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Commentary

SIR Edward Victor Appleton died on 22 April, at the age of 72, and it is with deep regret that we record his death. Sir Edward was, of course, one of the great pioneers of radio, and particularly propagation, but, unlike many of the great researchers, he was able, during his own lifetime, to see many practical applications and fruits of his work.

Appleton, who was born in 1892, was educated at Hanson School, Bradford, and at St. John's College, Cambridge, where he gained First Class in the Natural Science Tripos and was awarded the Hutchinson Research Studentship.

In August 1914 Appleton joined the West Yorkshire Regiment as a private and by the end of the war he was a captain in the Royal Engineers (Signals) the forerunner of the Royal Corps of Signals. In the course of his work he became interested in the fading of wireless signals and was puzzled as to its explanation: this gave him the desire to find out more about the way in which radio waves travel. At the end of the war he went to Cambridge University to teach physics under Sir J. J. Thomson and was thus enabled to maintain his interest in radio waves. In 1924 Appleton was appointed Wheatstone Professor of Experimental Physics, King's College, London. He retained this appointment until 1936 and it was during this period that he carried out some of his most important investigations on the ionosphere.

At this time the mechanism of long distance radio propagation was not really understood. Two scientists, Heaviside, in Great Britain, and Kenelly, in the United States, had independently suggested that there might be a reflecting layer in the upper atmosphere which thus prevented the waves from being lost in outer space and which returned them to the Earth. This theory had vigorous opponents, including some in Germany who flatly denied the existence of a reflecting layer.

In 1924 Appleton thought out a method by which the existence of the layer could be proved and, if it did exist, of measuring its height above the Earth. In order to carry out this work Appleton successfully applied to the Department of Scientific and Industrial Research for financial aid.

This important experiment took place in December 1924. The BBC lent its transmitter at Bournemouth for the occasion and a receiving station was set up at Oxford, the distance between the two places being suitable for the experiment as fading at Oxford on the Bournemouth wavelength was very marked. The principle of the experiment was that if signals of a definite wavelength were transmitted, two signals should be picked up by the receiver. One signal should travel along the ground and the other should be reflected back to Earth from the supposed layer in the atmosphere. If the two signals arrived in phase they would add together and give a strong signal. If, however, by slightly changing the wavelength, the two signals arrived out of phase they would tend to cancel and give a weak signal. If the two stations were fixed and the wavelength was varied continuously, the signals should wax and wane in strength and artificial fading would have been achieved. By counting the number of fades caused by a given change of wavelength it would be possible to calculate the distance by which the reflected path exceeded the ground path and by simple geometry the height of the reflecting layer could be calculated.

In the experiment everything worked according to plan and by 12.15 a.m. on 11 December 1924, Appleton had not only proved that a reflecting layer did exist but that its height above the Earth was 60 miles. The existence of the Heaviside, or E, layer had been established and, equally important, the work which was to lead to the development of radar had begun.

Appleton later proved that shorter wavelengths (10m to 50m) penetrated the Heaviside layer and yet were reflected back to Earth from higher up. This was the discovery of the 'F', or as as it is more popularly known, the Appleton layer, some 120 miles above the Earth.

In 1932-33 Appleton took a Radio Research Board expedition to Tromso in Northern Norway, to study the effect of the Aurora Borealis on radio. It was found that every time there was an Aurora, radio reflection from the ionosphere was cut down. This led to the discovery of the effect of sunspot activity on radio propagation; he subsequently showed that the reflecting power of the ionosphere varies in unison with sunspot activity which follows an 11 year cycle. An important result of this work has been the system of ionospheric forecasting and the prediction of optimum frequencies for transmission over any given radio circuit.

In 1936 Appleton returned to Cambridge as Jacksonian Professor of Natural Philosophy and in 1939 he became Secretary of the Department of Scientific and Industrial Research. He later became Principal and Vice-Chancellor of Edinburgh University.

Sir Edward Appleton received many honours including the Nobel Prize for Physics in 1947. He was a tireless and brilliant research worker and there is no doubt his name will remain for many, many years in the forefront of the pioneers of radio.

A Light Operated Gradient Controller for AGRICULTURAL DRAIN LAYING MACHINES

By G. O. Harries* and D. J. Perkins*

For field drains to function properly they must be laid with the minimum possible deviation from the intended gradient. In this article an automatic means of achieving this is described. The control system employs two beams of light interrupted at different frequencies and a photo-electric detector. The electronic circuits employed are described in detail.

(Voir page 422 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 429)

THE controller described was built primarily to enable the mechanical laying of agricultural field drains of the plastic pipe variety to be carried out at a speed and accuracy beyond that attainable with a human operator.

When the work was started no experimental or commercial apparatus of this nature was available but it later transpired that two commercial firms were independently working on this type of problem[1].

There are also in the literature descriptions of gradient controllers using a pendulum[2] and stretched wires for references and one description of a system using a narrow beam of light[3] but this method was apparently accurate only for short distances.

For field drains to function properly they must be laid with least deviation from the intended gradient. In practice, with a 3in diameter pipe this means to within ± 1in.

The present controller was developed originally for use on the N.I.A.E. plastic drain laying machine[4]. In this machine the main frame consists of two parts hinged together. The tine which cuts the channel and through which the pipe is fed is suspended from the pivot point of the two halves and is maintained at a constant angle to the vertical by parallel linkages.

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The angle between the front and rear parts of the frame can be varied and the depth of the tine is adjusted by alteration of this angle.

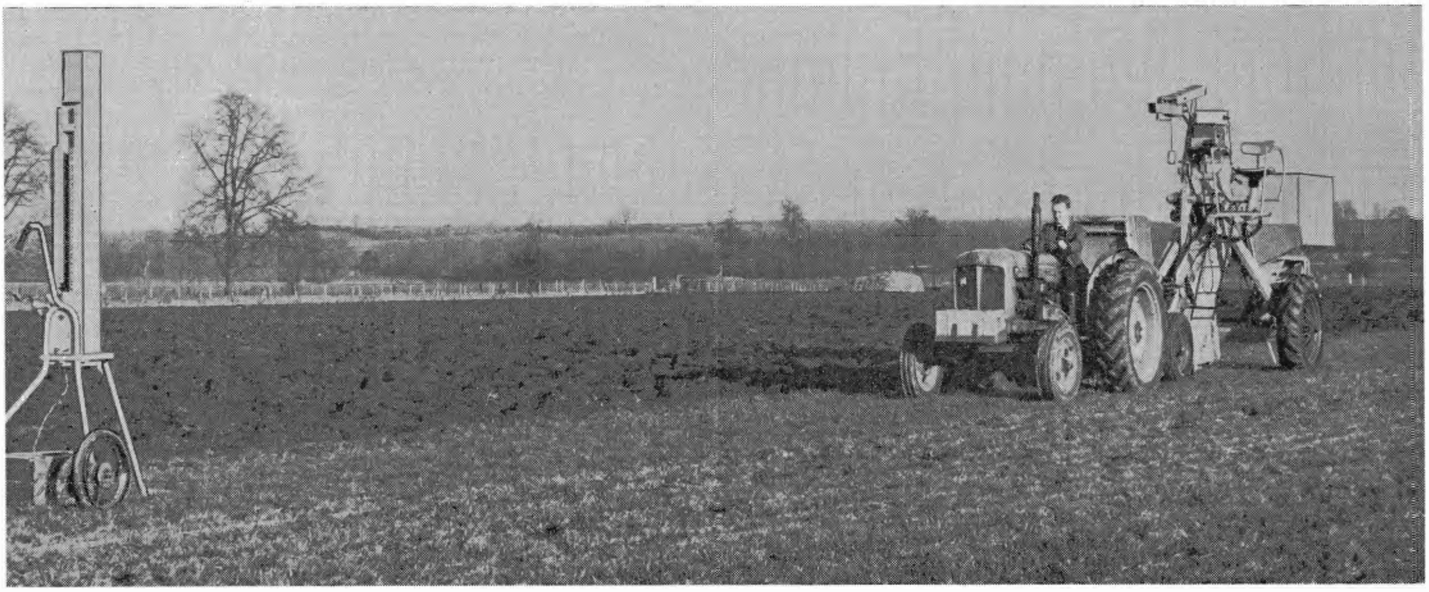
This alteration is achieved by means of a double acting hydraulic ram controlled by a two way solenoid valve, the appropriate operation of which is the function of the controller.

With the simple 'on-off' control provided by the circuit and a changeover solenoid valve adequate tolerance is achieved but with a suitable proportional valve, proportional control could be incorporated if higher accuracy was desired.

The controller uses as a gradient reference an optical system owing much in its derivation to the aircraft landing aid in which a colour difference is established between the upper and lower halves of a slightly divergent beam of light. In a particular case, there is a white upper band and a red lower band with an intermediate pink zone where there is a gradual transition from white to red.

An approaching pilot on the correct glide angle will see the pink colour of the intermediate zone between the bottom and top halves. If he is too high he will see a white light, and if too low a red light and the gradual transition from white to red gives him a proportional estimate of error. The simple optical design of this system

The gradient controller in use for drain laying



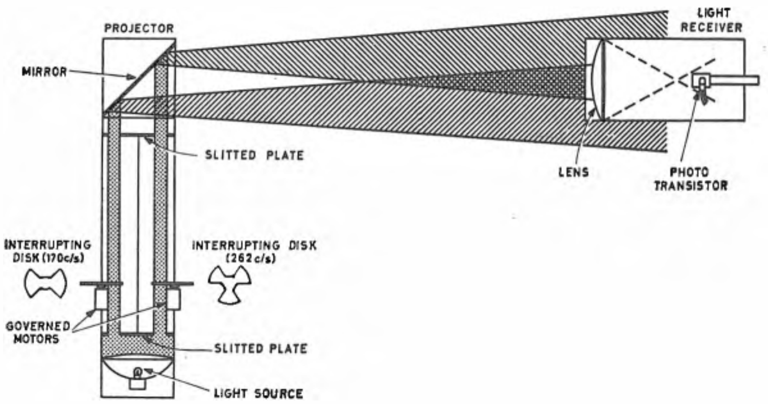


Fig. 1. Optical system used on depth controller

was adopted but different frequencies of interruption of the two halves are used to distinguish between them and a phototransistor is used as a light receiver. Thus vertical displacement from the set gradient can be detected by comparison of the intensities of the two frequencies.

The design and construction of the projector (Fig. 1) has been described elsewhere[5] and it is sufficient to say that it utilizes a 48W 12V car lamp of 50 000 candelas, and the two halves of the beam are interrupted mechanically by sectored disks driven by 24V governed motors, giving interruption frequencies of 170c/s and 260c/s respectively for the upper and lower beam. The divergence of the beams is small—the points of maximum intensity of the beams are only 1ft apart at 150ft from the projector compared with an initial separation of a few inches.

The controller and photoelectric detector are carried on the tine-carrying portion of the machine. The detector is mounted in a pendulum stabilized assembly which keeps the angle of inclination of the collimator tube constant despite variations of the attitude of the machine due to surface irregularities of the land (Fig. 2).

The light falling on the photocell has components at the two interruption frequencies and when the detector is positioned correctly on the centre line of the pair of beams these components will have equal intensity and give rise to equal amplitude components in the output voltage. A vertical displacement of the receiver from the centre line results in an increase in one component and a corresponding decrease in the other and the beam profile is such that substantially linear variation of intensity with angular error is obtained.

The photocell stage is followed by a pre-amplifier which brings the level of the weakest signal up to that required to drive the next stage—an amplifier using thermistors to give amplitude dependant negative feedback which gives constant amplitude output (see Fig. 3).

The intensity of the light falling on the photocell is inversely proportional to the square of its distance from the projector and as the original specification called for operation over an operating range of 50 to 350ft from the projector a 49 : 1 change of light intensity and consequently of signal amplitude was to be expected.

The circuit developed for this purpose does in fact give an output constant to within 1 per cent over an amplitude range of 10 : 1 and the output is constant to better than $\pm$1dB over a further reduction of 15dB in the input level. It should be noted that the stabilized signal is one which is the sum of the two components which still maintain the amplitude relativity they have at the collector of VT_2.

The output of the constant amplitude stage is taken to the inputs of the two frequency selective amplifiers where the two components at frequencies f_1 and f_2 are separately amplified and rectified to give d.c. voltages V_1 and V_2 proportional to the received intensities from beams A and B respectively. The error signal $V_1 - V_2$ is modulated at 1 000c/s in the modulator block to give an alternating voltage $v_s \propto (V_1 - V_2)$, with phase $\angle 0°$ or $\angle 180°$ depending on the sign of $V_1 - V_2$ and amplified as such by VT_{16} and VT_{17}.

Due to the action of the variable gain stage there is, at the collector of VT_{17}, a signal proportional only to the angular error.

Thus:

$$v_1 = kI\,(1 + x)$$

$$v_2 = kI\,(1 - x)$$

Where v_1 and v_2 are the components at VT_1 collector at f_1 and f_2 respectively, I is the intensity at distance d from the projector and x is the proportional change in intensity due to an angular error θ.

In the absence of the variable gain stage, and if A_1 and A_2 the gains of the selective amplifier are equal $= A$

$$V_1 = Av_1$$

$$V_2 = Av_2$$

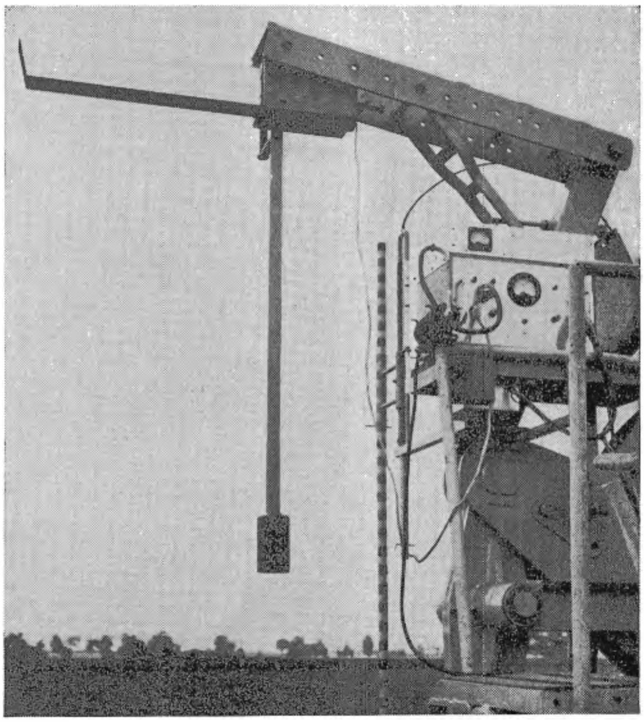
$$V_1 - V_2 = A\,(v_1 - v_2) = k\,.\,I\,.\,2\,x$$

i.e. the error signal v_s is proportional to $I\,.\,x$.

But variation due to I is eliminated by the variable gain stage and therefore $(V_1 - V_2) \propto x$ which is proportional to the angular error θ.

VT_{20} and VT_{21} and the two relays A and B constitute a phase sensitive bi-directional switch with a 'centre off' condition. The collectors are supplied with uni-directional voltage pulses derived from the same sources as the

Fig. 2. Controller and photo-electric detector mounted on the drain-laying machine



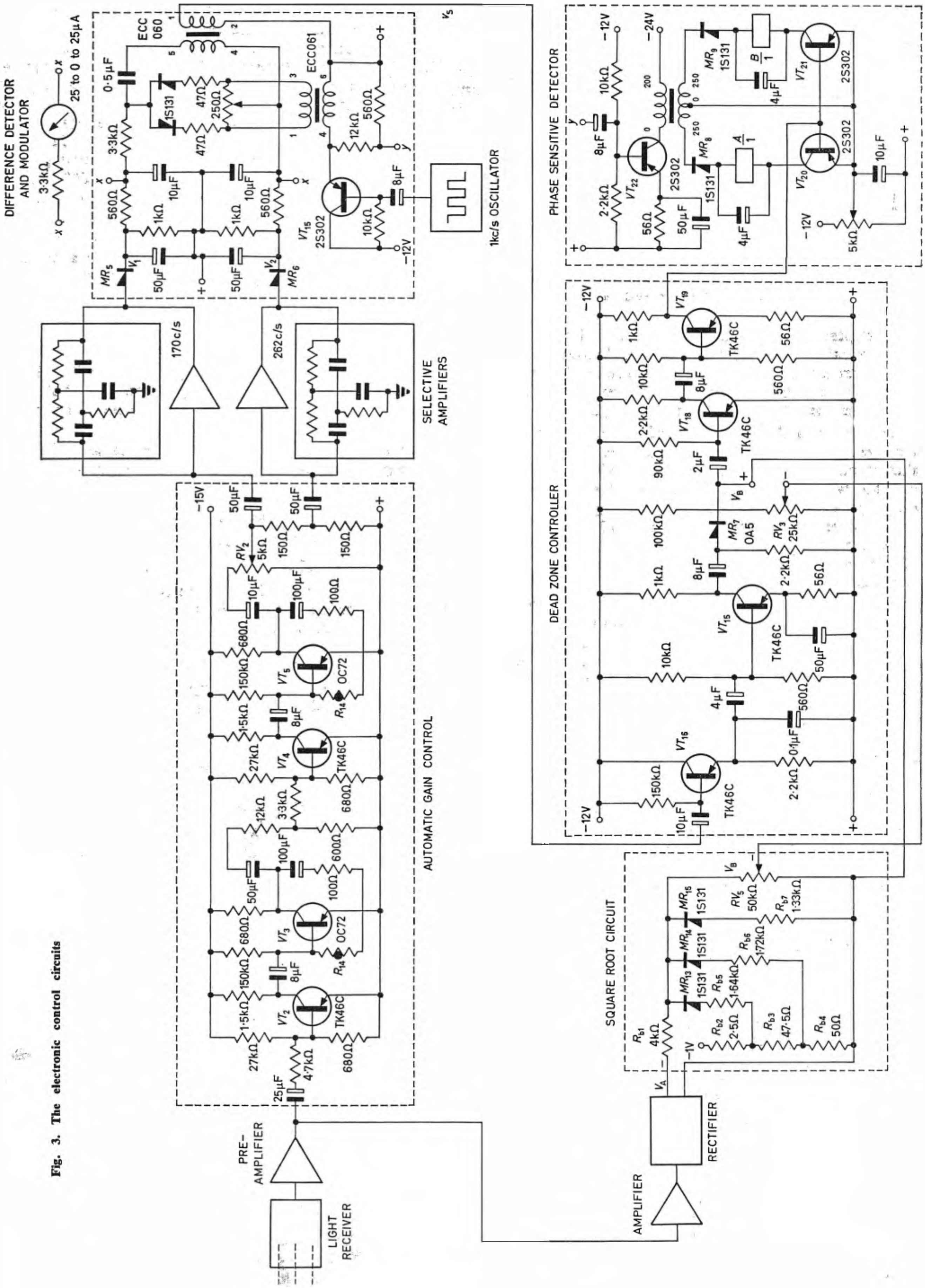


Fig. 3. The electronic control circuits

modulator voltage and conduction in VT_{20} or VT_{21} occurs only when a voltage of the same phase as the collector voltage is applied to the base of the transistor. The error signal at the collector of VT_{17} has to exceed the bias applied to MR_7 in order to proceed to the phase sensitive detector stage. In the case where V_B is derived solely from RV_3 the bias has the effect of introducing a fixed 'dead zone' into the operation.

That is, for a given setting of RV_3 a fixed value of $(V_1 - V_2)$ and hence of angular error is required to initiate correction.

Constant angular error, however, means increasing translational error as the range increases and to overcome this drawback the circuit of VT_{22} and VT_{23} and $MR_{13\text{-}15}$ has been incorporated. The sum voltage proportional to $1/d^2$ at the collector of VT_1 is amplified and rectified and applied to the circuit including $MR_{13\text{-}15}$ and the resistors $R_{b1\text{-}6}$. Due to the biased-diode circuit the voltage across RV_5 is approximately proportional to the square root of the voltage V_A and hence inversely proportional to the distance, i.e. $V_B \propto \sqrt{V_A}$ and $V_A \propto I \propto 1/d^2$.

$\therefore\ V_B \propto \sqrt{I} \propto 1/d$.

This voltage is added to that derived from RV_3 so as to enable, as d increases, progressively smaller error signals at VT_{17} collector to be passed on to the final stage.

There is therefore a dead zone which in terms of angular error is decreasing linearly as the distance increases. The two factors combine to give a dead zone of fixed vertical displacement regardless of distance.

Performance graphs of the measured gradient achieved in field tests are shown in Fig. 4. Fig. 4(c) shows the performance with fixed angular dead zone. Figs. 4(a) and 4(b) show the performance after the inclusion of the square root circuit.

An aspect of the performance not shown in Fig. 4(c) is that as the machine approached the projector the control became increasingly unstable as the displacement dead zone decreased and the limits of initiation of correction became very small. This instability did not occur after the inclusion of the square root distance compensation circuit.

The 25-0-25μA meter inserted at points x/x gives a visual indication of the error signal and is used in the initial setting up of the projector and receiver.

Its indication can also be used if complete automatic operation is not required. A changeover switch then over-rides relays A and B and the relief relays. The solenoid valve is then energized appropriately by a manually operated switch according to the meter indication.

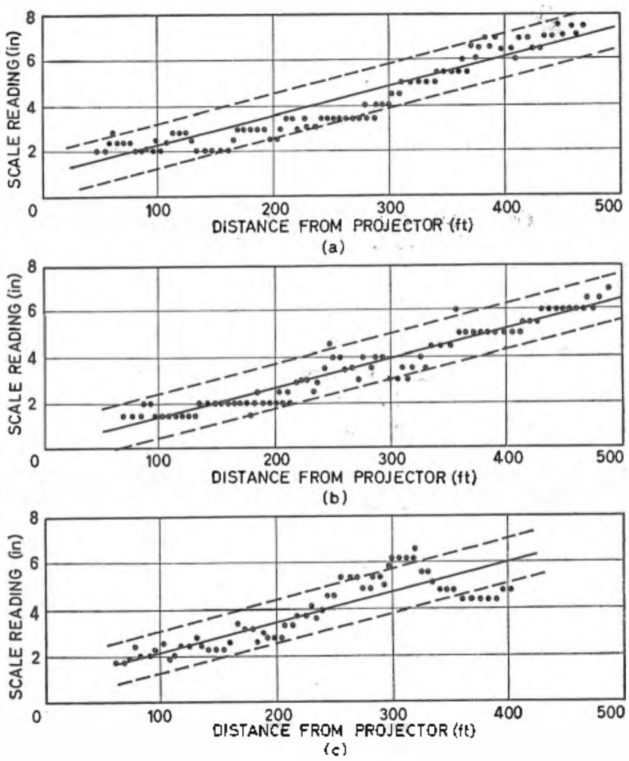


Fig. 4. Performance graphs

Conclusions

Field tests have shown that gradient control within the limits of accuracy required can be achieved with a drain laying machine by the system described.

Greater accuracy could no doubt be achieved with the same basic system if proportional control was introduced but it is doubtful whether in this particular application the increased cost would be justified.

Acknowledgments

The authors wish to thank the Director of the N.I.A.E. for permission to publish this article.

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An Integrating Solarimeter for Horticulture

An electronic device which accurately measures the amount of sunlight falling on any crop, and therefore enables the amount of water it requires to be accurately calculated, is now being developed.

Known as a special purpose integrating solarimeter, it not only indicates when a crop needs watering but also shows exactly how much it needs. This information could maintain optimum growing conditions wherever the device is used, while in arid parts of the world the more efficient use of available water which the device would make possible, would be especially valuable.

Recently the integrating solarimeter, a development of British Telecommunications Research Limited, Taplow, has been tested by several horticultural establishments in the U.K. These tests have been designed primarily to show how the equipment behaves under practical operating conditions.

Work carried out by the National Institute of Agricultural Engineering and similar establishments has shown that sunlight is the predominant factor affecting the water requirements of plants, other elements such as wind and humidity being relegated to a comparatively minor role by the plants' built-in control mechanism.

The integrating solarimeter consists of a panel of series-connected silicon photovoltaic diodes which convert light energy into electrical energy. Their output is used to produce a voltage proportional to the light input and also to produce the necessary power for operating a transistor circuit and electromagnetic counter.

The voltage, which is proportional to the power received by the convertor-diodes, is applied to a resistor-capacitor integrating circuit. The capacitor is also included in a monostable toggle circuit in such a way that the voltage developed across it triggers the toggle which, when operating, discharges the capacitor.

The amount of energy received by the solar convertors may therefore be determined by counting the number of times the toggle has operated and discharged the capacitors. This function is carried out by an electromagnetic counter. Calibration in the experimental model has been in the usual meteorological unit employed for this purpose, the milliwatt-hour per square centimetre.

A Small Transistorized Digital Computer
Arithmetic and Control Sections

By A. D. Booth*, D.Sc., Ph.D., and K. Cameron*, M.Sc.

The logic and circuits for the control and arithmetic sections of a new small sized all-purpose digital computer are described. The machine uses magnetic drum storage for 8192 words each having 32 bits and operates at a digit frequency of 150kc/s.

(Voir page 422 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 429)

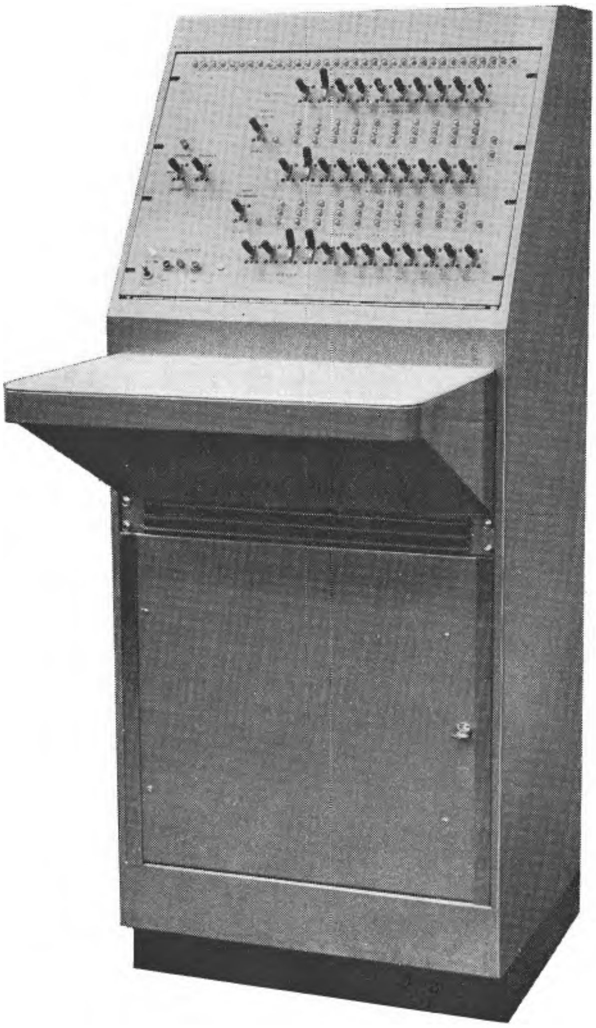
DURING the past 15 years the senior author has been responsible for the design and construction of a sequence of automatic computers. The earliest of these, A.R.C.[1,2] completed in 1948-49, used electromagnetic relays for logical and arithmetical operations and had as its storage organ the first magnetic drum to be constructed.

The sequence of machines culminated in the M.2, produced at Birkbeck College, University of London, in 1956[3]. Six machines of this type were constructed. They used a Wharf Engineering Laboratories magnetic storage drum Mk. 3 which provided storage for 8 192 words of 32 bit length on 128 tracks each holding 64 words.

For digital storage and for amplification and inversion the M.2 computers used thermionic valve circuits, based mainly on the 6J6 double triode. For decoding, and shift gating, semiconductor diodes of types CG10E and S.T.C. M.1 were adopted, mainly for reasons of cost.

Because of the characteristics of the diodes, and particularly those of the M.1 selenium disk rectifiers whose sole *raison-d'être* was their low cost (c.a. 1d each), the digit rate of the M.2, which operated in the serial mode, was restricted to 75kc/s. Again for reasons of cost, M.2 machines had only three shift registers, the logical minimum. These were: control register, accumulator register, and multiplier register.

Multiplication, in a system of this type, is achieved by an instruction of the form[4] 'Multiply the number held in storage location (*x*) by the multiplier held in the multiplier register, the first half of the product to appear in the accumulator and the second, and least significant half, in the multiplier register whose previous contents are displaced, after use, and lost.'



The M.3 computer. Store, arithmetic unit and systems centre

The disadvantage of a multiplier of this sort is that, since (*x*) is a location on the magnetic drum, in general one drum revolution must elapse for each of the constituent additions or subtractions involved in the multiplication. This would mean that, in the worst case, the multiplication time might be 32 drum revolutions or, in the M.2, about 2/3sec.

To overcome this difficulty, the M.2 machines were provided with a special instruction which wrote the same word in each position of one track. This, although inefficient from the point of view of storage, reduced the multiplication time to: 1 revolution time to load the track plus a maximum of one revolution time to perform the operation. That is to 1/25sec in the worst case.

