Einzelheiten*

STANDARD TELEPHONES AND CABLES LTD

Connaught House, Aldwych, London, W.C.2

AUTOMATISCHES TRIANGULATIONS-PEILGERÄT

Dieses neue Triangulations-Sichtgerät gibt zusammen mit einem Netz automatischer Weitausschnitt - Bodenpeil - stationen einfache und genaue Flugzeugortung für den FS-Kontrolldienst. Die Hauptaufgabe ist Kennung und Ortung von Flugzeugen, die in den kontrollierten Luftraum einfliegen oder ihn überfliegen. Für diesen Zweck werden nur die im normalen Verkehr mit dem FS-Kontrolldienst vom Flugzeug abgestrahlten Signale benutzt. Das ursprünglich für das STC Weitauschnitt-CADF-System bestimmte Sichtgerät kann schnell jedem anderen Peilgerät angepasst werden.

Das Sichtgerät des neuen PVT-2-Systems benutzt Kurzschluss-Fernsehen und stellt eine weitere Entwicklungsstufe des eingeführten PVT-1-Triangulationssystems dar. Letzteres ist ein Bodenortungsgerät, das in England und anderen europäischen Ländern seit einigen Jahren in Gebrauch ist.

Das in Farnborough ausgestellte Gerät konnte entweder mit „künstlichen" Signalen von einem Simulator oder direkten Signalen von zwei auf die Frequenzen des Zivilluftfahrt-Kontrolldienstes abgestimmten Peilgeräten gespeist werden. Eins der direkten Signale kam von der Zivilortungsanlage in Bovingdon, das andere von einer Zivilortungsanlage, die von Airtech Ltd ausgestellt wurde.

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ULTRA ELECTRONICS LTD

Western Avenue, Acton, London, W.3

VERKEHRS-STEUERSYSTEM

Diese Anlage trägt mit ihrem Drucktasten - Auswahlsystem wesentlich zur fortschreitenden Verkleinerung dieser Gerätetypen bei.

In ihrer Grundform enthält die Sprechstelle Modell UA 6010 15 Drucktasten zur Wahl von Nachrichtenverkehr (Sender und Empfänger), Eigenverständigung und Kabinenrundspruch. Trotzdem ist die Frontplatte nur 14,7 × 7,6 cm gross und das Gerät wiegt 1,4 kg.

Das UA 60-System ist dezentralisiert mit Verstärkern in jeder Sprechstelle; mit einem zusätzlichen zentralen Verteilerkasten bildet es ein umfangreiches Steuersystem für den Nachrichtenverkehr.

Das Fertigungsprogramm umfasst alle notwendigen Zusatzgeräte wie Verteilerkasten, Verstärker für Bodenpersonal, Anschlusskästen für Bodenpersonal und Sprechstelle für den Steward.

Ausser kleinen Abmessungen und geringem Gewicht infolge Anwendung moderner Transistortechnik und gedruckter Schaltungen ist Einbau von Druckknopf-Auswahl für 15, 25 oder 35 Dienste mit eingebauten Lautstärkereglern in den Tasten für alle Empfängerkanäle und mit Kantenbeleuchtung eine Hauptcharakteristik des UA 60.

Das System ist entsprechend den amerikanischen Installationsvorschriften konstruiert und in gleichem Masse für englische und amerikanische Anlagen geeignet. Auf Wunsch kann das System für Sonderanforderungen abgewandelt werden.

EE 26 777 *für weitere Einzelheiten*

VACTRIC (Control Equipment) LTD

Vactric House, Sloane Square, London S.W.1

SERVO-BAUSTEINE

(Abbildung Seite 657)

Im Rahmen des Fertigungsprogramms von Präzisions-Servo-Bausteinen in internationalen Gestellgrössen wurden drei neue Geräte gezeigt. Es handelt sich um einen Wechselstrommotor-Tachogenerator Grösse 15, einen Spaltfeld-Gleichstrommotor Grösse 15 und einen Wechselstrommotor Grösse 08.

Der Wechselstrommotor-Tachogenerator Grösse 15 hat einen zweiphasigen 400 Hz Motor und eine Tachogeneratorleistung von 3,0 V/1000 UPM mit einer Geradlinigkeit von $\pm 0{,}5\%$.

Das Abfallmoment des Spaltfeldmotors ist bei Höchsterregung 160 cmg. Der höchste externe Serienwiderstand ist 18 Ω und der Läuferhöchststrom 1 A. Die Läuferträgheit ist 13 cm^2, der Erregerstrom 40—0—40 mA und der Feldwiderstand 800 Ω pro Wicklung.

Der Wechselstrommotor Grösse 08 ist ein zweiphasiger 400 Hz Baustein mit einem Minimumabfallmoment von 219 cmg und einer Leerlaufgeschwindigkeit von 6200 UPM. Der Motor wiegt 48 g.