Now although, for multiplication, this is a fairly effective solution—the maximum time being about three times that which would be available using a special multiplicand register—for division the equivalent solution is less satisfactory. This is because the 'non-restoring' process[5] requires a knowledge, on the part of the machine, of the signs of the divisor and of the remainder at each stage of the operation and, to simplify the logical arrangements, the M.2 divider was built to involve the assumption that the divisor was negative. To achieve this condition a special entry sub-routine was needed and, because the sign of the quotient requires inversion at the end of the non-restoring process, an exit routine was also involved.

During the years which have elapsed since the design of the M.2 transistors have become available which have low cost, high speed, and great reliability. For this reason it was decided to design and build a new machine, the

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M.3. The structure of this machine is described in this article but its general differences from the M.2 are:

(1) It uses no thermionic valve circuits.
(2) An auxiliary register, the 'cycle register', is provided in the arithmetic unit.
(3) Because of the presence of the cycle register the multiplier and divider are now fully automatic.
(4) Its digit repetition rate is increased from 75 to 150kc/s.
(5) More sophisticated input-output arrangements are provided. These will be described in a subsequent article but are, in general, concerned with analogue sampling.

The Structure of M.3

The M.3 is a binary computer working with 32 bit numbers confined to the range $-1 \leqslant x < 1$. The first digit of a number represents the sign, being 0 for a positive number and 1 for a negative number. Negative numbers are expressed in the complementary form mod. 2. Thus $+ 1/4$ appears as 0·0100 0000 0000 0000 0000 0000 0000 000 and $- 1/4$ appears as 1·1100 0000 0000 0000 0000 0000 0000 000 (i.e. $2 - 1/4$).

Instructions are also represented by 32 bit numbers. To make possible program optimization 'one plus one' address instructions are used. A typical instruction is: Add the number in location 'X' into the accumulator and obtain the next instruction from location 'Y'. The first 10 bits of the instruction contain the 'X' address, the next 10 the 'Y' address, the next 5 the order to be performed and the next 6 the input to the control counter. The last bit is unused.

The M.3 is composed of three main units: the memory which is responsible for storing both instructions and data until required, the control which is capable of receiving and executing instructions stored in the memory, and the arithmetic unit which must, on command from the control, operate on stored data to produce the combinations of ordinary arithmetic.

The Memory

The memory of the M.3 consists of a magnetic drum having 128 tracks each with a capacity of 64 words. Two clock tracks are engraved on one end of the drum to provide turning impulses for locating word positions on any track.

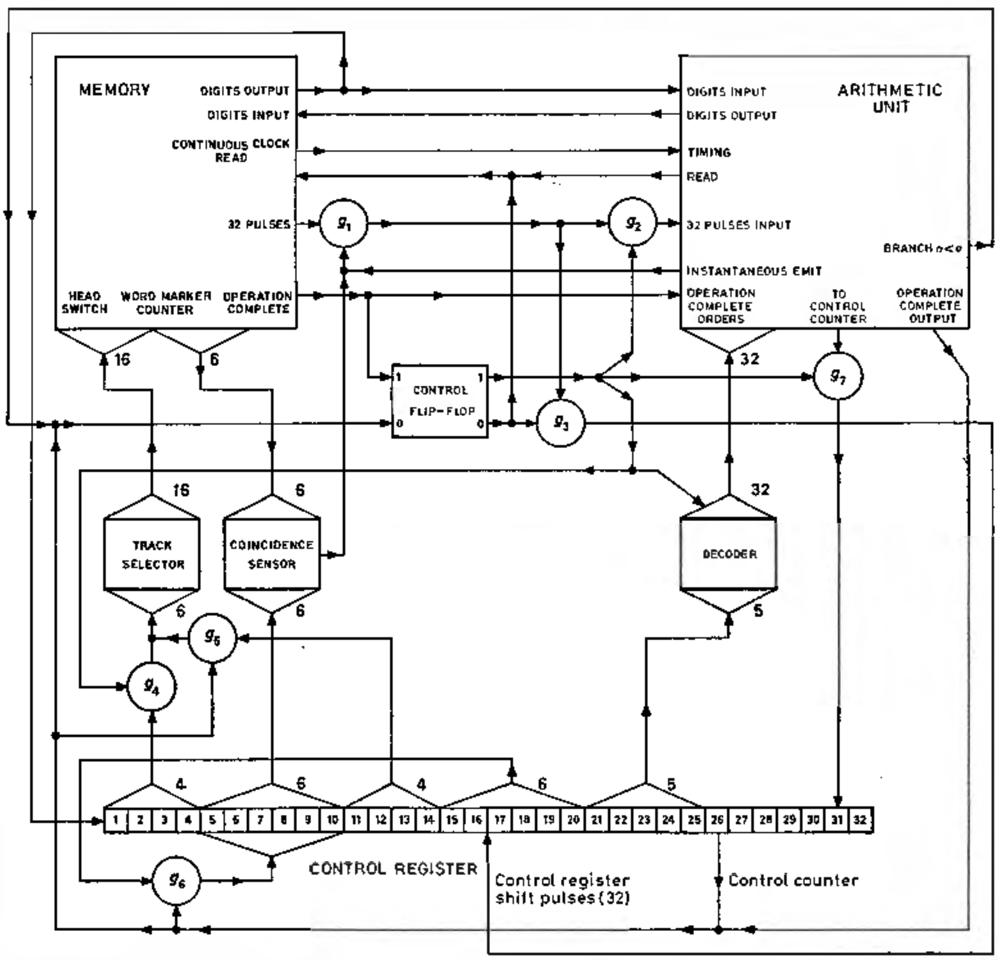
It will be seen later, when the drum circuits are described in detail, that 64 words are recorded on each track and that blocks of 16 tracks are used. This involves the provision of 6 + 4 = 10 bits for each memory address specified in an instruction. To avoid increasing the 32 bit word length to allow direct-addressing of any track, the 128 tracks are divided into 16 blocks, each containing 8 heads. The heads in the first block can be addressed by track numbers from 0 to 7. In the remaining fifteen blocks, to address a particular head, a block must first be switched on by a block switch order. Then heads in the particular block can be addressed by track location numbers from 8 to 15. Once a block is switched on, it will remain on until a different block is addressed by a block switch instruction.

The M.3 is a serial machine in which data transferred between the memory and the rest of the computer become available one bit at a time starting with the least significant bit. To transfer information to a memory location, the control addresses the 'X' track location and a comparison is made between the 'X' word location (stored in the control) and the word location shown by the word marker counter. When these are equal (coincidence), the memory circuits emit 32 bit markers.

If the least significant bit of the word being recorded is a '1', the first bit marker pulse is gated to cause a current pulse to pass in one direction through the recording head winding. The resulting magnetic field magnetizes a small spot on the drum surface.

If a bit in the word is a '0', the corresponding bit marker produces a similar current pulse which passes through the recording head winding in the opposite direction. This produces a magnetized spot with opposite polarity to the spot recorded by a '1'. The remaining bits in the word are recorded on the drum in a

Fig. 1. Control arrangements



similar manner by their corresponding bit marker pulses.

The memory generates an 'operation complete pulse' (op. comp. pulse) after emission of the thirty second bit marker pulse. This indicates to the control and arithmetic unit the completion of any operation in which information is transferred to or from the memory.

Information recorded on the drum induces a small voltage in the recording head as each magnetized element of the drum surface rotates under the recording head. If a '1' has been recorded in a particular bit location, the voltage induced in the head resembles a single cycle of a positive sine wave. If a '0' was recorded, the induced voltage resembles a single cycle of a negative sine wave. To determine the identity of a bit, the recording head output is amplified and the signal obtained is sampled during the central portion of the sine wave corresponding to each bit. If the amplifier output during this time is going negative, the sampling circuit recognizes the bit as a '1'. If the output is going positive, it is recognized as a '0'.

Access time to this type of memory is inherently slow as the drum must rotate to the proper word location before information can be recorded or received from the memory.

Information no longer needed can be erased from the memory by recording new information over the old. If recorded information is not removed in this manner, it will be retained for many years with negligible deterioration.

The Control

The M.3 control consists of three main sections: the control register which stores an instruction until it is executed, the decoder which interprets the instruction in the control register, and the control counter, which has been incorporated into the control register to control the number of basic operations performed in an instruction. Operation of the computer is controlled by the 'control flip flop' (c.f.f.); if it is in the '1' state the computer executes the instruction stored in the control register. If it is in the zero state, the memory must shift a new instruction into the control register.

With instructions requiring transfer of information between memory and arithmetic unit, the c.f.f. change to the '1' state shifts the '*X*' track location from control register stages 1 to 4 (c.r. 1-4) through the AND gate, g_4, to the track selector and permits the decoder to issue the order stored in c.r. 21-25 to the arithmetic unit (Fig. 1). When coincidence occurs between the available word location and the '*X*' word location (c.r. 5-10), 32 shift pulses from the memory cause the execution of the order. Following the thirty-second shift pulse, the op. comp. pulse generated by the memory passes through the arithmetic unit to zero the c.f.f., shift the '*Y*' track location (c.r. 11-14) through g_5 to the track selector and shift the '*Y*' word location (c.r. 15-20) through g_6 into the c.r. 5-10 locations. Zeroing of the c.f.f. instructs the memory to read and opens g_2 to allow the 32 shift pulses emitted by the memory on coincidence to shift the next instruction into the control register. Following the thirty-second pulse, the op. comp. pulse generated by the memory returns the c.f.f. to the '1' state ready to execute the next instruction.

With instructions requiring the completion of more than one basic operation, the c.f.f. change to the '1' state shifts the '*X*' track location into the track selector and permits the decoder to emit an instruction. As this type of instruction does not require coincidence with a word location, operation starts immediately. Each basic operation performed passes a pulse through g_7 to the control counter. When the required number of operations has been performed, the most significant stage of the control counter c.r. 26, generates an 'operation complete' pulse to zero the c.f.f., shift the '*Y*' track location into the track selector and shift the '*Y*' word location into c.r. 5-10.

When coincidence occurs, the zeroed c.f.f. shifts a new instruction into the control register in a manner similar to that described in the previous example. The op. comp. pulse following the shift resets the c.f.f. to unity, ready to execute the new instruction.

With branch instructions, the next instruction shifted into the control register is determined by the sign of a number stored in the arithmetic unit. When the c.f.f. switches to the '1' state, the '*X*' track location is set into the track selector by g_4 and a gating pulse from the decoder tests the sign of the number in question. If the sign bit is a '0' indicating a positive number, the arithmetic unit emits an operation complete pulse which zeros the c.f.f. and opens g_5 and g_6 to shift the next instruction to the control register from the '*Y*' memory location. However, if the sign bit is a '1', the arithmetic unit emits a pulse on the branch $n < 0$ line which zeros the c.f.f. but does not open g_5 or g_6. This results in the new instruction being shifted to the control register from the '*X*' memory location. Following the instruction shift, the operation complete pulse generated by the memory will set the c.f.f. to a '1' ready to execute the new instruction.

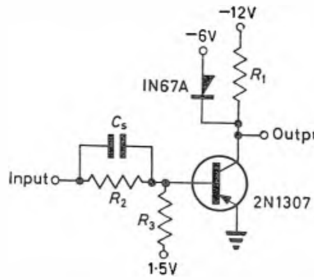


Fig. 2. Basic building block

The Arithmetic Unit

Operation of the arithmetic unit is governed by the control unit. When instructed, the arithmetic unit will perform right shifts, left shifts, additions, subtractions, multiplications and divisions. Provision is made for the emission of an operation complete pulse on completion of an operation, or alternatively, for generation of basic operation complete pulses for the control counter. The arithmetic unit contains three electronic storage registers, the accumulator, the shift register and the cycle register. Each can store a word, and have the property that stored digit patterns can be shifted to the right only. Before multiplication or division, the multiplier or divisor is shifted into the cycle register. Then, during the arithmetic operation, each time the stored number is required, a group of thirty-two shift pulses is used to cycle the register and to shift data from the thirty-second stage of the register to the arithmetic unit.

The Circuit Elements

The primary requirements in logical circuit design are reliability and acceptable speed. Secondary requirements of the circuit are simplicity, low cost and low power consumption. To ensure reliable operation, M.3 switching circuits are designed using a 'worst case' design procedure which implies that a circuit will work when all supply voltages and active and passive components are simultaneously at those extremes of their tolerance limits that will tend most to make the circuit inoperative. Component values and voltage levels are assumed to have ± 10 per cent variation. The transistor current gain which is rated from 60 to 300 by the manufacturer is assumed to be a minimum of 50. Circuits are designed to operate within the ambient temperature range from 40°F to 130°F assuming the greatest semiconductor variations with temperature.

Texas Instruments 2N1306 (npn) and 2N1307 (pnp)

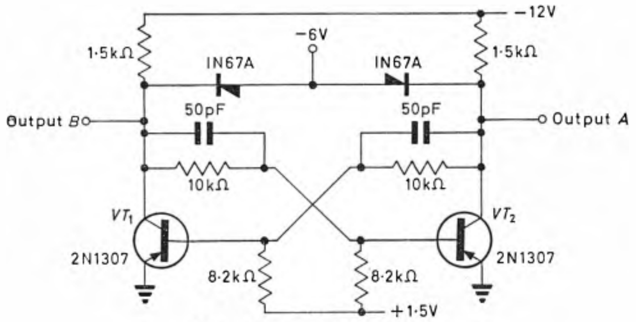


Fig. 3. The basic flip-flop

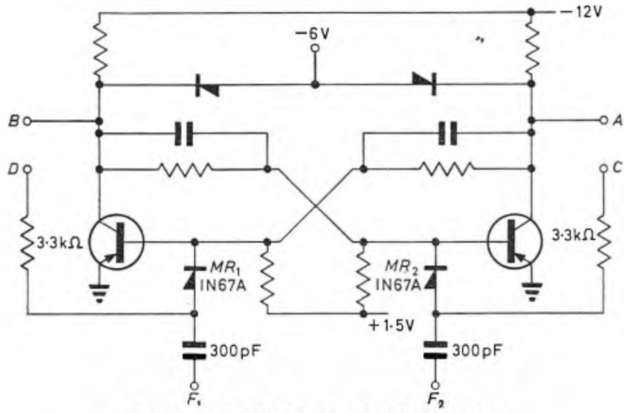


Fig. 4. Basic flip-flop showing input gating

germanium switching transistors are used in all logical circuits. These transistors, which have a minimum common-base alpha cut-off frequency of 10Mc/s, allow switching times in the 0·1 to 0·2μsec range.

The basic building block of many of the logical circuits used with the M.3 is shown in Fig. 2.

The Basic Flip-Flop

A circuit diagram of the basic flip-flop used with the M.3 is shown in Fig. 3. In state '1', when VT_1 is conducting and VT_2 is cut-off, output A is $-6{\cdot}3$V due to the clamping diode and output B is approximately $-0{\cdot}2$V due to the voltage drop across the saturated transistor.

The diode network shown in Fig. 4 is used to set the flip-flop. To shift a '1' into the flip-flop, C is set to 0 volts, D is set to -6V and a 6V positive going pulse is applied to F_1 and F_2 simultaneously.

Storage for an n bit number is obtained with an n flip-flop shift register. As data become available from the memory one bit at a time, serial registers which accept one bit at a time are used. This type of register is constructed by attaching the '1' output (A) of stage (m) to the '1' input (D) of stage ($m + 1$). Similarly, the '0' output (B) of stage (m) is connected to the '0' input (C) of stage ($m + 1$). All F terminals (Fig. 4) are connected to a common bus. A positive going 6V pulse is applied to this bus to shift the contents of the register one stage to the right (from stage (m) to stage ($m + 1$)).

A flip-flop can accept data from more than one source if an additional pair of diode gates is added to the flip-flop for each additional source. When more than one source is used, the 1N67A gating diodes are replaced by 1N625 diodes which have a much lower reverse leakage current. The source of information shifted into the flip-flop is determined by the pair of F_1, F_2 terminals which receive the 6V positive pulse.

A binary counter can be made from the flip-flop Fig. 4 by connecting the terminals A to C, B to D, and F_1 to F_2. When a positive going pulse is applied to F_1 and F_2 the flip-flop is caused to change state. To make an n stage binary counter, the '1' output of stage (m) is connected to F_1F_2 of stage ($m + 1$). This will cause stage ($m + 1$) to change state each time that stage (m) changes from the '1' to the '0' state.

In tests at 500kc/s, a four stage shift register constructed with unselected components was found to operate for all voltage and temperature variations within the design range. Bench tests show that this type of counter will operate at frequencies up to 1Mc/s.

The switching time for a flip-flop loaded by one AND gate and one shift register stage is 0·2 to 0·3μsec. The flip-flop is designed to supply or accept a 1mA load in either conducting or cut-off stage, but a large capacitive load results in a slowing of switching time. In this case, an emitter-follower is placed between flip-flop and load to retain switching speed.

Basic And Gates

The M.3 uses three different AND gates: the transistor AND gate, the inverting AND gate, and the diode AND gate. The signal input and the control inputs on any gate are interchangeable. The gate is turned on when all control inputs are —6V, but is turned off if any control input is 0V. The circuit diagrams of the basic gates and their logical characteristics are shown in Fig. 5.

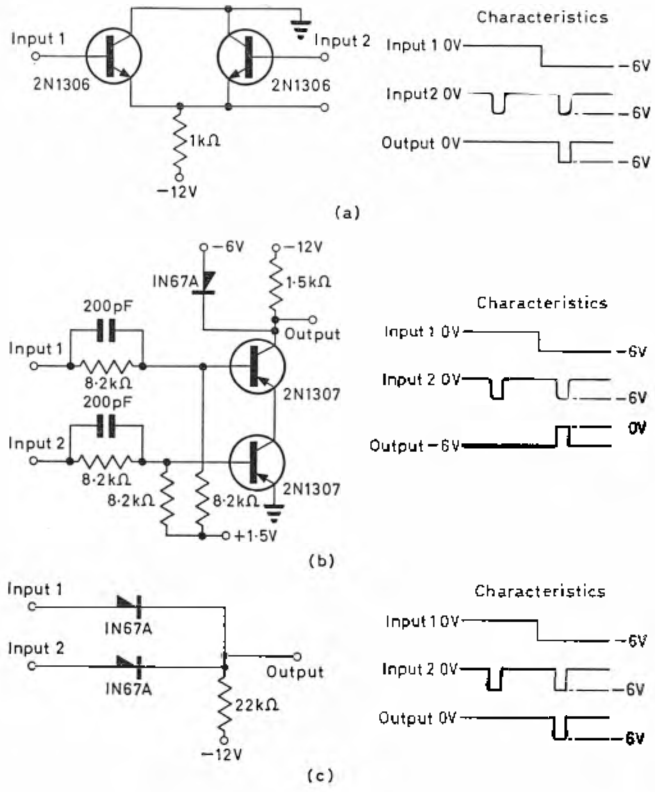
Basic Or Gates

The three OR gates used in the M.3 are shown in Fig. 6.

The transistor OR gate in Fig. 6(a) is most commonly used in the M.3. This gate has a 50kΩ input impedance, 50 to 100Ω output impedance, and produces a propagation delay of less than 0·05μsec. The circuit causes very little increase in the fall time of the input signal, but does not speed it up either. A signal into one input of the gate causes negligible noise on any other input.

Fig. 5. Basic AND gates

(a) Transistor gate *(b) Inverting gate* *(c) Diode gate*



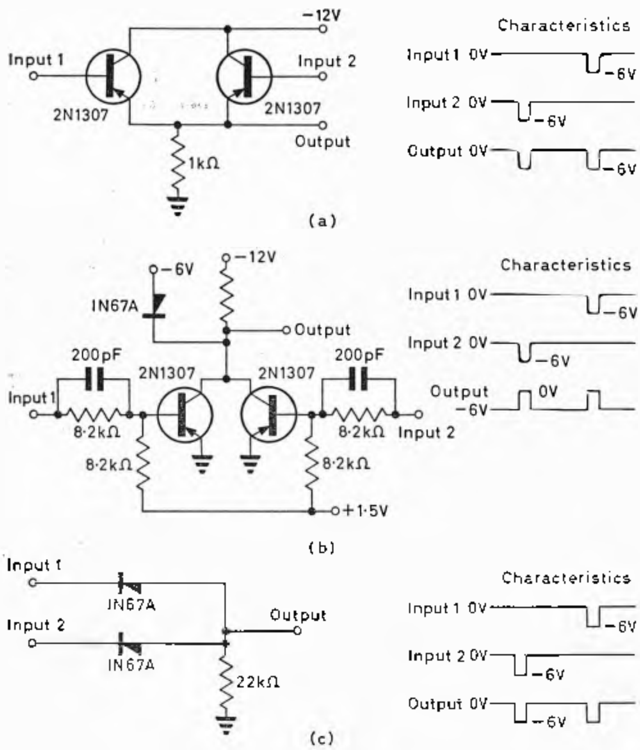


Fig. 6. Basic OR gate
(*a*) *Transistor gate* (*b*) *Inverting gate* (*c*) *Diode gate*

The inverting OR gate shown in Fig. 6(b) is useful if the output requires inversion with respect to the inputs. This gate has input and output characteristics similar to the inverting AND gate in the on state. An input signal causes negligible noise on the other input lines.

The diode OR gate shown in Fig. 6(c) is the simplest gate, but as the gate contains no active elements, the output impedance is determined by the output impedance of the circuits driving the gate. If heavily loaded, this gate normally has a power amplifier between the output and the load.

The number of inputs to any of the OR gates shown may be increased by adding more transistors or diodes in parallel with those present.

EMITTER-FOLLOWERS

The emitter-follower performs no logical function but, as it has a high input impedance and a low output impedance, it is very important in the construction of a digital computer. The emitter-follower is normally placed between circuits required to emit fast pulses and their loads if these are capacitive or require a large driving current.

The M.3 uses three types of emitter-followers. In applications where both the leading and the trailing edge of a pulse are important, the 'complementary pair' emitter-follower (Fig. 7(a)), is used. The output impedance from this circuit, when driven by a logical circuit, is 50 to 100Ω. This low resistance discharges any capacitive load *C* very quickly, preventing slowing of both leading and trailing edges of a pulse.

In cases where either the positive or the negative going edge of a circuit output is important but the opposite edge is not, the emitter-followers shown in Figs. 7(b) and (c) are used.

The npn emitter-follower has approximately 50Ω output impedance for d.c. conditions and positive going edges. However, when the input to the emitter-follower goes negative, the transistor is cut off and the load capacitance *C* must discharge through the 1kΩ resistor. This results in an exponential voltage decrease. As the leading edge of a pulse is usually important, the npn emitter-follower is normally used with circuits which emit positive going pulses.

The pnp emitter-follower has the opposite characteristics and exhibits a 50Ω output impedance for d.c. and negative edges, but approximately 1kΩ output impedance for positive edges. This emitter-follower is normally used with circuits which emit negative going pulses.

CIRCUIT LAYOUT TECHNIQUES

All logical circuits are mounted on 3½in × 8in, 22 contact, plug-in Veroboard. The Veroboard card was chosen as it permits easy circuit assembly, allows considerable freedom in circuit layout and is quite inexpensive. The card size was chosen mainly for economic reasons. A small card containing one or two logical circuits simplifies construction and testing, but the expense of the large number of cards and sockets required is not economically justifiable. The 8in long card used allows at least four logical circuits to be mounted per card. Card servicing is simplified by a plug-in test jack which permits easy access to all components mounted on the card.

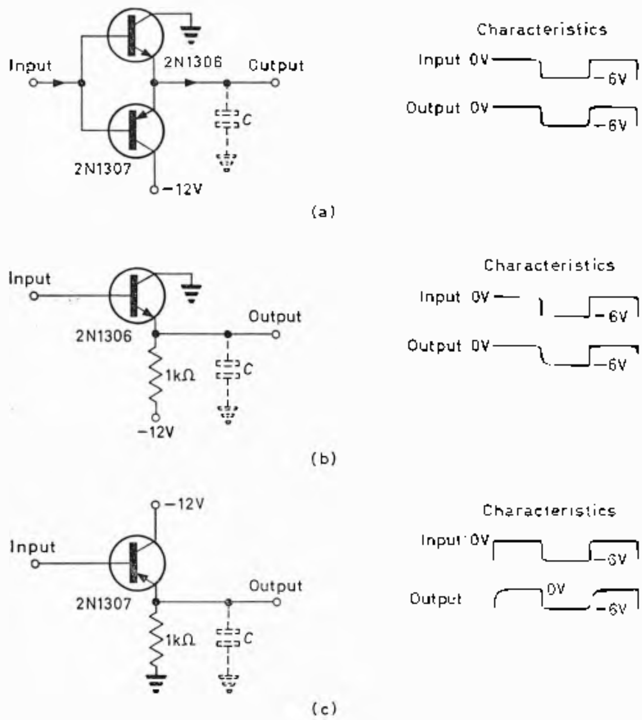
Each card in the M.3 is stamped with a drawing number. This drawing gives the location and description of all components and wires on the card. The destination and colour of wires connected to any of the 22 contacts via the plug-in socket is also shown. A small logical diagram on the top of each drawing shows the logical circuits and internal connexions on the card and also the socket pin numbers of all accessible input and output points of the logical circuits.

The logic cards are mounted in a 76 card rack. The drawing number for each card is stamped on the rack to ease servicing. Card locations are chosen to keep inter-card wiring to a minimum length.

The Store

The M.3 store consists of a Wharf Engineering Laboratories Mk.3 magnetic drum and the circuits required to

Fig. 7. Basic emitter-followers
(*a*) *Complementary-pair* (*b*) *NPN* (*c*) *PNP*



read and write information in a specified location.

The magnetic drum consists of a 9·75in diameter aluminium alloy cylinder 8in long which is driven by a small induction motor at 3 425rev/min. The outside surface of the cylinder is precisely machined and is coated with a thin homogenous layer of iron oxide and plastic. One hundred and twenty eight recording heads occupy individual tracks along the side of the cylinder. The recording heads are spaced approximately ·0005in from the magnetic surface of the drum.

Two engraved soft iron timing tracks[6] are mounted on one end of the cylinder. The first track is engraved with a single slot, which generates a single 'zero marker' pulse in a read head each drum revolution. The second track is engraved with 1 280 equally spaced slots. The output from the read head on this track is amplified to form a basic 75kc/s continuous clock for the computer and this is frequency-doubled to give the clock pulses actually used.

In many of the basic M.3 operations, groups of 32 pulses are required. These pulses are generated from the continuous clock and must occur approximately 5μsec after the start of each word.

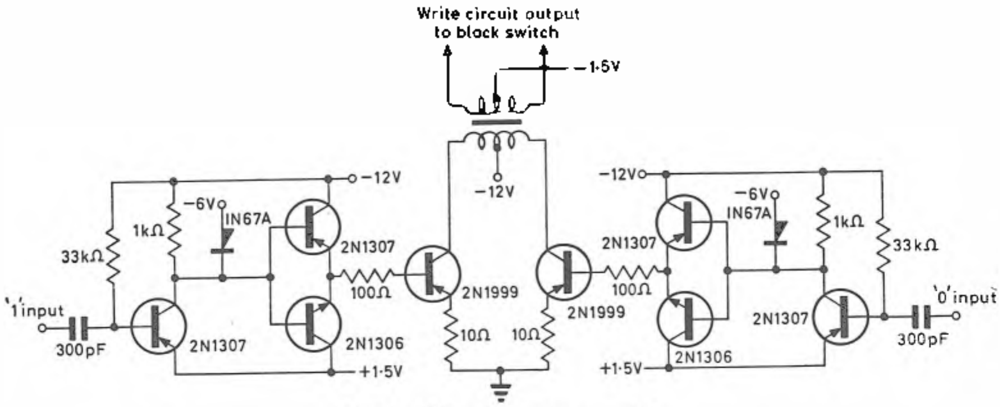


Fig. 8. Write circuit power amplifier

The system used to generate timing pulses in the M.3 obtains word marker pulses by counting the clock pulses. A word marker pulse is generated after every twentieth basic (i.e. 75kc/s) clock pulse, sixty-four word locations are thus designated per drum revolution. By doubling the frequency of the basic clock pulses, the capacity of each track is increased from 1 280 to 2 560 bits and the calculating speed of the computer is increased by a factor of two. Outputs from a counter control the opening and closing of the gate which emits groups of 32 pulses, thus giving reliable operation yet eliminating delicate clock track engraving and the relatively low signal levels associated with shallow markings. The design of the counter-coincidence senser and of the read-write circuits and track switch follow the logical and circuit principles described elsewhere[7,8].

The Head Switch

The magnetic drum used with the M.3 has 128 recording heads. The computer must be able to address any one of these heads to store or receive information. To do this, the heads are divided into 16 blocks, each containing eight heads.

Heads in the first block are assigned track numbers from 0 000 to 0 111. A head in this block may be switched on by placing the track number of the head in either the X or Y address of an instruction. Heads in this block are continuously available, and are independent of the block switch.

In the remaining 15 blocks, the heads in each block are assigned track numbers from 1 000 to 1 111. To address a head in this group, the block containing the required head is first switched on by a block switch instruction. The head can then be addressed by placing the track number in either the X or the Y address of the instruction as usual.

The head switch is composed of three main sections; a storage register which holds a track number as long as information is required from that track, a diode matrix which produces a single output for each combination in the storage register and a transformer-symmetrical transistor gate array[8] which is controlled by the output from the diode matrix and which turns on the head or set of heads required.

The Block Switch

The block switch must switch on one from a total of 15 available blocks. The block switch instruction triggers the block address stored in c.r. 1-4 into the block switch storage register. A 3μsec delay on the switch instruction allows this shift pulse to be used as an op. comp. pulse. The delay allows the c.f.f. to settle to unity state before being reset by the op. comp. pulse.

To prevent storage register loading, emitter-followers are placed on all outputs to the block selector diode matrix.

The Write Circuit

Information is stored on the drum surface in the form of small magnetized elements. These elements are magnetized by passing a current pulse through a head for a length of time less than 1 bit period. The amplitude of this pulse must be sufficient to allow removal of old information from the drum by recording new information over it.

Information was recorded in the M.2 by current pulses which resembled the positive portion of a sine wave. The '1' was distinguished from the '0' by passing the current pulse through the head in the opposite direction. This writing technique was tried on the M.3, but recording an unbalance of '1's or '0's resulted in an operating point shift of the transformer network between the write circuit and the head. The operating point returned to the normal level, but the return required a length of time greater than the recovery time between two word locations. This prevented reading information immediately after recording. The use of this system would have made programming more difficult and reduced operating speed.

The use of double pulse writing was adopted to overcome the d.c. shift problems. The current pulse used in this system resembled a complete cycle of a sine wave and has a peak value of 1A in each direction. Again '1' is distinguished from '0' by passing the current pulse through the head in the opposite direction. Adjustment of the current pulse shape allows d.c. level shift in this system to be practically eliminated.

The power amplifier circuit is shown in Fig. 8. The 2N1999 transistors which supply the write current are normally cut off by the +1·5V output from the complementary pair emitter-follower. The input to the emitter-

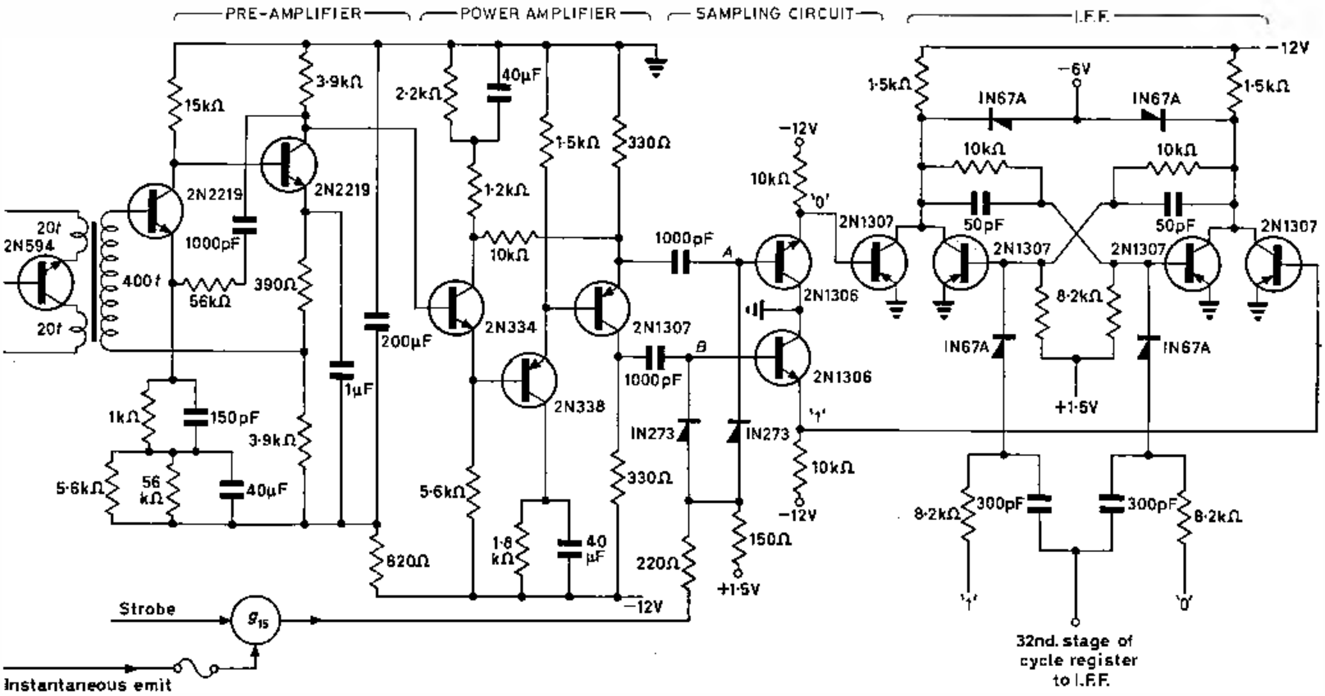


Fig. 9. Read circuit

follower is produced by a normally saturated 2N1307 transistor. A positive-going input pulse switches the 2N1307 off, causing its output voltage to switch to the clamped −6V level. This saturates the 2N1999 transistor causing current flow through the output transformer winding to the centre-tap.

The Read Circuit

To transfer information from the store, the small voltage induced in the recording head must be converted to a form acceptable to the logical circuits. This conversion is performed by the 'read circuit'; a high gain amplifier whose output, when sampled by strobe pulses, sets the incident digit flip-flop (i.f.f.) to the appropriate state (Fig. 9).

The signal induced in a recording head contains two basic frequencies, 75kc/s for alternate 1's and 0's and 150kc/s for continuous 1's or 0's. The signal level from the 1μH head is approximately 350μV peak-to-peak, however a 1:3·25 transformation at the head switch and a 1:10 transformation at the amplifier input transformer causes the amplifier input to appear as 9mV from a 1mH source.

The transformer-symmetrical transistor gate input to the amplifier is switched off during writing to prevent write circuit loading and extreme amplifier saturation.

The amplifier must not produce a large change in phase shift between 75kc/s and 150kc/s or the sampling circuit will not operate. Phase lag due to the inductive source impedance (1kΩ at 150kc/s) is less than 2° as the input impedance to the amplifier is greater than 50kΩ. Phase change due to the amplifier in the 75 to 150kc/s range is reduced by non-linear negative feedback. The effect of power supply noise is reduced by an *RC* filtered supply used with the preamplifier. The amplifier's low 60c/s gain eliminates problems due to 60c/s pick-up.

The sampling circuit requires two inputs; one the inverted image of the other. This is obtained by placing equal resistors in series with the collector and emitter of the output transistor and connecting to both collector and emitter.

Points *A* and *B* of the sampling circuit, which are connected to the amplifier outputs by 1 000pF capacitors, are normally clamped to a slightly positive potential by 1N273 diodes and the 2N1306 base to collector junctions. Negative-going strobe pulses from g_{15} reverse bias the 1N273 diodes allowing *A* or *B* to follow the input signal to a negative voltage. The negative level on *A* or *B* allows the attached 2N1306 transistor to operate as an emitter-follower and set the i.f.f. by applying a negative voltage to the direct coupled trigger transistor.

In cases where the cycle register sets the i.f.f. a signal from the arithmetic unit prevents strobe pulses from passing through g_{15} and shift pulses from the cycle register (a portion of the arithmetic unit) shift the contents of the thirty-second cycle register stage into the i.f.f.

Some Practical Details

The design and circuit testing of the M.3 elements was completed between January and April 1963. From April to September the technical staff of the laboratory worked on, and completed, the mechanical construction of the machine and of its plug-in cards. Very little trouble was experienced in the 'debugging' phase of the operation which consisted mainly in detecting misconnexions and faulty components. The machine was fully operational by December 1963 and is shown on page 368.

Acknowledgments

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They also wish to thank Wharf Engineering Laboratories for the gift of the Mk.3 storage drum used in the computer.

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An Amplifier with Linear Voltage Controlled Gain

C. I. Sach*, B.E.E.

This article describes a circuit which is used to obtain an amplifier stage whose gain is proportional to a control voltage. A simple theory for the operation of the device is presented together with some applications.

(Voir page 422 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 429)

DURING the course of development work on the vacuum deposition of thin films a need arose for a 1kc/s square wave amplifier whose gain could be voltage controlled. The effects of transistor parameter variations were required to be minimized so that units with closely similar characteristics could be easily constructed. This led to the development of the simple linear unit described in this article.

The basic configuration of the circuit is shown in Fig. 1 where two grounded base transistors VT_1 and VT_2 are supplied with emitter currents I_1 and I_2 respectively. An a.c. signal current I_s is capacitively coupled to the two emitters as shown. Initially it will be assumed that the amplitude of I_s is much smaller than I_1 or I_2 and that the capacitances have zero reactance at the signal frequencies. The signal current divides between the two emitters according to their incremental emitter resistances r_{e1} and r_{e2} if the contribution due to the base resistance is neglected. This is reasonable with a high gain transistor.

The signal current flowing into the emitter of VT_1 is given by

$$I_{s1} = I_s \frac{r_{e2}}{r_{e1} + r_{e2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

For a well behaved transistor

$$r_{e1} = 1/\gamma I_1 \text{ and } r_{e2} = 1/\gamma I_2 \quad \ldots\ldots\ldots \text{(2)}$$

where $\gamma = q/kT = 40$. Substituting these values in equation (1) gives

$$I_{s1} = I_s \frac{I_1}{I_1 + I_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

Thus if the bias currents are obtained from a source which varies I_1 in accordance with a control voltage while simultaneously holding $I_1 + I_2$ constant at a value I_c then the desired gain control characteristic is obtained. The output can be considered as the a.c. current I_{out} occurring at the collector of VT_1. This is superimposed on the steady emitter current I_1. The output collector signal current is

$$I_{out} = \alpha I_{s1} = \alpha(I_1/I_c)I_s \quad \ldots\ldots\ldots\ldots \text{(4)}$$

If I_s is a square wave signal then the output will be a faithful reproduction having flat tops.

Large Signal Inputs

In the previous analysis it was assumed that the signal currents were so small compared with the emitter currents that they did not change the incremental input resistances of the transistors. However for large signals where I_s is comparable with I_1 and I_2 the relationships defined in equation (2) are not valid. It thus becomes necessary to consider the large signal behaviour of the emitter-base junction.

It will be assumed that with the emitter-base region forward biased and the collector-base region reverse biased, the required relationship can be approximated by

$$I = I_o e^{\gamma v} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(5)}$$

In this, I is the emitter current, v the emitter-base voltage and I_o a constant which is the same for both transistors.

The circuit for analysis then becomes as shown in Fig. 2 where it is required to calculate the variation of I_3 with respect to the input currents I_1, I_2 and I_s. The circuit equations are

$$v_1 = e_1 + e_2 + v_2 \quad \ldots\ldots\ldots\ldots\ldots \text{(6)}$$

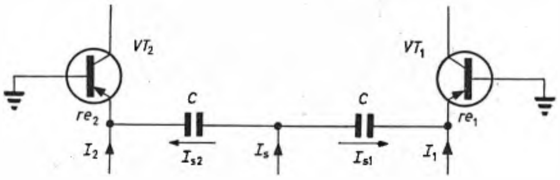


Fig. 1. Small signal operation

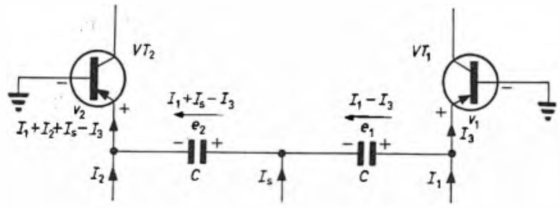


Fig. 2. Circuit for large signal analysis

which on differentiation with respect to time becomes

$$v_1' = e_1' + e_2' + v_2' \quad \ldots\ldots\ldots\ldots \text{(7)}$$

$$e_1' = \frac{I_1 - I_3}{C} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(8)}$$

$$e_2' = \frac{I_s + I_1 - I_3}{C} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(9)}$$

$$I_3 = I_o \exp(\gamma v_1) \quad \ldots\ldots\ldots\ldots\ldots \text{(10)}$$

Differentiation of equation (10) yields

$$v_1' = 1/\gamma \,.\, I_3'/I_3 \quad \ldots\ldots\ldots\ldots\ldots \text{(11)}$$

Similarly for VT_2

$$v_2' = \frac{-I_3'}{\gamma[I_1 + I_2 + I_s - I_3]} \quad \ldots\ldots\ldots\ldots \text{(12)}$$

where I_1, I_2 and I_s are regarded as constants. This latter assumption amounts to considering I_s as a step input at time $t = 0$. Substituting equations (8), (9), (11) and (12) in (7) the required equation for I_3 is obtained as

$$I_3'/\gamma \cdot \frac{I_c + I_s}{I_3(I_c + I_s - I_3)} = \frac{I_s + 2I_1 - 2I_3}{C} \quad \ldots\ldots \text{(13)}$$

This equation may be integrated to solve for I_3, thus yielding

* *Defence Standards Laboratories, Victoria, Australia.*

$$\int_{I_3(0)}^{I_3} \frac{dI_3}{I_3(I_3-I_c-I_s)(I_3-(2I_1+I_s/2))} = \frac{2\gamma t}{C(I_c+I_s)} \quad \ldots\ldots\ldots\ldots\ldots\ (14)$$

In this equation $I_3(0)$ is the value of I_3 at $t = 0$ immediately after the application of the input step function. The value of this initial condition can be obtained as follows.

Just prior to the step at $t = 0-$

$$I_1 = I_o \exp[\gamma v_1(0-)] \quad \ldots\ldots\ldots\ldots\ (15)$$

and

$$I_2 = I_o \exp[\gamma v_2(0-)] \quad \ldots\ldots\ldots\ldots\ (16)$$

Immediately after the step at $t = 0+$

$$I_3(0) = I_o \exp[\gamma v_1(0+)] \quad \ldots\ldots\ldots\ldots\ (17)$$

and

$$I_1 + I_2 + I_s - I_3(0) = I_o \exp[v_2(0+)] \quad \ldots\ (18)$$

Now up to time $t = 0+$, there will not have been time for the voltages on the capacitors to change. Therefore v_1 and v_2 must change by equal amounts over the interval $t = 0$. This implies

$$v_1(0+) - v_1(0-) = v_2(0+) - v_2(0-) \quad \ldots\ (19)$$

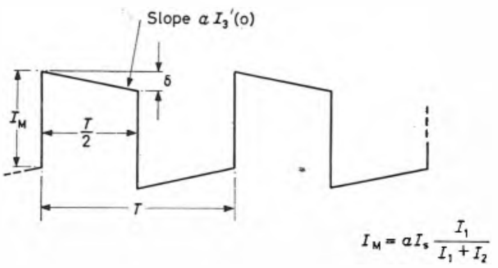


Fig. 3. Output waveform

Solving equations (15) through (18) for the terms specified in (19) and substituting them,

$$\ln(I_3(0)/I_o) - \ln(I_1/I_o) = \ln \frac{I_1 + I_2 + I_s - I_3(0)}{I_o} - \ln(I_2/I_o)$$

This simplifies to

$$I_3(0) = I_1 + I_s(I_1/I_c) \quad \ldots\ldots\ldots\ldots\ (20)$$

The initial variation at the collector output of VT_1, remembering that I_1 was already flowing in the emitter for $t < 0$, is then

$$I_{out} = \alpha I_s(I_1/I_c) \quad \ldots\ldots\ldots\ldots\ (21)$$

This result is interesting since it is precisely what was predicted in equation (14). This shows that as far as the initial front is concerned this mode of gain control is valid for both large and small signals. To investigate the behaviour fully for $t > 0$ equation (14) would need to be solved using the initial condition defined in equation (20). The mathematics involved in this step, although simple, are quite tedious and lead to a cumbersome equation defining the time variation of I_3. To avoid this, attention will be confined to the value of I_3' just after the step i.e. to $I_3'(0)$. This is possible since in practice one is not concerned with an isolated step function but with a train of pulses. Thus if the period of the square wave is short enough, the shape of the tops and bottoms of the pulses can be approximated by straight, though not necessarily horizontal, lines—their slope being defined by $I_3'(0)$. The required value is obtained by substituting the value of $I_3(0)$ into equation (13) and gives, after simplification,

$$I_3'(0) = (\gamma/C) \, . \, I_s \, (I_1/I_c) \, (I_c+I_s)$$
$$(1 - 2(I_1/I_c)) \, (1 - (I_1/I_c)) \quad \ldots\ldots\ (22)$$

The conditions under which $I_3'(0)$ is zero, i.e. where the pulses have flat tops, are seen from equation (22) to be

$$I_1 = 0$$
$$I_1 = I_c$$
$$\text{and } I_1 = I_c/2$$

These conditions are independent of the value of I_s. The first two conditions are expected since they describe respectively the state where VT_1 is cut off and where VT_1 passes the total current I_c and which therefore accepts the whole of the input signal current. The third condition describes the state where I_1 and I_2 are equal and hence both transistors VT_1 and VT_2 are operating under exactly the same conditions and thus share the input signal current equally. Apart from its limiting condition, the factor $(1 - (I_1/I_c))$ is always positive and therefore for a positive input step, the sign of $I_3'(0)$ is controlled by the factor $(1 - 2\,I_1/I_c)$.

Clearly $I_3'(0) > 0$ when $I_1 < (I_c/2)$

and $I_3'(0) < 0$ when $I_1 > (I_c/2)$

When the values of the coupling capacitances are unequal, as is likely when electrolytic capacitors are used, the condition defining the sign of $I_3'(0)$ is altered as derived in Appendix (1).

This shows that $I_3'(0) = 0$ for $I_1 = 0$ and $I_1 = I_c$ as before plus the changed condition that

$$I_1 = I_c \frac{C_1}{C_1 + C_2} \quad \ldots\ldots\ldots\ldots\ldots\ (23)$$

Thus $I_3'(0) > 0$ when $I_1 < I_c \dfrac{C_1}{C_1 + C_2}$

and $I_3'(0) < 0$ when $I_1 > I_c \dfrac{C_1}{C_1 + C_2}$

For given values of I_c and I_s equation (22) may be differentiated to find the values of I_1/I_c which yield maximum values of $I_3'(0)$. The conditions are

$$I_1/I_c = (1/2) \pm (\surd 3/6) \quad \ldots\ldots\ldots\ (24)$$

and the corresponding values of $I_3'(0)$ are given by

$$I_3'(0)_{max} = \pm\ 0{\cdot}08\,(\gamma/C) \, . \, I_s \, (I_c + I_s) \quad \ldots\ldots\ (25)$$

It follows directly from equation (25) that the undesirable slope on the output pulses can be reduced to any desired level by using a sufficiently large value of the coupling capacitance C.

Figure of Merit

A useful figure of merit for this type of application where a square wave signal is used can be explained by reference to Fig. 3. Here the output of transistor VT_1 consists of a step $I_M = \alpha I_s \, . \, I_1/I_c$ and a slope of $I_3'(0)$. If the frequency of the square wave is f then the period is $T = 1/f$. The sag of the top of the pulses is indicated as δ. The figure of merit can then be defined as

$$M = |\delta/I_M| \quad \ldots\ldots\ldots\ldots\ (26)$$

From this definition, the lower the value of M the better the system.

$$\text{But } \delta = \alpha I_3'(0) \, . \, (T/2)$$
$$\text{i.e. } \delta = \alpha\,(I_3'(0)/2f) \quad \ldots\ldots\ldots\ (27)$$
$$\text{and } I_M = \alpha\,I_s \, . \, (I_1/I_c)$$

Substituting these expressions in equation (26) together with equation (22)

$$M = |(\alpha/2fC)\,(I_c+I_s)\,(1-2(I_1/I_c))\,(1-(I_1/I_c))| \quad \ldots\ldots\ (28)$$

This has a maximum value, corresponding to the worst pulse shape when

$$I_1/I_c = 3/4 \quad \ldots\ldots\ldots\ldots\ldots\ (29)$$

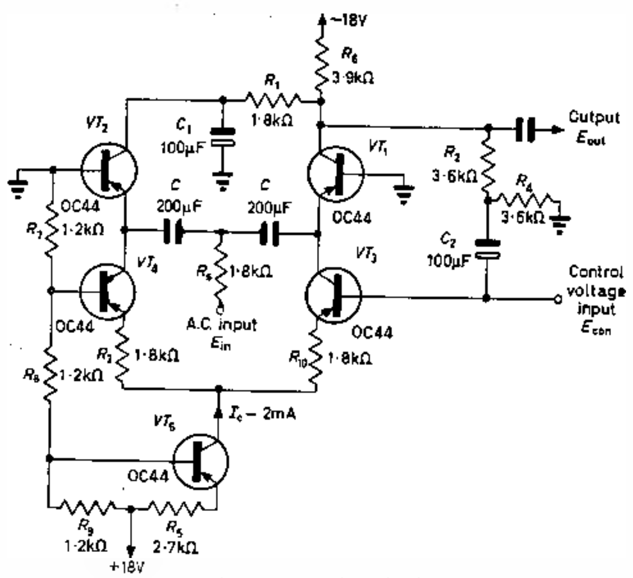


Fig. 4. A practical circuit

Substituting this value in equation (28) gives

$$M_{max} = \gamma/16fC\,(I_c + I_s) \quad \ldots\ldots\ldots\ldots (30)$$

This latter expression is the basic design equation for the circuit.

Practical Unit

An amplifier designed for operation at 1kc/s with input currents up to 1mA and a figure of merit of 1/25 is shown in Fig. 4. VT_1 and VT_2 form the current dividing control for the input signal. Although the previous analysis has assumed a perfect current source for the signal the results are valid if a voltage source is used in conjunction with a series input resistance R_s provided

$$R_sC \geqslant 5/fM_{max} \quad \ldots\ldots\ldots\ldots\ldots\ldots (31)$$

The basis of this equation is given in Appendix (2). In this case $C = 200\mu$F which means an input resistance of $R_8 \geqslant 600\Omega$ is necessary. In fact, a value of 1·8kΩ is used which, with an input square wave of amplitude up to 2V, produces a maximum input current amplitude of 1mA.

Transistors VT_3, VT_4 and VT_5 are used to produce the required emitter currents I_1 and I_2. VT_5 produces a constant current $I_c = 2$mA which is then split into I_1 and I_2 in the differential stage VT_3 and VT_4. The voltage at the base of VT_4 is held at +6V while the control voltage is applied to VT_3. When this is +6V, the current I_c is divided equally between I_1 and I_2. When the control is about +2V, all the available current I_c flows through VT_3, i.e. $I_1 = I_c$. At the other extreme when the constant voltage is +10V, $I_2 = I_c$, i.e. $I_1 = 0$. The control voltage required to achieve this range of operation is relatively independent of the transistor parameters because of the use of resistors R_3, R_{10} and R_5 in series with the respective emitters.

To a first approximation, where $R_3 = R_{10}$,

$$I_1 = \frac{6 + R_3I_c}{2R_3} - (E_{con}/2R_3) = 2{\cdot}5 - (E_{con}/4) \quad \ldots (32)$$

The output signal is taken from the collector of VT_1 and is preferably capacitance coupled to a low impedance current amplifier. In order that the average d.c. voltage level at this collector should not vary with I_1, the output of VT_2 is added to I_1 so that the average current through R_6 is closely equal to the constant current I_c plus that coming through R_2 and R_4. This will produce a constant average d.c. level at the output. Before adding the output of VT_2 to VT_1, however, it is necessary to remove the a.c. signal components from the VT_2 output. This is done by the filter stage (C_1, R_1). The resistance R_1, together with R_2 and R_6, shunts the input of the following amplifier which should therefore be low impedance so it receives all the signal current available from VT_1. The presence of C_1, R_1 results in a step of control voltage producing a change of pulse amplitude in the output, but this is superimposed on a step and subsequent exponential decay of the voltage level at the collector of VT_1. This occurs because the change in control voltage alters the bias currents I_1 and I_2 but only the change in I_1 is experienced immediately at the output, that due to I_2 is delayed by the integrating action of C_1. This variation in output, which occurs even when there are no input pulses, may not be troublesome in some cases but has been eliminated in this case so the circuit is of more general application. This is achieved by feeding the control signal into the output via a network R_2, R_4 and C_2 having a phase lead characteristic which is adjusted to compensate for the lag characteristic of R_1 and C_1.

The theoretical requirements for balance are derived in Appendix (3) and indicate that:

$$R_2 = 2R_3 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (33)$$

and

$$R_4 = \frac{C_1R_1R_2}{C_2R_2 - C_1R_1} \quad \ldots\ldots\ldots\ldots (34)$$

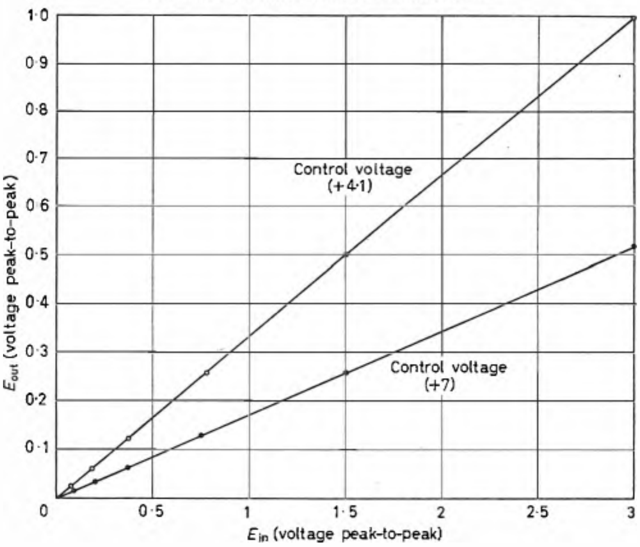
In practice the actual values are set while applying a square wave to the control terminal with no a.c. signal present. Resistance R_2 is then adjusted until no spikes are present (high frequency compensation) and then C_2 adjusted to eliminate ripple (low frequency compensation).

Performance

In testing the circuit for linearity, the stage has not been terminated with an amplifier but has the output taken as a voltage from the collector of VT_1.

Fig. 5 shows the variation of input to output pulse amplitudes for two values of control voltage. It shows that the circuit is linear for input signals of up to 3V peak-to-peak i.e. input currents up to ±1·5mA. Fig. 6 shows a plot of gain against control voltage for a fixed amplitude input signal of 1·5V peak-to-peak. Except at the extremes of the controlling range, where the behavioural

Fig. 5. Amplifier transfer characteristic



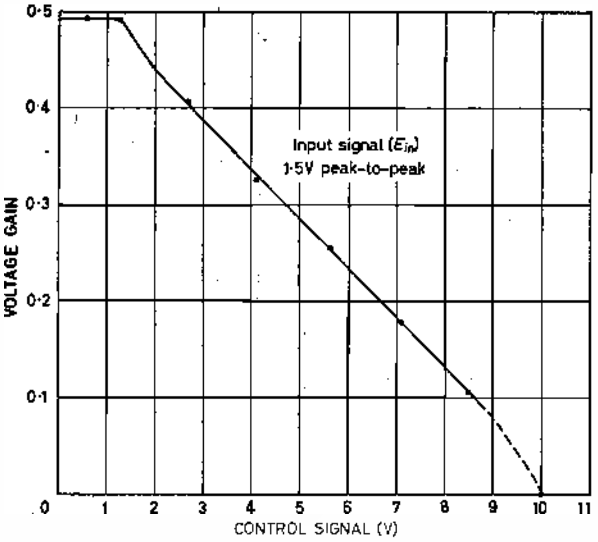


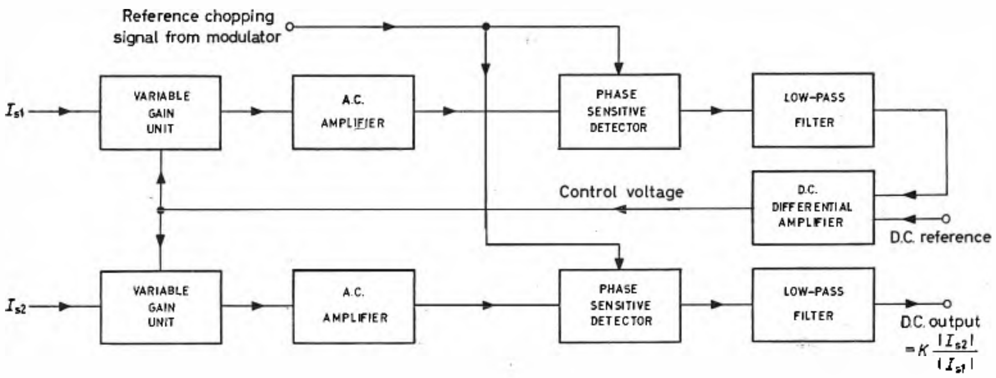
Fig. 6. Gain control characteristic

equation (5) is not obeyed by both units, the linearity is within 5 per cent of the straight line of best fit. The transient response, when the adjustment described previously is made, is such that for a step change of control voltage or a change of input pulse level, the output is a step in amplitude which settles down immediately to its correct value. As indicated in Fig. 6 the linearity of the gain characteristic does not extend to zero gain. If required, however, this can be achieved with a slight increase in complexity as follows. The input signal, as well as being fed into the gain controlling stage via R_s may be fed to a stable phase inverting amplifier whose output should pass, via a resistor (R_{11}) and d.c. isolating capacitor, to the collector of VT_1. The two signal currents flowing into this point are now out of phase. R_{11} is then adjusted so that at the control voltage which is to produce zero gain there is precise cancellation. At other control voltages, an output signal will appear whose amplitude is proportional to the deviation of the control voltage from the zero gain value. This will reduce the slope of the gain-control voltage curve and there will be a phase change in the output signal across the zero gain point.