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Zusammenfassung der wichtigsten Beiträge

Ein Sonderzweck Analog-Digital-Wandler von G. C. Henderson

Zusammenfassung des Beitrages auf Seite 602-608

Der hier beschriebene Analog-Digital-Wandler wurde für ein Datenverarbeitungssystem zur Analyse von Zeitmultiplex-Fernmessungsaufzeichnungen entwickelt. Mit nichtlinearen Spannungsanalogen des zu messenden Parameters, einer Anzahl von Eichspannungen und einer Reihe von Stroboskop-Impulsen am Eingang bildet der Wandler eine binäre und eine analoge Abgabe, die beide in gewünschten Einheiten in linearer Beziehung zum Parameterwert stehen. Automatische Korrektur der Gesamtverstärkung des Systems und der Pegeldrift ist vorgesehen.

Statisches Schalten von G. H. Ohlsen

Zusammenfassung des Beitrages auf Seite 609-613

Zweck und Vorteile der ruhenden Schaltung und ihre Ableitung aus der Digitalrechnertechnik werden besprochen. Vorliegende Methoden werden verglichen und ein vollständiges System mit NOCH-Einheiten als Logikelementen mit Behandlung und Lösung einfacher Probleme beschrieben.

Der Differentialanalysator und seine Verwirklichung in Digitalform von P. L. Owen, M. F. Partridge und T. R. H. Sizer

Zusammenfassung des Beitrages auf Seite 614-617

Dieser Beitrag beschreibt den Differentialanalysator sowohl in seiner ursprünglichen mechanischen Form als auch einer späteren Digitalentwicklung. Rechenmaschinen dieser Gruppe verarbeiten im allgemeinen Information, die sich kontinuierlich ändert, wie sie z.B. in der Lösung von Differentialgleichungen auftritt.

Vor kurzem wurde im Zusammenhang mit Anwendung der Digitaltechnik Interesse für diese Differentialanalysatoren erregt, das zur Entwicklung des Digital-Differentialanalysators (abgekürzt DDA) führte. Dieser Rechner hat grosse betriebsmässige Anpassungsfähigkeit und die dem Digitalsystem eigene Genauigkeit.

Ein automatischer Türöffner mit Verschlüsselung von J. D. Storer

Zusammenfassung des Beitrages auf Seite 617-619

Ein einfaches Geheimschloss wird beschrieben, das mittels Druckknöpfen betätigt wird, die mit den Buchstaben des Alphabets gekennzeichnet sind: Vier Buchstaben müssen in der richtigen Reihenfolge bedient werden. Die Schaltung besteht aus Drehwählern und Relais.

Eine Kaskoden-Triggerschaltung mit einem pnp und einem npn Transistor von P. Arnoldt

Zusammenfassung des Beitrages auf Seite 620-623

Verwendung eines pnp und eines npn Transistors in Kaskodenanordnung in einer monostabilen Triggerschaltung wird beschrieben. Durch Vorschaltung eines Dioden-Integrators wird eine Frequenzteilerstufe gebildet. Die besten Bedingungen für betriebssicheres Arbeiten werden abgeleitet. Praktische Werte werden für eine Stufe angegeben, in der 100 kHz Eingangsimpulse zuverlässig über einen Temperaturbereich von 5 . . . 50°C durch 10 geteilt werden. Die Ausgangsimpulse der Stufe sind zum Treiben eines Folgestufeneingangs geeignet.

Die Triggerschaltung kann auch zur Erzeugung von Kippschwingungen oder als Zeitmodulator Verwendung finden.

Verwendung von Siliziumwiderständen in der Gleichstromstabilisierung von Transistor-Schaltungen von D. H. Mehrtens und J. T. Zakrzewski

Zusammenfassung des Beitrages auf Seite 624-629

Eine neue Methode zur Stabilisierung des Gleichstrom-Arbeitspunktes von Transistoren unter Verwendung von Siliziumwiderständen wird vorgeschlagen und ihre Anwendung sowohl für Kleinsignal- als auch Leistungstransistoren besprochen. Es wird Beweis geführt, dass es mit dieser Methode in den weitaus meisten Fällen möglich ist, über den ganzen Betriebstemperaturbereich einen konstanten Kollektorstrom zu erzielen.

ISABEL: Dezimalzähler mit binären Stufen von J. A. Goss

Zusammenfassung des Beitrages auf Seite 630-634

Beschreibung einer verbesserten logischen Anordnung eines Dezimalzählers, die sich auf bistabile Elemente stützt. Vorteile gegenüber üblichen Methoden werden diskutiert und die Arbeitsweise verschiedener Schaltungen angegeben, die diese Methode benutzen.

Ein verbessertes automatisches Messverfahren für ionosphärische Absorption von L. Thomas

Zusammenfassung des Beitrages auf Seite 635-639

Während des internationalen geophysikalischen Jahres wurde im University College in Swansea die ionosphärische Absorption automatisch gemessen. Die beschriebene Anlage ist ein Fortschritt gegenüber früheren Modellen, die die Mittelamplitude des Echos über einen Zeitraum von ungefähr einer Minute aufzeichneten. Das ganze System ist auf Triggerspannungen mit einem Impuls pro Sekunde synchronisiert, wodurch die Störgeräuschsignale besser ausgeglichen und Störung anderer Dienste auf ein Minimum reduziert werden. Die allgemeine Arbeitsweise der Anlage wird besprochen und ein Vergleich zwischen automatischen Messungen und dem manuellen Standardverfahren angestellt.