Applications

(a) The gain control stage was specifically designed for forming the ratio of two electrical signals from photomultipliers in the reference and sample beams of an optical absorption measuring instrument. As the signals are already in a chopped form at 1kc/s it is better to use these signals directly rather than demodulate them and then to operate a dividing circuit. The procedure adopted is shown in Fig. 7. Here the signal I_{S1}, which can be regarded as a reference, although it may vary, is fed to a gain control stage, the output of which is a.c. amplified, phase sensitive detected and filtered. The d.c. output is then compared with a fixed reference signal in a differential amplifier. Any difference is amplified to provide the controlling voltage to the variable gain stage. With a sufficiently high loop gain the system acts to hold the demodulated output constant although I_{S1} may vary. The control voltage is also fed to an identical variable gain unit, amplifier, phase sensitive detector and filter which operates on the second signal I_{S2}. The output of the second filter is then proportional to the desired ratio of the original two variables.

Fig. 7. System for ratio measurement



(b) Another application is that of a simple voltage multiplier where one voltage could be converted to an amplitude modulated pulse train to provide an a.c. signal, and the second input (with suitable d.c. level shifting) used as the control voltage. The output could then be phase sensitively demodulated to obtain the desired product.

Conclusion

A voltage controlled variable gain amplifier with good linearity has been described. Although the circuit was used at 1kc/s, there is probably no reason for its not operating at higher frequencies, at least up to the point where the input impedance of the grounded base stages shows a reactive component. The linearity does not extend down to zero gain, but it can be achieved with an additional circuit if desired.

Acknowledgment

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Appendix

(1) Non-Equal Coupling Capacitances

When the coupling capacitances are not equal the equation for I_3' (0) is different from that given in equation (22). If the capacitances associated with VT_1 and VT_2 are designated as C_1 and C_2 respectively and apart from this the same nomenclature is used as in Fig. 2 the circuit equations can be written as

$$v_1' = e_1' + e_2' + v_2' \quad \ldots\ldots\ldots\ldots (35)$$

$$e_1' = \frac{I_1 - I_3}{C_1} \quad \ldots\ldots\ldots\ldots (36)$$

$$e_2' = \frac{I_s + I_1 - I_3}{C_2} \quad \ldots\ldots\ldots\ldots (37)$$

$$v_1' = (1/\gamma I_3) \,.\, I_3' \quad \ldots\ldots\ldots\ldots (38)$$

$$v_2' = \frac{-I_3'}{\gamma[I_o + I_s - I_3]} \quad \ldots\ldots\ldots\ldots (39)$$

Substituting equations (36) through (39) into (35) and simplifying

$$I_3' = \frac{\gamma}{C_1 C_2} \frac{I_3(I_o + I_s - I_3)}{I_o + I_s} [I_1(C_1 + C_2) - I_3(C_1 + C_2) + C_1 I_s] \quad \ldots\ldots\ldots\ldots (40)$$

The initial value of I_8 (0) is unaffected by the values of capacitance and thus equation (20) is still applicable. This gives

$$I_s'(0) = \gamma \frac{C_1 + C_2}{C_1C_2} I_s((I_1/I_c))(I_c + I_s)(1 - (I_1/I_c))\left(\frac{C_1}{C_1 + C_2} - (I_1/I_c)\right) \quad (41)$$

This equals 0 when $I_1 = 0$ and $I_1 = I_c$ as before together with

$$I_1 = I_c \frac{C_1}{C_1 + C_2} \quad (42)$$

(2) Series Input Resistance R_s

When the input current to the device is supplied from a voltage source a series resistance (R_s) must be used to approximate a current source. A guide to the minimum value of this resistance can be obtained by the non-rigorous method below. Consider a step voltage (E_s) applied to the input through R_s under the condition where VT_2 is cut off, i.e. all the input current is instrumental in producing an output. The input current is

$$I_s = I_s(0) \exp(-t/R_sC) \quad (43)$$

where $I_s(0) = E_s/R_s$

By differentiation

$$I_s' = -\frac{1}{R_sC} I_s$$

Thus there will be a sag (δ_s) on the output pulse given by

$$\delta_s = (T/2) I_s'(0) = (1/2f)(1/R_sC) I_s(0) \quad (44)$$

Now if the system is to have a figure of merit of M then the maximum allowable sag for an input $I_s(0)$ is

$\delta = M\ I_s(0)$ from equation (25)

In order that the preceding analysis should apply it is wise to make the additional sag contribution due to the imperfect input conditions substantially less than this. By stipulating $\delta_s \leqslant 1/10\,\delta$

i.e. $(1/2f)(1/R_sC) I_s(0) \leqslant (1/10) M\ I_s(0)$

this yields

$$R_sC \geqslant 5/Mf \quad (45)$$

(3) Isolation of Output from Control Input

The required relationships existing between the components R_1, C_1, R_2, C_2 and R_4 to provide the desired isolation is calculated as follows. Assume that a signal whose Laplace transform is $E(s)$ is applied to the control input and further that because of the compensating components there is no change in the output d.c. level.

If the current gains of the transistors are taken as unity, then the input produces a change of $-E(s)/2R_3$ in the current flowing out of VT_1 and a change $E(s)/2R_3$ from VT_2. This latter current does not immediately flow into the output point because of the shunt path through C_1. In fact the current will be

$$\frac{E(s)}{2R_1} \frac{1}{1 + SC_1R_1}$$

The sum of the two currents is then

$$I_4 = -\frac{E(s)}{2R_3} \frac{SC_1R_1}{1 + SC_1R_1} \quad (46)$$

The current flowing into the output point because of the compensating network is

$$I_5 = E(s)/R_2 \frac{SC_2(R_4R_2/(R_4+R_2))}{1 + SC_2(R_4R_2/(R_4+R_2))} \quad (47)$$

Now since it has been assumed that there is no change in the output then $I_4 + I_5$ must equal zero.

Therefore

$$1/2R_3 \frac{SC_1R_1}{1 + SC_1R_1} = 1/R_2 \frac{SC_2(R_4R_2/(R_4+R_2))}{1 + SC_2(R_4R_2/(R_4+R_2))} \quad (48)$$

Comparing the two sides of the equation it may be concluded that for the required zero output the following relationships must be satisfied.

$$R_2 = 2R_3 \quad (49)$$

$$C_1R_1 = C_2 \frac{R_4R_2}{R_4 + R_2} \quad (50)$$

Seastations for Aircraft Communications

A new company called Seastation Telecommunications Ltd has been formed to develop and supply trans-oceanic telecommunication systems to provide navigation and communication facilities for high-speed air traffic, especially on the North Atlantic routes. These facilities will consist of permanent floating Seastations for carrying radio, radar and other aeronautical navigational equipment, interconnected with each other and with shore stations by a submarine cable communication system.

Seastation Telecommunications Ltd has been formed with equal shareholdings of Submarine Cables Ltd and Cammell Laird & Co. (Shipbuilders & Engineers) Ltd. Cammell Laird is responsible for the Seastation aspect of the study and Submarine Cables of the communication system.

At the present time when an aircraft is crossing the wider oceans it is out of range of first class communication services. It cannot be contacted and it cannot contact its land bases with the reliability and regularity which is desirable for a good control of air traffic and to achieve the highest standards of safety. To overcome this difficulty a floating Seastation has been designed which can be moored in mid-ocean in deep sea and which is suitable both for the termination of a submarine cable and also for the installation of radio equipment. Communications from aircraft in the vicinity of the Seastation can be passed to the distant shore by means of the submarine cable, and reliable circuits of the very highest quality can be obtained from aircraft to land and vice-versa. The installation of Seastations at intervals along the routes overflown by aircraft crossing the oceans can provide entirely dependable communication with these aircraft at all times.

A Seastation consists of a tubular structure typically about 400ft in length and 16ft in diameter, floating vertically in the sea with the greater part of its length immersed. The top end of the cylinder supports a superstructure well above the reach of waves and providing accommodation for equipment, for crew, for a helicopter landing deck and for aerial systems. The bottom end of the cylinder is moored by three cables to anchorages on the sea bottom. The submarine telephone cables leave the bottom of the Seastation and fall in catenaries to the ocean bed. Power is supplied by diesel oil generators and fuel supplies and provisions for a considerable period are carried.

The motions of the sea decrease rapidly with distance below the sea surface and the configuration of the Seastation described makes use of this fact to the maximum advantage, achieving remarkable stability in the roughest weather. Calculations which have been confirmed by scale model tank tests indicate that for 95 per cent of the time in the North Atlantic the half amplitude pitch or roll will not exceed 0·5° and the vertical motion 0·5ft. Even for extreme conditions the performance meets in full the operational requirements.

The primary communication services provided from a Seastation are intended to be radio in the v.h.f. and u.h.f. wavebands for air traffic control, for airline company traffic and for passenger-to-shore conversations. In addition a number of navigational services for aircraft can be accommodated and primary and secondary radar facilities can be added. Weather reporting and weather forecasting are other uses and all the services can be envisaged as applicable to ships as well as to aircraft.

A Standard Frequency Source

By S. J. Cotton*

A source of standard frequencies is described in which one frequency from the range 40c/s, 50c/s, 80c/s, 100c/s, 200c/s, 250c/s,....20kc/s, 25kc/s, 50kc/s, 100kc/s can be selected by means of a switch. This is obtained from a 100kc/s crystal oscillator and a number of frequency divider stages using diode pump circuits. After pulse shaping, rectangular pulses of height greater than 50V are produced, while the output impedance of the circuit is low. By also driving a clock from a 50c/s supply derived from the same 100kc/s oscillator, a check is maintained on the long term frequency of the source.

(Voir page 423 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 430)

SOME years ago it was felt that a standard frequency source from which one of a number of pre-arranged standard frequencies could be obtained by means of a selector switch would be a useful addition to the measurements laboratory. A 100kc/s crystal oscillator was available and by means of a thermostatically controlled oven a long term accuracy greater than one part in $1{\cdot}4 \times 10^6$ was possible. The accuracy of the final output was, of course, determined by this oscillator. It was now a question of designing a reliable frequency divider. A similar but separate frequency divider was also designed to give a 50c/s output which was amplified and used to drive a synchronous clock. Accurate time measurements were thus possible, and this also provided a check on the long term stability of the source.

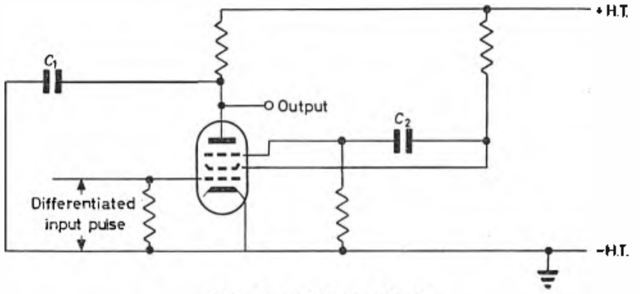


Fig. 1. Transitron circuit

Frequency Divider Circuit

One well-known method that could be used is to feed the differentiated output from the 100kc/s oscillator on to the grid of a pentode in a transitron circuit as shown in Fig. 1.

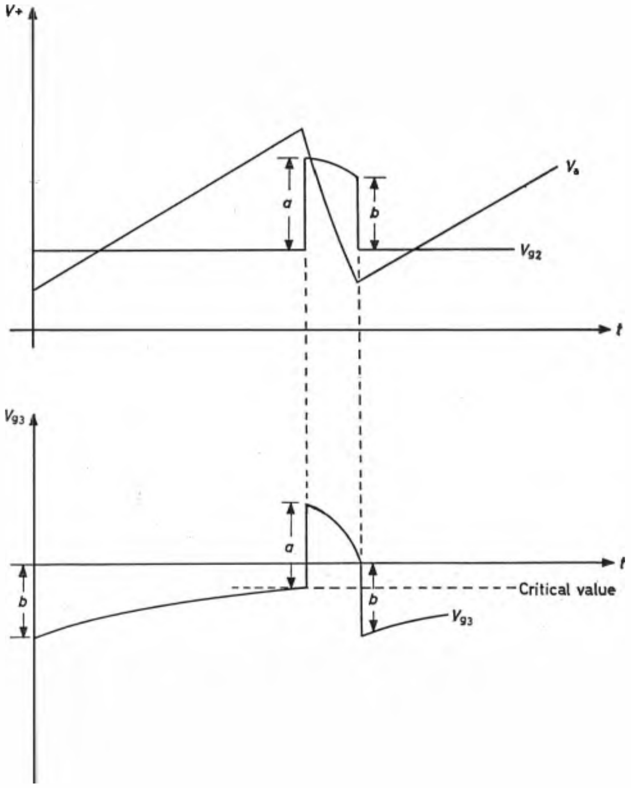
In describing the sequence of events in this circuit one can commence at the point when C_1 is beginning to charge. The anode potential will be insufficient to cause anode current to flow since, as will be seen later, the suppressor is also negative. When free running, the anode potential rises to a point where anode current flows and the screen current will correspondingly fall, causing the screen potential and consequently the suppressor potential to rise. This will produce a further increase in the anode current so that the process is cumulative and, therefore, C_1 discharges rapidly. The anode current will remain constant, while this is taking place, until the knee of the $I_a - V_a$ characteristic is reached, when the anode current will fall and the screen current will correspondingly rise. The screen potential and, therefore, the suppressor potential will fall, and the latter will become negative cutting off the anode current so that C_1 can begin to charge again.

If during the charging time of C_1 a negative pulse is applied to the grid, this will reduce the screen current and, therefore cause a rise in both the screen and suppressor potentials, which will trigger off the discharge of C_1 earlier than if the circuit had been free-running. In this way the frequency of oscillations can be locked to that of the applied signal or some sub-multiple of it.

The wave-shapes of the anode voltage V_a the screen voltage V_{g2} and the suppressor voltage V_{g3} are shown in Fig. 2. It will be seen that as soon as the suppressor voltage reaches a critical value anode current begins to flow and C_1 begins to discharge.

Fig. 3 shows the effect of injecting into the grid circuit pulses of frequency higher than that of the natural frequency of the circuit. These can cause the suppressor to reach the critical value earlier and thus lock the pulse repetition rate of the circuit; in the example given to

Fig. 2. Anode and screen grid waveforms



* *Nottingham Regional College of Technology.*

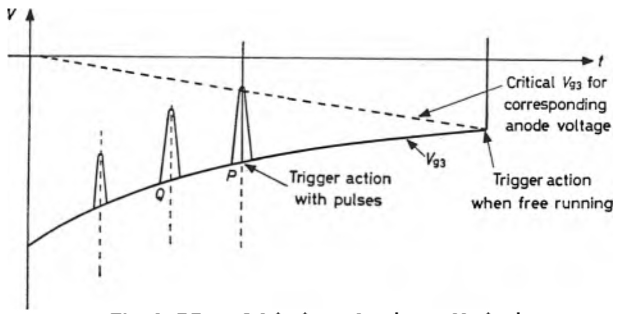


Fig. 3. Effect of injecting pulses into grid circuit

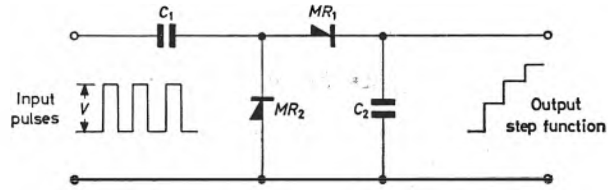


Fig. 4. Diode pump circuit

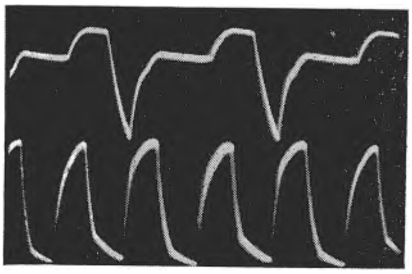


Fig. 5. Anode voltage V_1 = voltage across C_2

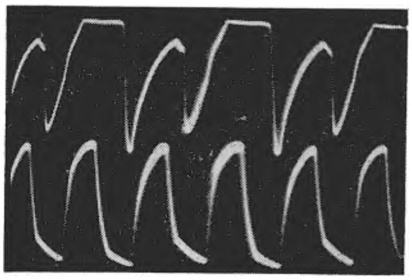


Fig. 6. Grid voltage V_1

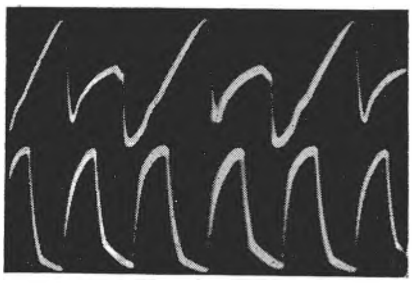


Fig. 7. Anode voltage V_2

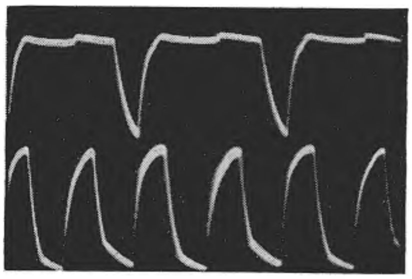


Fig. 8. Grid voltage V_2

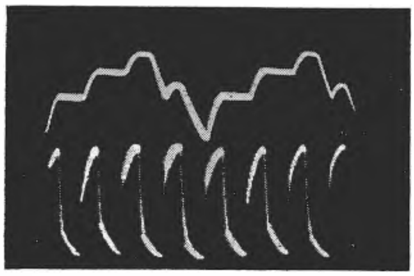


Fig. 9. Anode voltage V_1 = voltage across C_2

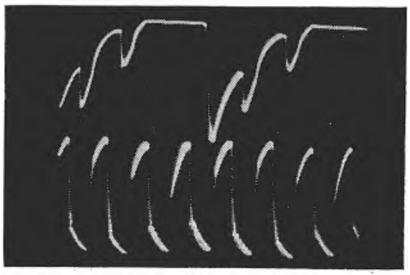


Fig. 10. Grid voltage V_1

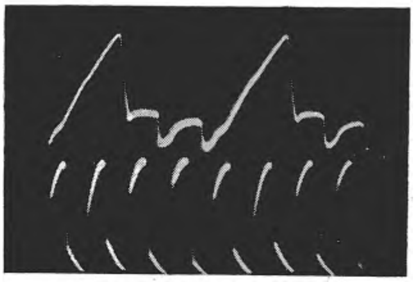


Fig. 11. Anode voltage V_2

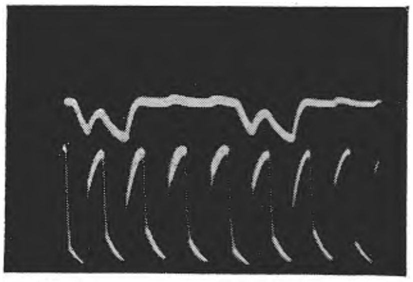


Fig. 12. Grid voltage V_2 (reduced scale)

one-third that of the injected pulses. For this locking to be accurate, the leading edge of the pulse should be very steep; hence the need for a differentiated pulse. If the amplitude of the pulse were increased the second pulse could be made to cut the critical voltage line and the pulse repetition rate could be increased to half that of the injected pulses. Similarly by a reduction in the amplitude of the pulses the pulse repetition rate could be reduced to a quarter or a fifth that of the injected pulses. It will be observed, however, that the variation in pulse height to change from the third to the fourth or any subsequent sub-harmonic of the injected pulse is small so that the use of a switched attenuator to select any particular frequency may not be very reliable. In practice it was found that the ageing of the valves or variation of supply voltage were sufficient to cause an error of selection.

A somewhat different approach was, therefore, needed and use was made of the 'diode pump circuit'. This is fairly well known and consists of a circuit as shown in Fig. 4.

At the leading edge of the pulse when the voltage increases positively by an amount V, MR_1 will conduct and charge C_2. Neglecting the potential difference across MR_1 the applied voltage V will divide to give a voltage output across C_2 of $C_1/(C_1+C_2) \, . \, V$.

If the forward resistance of MR_1 is small then this output voltage step should have a small rise time. When the applied pulse subsequently decreases by V, C_1 can discharge through MR_2 but MR_1 will prevent the voltage across C_2 being affected. When the next pulse is applied the charging voltage across $C_1 + C_2$ is now:

$$V\left(1 - \frac{C_1}{C_1 + C_2}\right)$$

$$= \frac{C_2}{C_1 + C_2} \, . \, V$$

The height of the second step of the output voltage is, therefore, $C_1C_2/(C_1+C_2)^2 \, . \, V$ and the total voltage across C_2 is:

$$\left(\frac{C_1}{C_1 + C_2} + \frac{C_1C_2}{(C_1 + C_2)^2}\right) V$$

$$= \frac{C_1^2 + 2C_1C_2}{(C_1 + C_2)^2} \; V$$

$$= \left(1 - \frac{C_2^2}{(C_1 + C_2)^2}\right) V$$

In general after n steps this could be written as:

$$\left\{1 - \left(\frac{C_2}{C_1 + C_2}\right)^n\right\} V$$

and the height of the n^{th} step =

$$\left\{\left(\frac{C_2}{C_1 + C_2}\right)^{n-1} - \left(\frac{C_2}{C_1 + C_2}\right)^n\right\} V$$

In Fig. 5 the upper trace shows the voltage across C_2 when $C_1 = 2\,000$pF and $C_2 = 500$pF. The lower trace, as in all the oscillograms shown, gives the applied pulse train, not necessarily to the same scale. The height of the first step $= (2/2{\cdot}5)V = (4/5)V$ and that of the second step $= (4/25)V$ or one-fifth that of the first step. Fig. 9 shows similar curves for $C_1 = 2\,000$pF and $C_2 = 2\,200$pF. This gives the height of the first step as $(10/21)V \simeq \frac{1}{2}V$ and that of the second as $(110/441)V \simeq \frac{1}{4}V$. This gives the ratio of the height of the second step to that of the first as $\simeq 1:2$.

Similarly the height of the third step $\simeq \frac{1}{8}V$ so that the ratio of the third to the second step $\simeq 1:2$.

The height of the final step is the critical one as far as accuracy of triggering is concerned and should be as large as possible.

Putting $\dfrac{C_2}{C_1 + C_2} = k$

the height of the n^{th} step $\Delta V_n = (k^{n-1} - k^n)V$ and $d(\Delta V)/dk = [(n-1)k^{n-2} - nk^{n-1}]V = 0$ for ΔV to be a maximum value; i.e. $(n-1) - nk = 0$ or $k = (n-1)/n$.

The values of C_1 and C_2 could, therefore, be adjusted to give the maximum voltage jump for the step prior to the triggering action of the succeeding circuit but these values would also fix the value of voltage across C_2 at which triggering takes place. Taking the figures given for Fig. 9, $k = 2\,200/4\,200 \simeq \frac{1}{2}$ so that the triggering voltage would have to be approximately between $[1 - (\frac{1}{2})^2]\,V$ and $[1 - (\frac{1}{2})^3]\,V$ that is between $\frac{3}{4}V$ and $\frac{7}{8}V$. Considering the optimum condition $k = \frac{2}{3}$ then for a value of $C_1 = 2\,000$pF, C_2 would have to be $4\,000$pF and the triggering voltage would have to be between $[1 - (\frac{2}{3})^2]\,V$ and $[1 - (\frac{2}{3})^3]\,V$ that is between $(5/9)V$ and $(19/27)V$.

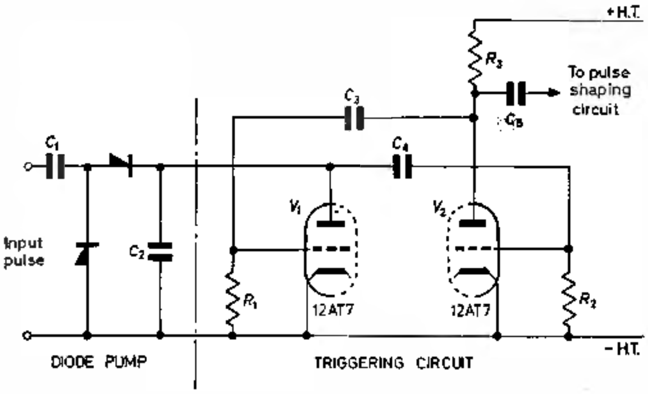
In practice C_1 can be kept constant and for any sub-harmonic of the input signal to be produced the optimum value of C_2 can be switched into the circuit. A further switch is then required to adjust the triggering voltage so that the correct voltage step is selected. Each circuit will thus require two switches. By means of the first circuit either 100kc/s, or 50kc/s, or 25kc/s, or 20kc/s may be selected. For further subdivisions, the output from the first circuit can be fed into a second circuit after pulse shaping, and by means of five such circuits permanently connected in cascade it is possible to subdivide down to 50c/s or 40c/s or lower.

Multi-wafer switches were built up with eleven-way wafers so that each switch could select one of eleven frequencies. Eleven wafers were required per switch—two for each circuit and one to determine from which circuit the final output should be taken. By means of three such switches, together with a fourth switch to select one of these three, very good coverage of the frequency range from 40c/s up to 100kc/s can be obtained.

The next problem was the design of the triggering circuit. The circuit shown in Fig. 13 was finally adopted.

The grid potential of valve V_1 is produced by current flowing through R_1 charging or discharging C_3. At the beginning of a pulse train this bias voltage will be negative, so that valve V_1 will be non-conducting and the stepped output voltage from the diode pump circuit will build up between the anode and cathode of V_1 until the anode voltage is sufficiently positive for conduction to begin.

Fig. 13. Triggering circuit



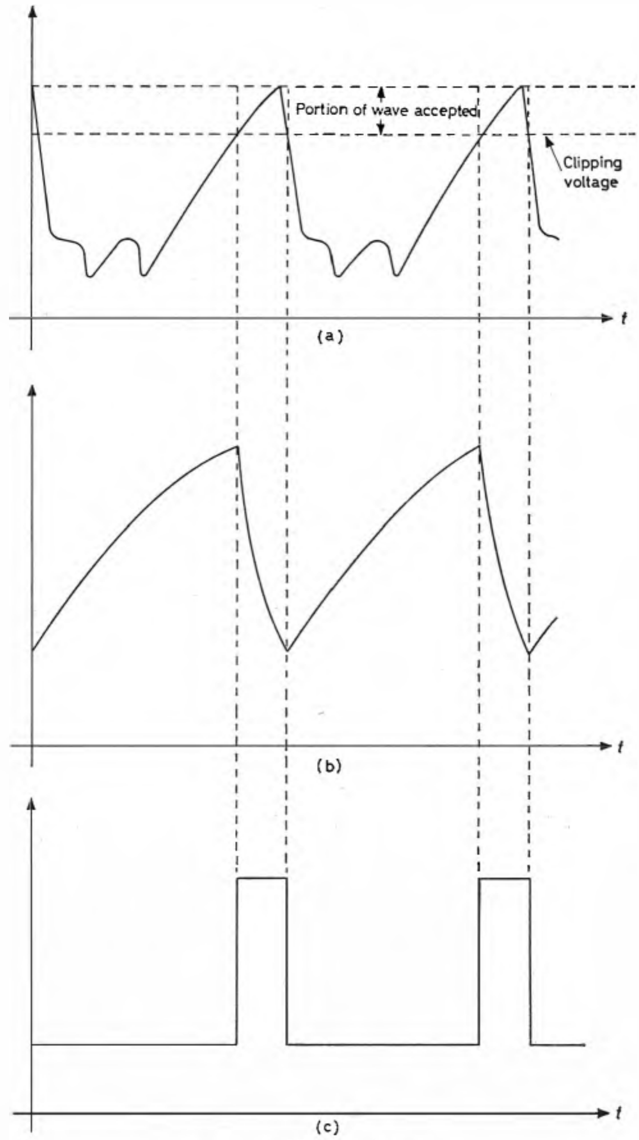


Fig. 14. Circuit waveforms

During this time the grid of V_2 will be held positive so that V_2 conducts heavily and its anode voltage will be low. As soon as V_1 begins to conduct, its anode potential will fall and drag down the grid potential of V_2 causing its anode potential to rise. This drives the grid of V_1 positive and produces a rapid discharge of C_2. For a divide-by-two circuit in which C_2 is relatively small, this discharge time is only a fraction of a pulse width as is seen in Fig. 5, but for a divide-by-four circuit in which C_2 is much larger, Fig. 9 shows the discharge time as equal to one pulse time. When C_2 has nearly discharged, the next pulse will make the anode of V_1 and the grid of V_2 go positive. This will reduce the anode potential of V_2 and drive the grid of V_1 negative, so that the circuit is ready to receive the next pulse train.

The oscillograms of Figs. 5 to 12 show clearly the operation of the circuit. The flat portion of Figs. 6 and 10 shows when the grid of V_1 is positive and the period over which this valve is conducting. Over the corresponding period in Figs. 8 and 12 there is a dip in the grid voltage curve for V_2 which produces a voltage rise in the anode voltage of V_2 as seen in Figs. 7 and 11.

The pulse shaping circuit clips off the lower portion of the output wave from V_2 amplifies, inverts and integrates the result to give a wave shape as shown in Fig. 14.

The output selector wafer switch connected the output from the appropriate pulse shaping circuit to a common output circuit composed of a voltage amplifier and wave shaping circuit which produced rectangular pulses as shown in Fig. 14(c), followed by a cathode-follower to give a low impedance output and a pulse height of 50V or more.

It was found that the characteristics of the germanium diodes used in the pump circuits were very temperature sensitive so that these diodes were finally placed in the thermostatically controlled oven with the crystal.

Clock Circuit and Frequency Check

A further set of five unswitched frequency divider circuits in cascade was driven by the same 100kc/s oscillator to give a 50c/s output which was used after amplification to drive a normal a.c. synchronous clock. After four days the accuracy of the time indicated was within the accuracy of reading the clock. This was within a quarter of a second and meant that the long term frequency accuracy was greater than one part in $1{\cdot}4 \times 10^6$.

Frequency Check and Display

A cathode-ray tube was also incorporated with its own time-base so that the wave shape of the output pulse could be displayed. It was also arranged that the time-base voltage could be replaced by the standard 200kc/s transmitted by the BBC. By beating the 100kc/s output from the oscillator with this, the frequency of the oscillator could be accurately adjusted by varying its feedback capacitor.

Conclusion

A standard frequency source has been produced of sufficient accuracy to meet any normal laboratory requirement. It can be quickly used for calibrating or timing and because of its low impedance output can be fed round the laboratory to any point and used by more than one person at a time.

Acknowledgement

The author would like to thank the Governors and Principal of the Nottingham Regional College of Technology for permission to publish this article.

High Reliability Marine Radar

The Decca TRANSAR series is claimed to be the first full range of transistorized marine radar in the world. In announcing this advanced equipment Decca also claim to have established new standards of reliability for shipboard electronic equipment as a result of the rigorous testing and quality control procedures which have been adopted for this new equipment. All TRANSAR radars have been certified as meeting in full the type approval requirements of the British Board of Trade and the United States Federal Communications Commission.

The TRANSAR series comprises 17 radars, meeting all requirements from the small inexpensive relative motion radar to high performance true motion equipment. The operational demands of all classes of vessels are fully catered for. At the same time the shipowner is provided with a wide choice of price and performance from each type of radar.

The 17 new TRANSAR radars are divided into five principal groups as follows:

Group 2 *Low Cost Radar:* two sets offering a choice of 6 or 12in display units.

Group 3 *9in Display Relative Motion Radar:* five sets offering a choice of 4, 6 or 9ft aerials with 10 or 25kW transceiver.

Group 4 *12in Display Relative Motion Radar:* four sets offering the choice of 6 or 9ft aerials with 10 or 25kW transceiver.

Group 5 *High Definition Radar:* two 10kW sets with 12in displays offering a choice of 6 or 9ft aerials.

Group 6 *True Motion Radar:* four sets offering a choice of 6 or 9ft aerials with 10 or 25kW transceiver.

In addition to these 17 radars Decca also manufacture four river radars designed primarily for use on inland waterways.

The new Decca marine radars have been designed from the outset to give entirely new standards of reliability. The TRANSAR radars are claimed to be the first commercial marine radars in the world developed and produced under planned reliability testing conditions, based on the proposals of the United States Government Advisory Group on the Reliability of Electronic Equipment (AGREE). These proposals call for the use of test procedures with statistical analysis throughout component selection, unit design, prototype evaluation and final production. To implement this programme the Decca Company has invested substantial capital to build up a reliability testing centre which is almost certainly among the best equipped in the United Kingdom. This unit has been in operation throughout the design and development phase of the TRANSAR radars. Heat, cold, immersion, spray, vibration, corrosion, humidity, shock, wind loading and life testing are some of the rigorous climatic, durability and performance tests which the radars have survived. The AGREE test unit is now being used for production testing on a large scale. Batches of radars from production are undergoing 500 hour testing periods which include intensive temperature and humidity cycling to ensure that the reliability and performance standards of the original design are being maintained.

All the TRANSAR radars employ slotted waveguide aerials of completely watertight construction, providing excellent performance with narrow horizontal bandwidths and exceptionally low side-lobe levels. The availability of aerial units of 4, 6 and 9ft horizontal aperture ensures that the various radars in the series provide the correct performance for their roles and that any installation limitations as regards size can be allowed for.

The transceivers used in the TRANSAR series offer a choice of 3, 10 or 25kW peak power. The 3kW unit, suitable for 24 mile radars, incorporates all normal facilities including dual pulse lengths and full remote control from the display position. The 10 and 25kW units feature multiple pulse lengths and pulse repetition frequencies, dual beamwidths and other refinements ensuring optimum performance at all ranges.

With the exception of the true motion display which is a pedestal mounted unit, the other displays are all suitable for installation either to a bulkhead or deckhead, or by means of a pedestal. A variable range marker reading from zero to the full displayed range is available for all displays with the exception of the 6in diameter unit.

Capacitors with Thin Oxide Film Dielectrics

By B. Walton*, B.Sc., A.Inst.P.

The methods of preparing thin oxide dielectric films are reviewed briefly and it is concluded that the vacuum deposition of refractory metal oxides provides the best results. The process by which this can be carried out and the production of such capacitors are described in some detail. The properties of these capacitors are reviewed and it is shown that they possess many desirable qualities.

(Voir page 423 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 430)

CONVENTIONAL discrete capacitors are available in a wide variety of types but in considering the development of a new capacitor with desirable properties, particularly one capable of being produced in flat film form, attention was focused on electrolytic and glass capacitors. Although superficially very different, these two types of capacitor have the basic common feature of employing a metal oxide dielectric. The dielectric layer is very thin (of the order of 1 000Å) in the electrolytic capacitor, so that the capacitance per unit volume is exceptionally high, but the electrical properties are impaired by the need to provide an electrolytic electrode. Glass capacitors, on the other hand, have excellent electrical properties but, because of the method of manufacture, the dielectric layer is relatively thick and the capacitance low. A capacitor with a very thin oxide dielectric but without the need for the self-healing action of an electrolytic contact would have the merits of both types. The aim of the work described was to produce such a component.

Methods of Preparing Thin Oxide Film Dielectrics

To be useful as capacitor dielectrics thin films must be capable of withstanding voltage stresses of the order of 10^6V/cm. This precludes the use of crystalline films since grain boundaries are a source of electric weakness. Dense, amorphous, oxide films which are adherent to the underlying substrate have been prepared in a number of different ways, which fall into three main categories.

(a) Oxidation of Metal Surfaces

The oxidation may be accomplished by anodization or by heating the metal surface in an oxidizing atmosphere. The oxide layers formed in this way on evaporated metal surfaces have properties superior to layers formed on the bulk metal, presumably because of impurities in the latter, its granular nature, and the roughness of the surface. The evaporated films have the smoothness of the underlying glass. Advantage of this has been taken in the development of microcircuits in which the capacitor dielectric is formed by anodizing an evaporated metal film, notably tantalum, in situ on the substrate[1].

(b) Decomposition of Metallic Compounds

The hydrolysis of titanium tetrachloride to form titania and the pyrolysis of methyl orthosilicate to form silica, in both cases from the vapour phase, have been used to form good quality anti-reflection coatings for glass[2]. It appears, however, that it is difficult to produce completely dense films by these methods. The micro-porosity which occurs renders the electrical properties sensitive to atmospheric moisture. Some attempts have also been made to produce capacitor dielectrics by depositing films of alkoxides from suspensions in liquids. These are then decomposed by heating to form the oxide[3]. No successful capacitors have been reported.

(c) Vacuum Deposition

Thin films of metal oxides, particularly the more refractory ones, have generally been prepared in vacuum by reactive sputtering but the process is rather slow. Most vacuum deposited thin film capacitors, therefore have been prepared by the direct evaporation of silicon monoxide which has a high vapour pressure and can be evaporated rapidly at a relatively low temperature from a simple source.

All three of the above methods have been used to prepare dielectric films but the best results have been obtained by the vacuum deposition of refractory metal oxides.

The Evaporation of Refractory Metals and Oxides

For the rapid evaporation of substantial quantities of refractory materials very intense heating is required. This may be provided by bombarding the material with a stream of electrons emitted from a filament and accelerated by a strong electric field. This technique was first suggested by O'Bryan[4] as early as 1934 but it was not until 1958 that a successful development was reported by Milleron[5]. He devised an elegant method for the continuous evaporation of metals by electron bombardment.

The evaporation took place from a molten bead on the end of a wire, which was maintained at 5 to 10kV above earth potential and placed just below a small circular tungsten filament at earth potential. The wire was fed continuously from a spool so that the position of the tip remained constant. The method can only be used for comparatively small diameter wires, thus limiting the rate of evaporation.

Modified versions of the above method have been devised for the rapid evaporation of a variety of metals and metal oxides. This has involved the design of electron bombardment heating systems capable of dissipating over 1kW of h.t. power, with currents of the order of 1A. The copious stream of electrons emitted from the filament when such heavy currents are used must be concentrated on the target anode. This was achieved by surrounding the filament and anode with metal screens maintained at the same potential as the filament. The target anode was essentially in the form of a short cylinder standing on the baseplate. The screens were arranged symmetrically around this target and their position, shape, and the position of the filament relative to the target, were adjusted empirically to obtain maximum concentration of heating on the top of the target. Immediately above the target and filament there is a large hole in the top cover screen through which the evaporant passes. This is covered with a wire mesh screen.

The design and selection of materials for the target itself depended on the material to be evaporated and a number of different target arrangements were devised. Those for aluminium and silica will be described.

Aluminium is one of the metals with a low melting point

* *Welwyn Electric Ltd.*

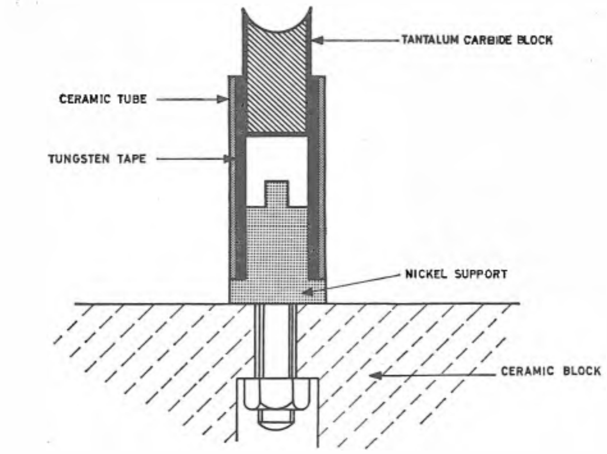
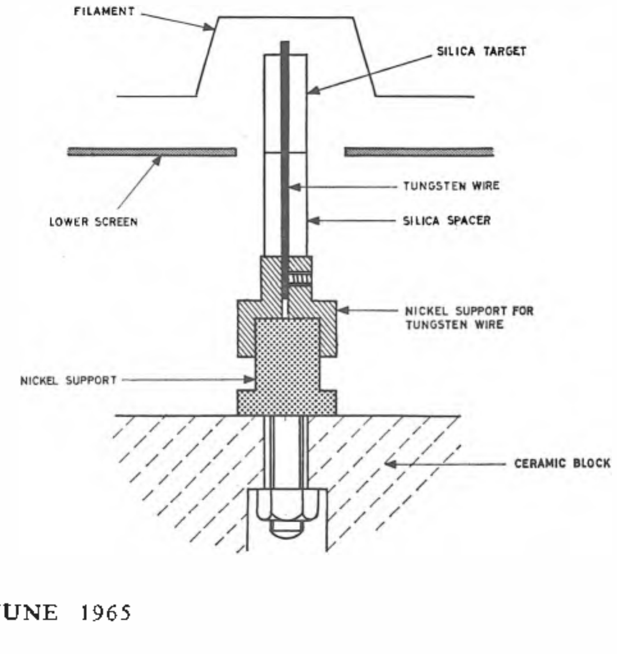


Fig. 1. Target assembly for the continuous evaporation of aluminium

but high evaporating temperature which therefore cannot be evaporated directly from a molten drop on the end of a wire; the molten metal must be suppported. Tantalum carbide was selected for the hearth block. This is a highly refractory, electrically conducting material available in the form of a sintered solid. A short rod of the material, of diameter $\frac{1}{8}$in and with a concave end face was supported by a thin walled ceramic tube lined with a tungsten tape (Fig. 1). The ceramic tube provided mechanical support without allowing much heat to be conducted away from the hearth and prevented direct bombardment of the tungsten tape which was at h.t. potential. The tungsten tape made the electrical connexion to the hearth and was in contact with a nickel block bolted directly to a ceramic insulator which in turn rested on the baseplate at earth potential. In this way the electrical stress was confined to an insulator maintained at a relatively low temperature. Aluminium wire was fed from a spool by motor driven rubber rollers on to the heated top of the tantalum carbide block. In this way, the metal was evaporated continuously at the rate of about 0·2g/min with a power input of some 650W.

For the evaporation of silica the tantalum carbide block was replaced by a short length of silica tubing which itself became the target (Fig. 2). This was supported on another length of silica tubing which in turn rested on the same

Fig. 2. Source for the evaporation of silica by electron bombardment



base used for the tantalum carbide target. Silica is, of course, an insulator at room temperature and a tungsten wire passing through the bore of the silica tubing was therefore provided. The tip of this wire was bombarded first and became very hot indeed, (sufficiently hot to melt the tungsten) thus heating up the surrounding silica. The silica then became conducting so that it was rapidly heated by direct electron bombardment and evaporation took place. The rate of evaporation is of the order of 0·1g/min so that at a distance of 20in the rate of deposition is about 200Å/min.

Production of Capacitors

The surface on which the films are deposited must be very smooth, and since ceramic substrates offer many advantages for integrated circuits, glazed alumina is used. After the application of metal contact lands, to which leads are subsequently soldered, the substrates are thoroughly cleaned using conventional procedures. From this stage onwards, until the completion of the capacitors the substrates are kept in a dust-free clean room and not touched by hand. It is extremely important to prevent contamination of the substrate surface and avoid dust inclusions in the dielectric film.

The vacuum plant itself is of conventional design and the substrates are held by small springs in an orthogonal array of holes cut into a 22in diameter brass disk. The three sets of thin metal masks required respectively for the base electrode, dielectric and counterelectrode, are mounted on similar disks which accurately register on the substrate holder. The substrates are pressed firmly into contact with the masks by springs mounted on a third circular backing plate. The masks themselves are punched from a continuous length of nickel silver strip. Loading the substrates into the holder, unloading, and mask changing can be carried out in a few minutes but the chamber must be opened twice for mask changing so that it has to be evacuated three times per cycle. The provision of a large pumping system, however, ensures that this does not greatly lengthen the cycle time. Furthermore, a large number of substrates is processed in each cycle (e.g. over 100 samples of the relatively large 1in square size) so that the deposition process is very economic.

Aluminium is used as the electrode material because it has a high electrical conductivity and forms a stable oxide which bonds strongly to the metal. The latter property is important in promoting the strong adhesion of the metal to the glaze[6]. Aluminium also has the advantage of enabling minor defects in a capacitor to be 'cleared'. In this process aluminium covering a weak part of the dielectric layer is converted to the insulating oxide by deliberately causing electrical breakdown and the creation of a high temperature spark. The aluminium is normally evaporated until the sheet resistivity falls to 1 to 5Ω/sq. By keeping the pressure below 5×10^{-5} torr and depositing the metal very rapidly this conductivity can be achieved in films only a few hundred Angstroms thick.

The silica layer is normally 2 000 to 5 000Å thick. The thickness is controlled either by evaporating a fixed mass of silica or by observing the colour changes of a control layer deposited on to a titanium film. Substrates mounted in the centre of the holder, directly above the source, are closer to the source than those near the outside edge of the holder and would therefore normally receive a substantially thicker deposit of silica. This is prevented by interposing between the source and the substrates a rotating vane which cuts off some of the silica vapour. The shape of the vane is arranged, by experiment, to be such that a film of uniform thickness is obtained.

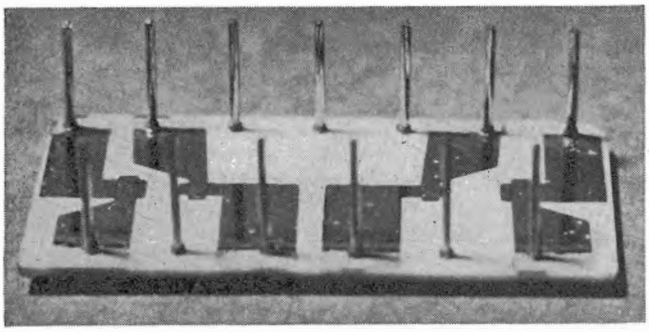


Fig. 3. Typical substrate with capacitors

The counterelectrodes are normally deposited so that they cross right over the base electrodes. The effective area of the capacitor then only depends on the width of the two electrodes and not on their relative positions. This means that registration of the masks relative to the substrates need not be very precise.

After removal from the vacuum chamber, a steadily rising voltage is applied to the capacitor up to a maximum of twice the peak working voltage. Defects 'spark out' as the voltage rises until the capacitor will withstand the full voltage without breakdown. The capacitors are then ready for measurement, lead fitting and protection. A photograph of a typical substrate on which capacitors have been deposited is shown in Fig. 3.

Properties of the Capacitors

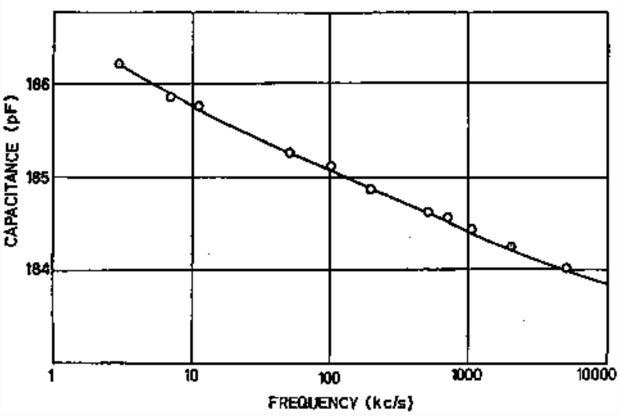
Properties of the Dielectric

The properties of the dielectric approximate to those of bulk vitreous silica. X-ray diffraction, electron diffraction and electron microscopy fail to reveal any crystalline structure. The dielectric constant has been calculated to be 4·2 which is a little higher than the value for pure fused silica (3·9). This may be due to inaccuracies and uncertainties in the measurement of film thickness or it may be due to minor impurity inclusions in the film. This value for the dielectric constant gives a capacitance of 12 400pF/cm² for a film 3 000Å thick.

A very important property of the dielectric is its relative insensitivity to atmospheric moisture. Even when immersed in water in an unprotected condition, the dielectric seems to be little affected, so that performance of the finished capacitors is not critically dependent on providing a moisture resistant coating. This is in marked contrast to many other thin film dielectrics.

The electric strength of the dielectric, as measured by the voltage breakdown of the capacitors, varies considerably from one unit to another. This is almost certainly due to the presence of 'defects' in the film. As already mentioned the defects are cleared by sparking at steadily increasing voltages. This process cannot be carried on indefinitely, however. Above a critical voltage the amount of sparking increases rapidly and large areas of the counter-electrode are removed. In some cases breakdown voltages as high as 500V/μ have been achieved, which is about half the intrinsic electric strength of fused silica. A more typical value, however, is 200 to 300V/μ. In general, capacitors of small area have higher breakdown voltages than larger ones and this is clearly a matter of the statistical chance of defects occurring in a given area.

Fig. 4. Variation of capacitance with frequency



Electrical Parameters of the Capacitors

Capacitance Value

The usual range of film thickness is from 2 000 to 5 000Å so that the capacitance per unit area varies from just under 20 000pF/cm² to 8 000pF/cm² with corresponding working voltages of, say, 20V and 50V respectively.

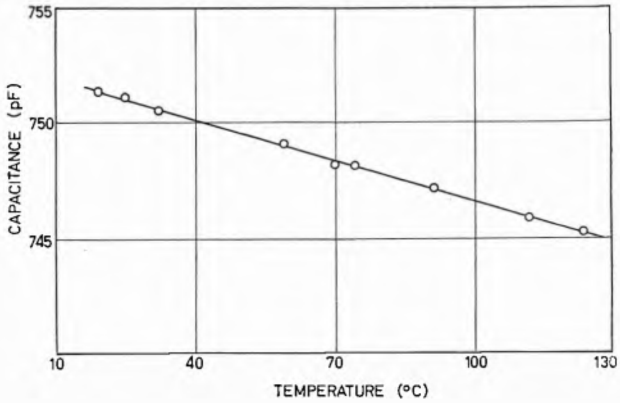


Fig. 5. Variation of capacitance with temperature
(capacitance measured at 10kc/s)

A tolerance of ± 10 per cent can readily be obtained without adjustment.

The capacitance is not independent of the frequency, although over a wide range of frequencies the variation is only slight. The value falls by 0·2 per cent to 0·5 per cent per frequency decade over the range 100c/s to 10Mc/s (Fig. 4). At high frequencies the electrode resistance becomes important. For a capacitor having a series resistance R_S the impedance has equal resistive and reactive components when $\tan\delta = 2\pi f_C C R_S = 1$. For the silica capacitor in question the series resistance is a few ohms, and the 'cut-off frequency', f_C, a few tens of megacycles per second.

The variation of capacitance with temperature over the interval -40°C to $+150$°C is fairly linear (Fig. 5). The temperature coefficient of capacitance ranges from -80×10^{-6}/°C, to $+100 \times 10^{-6}$/°C which is satisfactorily low for most applications.

Loss Tangent

The value of $\tan\delta$ depends of course upon the frequency of measurement. At 1kc/s the value lies between 0·001 and 0·01 with a typical value of 0·0025. Fig. 6 shows the variation in $\tan\delta$ for a 100pF capacitor over the frequency ranges 100c/s to 10Mc/s.

There are three contributions to the energy loss in a capacitor when an alternating field is applied. There is loss due to dissipation in the parallel leakage resistance (R_p), loss in the series electrode resistance (R_S) and internal loss in the dielectric itself.

The contribution to the loss of the series resistance is given by $\tan\delta = 2\pi f C R_S$.

For a capacitor of 1 000pF with a series resistance of, say, 5Ω, $\tan\delta_S \simeq 3 \times 10^{-8} f$. Thus, above 1Mc/s this effect dominates the loss and is responsible for the rapid rise in $\tan\delta$ shown in Fig. 6. By increasing the conductivity of the electrodes and adopting a favourable geometry, however, this loss can be greatly reduced so that the upper frequency limit of operation is considerably raised.

The loss due to the d.c. leakage resistance is given by $\tan\delta_p = 1/(2\pi f C R_p)$. The leakage resistance is actually between 20kΩ Farad and 100kΩ Farad so that again taking the case of a 1 000pF capacitor, $\tan\delta_p \simeq (3 \times 10^{-6})/f$.

This is quite negligible even at 1c/s and cannot account for the rise in $\tan\delta$ below 1kc/s.

This rise and the finite value of $\tan\delta$ over the intermediate frequency band must be due to dielectric loss. At least two kinds of relaxation process must be involved;

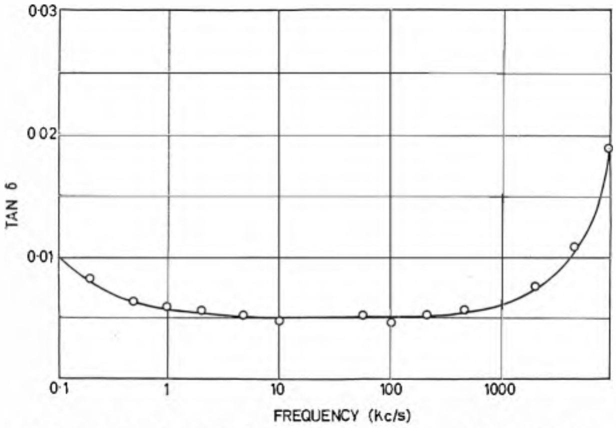


Fig. 6. Variation of tan δ with frequency for a 100pF capacitor

one such that the loss is substantially independent of frequency over a wide range of frequencies, and the other slow so that loss only occurs at low frequencies. This is confirmed by the variation of $\tan\delta$ with temperature. A high frequencies (10kc/s and above) $\tan\delta$ only increases by 60 per cent to 100 per cent to a figure of, say, 0·004 when the temperature is raised from 20°C to 120°C. At low frequencies (< 100c/s), however, $\tan\delta$ may increase fivefold when the temperature is raised by a similar amount (Fig. 7).

Test Data

No specification exists for silica capacitors, nor indeed for any other form of flat film capacitor. In tests based on a specification for mica capacitors, DEF 5132, the change in value of thin film silica capacitors after 1 000 hours at 100°C with 10V applied was less than 0·1 per cent and the changes in $\tan\delta$ were negligible.

In climatic tests to the same specification, the change in capacitance after 6 damp heat cycles (at 55°C and 95 per cent r.h.) followed by 5min load at 40V was again less than 0·1 per cent and the change in $\tan\delta$ was negligible. The application of voltage stress in dry or in moist conditions had no appreciable effect on the capacitors.

Approximately 90 capacitors of each of three values, 200pF, 750pF and 3 000pF were stored for four months at room temperature. These capacitors were drawn from early experimental batches and some samples developed faults that were identified with imperfections in manufacturing techniques which have now been eliminated. The remainder generally increased in value slightly and the

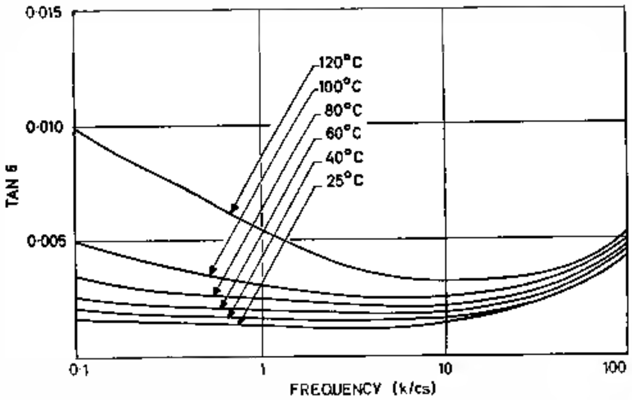


Fig. 7. Variation of tan δ with frequency at different temperature (750pF capacitor)

changes fitted a distribution having a median value of $\Delta C = +0{\cdot}5$ per cent with 95 per cent less than $\Delta C = +2{\cdot}0$ per cent.

The operating temperature is limited by the organic protection applied, not by any fundamental deterioration of the dielectric itself.

Acknowledgment

Many contributions were made in this investigation by Mr. J. Rutherford and Mr. E. T. Shepherd.

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A Telephone Exchange Using Dry Reed Relays

The recent opening of the Electronic Exchange Unit at Leamington is an important milestone in the development of electronic exchanges for the British telephone network. This is the first electronic unit to be used in public service following the decision, taken in 1963, to concentrate U.K. development resources on space division systems using reed-relays.

The Leamington and Peterborough units are service trials of an exchange system suitable for exchanges serving up to 2000 subscribers. For exchanges larger than 2000 lines the Post Office and the industry are co-operating in the development of a somewhat different electronic exchange system but which also uses reed-relays.

Both British reed-relay systems now being developed offer all the advantages looked for from electronic systems. They work much faster and have the capability for providing new subscriber services. They will be more reliable in operation and such failures as do occur will be detected automatically and avoided. The service they give is expected to be of a high standard and they will be cheaper to run and take up less space.

The key component in the Leamington unit, as in the other British electronic systems under development, is the reed-relay which is used for speech path switching and certain control functions. A miniature reed-relay which provides four contacts in a volume of about 2in^3 has been specially developed for British electronic exchanges. Each contact is gold plated and is protected from dust by a glass seal; it is expected to withstand many millions of operations without failure.

The Leamington unit is a centrally controlled system in which all connexions are set up at high speed by electronic common equipment. This is duplicated, and a careful system of fault detection ensures that faults in either one of the control equipments do not affect subscribers.

Curvature Attachment for a Surface Finish Instrument

By B. B. Trott*, B.Sc., Ph.D.

An attachment is described for a surface finish instrument, to derive the second differential and curvature of the surface profile. A circuit description, details of calibration and test results are given.

(Voir page 423 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 430)

MOST surface finish instruments, e.g. the Talysurf, record the profile of the surface and the average variation of height from the mean (centre line average or c.l.a.). The c.l.a. reading does not take into account the periodicity of surface variation. Myers[1] suggested that the c.l.a. of the first and second differentials of the profile should also be measured. Rubert[2] and Reason[3] made other suggestions for overcoming the difficulty.

The present requirement was to construct an attachment for a Talysurf surface finish instrument, to display the second differential on a recorder trace. It was not intended to measure the c.l.a. of the second differential. It was realized during the work that the attachment could easily be converted to show the instantaneous curvature of the surface profile, and the circuit was modified accordingly. Curvature is easier to comprehend than the second differential of the profile.

Circuit Description

The input (Fig. 1) is taken from the 'average meter' output of the Talysurf, which comes from the grid circuit of the valve driving the pen recorder.

The signal, which represents the surface profile, is amplified by V_1 and attenuated when necessary by S_1 and S_2. S_1 is set to offset the vertical (surface height) magnification of the main Talysurf instrument, so that the signal passed on by the cathode-follower V_{2a} is in constant relation to the variations in surface height (y), for a given horizontal magnification. The signal is reduced by 5 times when the horizontal magnification is 20 times (i.e. when the stylus traverses the surface at 0·01in/sec instead of at 0·002in/sec as it does at 100 times horizontal magnification).

V_3 and the associated components form the first differentiating stage. If V is the signal voltage at the cathode of V_{2a}, and t is time in seconds, then the signal voltage W (the change from the steady voltage) at the anode of V_3 is given by:

$$W = T \, . \, dV/dt,$$

where T is a constant, with the dimensions of time, approximately equal to $C_4 . R_{25}$, $C_5 . R_{26}$ and $C_6 . R_{27}$. L_1 limits the high frequency response of the stage to 6, 12, or 25c/s, according to the setting of S_4. R_{23} or R_{24}, plus 3kΩ from the resistance of L_1 and the output resistance of V_{2a}, damps the inductance-capacitance circuit (0·7 × critical damping).

Now if the horizontal and vertical positions of the stylus are given by x and y, the known quantities are dV/dy and dx/dt. Let $dV/dy = k$ volts per 0·001in when the horizontal magnification is 100×. Now:

$$dy/dx = \frac{dV/dt}{dV/dy \, . \, dx/dt}$$

$$\therefore \; W = T \, . \, dV/dt \, .$$
$$= T \, . \, dV/dy \, . \, dx/dt \, . \, dy/dx$$
$$= 2Tk \, . \, dy/dx$$ at either 20× or 100× horizontal magnification.

The signal from the anode of V_3 is attenuated by the range switch S_4, which sets the second differential or curvature (in reciprocal inches) represented by full scale deflexion of the auxiliary pen recorder. The maximum output at the cathode of the cathode-follower V_{4a} is pW when the apparatus is set for 100 × horizontal magnification, and 0·2 pW when the apparatus is set for 20× horizontal magnification, p being a constant, approximately equal to 0·5, when the attachment is set for second differential.

The cathode of V_{2b} is maintained at the mean voltage of the junction of R_{34} and R_{41}. When the attachment is set for curvature the network consisting of resistors $R_{53\text{-}55}$ and Zener diodes $MRZ_{2\text{-}7}$ changes p from a constant to a non-linear function such that $d(pW)/dW$ is $\frac{1}{\{1 + (dy/dx)^2\}^{3/2}}$, (±20 per cent), times the constant value.

The values of the components were calculated numerically.

V_5 and the associated components form the second differentiating stage. By a similar calculation to the previous one, if X is the signal voltage on the anode of V_{5a}, then $X = T \, . \, d(pW)/dt$.

When the apparatus is set for second differential and S_4 is set to '200 reciprocal inches', then:

$$X = Tp \, . \, dW/dt = Tp \, . \, d/dt \, (2Tk \, . \, dy/dx)$$
$$= 2T^2pk \, . \, dx/dt \, . \, d^2y/dx^2$$
$$= 4 \times 10^{-3} \, . \, T^2pk \, . \, d^2y/dx^2$$

When the apparatus is set for curvature, with S_4 set to '200 reciprocal inches', then:

$$X = T \, . \, d(pW)/dW \, . \, dW/dt$$
$$= \frac{4 \times 10^{-3} \, . \, T^2pk}{\{1 + (dy/dx)^2\}^{3/2}} \, . \, d^2y/dx^2$$
$$= 4 \times 10^{-3} \, . \, T^2 \, pk \, . \, 1/R$$

where $1/R$ is the instantaneous curvature of the surface profile.

The signal passes through an additional low-pass filter to an output stage and recorder similar to that of the main Talysurf instrument. The gain control RV_2 is adjusted to make the full-scale deflexions of the recorder agree with the settings of S_4.

Calibration

For calibration S_1 is set to position 1, S_2 is set to '100 times horizontal magnification', the range attenuator is set to '200 reciprocal inches', and S_3 is set to 'calibration',

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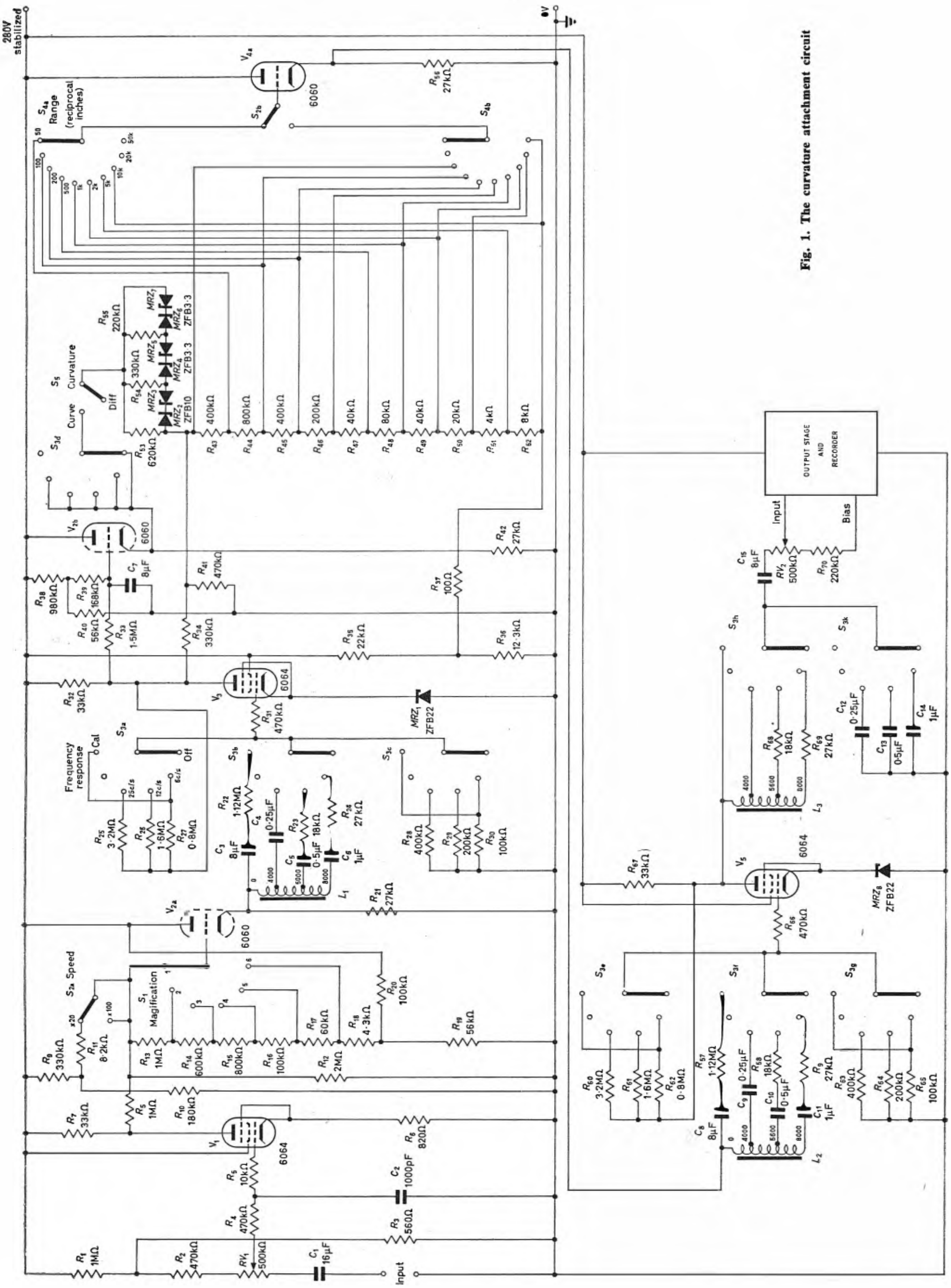


Fig. 1. The curvature attachment circuit

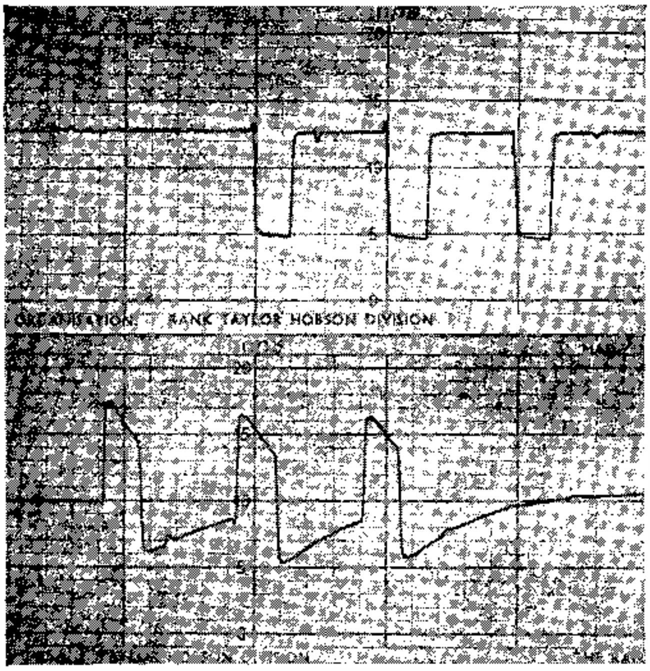


Fig. 2. Calibration traces

which automatically disconnects the curvature clipping circuit. For calibration the settings of S_1 and S_2 do not have to agree with the control settings on the Talysurf. A suitable sample, such as the standard test piece, is used in the Talysurf, and the gain control of the differential attachment is adjusted until the deflexions on the two recorders are similar. The sample should preferably give a sharp square waveform, as the differentiating attachment is a.c. coupled and the trace droops. In Fig. 2 the upper trace is the normal Talysurf trace, with a vertical magnification of 10 000 times and a horizontal magnification of 100 times, and the lower trace is the auxiliary trace.

The traces are of opposite sign during calibration. In normal use a positive deflexion on the curvature recorder corresponds to a projection from the test piece. This is mathematically incorrect but agrees with the instinctive thoughts of the operator.

When the differentiating attachment is set on 'cal' the capacitors of the differentiating stages are replaced by calculated resistances, in series with large capacitors to maintain d.c. levels. Let the sample have a sine wave profile with a periodicity of N cycles per inch and an amplitude of 0·001in. If this sample was tested for second differential, with the Talysurf set for 1 000 × vertical amplification and 100 × horizontal amplification, the main recorder would give a peak deflexion of full scale. Let the auxiliary recorder, with the differentiating attachment set at 200 reciprocal inches, also read full scale on the peaks of the sine wave. (The recorder gives a centre-zero indication). Then the peak second differential is 200 reciprocal inches. The surface profile is described by:

$$y = 0{\cdot}001 \sin (2\pi N x)$$

and the second differential is given by:

$$d^2y/dx^2 = -0{\cdot}001 \,.\, 4\pi^2 N^2 \,.\, \sin (2\pi N x)$$

where y is the vertical height of the surface, and x is the distance along the surface, both measured in inches.

$$\therefore\ 200 = 4\pi^2 N^2 \times 0{\cdot}001$$

$$\therefore\ N = 71{\cdot}1$$

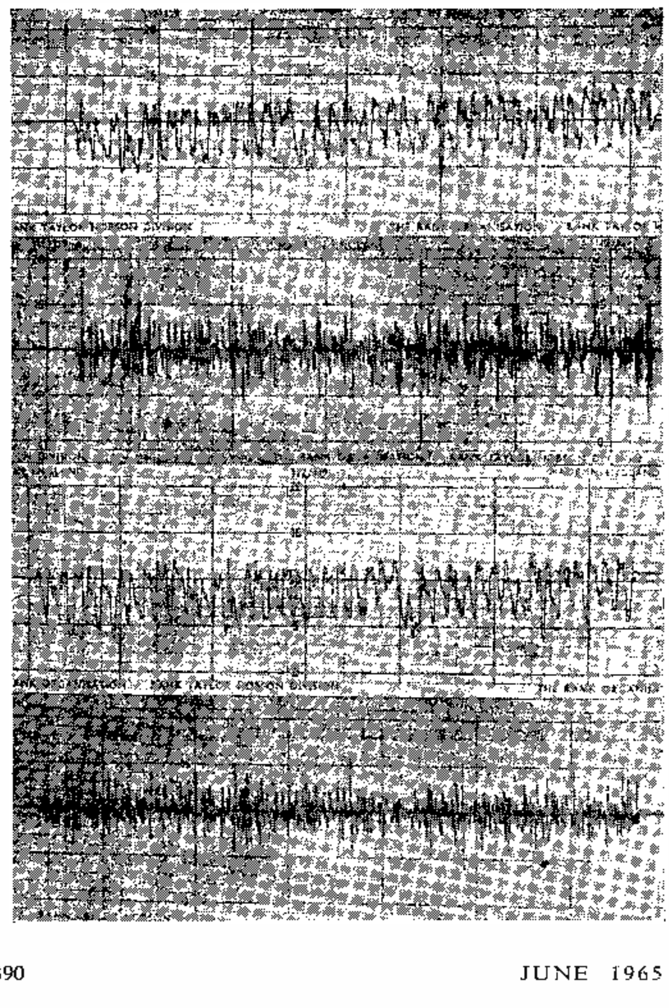
At a horizontal magnification of 100 ×, the Talysurf stylus travels at 0·002in/sec. Therefore with a periodicity of 71·1 cycles per inch, the frequency of the signal is 0·142c/s.

If the differentiating attachment was switched to 'cal' in these circumstances, it should give a similar maximum deflexion. Therefore the resistances which replace the differentiating capacitances should have a similar impedance at 0·142c/s. As the differentiating stage is set as though for the 1·0μF capacitors on 'cal', the resistance should be 1·12MΩ.

The stylus of the Talysurf has a radius at the tip of about 0·00005in. This adds to the radius of a curvature (decreasing the reading of curvature) on projections from the surface, and subtracts from the radius of curvature (increasing the reading of curvature, with a theoretical maximum of infinity) in depressions. The effect on second differential is similar but more complicated.

The reading for curvature will be $1/\sqrt{2}$ times the correct value (the usual criterion for frequency response) on a profile with a curvature of approximately 0·00012in. On a projection of this curvature the maximum horizontal travel of the centre of the stylus, the travel between 45° slopes, would be 0·00024in. The apparatus cannot be operated in practice with the 25c/s cut-off frequency owing to noise. With 12c/s cut-off frequency the signal is attenuated to about 30 per cent at 12c/s and 80 per cent at 6c/s. At 100 × horizontal magnification, when the stylus travels horizontally at 0·002in/sec, the response will be 80 per cent for variations with a half-wavelength of about 0·00017in. Curvatures up to about 10 000 reciprocal inches should therefore be measurable.

Fig. 3. Traces from endmilled sample



Results

The attachment has been tested with a variety of surfaces. The values of maximum curvature and second differential given in Table 1 refer to isolated peaks. From the traces obtained, a numerical value of peak curvature or second differential would not be a good routine description of a surface. However, the patterns of the traces were interesting. Fig. 3 shows traces obtained from an endmilled surface. The top trace is an ordinary Talysurf profile trace obtained at 2 000 times vertical magnification and 20 × horizontal magnification. The second trace was obtained at the same time from the auxiliary recorder, with the attachment set for second differential, at a sensitivity of 2 000—0—2 000 reciprocal inches. The third trace is a fresh profile trace, and the bottom trace is the corresponding auxiliary trace, this time with the attachment set for curvature. A high-frequency out-off of 12c/s was used, as there was too much noise on the trace at the 25c/s setting.

TABLE 1

SURFACE	C.L.A. (μIN.)	MAXIMUM SECOND DIFFERENTIAL (RECIPROCAL IN)	MAXIMUM CURVATURE (RECIPROCAL IN)
Turned	38	1 000	900
End Milled	108	1 700	1 300
Shaped (across grain) ..	173	1 500	1 200
Horizontal milled (with grain)	28	1 800	1 400
Horizontal milled (across grain)	63	1 500	1 300
Ground (with grain) ..	2	40	30
Ground (across grain) ..	1·5	150	130

Acknowledgments

The attachment was constructed by Mr. M. R. English.

Thanks are due to Rank Taylor Hobson Ltd for information supplied.

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A New Digital Teaching Machine

Lancashire Dynamo Electronic Products (M.I. Group) of Rugeley, Staffordshire, has manufactured on behalf of Educational Systems Limited a new teaching machine called the tm 1024.

The tm 1024 is a fully-transistorized machine based upon digital techniques and uses a 35mm back projection system. It is claimed to be the only machine of its kind: all programme movements irrelevant to the learning process have been eliminated and unlike other teaching machines the tm 1024 has only two control buttons for the student to operate -a 'Yes' button and a 'No' button.

The film is loaded on to two spools mounted on a retractable tray in the lower part of the machine. This tray also contains the spool motors, pinch roll drive, light source and optical lens assembly.

The film transport and mechanism system has been kept as simple as possible to ensure a high degree of reliability. Mechanical brakes and clutches have been avoided. The two spool motors are permanently energized to drive in opposite directions, thus holding the film in tension and preventing spillage. The film movement is achieved by means of a pinch drive from a reversible d.c. motor through a worm and pinion. This motor has dynamic braking and can stop the film within $\pm 0{\cdot}02$in, thus achieving the required positional accuracy.

The light source is a 100W quartz iodine lamp which ensures good viewing under high ambient light conditions.

The 'Yes' and 'No' buttons select the next phase of the programme to be viewed as follows:

Down both vertical edges of each frame is a binary code consisting of clear and opaque areas which indicate the number of frames to the next frame to be viewed and the direction of travel. Thus if the 'Yes' button is pressed the code on the right edge of the frame is stored in the register. On releasing the button the pinch roll drive is energized in the required direction of travel and as each frame passes a photocell it is counted and subtracted from the contents in the register. If the film is more than one frame away from the required position, the drive is energized 'fast'– that is six frames per second– when it is one frame away the speed is reduced to half a frame per second, thus when the register is at zero the new frame has been reached and the drive motor is de-energized.

Pressing the 'No' button causes a code on the left-hand edge of the frame to be transferred into the register and a similar action then takes place. The coded information is read by two groups of ten photocells positioned on each side of, and behind, a screen. Nine of these photocells detect the code and the tenth determines the direction of travel. A further cell is used for counting the frames as the film moves.

The programmer when compiling the programme can branch into sub-routines which the machine can accommodate. These are used where necessary and then the student is returned to the main stream.

To avoid eye strain and distraction due to the flickering effect caused by the fast movement of the film a shutter is brought into operation under automatic control.

The electronic circuits are fully-transistorized and are mounted on plug-in printed circuit boards as used in industrial control systems, which ensures the same high degree of reliability required by industry.

The original research work on the tm 1024 was carried out by the National Physical Laboratory.

The digital teaching machine

A Pulse Frequency Multiplier for Digital Phase Measurement

By L. Molyneux*

An analogue frequency multiplier capable of a multiplication ratio of 360 is described which allows the measurement of phase difference by digital means.

(Voir page 423 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 430)

MEASUREMENTS of phase differences by digital means may be made by first changing the reference and the variable wave trains into pulse form and then determining the time that elapses between a pulse of the reference train and one in the variable train. The time interval is determined as a count of the number of cycles of a scale frequency that occur during this interval. If the ratio of the scale frequency to the reference frequency can be made three hundred and sixty to one then the reading of the counter, after the measurement has been made, gives the phase angle in degrees. The main difficulty lies in the design of the frequency multiplier; conventional multipliers for factors as large as three hundred and sixty are elaborate and become particularly so if there is the additional requirement that the input frequency may vary. The multiplier to be described is basically an analogue device and the ratio between input and output frequency is therefore not exact. However, there is a simple way of checking the ratio, and symmetry of form, together with negative feedback, lead to a stable device.

Principle

Fig. 1 shows the essential features of the multiplier. The pulses of the reference or input frequency are arranged to be of such form and polarity as to maintain VT_1 on for a time long compared with that necessary to fully charge $C_{t(in)}$, the two diodes on the emitter of VT_3 together with $C_{t(in)}$ form a diode pump[1], so that a current proportional to the input frequency flows from the emitter and hence into the collector of VT_3. VT_3 is connected in the common base mode, hence the collector current is almost equal ($I_c = \alpha I_e$) to the emitter current. If VT_2 were absent then this collector current would flow into the amplifier, and, because of the way the circuit is arranged, would cause the voltage-to-frequency convertor to produce a high frequency. But VT_2 is in fact connected to VT_3, the input to the diode pump this time coming from the output of the voltage to frequency convertor. The collector current of VT_2 opposes that of VT_3 tending to reduce the input to the amplifier and hence the output frequency. The amplifier has high gain so that only a small part (less than 0·1 per cent) of the collector current of VT_2 and VT_3 is needed for drive and the circuit quickly (~2sec) reaches equilibrium when the current in one diode pump is equal to that of the other.

The expression for the current in the diode pump circuit is:

$$I = f \cdot \nu \cdot c$$

where f is the frequency, ν the voltage swing and c the capacitor value. Now the circuit, by means of the negative feedback action just described, tends to equate the currents of the two diode pump circuits so that:

$$f_{in} \times C_{t(in)} \cdot \nu_1 = f_{out} \cdot C_{t(out)} \cdot \nu_2$$

The voltage swing in both cases can be taken to be equal to the supply voltage since the differences in base-emitter saturation voltage of VT_1 and VT_4 can be neglected with respect to 12V.

Hence:

$$f_{out} = f_{in} \cdot \frac{C_{t(in)}}{C_{t(out)}}$$

which is to say that, provided the assumptions are true, the scale factor depends simply on the ratio of two capacitors.

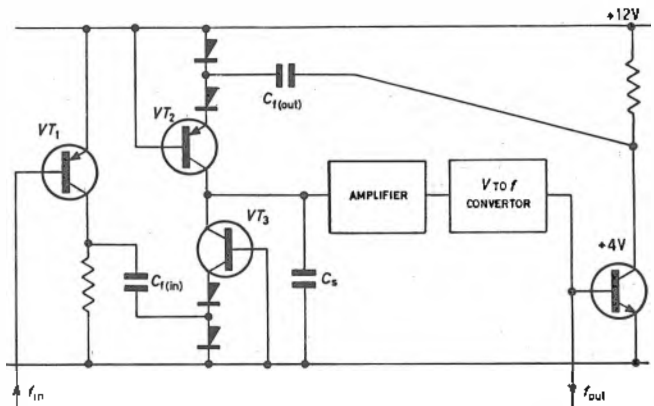

Fig. 1. Essential features of multiplier

C_S is a smoothing capacitor. The multiplication factor is g_1, i.e. $G(mf) = \frac{C_{t(in)}}{C_{t(out)}}$

A Practical Circuit

A simple demonstration of the principle is shown in Fig. 2. S marks the summing point[2] at which the outputs from the diode pumps are compared. VT_9, VT_{10}, VT_{11} and VT_{12} form the amplifier used to drive the voltage to frequency convertor using transistors VT_5, VT_6, VT_7 and VT_8. It will be noted that the transistor (VT_4) which provides the input to the output frequency diode pump circuit has an extra load resistor connected to a potentiometer RV_1. This circuit allows the voltage swing of VT_4, and hence the output of the associated diode pump, to be changed by about 5 per cent: it is used as a fine 'front panel' control of the multiplier ratio. Course adjustments are made with the trimmer capacitor ($C_{t(out)}$). It is necessary that the output current from the input diode pump circuit shall remain constant to better than one part in 360 (for 1° accuracy) during one cycle of the input frequency. The smoothing takes place in two stages, firstly the 100μF capacitor (C_Q) connected to the collector of VT_3 and secondly the 250μF capacitor (C_5) connected to the collector of VT_9. At first sight the resistor between the collectors of VT_3 and VT_2 might seem unnecessary but, if it is removed, the circuit becomes unstable tending to oscillate at a low frequency: as the large capacitor in the collector circuit of VT_3 becomes a second phase lag in the feedback circuit. It is possible to adjust the value of this resistor to give a condition closely resembling critical

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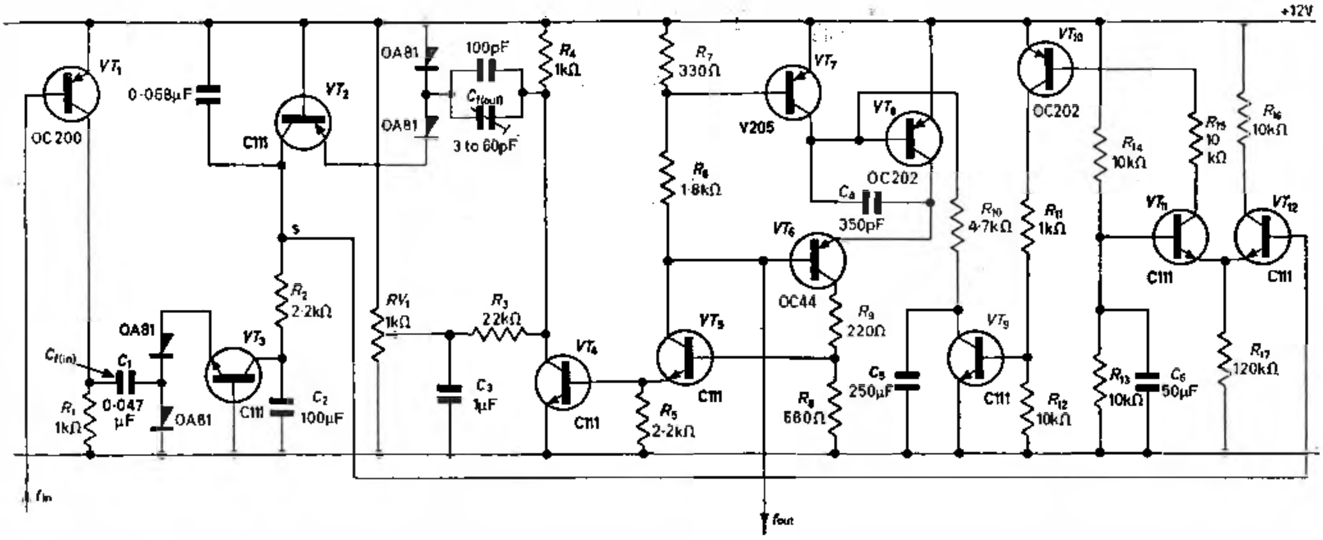

Fig. 2. The complete circuit

damping, the stated value gives an over-damped effect.

Digital Phase Measurement

Fig. 3 shows the logical diagram necessary for digital phase measurement. This diagram assumes that the reference and variable wave trains have been converted into trains of short pulses. The bistable units are shown in the 'rest' or 'between reading' state. To take a reading the counter is cleared, then a pulse sent to the 'start' input which changes the state of the scale bistable and provides an input to gate A. There will be no output from this gate until a reference pulse occurs. When this happens the output from gate A causes the master bistable to change its state and in doing so provides one input to gate B. It should be noted here that it is important that the width of the reference pulses should be less than the period of the highest output frequency, so that even if the start pulse occurs during an input pulse the instant of changeover of the master bistable will not be significantly different from the case where it occurs between pulses. When the master bistable changes its state pulses at the output frequency can pass into the counter. If the check switch is open the master bistable is changed back to its original state by the subsequent reference pulse and the counter will then indicate a number equivalent to a complete cycle. In this condition RV_1 (Fig. 2) is used to bring the number indicated by the counter to 360. When the check switch is closed the master bistable is returned to its rest state by a pulse from the variable pulse train. The counter in this case indicates the phase lag, in degrees, between the two pulse trains. When the master bistable returns to its rest condition it also returns the bistable to its rest condition, thus preventing further reference pulses from passing through gate A and affecting the state of the master bistable.

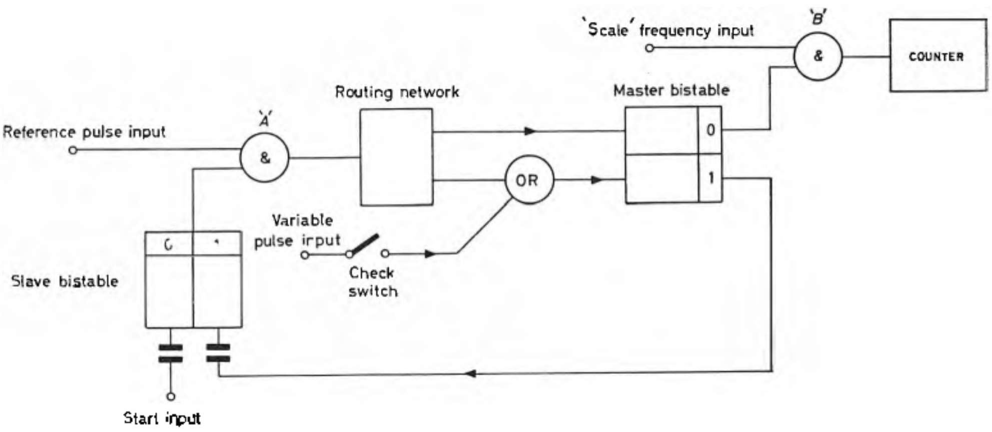

Fig. 3. Logical diagram of gating circuits for phase measurement

TABLE 1

f_{in}	f_o / f_{in}	Supply (V)
200	361·0	12
300	361·2	12
400	360·4	12
500	359·6	12
600	359·3	12
400	361·8	10
400	359·2	14

Performance

The circuit was designed for use with a spinner magnetometer[3] and in this form was required to work at frequencies between 350 and 400c/s. However, the circuit maintained its ratio over a much wider frequency range as Table 1 shows. This also shows the comparatively small effect of a change of supply voltage on the multiplication ratio. 200 and 600c/s represent the frequency limits of the circuit in the form shown in Fig. 2. The voltage-to-frequency convertor[4] limits the upper frequency. The circuit could be used at lower frequencies if the smoothing, diode pump, and integrating capacitor of the voltage-to-frequency convertor were all increased in value.

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A Pulse Height Monitor

By M. Bronzite*, B.Sc.

In this article a circuit is described for monitoring pulse amplitudes. It is simple in operation, can handle a wide range of input waveforms over a wide frequency band and gives better than 1 per cent accuracy.

(Voir page 423 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 430)

THE simple parameters of a pulse train are pulse repetition frequency, pulse width or mark-to-space ratio, polarity, and amplitude. The first three may be determined by means of the appropriate analogue circuit, which will provide a d.c. voltage output, proportional to the required parameter. However, a measure of the fourth normally requires the use of an oscilloscope plus observer, a process which can prove inconvenient and inaccurate, especially in remote equipment. It is intended in this article to describe a circuit for monitoring pulse amplitudes which is simple in operation, can handle a wide range of input waveforms, operates over a wide frequency band, and which will give better than 1 per cent overall accuracy.

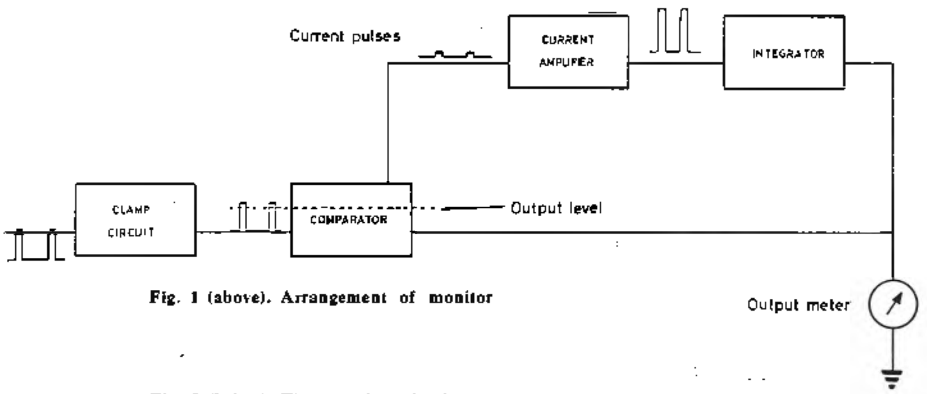
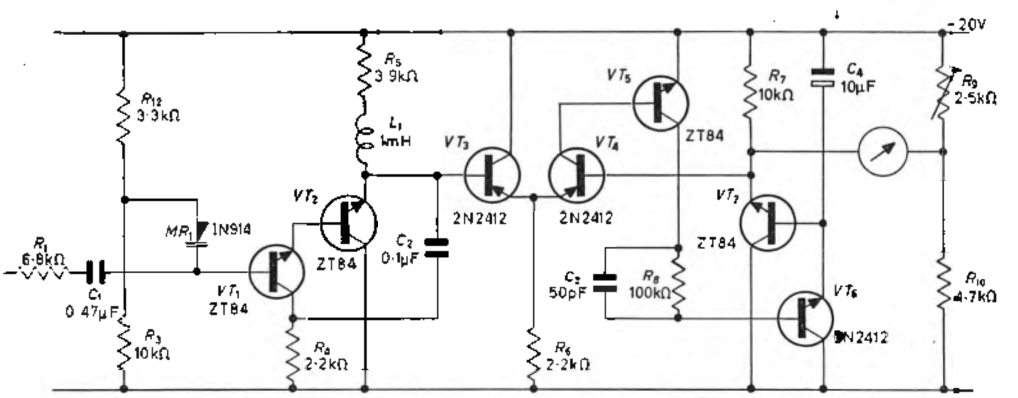


Fig. 1 (above). Arrangement of monitor

Fig. 2 (below). The complete circuit



Circuit Description

Fig. 1 illustrates the mode of operation. The signal passes through a clamp circuit, which maintains the most negative part of the waveform at a constant potential. This signal is then compared with a d.c. level, which is derived from the output voltage. If, as in the diagram, a part of the signal exceeds the d.c. level, then a current pulse is obtained from the comparator. This is amplified and fed to an integrator which has a long time-constant. This results in an increased d.c. voltage from the integrator which is fed back to the comparator. Eventually, equilibrium is reached, where the output from the comparator has to supply only the losses of the integrator. If the output signal is now reduced, the output level will slowly drop, due to the losses of the system, until a new equilibrium point is reached. At these points of equilibrium, the output level becomes almost exactly equal to the pulse amplitude, and can be measured with an appropriate form of d.c. meter.

The actual circuit is shown in Fig. 2. Capacitor C_1 and diode MR_1 comprise the clamp circuit. Transistors VT_1 and VT_2 are emitter-followers which provide a high load impedance to the clamp. Forward bias to these transistors is provided by resistors R_2, R_3 and R_5. The choice of R_5 is a compromise between conflicting requirements: it should be high so that the clamp is not loaded; and it should be low in order to maintain a reasonable collector current in VT_1, with resulting good frequency performance. The inductor L_1 and the Bootstrap components C_2 and R_4 are inserted to maintain the high input impedance at high frequencies[1]. The comparator consists of the long tailed pair VT_3 and VT_4. When the signal exceeds the output level, VT_4 switches on, providing a current pulse which is fed to the current amplifier VT_5 and VT_6. R_8 limits the collector current of VT_5, but is by-passed by C_3 at high frequencies. The output of VT_6 is integrated by C_4 and the voltage across this capacitor is fed back to the long tailed pair, via emitter-follower VT_7. R_9 and R_{10} provide the zero adjustment to the output meter. These resistors are necessary to offset the forward bias discussed above.

Results

With a sine wave input of 10V, the frequency response for 1 per cent output accuracy, was from less than 50c/s (the limit of the generator) to 1·1Mc/s. With a square wave input, the frequency response was 17c/s to greater than 500kc/s (the limit of the square wave generator). Table 1 shows the range of pulse widths that can be monitored at different frequencies. In order to measure, accurately, the circuit linearity over the range of operation (arbitrarily 3 to 10V), a square wave was fed into a saturating common emitter amplifier, with the transistor working in

* *Kelvin Hughes Division, S. Smith & Sons (England) Ltd.*

the inverted mode, to give negligible saturation voltage. The supply voltage to the transistor is then an accurate measure of the amplitude of the signal, which is made the input to the circuit. This was measured with a digital voltmeter, as was the output, which was calibrated to give no error at 6V. The magnitude of non-linearity is shown in Table 2. It can be seen that the error at any voltage is less than 1 per cent of the maximum signal.

Modifications

It is to be anticipated that most of the limitations to the circuit performance will be found in the clamp circuit, since error in the later sections will be reduced by the action of the feedback. From Table 2 it can be seen that there is a constant increment of error proportional to the amplitude. This is partly due to the attenuation of the input network: $R_r/(R_r + R_s)$ where R_r equals the reverse impedance of the diodes in parallel with the input impedance of the emitter-followers, and R_s equals the source impedance in series with R_1. Another attenuator consists of the base emitter diodes of VT_1 and VT_2, and the emitter load. Thus, improvements in linearity can be obtained by reducing the source impedance (R_1 was only introduced to simulate such a source impedance), by increasing the input impedance of the emitter-followers, and by using a constant current source as the emitter load. By such means, a linearity of 0·1 per cent should be attainable. From Table 1 it is evident that a narrow negative going pulse will give erroneous results. This again is due to the relatively low input impedance of the emitter-followers, with consequent loss of charge from C_1. By using a transistor with high gain at low collector currents (say, $\beta = 50$ at $I_c = 10\mu A$) for VT_1, and increasing the value of C_1, a considerable improvement should occur. If it is desired to improve the frequency performance of the circuit, then the capacitance across R_r (see above) would have to be reduced. This could be done by using improved active elements for the clamp. Another approach would be the use of positive feedback to cancel out the capacitance, although this might prove simpler in theory than in practice[2]. For operation up to, say, 10Mc/s, it may be necessary to improve the current amplifier to cope with the smaller signals that will be available

Although no effort was made to make the circuit temperature invarient, this would not prove difficult. The output section can cause no change, being in the feedback loop, the long tailed pair will be self compensating, and the clamp circuit can be compensated by diodes in the bias chain. In order to make the output independent of supply voltage variations, the diode MR_1 and the zero adjust resistors R_9 and R_{10} should be returned to a common Zener point. The output currently takes about 1sec to reach equilibrium. This time-constant was simply chosen to permit operation at low frequencies, and could be altered as required by attention to the current amplifier, and altering the value of C_4. Thus, if a shorter time is required, then R_8 would be increased and C_4 would be reduced.

Applications

One of the more obvious uses for this circuit would be as the back end of a peak-to-peak reading voltmeter, which could handle sinusoidal and non-sinusoidal signals. It might be necessary to include a signal source of known amplitude to provide zero adjustment, although this could probably be done on manufacture, if R_2, R_3, R_9 and R_{10} are high stability resistors. With some care in design, the device could be made accurate enough to be used with a digital voltmeter. In any case, the facility for pulse measurements would greatly increase the range of present day voltmeters. Further application could be found in data loggers, and 'count-down' systems, where it is desirable to have information in the form of varying d.c. levels prior to multiplexing. Another possible function could be the detection of infrequent pulses in a pulse train with differing amplitudes from the average. A resistor in the collector circuit of VT_3 could be used for this purpose.

TABLE 1
Range of pulse widths for 1 per cent variation of output. Pulse is positive going.

FREQUENCY	PULSE WIDTH
20c/s	150μsec—47·5msec
1kc/s	1.5μsec—720μsec
10kc/s	150nsec—65μsec
100kc/s	150nsec—5·5μsec

Pulse amplitude = 8V

TABLE 2
Circuit linearity.

INPUT SIGNAL AMPLITUDE (V)	MAGNITUDE OF ERROR AT OUTPUT (MV)
10	0
9	−45
8	−32
7	−19
6	−1
5	+17
4	+36
3	+54

Input frequency = 1kc/s
Pulse width = 500μsec

Conclusion

While the title of this article uses the word 'pulse', it has been shown that the circuit as described will provide accurate measurement with a wide range of waveforms. Modifications to improve its performance, and possible applications, have also been discussed. In general, it is suggested that the circuit will permit the design of amplitude monitoring equipment that uses square wave techniques, rather than sinusoidal.

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Computer Read-out by Television

Many of the most complex computer installations are concerned with 'real-time' situations, in which data is processed arising from a complex pattern of events as they actually occur. The output from such a system consequently needs constant up-dating to ensure that from moment to moment it is exactly in accord with the changing input data.

Clearly, a conventional paper print-out is of little use for such a situation. One alternative is to present the information on a cathode-ray tube display, and development work has been carried out in this direction using steered beam techniques, in which the electron beam is deflected to 'write' out the display on the tube face. Equipment of this kind, however, is both complex and costly.

A new approach to the problem has now been made by the Data processing division of Automatic Telephone & Electric Co. Ltd—a member of the Plessey Group—and a system has been developed which enables ordinary low-cost television monitors to be used for this purpose.

Diagrammatic information can also be presented and definition using a standard frame of 625 lines is adequate for most applications, but if necessary this can be increased to the limit imposed by spot-size, by increasing the number of lines.

THE 'EARLY BIRD' SATELLITE AND GOONHILLY DOWNS EARTH STATION

THE 'Early Bird' satellite was launched from Cape Kennedy, U.S.A., on 6 April and was thrust by its 'Kick Motor' into a circular equitorial orbit at a height of 22 300 miles, on 9 April. It now occupies a relatively stationary position over the Atlantic, midway between South America and Africa. Several successful transatlantic television exchanges already have taken place via the satellite and it is due to come into use for commercial telephone traffic on 1 June as part of tests to determine the most acceptable and practicable type of satellite system for public use.

The Satellite

The satellite, which is owned by the Communications Satellite Corporation, to which Great Britain is a subscriber, was built by Hughes Aircraft Company. In size and appearance Early Bird is similar to the Syncom satellites, being 28·4in in diameter and 23·25in high, exclusive of antennas and apogee motor and having a weight of 85 lb.

The spacecraft is built around an aluminium and magnesium riveted structure. This outer structure supports the solar cell panels and contains the hydrogen peroxide gas system tanks, the axial and radial jets of the control system and most of the spacecraft electronic equipment. The electrical power system consists of 6 000 silicon solar cells, two 21-cell nickel cadmium batteries and voltage regulators. The solar cells can provide 45W without drain on the batteries when the satellite is not shadowed by the Earth.

The Goonhilly Downs Ground Station

In order to operate with this type of high altitude satellite a number of changes have been necessary at the Earth stations taking part in this experiment. The most important modifications at the Goonhilly Downs station[1] have been those to the aerial.

The reflector has been rebuilt and now consists of 24 adjustable stainless steel petals surrounding a 25ft diameter paraboloid. The reflector profile tolerances are determined by the required radiation patterns, which must be such that the levels of side lobes do not result in interference to or from terrestrial radio-relay systems and other satellites; the reduction in gain caused by profile imperfections must also be acceptable. To meet these requirements, the individual petals of the reflector are constructed of panels made to a tolerance of $\pm 0{\cdot}025$in over 99 per cent of their surface. Alignment of one panel relative to another is such that the surface of the complete reflector is within $\pm 0{\cdot}1$in of the 'best fit' paraboloid over 99 per cent of its surface. The loss in gain due to surface imperfections is estimated to be 0·3dB at 6 000Mc/s and 0·1dB at 4 000Mc/s. The angular aperture of the reflector has been reduced from 180° to 140°; this eased the design of the primary feed so that more efficient illumination of the reflector could be obtained.

The new reflector surface has been fitted on top of the original surface. The central 25ft diameter paraboloid, although manufactured in four quadrants, was machined as one piece to very high accuracy. Each of the surrounding 24 petals has its own stiff backing girder structure carrying accurately machined trays, and these, in turn, bear the stainless steel reflector membrane. The position of the membrane on the backing structure can be adjusted to give accurate control of the shape of each petal, and the petals, when in position in the reflector bowl, are carried on jacks to permit adjustment of the assembled bowl. The additional weight on the front of the aerial is 120 tons because of these modifications, and to balance this a lead counterbalance has been added. The total gross weight of the rotating part of the modified aerial is about 1 100 tons.

Primary Feed

The primary feed at the focus of the reflector is required to transmit up to 10kW of radio energy at a frequency of 6 000Mc/s and to receive simultaneously signals at 4 000Mc/s having the very low level of about a micro-microwatt. The dual requirement of transmitting and receiving at different frequencies necessitates the use of a coaxial configuration of apertures to obtain the best aerial efficiency. The feed therefore consists of an open-ended coaxial waveguide having a hollow inner conductor. The lower-frequency signals, used for reception, are carried in the outer coaxial waveguide and the high-frequency signals are transmitted through the inner tube.

A dish is mounted on the outside of the waveguide to reduce rearward radiation from the feed and spillover past the rim of the reflector. It also provides a means of shaping the feed radiation diagram, and obtaining high aerial efficiency and low noise.

The coaxial waveguide configuration with its circular inner tube is transformed along the length of the feed into separate rectangular waveguides for connexion to the main waveguide feeder runs.

Aerial Control System

The basic control system at Goonhilly uses predictions, prepared in the U.S.A., of the position of satellite throughout the usable parts of its orbit.

Although Early Bird has been launched into a synchronous orbit, its plane may be inclined by a few degrees to the equator, and this will make it appear to trace out a tall, thin figure-of-eight once a day. The required tracking speeds are, however, very much lower than those of Telstar and Relay, in fact less than one or two degrees per hour for most of the time. The control system has therefore been modified so that, when required, steering data can be read from a control tape once per minute instead of once per second. In consequence, a simplified computing program enables a 300ft control tape for twelve hours tracking of Early Bird to be prepared in less time than is required for one hour's operation with Telstar.

Vernier Tracking Facilities

Small steering errors due to wind gusts or imperfect predictions are corrected by swinging the aerial beam independently of the motion imparted to it by the aerial mount. A beam-swing mechanism, controlled automatically by error signals, moves the aerial feed about the true focus of the paraboloid, setting the beam accurately on the satellite. The tracking equipment includes an error-sensing unit of the conical-scan type in which the aerial feed rotates about an axis slightly offset from its own axis, scanning the aerial beam conically. When the satellite is off the scanning axis, but still within the beam, the beacon signal from the satellite is amplitude modulated at the scan frequency. Error signals in two orthogonal planes, derived from the amplitude and phase of the superimposed modulation, control the beam-swing mechanism to bring the scanning beam into track wth the satellite. This part of the system is therefore an auto-follow system which continuously minimizes small steering errors.

The scan speed is about 1 000rev/min and the eccentricity of the scanning feed 0·15in, resulting in an angular offset of the beam of 0·02°, one-tenth of the beamwidth. The deterioration in aerial gain due to offsetting the beam for scanning is only 0·13dB which allows the high aerial efficiency to be retained, an essential feature in working to long range satellites. Although the magnitude of the scan is so small, adequate tracking sensitivity is obtained by employing a high-gain tracking receiver with an output bandwidth limited to 2c/s. The pull-in range of the conical-scan sensor is 0·2°. It is very unlikely that errors will accumulate to this magnitude faster than the auto-follow system can correct them.

TRANSMITTING EQUIPMENT

Standard frequency modulating equipment, of the type used in normal line-of-sight microwave radio links, accepts the input multi-channel telephony or television signals and produces a frequency-modulated 70Mc/s output. The deviation employed is several times greater than the standard adopted in normal terrestrial circuits. Further intermediate frequency amplification occurs before the modulated signal is transmitted over coaxial cables between the control building and the aerial site.

Because of the greater orbital height of Early Bird, as compared with Telstar or Relay, some increase in the power of the signals transmitted from earth stations may be desirable. A new water-cooled travelling wave tube, having a clover-leaf slow wave structure and a ceramic output window has been specially developed that can supply 8kW of power at the Early Bird frequency, or 5kW when required for Telstar.

New auxiliary low power driving stages of the transmitter enable it to be switched to either the European or American frequency assignment for Early Bird or to the Telstar transmit frequency.

RECEIVING EQUIPMENT

Reception of very weak signals from satellites depends upon the use of a pre-amplifier having an extremely low level of internal noise. The principal type of amplifier in use in the various Earth stations is the travelling wave ruby maser.

The maser requires an operating temperature only a few degrees above absolute zero, and this is achieved by immersing the device in a bath of liquid helium.

The original installation at Goonhilly incorporated the first fully operational travelling wave maser made in Britain, and this was used in all the experiments with Telstar and Relay.

The operating frequencies for the Early Bird satellite are sufficiently different from those of Telstar to require considerable modification to the maser, and an entirely new maser has been installed, incorporating developments since 1962.

The new design has a greater gain and bandwidth, but the greatest improvement lies in the reductions of the internal noise level to less than half its previous value, and an improvement in stability achieved by using a lightweight superconducting magnet (immersed in the liquid helium bath) instead of a heavy external permanent magnet. The use of a larger dewar vessel to hold the liquid helium should increase the operating life to about two days.

Monitoring and control circuits have been built into the new equipment to overcome possible interruptions caused by the failure of auxiliary equipment. Another complete maser will be installed later in 1965 to provide a main and standby receiving channel.

The maser is followed by a low-noise travelling wave tube which provides further amplification at microwave frequencies and is then down-converted in frequency to 70Mc/s. An all solid-state pre-amplifier follows this and then conventional i.f. amplifiers for transmission back to the control building.

Because the carrier/noise ratio over the satellite link is so low, conventional discriminator-type frequency demodulators cannot be used, and an f.m. negative-feedback demodulator is used instead. In this type of receiver the instantaneous frequency of the incoming signal is continuously tracked and the noise bandwidth is limited by a filter of narrower passband than that occupied by the whole deviation range of the r.f. carrier.

TEST FACILITIES

An improved design of power measuring equipment has been developed to enable a sample of the transmitted power launched into space to be measured at the vertex of the aerial. The device is not affected by temperature changes, and is sufficiently sensitive and compact to be used as a hand-held radiation monitor. In addition, a miniature transmitter has been installed at the vertex that operates on the same frequency as the transmitter in Early Bird. The aerial, therefore, has a satellite simulator built into it, and the whole of the Earth station equipment can be checked under realistic conditions without pointing the aerial to an Earth-bound distant checking station.

Equipment has also been provided that can inject an edge-of-band pilot signal at various points in the transmission path to ensure that the station is functioning correctly and to provide a ready means of fault localization.

The Overall Communications System

The Early Bird, HS-303 communication satellite system is designed to provide up to 240 high-grade telephone circuits across the Atlantic between the American Earth station at Andover (Maine) and three European Earth stations at Goonhilly Downs, Pleumeur Bodou in Brittany and Raisting in W. Germany. The system is capable of providing continuous service but initially will be restricted to from 12 noon to 12 midnight G.M.T. Monday to Friday when the trans-Atlantic telephone traffic demand is high. It may also be available for occasional bothway television transmissions.

The satellite will operate at any one time between two stations, one on either side of the Atlantic. The three European Earth stations will operate on a consecutive basis, each station providing the European terminal of the satellite link for one week in every three week period. This arrangement avoids the need at this stage for each station to provide its own standby facilities and enables a fully operational system to be established. Each station thus functions in turn as the European terminal while the other stations provide the necessary standby facilities. The stations will operate a 3-week rota, each either being operational, on standby, or available for maintenance.

By operating the European Earth stations in this way provision has had to be made for an interconnecting terrestrial network of radio-relay and cable links between each Earth station and its national switching centre and between the switching centres which are in London, Paris and Frankfurt. By this means the requisite numbers of circuits are made available at the switching centres irrespective of which Earth station is acting as the European terminal.

Applications of Information Storage in Magnetic Memories

By D. M. Bernstein*, B.Sc.

A number of types of analyser employing magnetic storage have been developed for use in nuclear physics. In this article, some of these equipments are reviewed and possible uses in other fields of measurement are indicated.

(Voir page 423 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 430)

MAGNETIC memory analysers have been developed specially for the requirements of studies in nuclear physics. These analysers had initially 100 channels and then 200, 400, 1 024 and 4 096 channels.

The initial requirement for these equipments was to classify pulses from particle detectors as a function of their amplitude in order to obtain spectra or histograms of the number of events as a function of energy.

Users of these equipments had available devices with much greater flexibility than was initially envisaged. The designers have also added new performances bringing the equipments on a par with complex computers. It is thus apparent that the equipments so produced could have useful applications in fields other than nuclear.

The object of this article is to indicate the possible applications of such equipments which had been developed specifically for the nuclear field and to give the specific characteristics which have been achieved for nuclear phenomena which have influenced the design of the equipments and to indicate possible uses in other fields of measurement.

Description of Equipment

Memory Blocks

The storage of information in ferrite cores which is now well known requires two auxiliary scalers.

(a) *The Arithmetic Scaler* in which is stored the numbers which are transferred before being written in the memory or after having been read out of the memory. The scaler is in binary coded decimal 1248. The access to this memory is serial, both in addition and in subtraction. There is a serial access to the input of each decade and a parallel access to each flip-flop. Its resolution time is of the order of 1μsec. Outputs are available in parallel in 1248 code. A decoding system from parallel to serial is available enabling the results to be read out in sequence in 1248 code. A decoding mechanism of this last digit enables it to be changed in decimal or to any other selected code. An output in analogue form decoding three decades at a time gives a d.c. level proportional to the conditions of the scaler.

(b) *The Address Scaler* enables a given channel to be chosen (in amplitude spectrometry) or a word (using computer terminology) situated in the memory. These scalers are decimal in 1248 code for lower numbers of channels, i.e. 100, 200 or 400, and in binary for channel numbers 1 024, 2 048, 4 096 and greater.

Access to these scalers can be in serial form up to a maximum frequency of 20Mc/s, in parallel at each stage or partially in serial and partially in parallel for the other stages. The outputs are exactly the same as those from the arithmetic scaler. Specific equipments have been developed comprising for example 400, 1 024 or 4 096 channels with 10^5 or 10^6 counts in each (or in computer language 400, 1 024 or 4 096 words, each having 20 bits).

Convertors

Under the heading of this general term there are various different equipments detailed as follows:

Pulse Amplitude Convertors

These are used in amplitude analysers in nuclear physics. They enable the peak amplitudes of pulses to be measured, the measurement being translated into a train of pulses (at 4Mc/s for example) where the number of pulses is proportional to the amplitude.

This number of pulses positions either in pure binary or in decimal binary a scaler which gives the number or order of the address.

These convertors analyse amplitudes from 0 to 10V into 100, 200, 400 or 800 points (or 32, 64, 128, 256, 512 etc.). The dynamic range is defined as the difference between the smallest and the largest pulses which can be analysed with the same controls (namely 50), the integral linearity (less than 0·05 per cent) or the differential linearity (less than 1 per cent). Because of their initial source of information these convertors will accept at their input non-periodic signals.

Digital Voltmeters (Analogue to digital convertors)

The measurement here is obtained on the d.c. level variation. For a given time the measurement is indicated either by a train of pulses wherein the number of pulses is proportional to the size measured or by information coded in parallel in 1248 code.

Time Coders

The measurement of time between two given events is achieved by noting the passage of a train of pulses, the number of which is proportional to the time being measured.

Time to Amplitude Convertors

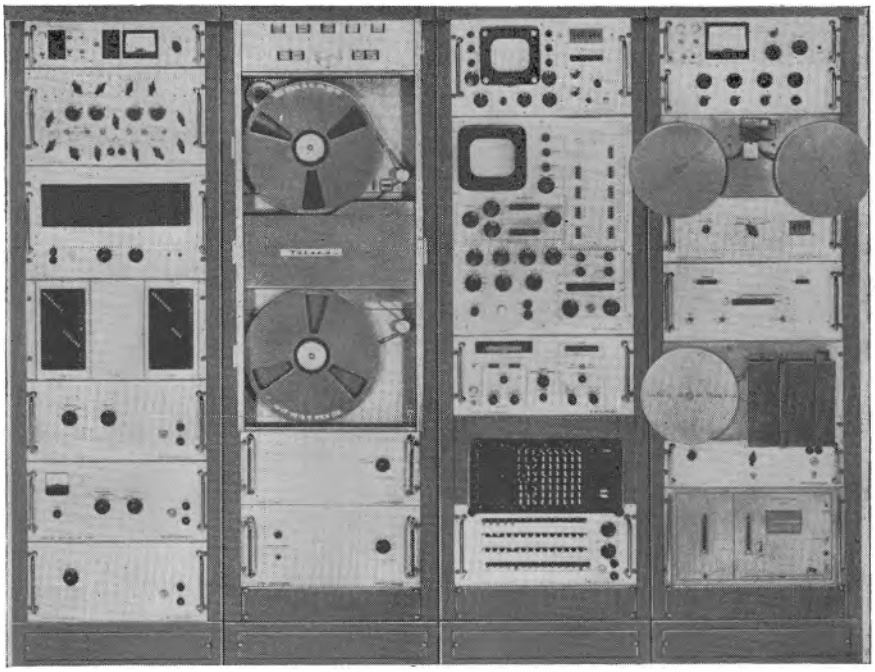
These are intermediate convertors. A time interval is converted to an amplitude pulse proportional to the time. This pulse is then sent to an amplitude convertor. In this way the time scaler is foreshortened for a given measurement. These convertors are used in the nanosecond range.

Routing Devices

These equipments are made up firstly of mixing circuits which send all the signals under investigation to the input of one convertor and also to logic circuits which provide for each detector a routing signal in the form of binary coded pulses or decimal coded pulses. These signals will give the additional information simultaneously with a

* *Miles Hivolt Ltd.*

given convertor showing the source of this signal which could have come from one of many measuring sources or alternatively, from one of many complementary parameters such as angles, distances, voltages etc.



A complete multi-parameter analysis system showing from left to right amplitude convertor and time coding and programming units followed by the magnetic tape system and buffer memory for pre-processing of data, which then feeds the 4096 channel memory block with isometric display and magnetic tape output and computing facility, followed finally by the various output facilities, namely punched tape read out and read in, magnetic tape read out and fast parallel digital printer

Intermediate Memories

Intermediate Analogue Storage

(a) *On Capacitors:*

Electrical pulses can be stored in capacitors. Such storage means that one can wait until the main memory is ready to accept data. The access time of a magnetic memory is of the order of 10μsec, but the dead time of a convertor can be as high as 200μsec. By using two or four capacitors as intermediate storage devices one can achieve maximum utilization of the memory in the same way as under the conditions of feeding statistically varying signals. One can accept for example two pulses only 1μsec apart in time.

(b) *On Magnetic Tape:*

This process is purely mentioned as a possibility since, in practice, it is never normally used before a ferrite core memory.

Intermediate Storage Addresses

(a) *On the Intermediate Address Scaler:*

If several address scalers are used one can use them separately in time in order to measure a large number of pulses. When the main address scaler of the memory device is free the data is transferred successively in parallel. This results in a significant improvement in the pseudo periodic use of a memory block in view of the fact that the pulses being considered are statistical events.

(b) *On Magnetic Tape:*

Information from the coders is sent to the address scaler in binary code. The final position of this scaler is then written on to magnetic tape. In the case of nuclear experiments this enables the total number of parameters stored to be considerably increased and to re-read selectively the information with the memory blocks.

Sixteen or 25 track tapes are used which enable correlation phenomena to be studied over a range of twice 256 points for example.

Transfer of Information from the Magnetic Memory on to Magnetic Tape

Results stored in 1248 code can be transferred at very high speed on to four-track magnetic tape. This increases indefinitely the storage capacity of the device as well as offering the best possible method of clearing the memory should the device be required for re-use very quickly (400 channels in 4sec), as well as enabling intermediate multiplication and division factors to be operated on the data.

Transfer on to Intermediate Arithmetic Scalers

Each time a given bit of information is read out from the memory into the arithmetic scaler it is possible to carry out simple arithmetic functions with this number, such as addition, subtraction, multiplication by a given factor.

It is also possible, however, to transfer this data on to an external arithmetic scaler enabling more complex functions to be carried out such as multiplying by any other number in the memory. It should be noted that in such an extremity there is very little difference between such equipments developed for nulcear physics and computers considered on their own.

Automatic Programmes

Memory blocks or analysers have control circuits permitting different successive operations to be carried out which are both necessary and useful. The storage of information in the memory takes place for a given sequence of operation where the state of the address scaler chosen gives the previous number stored in the channel of the memory, writes it temporarily into the arithmetic scaler, carries out an operation, such as for example, adding one or subtracting one, and then re-writes the new number in the same position on the memory. The reading of data is achieved by a similar sequence but does not affect the contents of the arithmetic scaler. Automatic programmes enable storage of data to be carried out for a preset time either with or without automatic correction of the dead time of the equipment, followed by the reading out of these results on to a printer, recorder, magnetic tape or punched tape device. These operations can be re-cycled automatically during which a given external parameter is changed. An automatic transfer programme includes the re-writing in the second half of the memory previously stored data from the first half while still retaining the results in the first half.

Another facility is sub-grouping which enables data to be fed in or read out from a quarter or a half of the memory in the case of 400 channel devices, or any other fractions for 1 024 and 4 096 channel devices, or between any two channels.

Uses in Nuclear Physics

Multi-Channel Pulse Height Analysers

Such a device classifies pulses coming from particle detectors into, say, 400 groups as a function of their amplitude. The statistical characteristics of the arrival of these pulses and their high repetition frequency have justified the use of ferrite core memory storage. Also in other fields it is required to classify pulses as a function of their amplitude, and also their arrival as a function of time. The study of noise has been achieved in this way. One measures the noise for a short time by measuring the amplitude variation giving the probability density.

Multi-Scaler

A number of nuclear physics experiments are concerned only with measuring the number of events. A scaler counts for a given time and then reads the result. Storage of the information allows the results to be transferred to the memory after which the subsequent measurement can be achieved very quickly. The measurement of the decay of an isotope of short half life is thus very easy. Each measurement can be taken at intervals as short as 10μsec.

Time of Flight Analysers

A time coder and a storage block of 1 024 channels for example would define a neutron time of flight analyser. This equipment classifies detected neutrons as a function of their energy by measuring the time taken to traverse a given distance. The time for each channel can be between 1nsec and 32μsec for example. It is also possible to expand the region of interest up to $2^{11} \times$ the channel width.

Multi-dimensional Analysers

Multi-dimensional analysers study the correlation of several parameters. Data coming from two or three convertors is accepted only as a function of the correlation conditions. Two convertors and a 4 096 channel memory block constitutes a multi-dimensional analyser of 64×64 channels. Such an equipment would enable correlation studies to be carried out on two gamma ray spectra for example. An improvement of the flexibility of such a storage system is achieved by using intermediate address storage on magnetic tape. With a magnetic tape of 25 tracks, phenomena can be stored in correlations of $256 \times 256 \times 256$. Read out of information is chosen selectively in a 1 024 or 4 096 channel memory block. One particular non-nuclear example of the applications of such a device is using the equipment to show variations in background noise. The statistics of the number of times a noise amplitude V_1 will be followed in a given time between t and $t + dt$ by another pulse of amplitude V_2.

Applications Resultant upon Storage Capacities

Storage of data in cores has several advantages:

(a) The speed of access for both reading and writing.

(b) The ease of access (compared to the access to magnetic tape of similar capacity).

(c) It minimizes the number of operations because of the fact that the data is stored once and for all in the memory.

Correlation Function

If the curve $Y = F(X)$ is written in the memory one has the following:

By giving X various values corresponding to the number of channels available in the memory one can write in each channel the number Y. If now the output is taken to a digital voltmeter or some other analogue to digital convertor or to a counting scaler, each time that results are fed to the address scaler of a memory block the arithmetic scaler will contain the corresponding Y information.

Systems exist which permit one to read-out or to print out during a measurement the square, the cube, the square-root or even the logarithm of a measured number.

Pulse Programme Generators

The analyser operating in the multi-scaler mode has the following operational programme:

(a) Accepts the number of A stored in the first channel and transfers it to the arithmetic scaler.

(b) Counts the number of pulses coming from the external sources and adds them to A during the given time.

(c) At the end of this time re-writes in this channel the final results $A + B$.

(d) Does the same in the next channel.

The store command is given by an external signal. It stops the storage and counting and interrupts the memory programme.

Utilization of High-Speed Storage

The multi-timer has already been referred to. In the same way as all measurements can be converted by a train of pulses or even better by the position of a scaler so data can be stored very rapidly in the memory.

Ultra-fast Digital Voltmeter

(a) *Measurement of Variable Amplitude*

If any amplitude varies with time this can be followed on a potentiometric recorder, the accuracy of which can be 0·5 per cent, and the frequency can be several times per second.

In order to increase the speed it is necessary to use fast recorders but it is not possible to hope to be able to achieve speeds of the order of kilocycles per second since the accuracy would not be much better than 1 per cent.

(b) *Statistical Variation of Amplitude*

The output of the analogue to digital convertor is fed to the address scaler of the memory block, and one can therefore see how many times an amplitude has occurred at a given value. This is what was referred to in scaling and measurement of background noise, but it is also possible to measure a continuously variable amplitude.

Moreover, with several convertors it is relatively simple to study the correlation among several amplitudes.

Conclusion

The object has been to explain the various new applications of multi-channel memory blocks. If one appreciates the potential applications of large computers on the one hand, the advantages of numerical measurement on the other hand, it is useful to show that the storage of data in ferrite core memories, of relatively modest capacity and similarly modest price, can find different applications from the nuclear physics measurements for which they were originally developed. Many applications have already been found in electronics, aerodynamics, biology etc. For example, ferrite core memory blocks are used to measure the variation in water droplet size from nozzles of different diameters where the distribution in size can be displayed very rapidly.

A High Voltage Pulse Generator using Switched Thyratrons

By T. Chan*, M.Eng., and M. W. Gunn†, Ph.D.

The design of a high voltage pulse generator using hydrogen thyratrons in an on-off switching cycle is described. This design seeks to combine the advantages of 'line type' and 'hard valve' generators by providing an output pulse which can be continuously varied in duration with a low output resistance. The generator described produces well shaped rectangular pulses up to 4kV in magnitude continuously variable in length from 0·2μsec with a source resistance of approximately 13Ω. The design can be readily extended to provide output voltages to a maximum of 16kV.

(Voir page 423 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 430)

TWO common forms of high voltage pulse generators are the hard valve generator and the line type generator[1]. A typical hard valve generator comprises a charged capacitor which is periodically connected to the load via a thermionic valve, which has been switched on for the duration of a positive pulse applied to its grid. An example of such a generator is the output stage of the rectangular pulse generator circuit discussed by Edwards[2]. The usual advantage claimed for the hard valve generator is that it provides a well shaped rectangular pulse, but in practice this is compromised by its inability to feed low resistance loads. Typical valves used for the switching

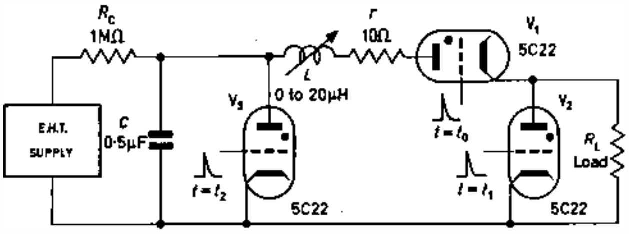


Fig. 1. Basic circuit of pulse generator

function have resistances of about 200Ω during conduction and peak current limitations of about 15A. The provision of large voltage pulses to loads of the order of 50Ω is clearly impracticable with such switches. Also with this form of generator malfunction can cause damage to the load, because the energy stored in the capacitor is normally about fifty times that required for a single pulse.

The line type pulser uses a thyratron as the switching element and has the advantage that it can be designed with an output impedance of 50Ω, which facilitates the feeding of both low and high resistance loads. However, as previously discussed[3], design features, such as the placing of the load in the cathode circuit and the use of a choke in the anode circuit, are required to obtain reasonably shaped rectangular pulses. Also in practice the pulse length cannot be varied continuously and is limited to a few microseconds because of the physical bulk of the pulse forming cable. Other disadvantages of this type of circuit are that the amplitude of the output pulse is only one-half of the extra high tension supply voltage and the load impedance must be matched to the generator output impedance.

This article discusses the design of a pulse generator which seeks to combine the advantages of both of the above types of pulsers. The circuit operation is similar to that of a hard valve generator but utilizes thyratrons, which connect a charged capacitor to the load, in an on-off switching cycle. For convenience it has been designated a thyratron 'on-off' pulse generator.

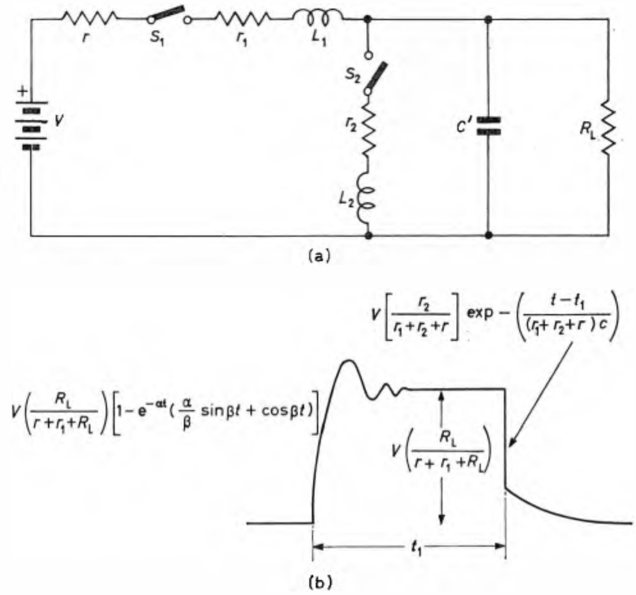


Fig. 2. (a) Equivalent circuit for V_1 and V_2
(b) Theoretical output pulse

Basic Circuit

The basic circuit of the generator is given in Fig. 1. The output pulse is initiated by firing thyratron V_1 at time $t = t_0$ and terminated by switching on V_2 at time $t = t_1$ to give an output pulse duration of $(t_1 - t_0)$. However the trailing edge characteristics of this pulse are not satisfactory[2] and have been improved in this circuit by the addition of V_3. This is fired at time t_2 about 0·1μsec after t_1 and serves to reduce the long trailing edge which would otherwise be present.

The shape of the output pulse resulting from the operation of V_1 and V_2 can be derived from consideration of the equivalent circuit given in Fig. 2. In this circuit r_1, L_1, and r_2, L_2 are the resistive and inductive elements of the valves when conducting. The grid-anode capacitances have been included in the capacitance C' which also provides for the primary-secondary winding capacitance of the filament transformer of V_1. The waveform of the

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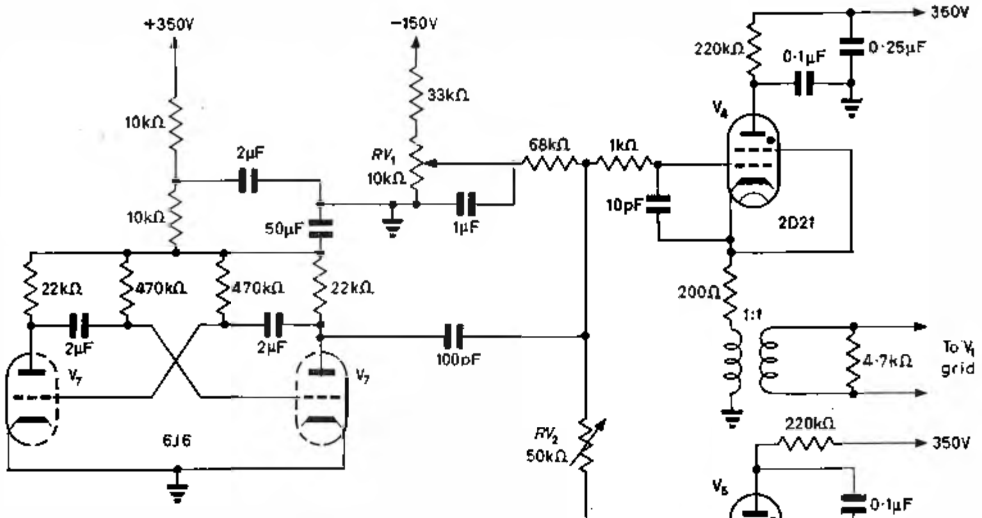
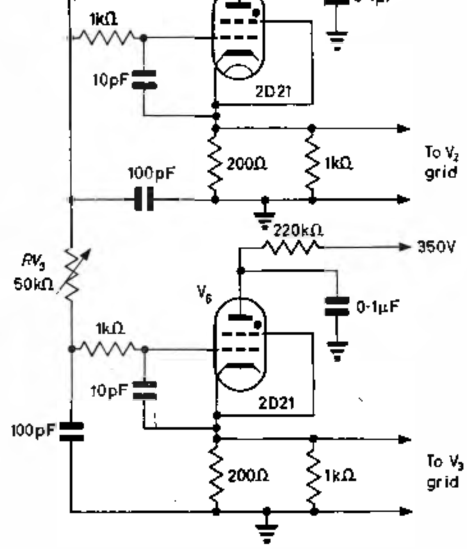
Fig. 3. Trigger pulse generator circuit





output pulse across the load R_L is determined in the following three steps:

(1) *Leading Edge*: The switch V_1 is closed at $t_0 = 0$ and $V(t)$ is evaluated over the time interval $0 \leqslant t \leqslant t_1$. The output voltage across R_L is:

$$V(t)\Big|_{0 \leqslant t \leqslant t_1} = \frac{VR_L}{r + r_1 + R_L}\left[1 - e^{-\alpha t}\left((\alpha/\beta)\sin\beta t + \cos\beta t\right)\right] \quad \text{.........} \; (1)$$

where

$$\alpha = \frac{r + r_1}{2L} + \frac{1}{2R_LC'} \text{ and } \beta = \left[\frac{r + r_1 + R_L}{L_1C'R_L} - \alpha^2\right]^{1/2}$$

(2) *Pulse Top*: Over the time interval $0 < t < t_1$, if $t \gg 1/\alpha$, the term $e^{-\alpha t}$ in equation (1) tends to zero and the output waveform becomes:

$$V(t)\Big|_{0 > t > t_1} = \frac{VR_L}{r + r_1 + R_L} \quad \text{........} \; (2)$$

In the actual circuit this voltage will fall exponentially with a time-constant $(r + r_1 + R_L)C$, which is much greater than t_1, as a charged capacitor C is used instead of the battery V in Fig. 2.

(3) *Trailing Edge*: The switch V_2 is closed at $t = t_1$ and causes the voltage across the load R_L to drop very rapidly to the value:

$$V\left[\frac{r_2}{r_1 + r_2 + r}\right]$$

assuming that $R_L \gg r_2$. This voltage then decays exponentially with the time-constant $(r_1 + r_2 + r)C$, hence:

$$V(t)\Big|_{t \geqslant t_1} = V\left[\frac{r_2}{r_1 + r_2 + r}\right] \exp -\left[\frac{t - t_1}{(r_1 + r_2 + r)C}\right] \quad \text{............} \; (3)$$

The decay time of equation (3) occupies many microseconds and has been reduced in this circuit by the addition of V_3. This valve is fired at a time t_2 immediately following t_1 and introduces another exponential factor:

$$\exp -\left[\frac{t - t_2}{r_3C}\right]$$

into equation (3) which results in a much faster cut off.

Summary of Operation

The operation of the circuit can thus be summarized as follows:

(1) V_1 is fired at $t = 0$ to produce a voltage step output across the load resistance R_L.

(2) This output voltage is maintained until time $t = t_1$, when V_2 is fired. The pulse magnitude then drops practically instantaneously to about one-seventh of the peak value.

(3) V_3 is now fired to reduce the remaining output voltage to zero.

Circuit Components

Hydrogen thyratrons type 5C22 are used for the switching valves V_1, V_2 and V_3. This type of valve has maximum ratings of 16kV anode voltage, 325A pulse anode current, and can be triggered with positive voltage pulses greater than 150V. Data on the impedance of these valves during conduction are not readily available and have been obtained from the experimental work on this generator. The major valve capacitance (the grid-anode capacitance) and the inductance between anode and cathode were measured for the non-conducting valve as 15pF and 2μH at 1Mc/s. The resistance of the valve during conduction was measured from output pulses using equation (3) and was found to be 2·4Ω. Comparison of actual output pulses with theoretical waveforms obtained from a numerical solution of equation (1) confirmed these equivalent elements for the valve.

The output pulse obtained with this circuit is convenient for measurements as the top is flat and the trailing corner is very sharp. The variable inductance in the anode lead of V_1 is used to reduce the oscillation on the leading corner of the pulse and it can be adjusted to give optimum conditions for any particular load configuration.

The resistance r in the circuit serves to limit the current through V_1 and V_2 when V_2 is fired. Substitution of a larger value gives the advantage of reducing the magnitude of the pulse tail described by equation (3) at $t = t_1$, but this also results in a decrease in the magnitude of the output pulse described by equations (1) and (2). The decay time of the pulse tail can also be decreased by reducing C but this will increase the sag of the top of the pulse. The component values shown in Fig. 1 have been used for the generation of 4kV 0·5μsec pulses at a repetition rate of 1 pulse per second.

The output pulse length can be continuously varied by varying t_1 subject to the condition that for a satisfactory

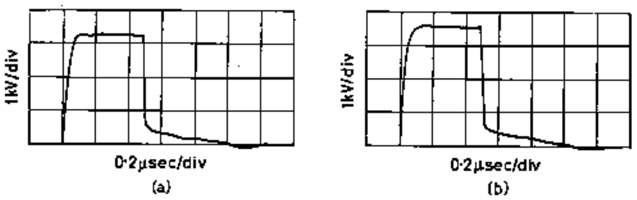


Fig. 4. Typical output pulses

flat top $(r + r_1 + R_L) \gg t_1$. For low values of R_L this leads to an increase in the value of C which in turn increases the demands on the e.h.t. power supply unit.

The Trigger Pulse Generator

The pulses required to trigger the hydrogen thyratrons V_1, V_2 and V_3 in the main generator are produced by the circuit given in Fig. 3. The multivibrator section built around V_7 provides positive pulses at the required repetition rate, in this case 1p/s. The pulses overcome the standing bias produced from the -150V supply and trigger the small thyratron V_4, which in turn fires V_1 in the main generator to initiate the output pulse across the load. The triggering conditions of V_4 are adjusted by the potentiometer RV_1 and the trigger pulse for V_1 is taken via the well insulated transformer in its cathode circuit. The construction of this transformer is described below.

The output pulse is terminated by firing V_5 at the time t_1 which is determined by the RC combination (50kΩ, 100pF) in its grid circuit. The time-constant of this combination is adjusted by the potentiometer RV_3 and the output pulse from this tube fires V_2 in the main generator. Finally V_6 is fired after a further delay of about 0·1μsec, set by the adjustable RC combination in its grid circuit. This valve fires V_3 in the main generator to reduce the duration of the tail of the output pulse.

After the required difference in the firing times of V_5 and V_6 has been set by potentiometer RV_3, the output pulse duration can be adjusted continuously by variation of the 50kΩ potentiometer in the grid circuit of V_5. For the circuit given this range is 0·2 to 5μsec approximately and can readily be extended by using a grid capacitor larger than 100pF.

The Trigger Pulse Transformer

The grid of V_1 carries the full output pulse voltage and must therefore be insulated from earth. It is fed by a well insulated transformer with a primary of 150 turns of 30 a.w.g. enamelled copper wire wound in three layers on a ferrite core (Philips D45/39). The secondary also has 150 turns but is wound in four layers and separated from the primary by four layers of 0·25mm polythene sheet to give insulation to about 30kV. This construction results in a primary inductance of 0·9mH, a secondary inductance of 0·8mH and a primary-secondary capacitance of 35pF.

Constructional Details

Details of the physical layout of the generator are given in Fig. 4. The hydrogen thyratrons V_1, V_2, V_3 are used in horizontal positions and are located so as to minimize the lengths of interconnecting leads. The sockets for these valves are insulated from the chassis on fibre board stands and the chassis is deep enough (2½in) to carry V_4, V_5, V_6, V_7 and the filament transformers for V_1 and V_2 underneath. The control for the well insulated 20μH variable inductance is brought out on the front panel together with those for the repetition rate, pulse length (potentiometer RV_2), pulse tail shape (potentiometer RV_3) and the negative bias control (potentiometer RV_1). The two last mentioned controls can be locked after setting.

The entire chassis is enclosed in a ventilated metal cabinet 10in high with a hinged top lid. This provides X-ray shielding during operation and allows convenient access to the main elements of the pulse forming circuit.

Performance

Typical 0·5μsec output pulses, with overshoot controlled by the variable anode inductance, are given in Fig. 5. These waveforms were taken across resistive loads of 66Ω and 200Ω using an e.h.t. supply capable of 3·9kV at 3mA and a 6·5ft length of coaxial output cable having a capacitance of 29·5pF/ft. They illustrate the main characteristics of the pulse shape, that is the flat top and the sharp trailing corner, which is produced by this type of generator. They also illustrate the ease with which different load resistances can be fed without matching arrangements and the manner in which the amplitude of the output pulse approaches the e.h.t. voltage as the load resistance increases.

For a pulse length of 0·5μsec and a 66Ω load, a charging capacitor of 0·5μF is required to obtain a negligible sag of the pulse top. If this capacitor is reduced for example to 0·1μF, the magnitude of the trailing corner will decrease by about 700V. If long pulses in low resistance loads are required, consideration must be given to the e.h.t. power supply power capabilities and to the size of the charging capacitor as discussed in the text.

The circuit is versatile and convenient to use for laboratory measurements because of the ease with which the pulse length can be varied and with which loads of widely varying resistance can be fed. Also the pulse shape has the advantage of a flat top and a sharp trailing corner which gives a convenient reference point for measuring purposes.

Acknowledgments

The major part of this work was carried out on the Defence Research Board of Canada Grant Number 5501-23, for research on semiconductor properties in the Electrical Engineering Department of McMaster University.

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LETTERS TO THE EDITOR

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

Counters and Shift Registers Using Static Switching Units

DEAR SIR,—In connexion with the above article by J. F. Young that was published in the March edition of *Electronic Engineering*, I should be grateful if I could obtain the author's clarification on the following points.

In describing the voltages acting in the binary stage circuit of Fig. 4, it is stated that with VT_1 conducting, the base input voltage to VT_1 is at 5V negative; thence it is inferred that VT_1 collector is also at -5V, thus giving a final voltage charge across capacitor C_1 with VT_1 'on' of $(30-5)=25$V. As the resistor values shown in the subsequent Fig. 5 would indicate that the 'on' transistors are correctly driven into full saturation, then it would seem that the 'on' collector voltages should be (approximately) zero. The base to emitter voltages also must be approximately zero when any transistor is conducting, unless the unlabelled common emitter supply line is standing at -5V for some reason or other not stated in the article.

However, even regardless of the actual d.c. levels of voltage that exist around the 'on' transistor, when a positive-going pulse of 15V peak is applied to the circuit this full voltage step, neglecting diode voltage-drops, appears at the base of the 'on' transistor, thus giving a 15V reverse voltage between base and emitter of the transistor, not 10V reverse as stated.

Finally, is there any attraction not immediately apparent in the choice of the diode-coupled bistable circuit shown, which with the pulse steering circuit requires two capacitors, four diodes and 11 resistors surrounding the two transistors per stage. This compares with two capacitors, two diodes and eight resistors necessary with the more common Eccles-Jordan resistor-coupled bistable circuit with an identical pulse-steering network to gate the input divide-by-two signals.

Yours faithfully,

S. L. HURST.

Bristol College of Science and Technology.

The author replies:

DEAR SIR,—The summary of my article confirms the title by pointing out that counters involving universal high voltage transistor-diode switching units are to be discussed. It was assumed that the reader would be acquainted with reference 1 quoted in the article, in which reference the advantages of the transistor-diode arrangement were discussed. To each standard unit is added one resistor R_1 and one capacitor C_1 in order to use it in a counter. Economics of production come from the repeated use of standard units (rather than the construction of special circuits as suggested by Mr. Hurst) and the object of my article was to show one way of incorporating this standard unit into a special application.

I re-stated in the first sentence of the offending paragraph of my article that transistor static switching units were being coupled together. A few sentences later I wrote "if VT_1 is conducting then C_1 charges up to say 25V if the input to VT_1 is at 5V negative in this condition." Unfortunately, Mr. Hurst adds an extra word for himself and writes "*base* input voltage to VT_1 is at 5V negative". He then proceeds to demolish such a statement. I agree with the demolition, but then I did not make this statement; he did. In his third paragraph, Mr. Hurst again ignores the presence of the input resistor chain in each unit and so reaches a false conclusion.

Yours faithfully,

J. F. YOUNG,

Sutton Coldfield.

Feedback Transistor Oscillators

DEAR SIR,—Having for some years used transistors in the common-collector configuration in a variety of Colpitts type crystal oscillators, I was surprised to note the conclusions of your contributor, B. Shahzadi, in the January issue, that there cannot be oscillations in such circuits and that it is mandatory for the tank to be placed across the base and the collector.

The majority of references in the literature are to the common-emitter configuration. I suspect that this has arisen because of the preference of most text-book writers, when dealing with valve circuits, for the active elements to be placed between the anode and the grid. Scroggie[1], however, as long ago as 1957 demonstrated the superiority of a transistor oscillator of the type originally devised by Gouriet[2] over the more conventional feedback transformer types; this oscillator is used in the common-collector mode. Obviously, the Gouriet being the first or second cousin of the Colpitts, the same considerations would apply to the operation of that circuit as a Colpitts.

Getting nearer home to Mr. Shahzadi, Commander Paul Lee of the U.S. Navy has published details[3] of a low-C Colpitts[4] using the common-collector mode. Other North American references embodying circuits utilizing the same mode are set out at the foot of this letter; they include a Colpitts crystal oscillator[5] for 9Mc/s, another Gouriet[6] and another low-C Colpitts[7].

In my own work on crystal oscillators I have successfully used the Colpitts type in the common-collector mode in circuits operating between 100kc/s and

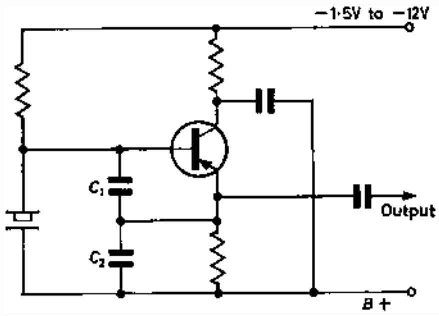

Fig. 1. Outline Colpitts crystal oscillator using common-collector mode

9Mc/s. Fig. 1 shows the basic circuit, which does not utilize any inductors. C_1 and C_2 have to be chosen to suit the crystal frequency and its constants. In the case of oscillators used as standards of frequency the choice of transistors having a low base-emitter capacitance which remains stable is of importance. There are a number of interesting features about this circuit but, as I hope to publish the results of my work, I may perhaps be forgiven if I do not elaborate on these points in this letter. However, all my oscillators oscillate! In order to satisfy myself that the circuit would also oscillate if an inductor were used instead of a crystal, I clipped a 5mH r.f. choke into a circuit used for crystals in the 300 to 500kc/s range; the bias arrangement was left undisturbed by placing a 0·1µF capacitor between the choke and the base of the transistor. The circuit 'took off' at a frequency very close to that expected from theoretical considerations.

I observe that Mr. Shahzadi does not deal with the analysis of any valve circuit. I prefer the analysis of the Colpitts as a negative resistance oscillator given by Gouriet[2]. This analysis also is given by Sandeman[8]. Having regard to the characteristics of a transistor when operated in grounded-collector, I find it very difficult to understand, in the light of Gouriet's analysis, why it should be thought that oscillations will not occur in this mode, given suitable circuit component values.

Your faithfully,

R. H. MUNRO,
Hong Kong.

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8. SANDEMAN, E. K. Radio Engineering, Vol. 1, Ch. XI.2.1 (1947).

The author replies:

DEAR SIR,—This is with reference to the conclusions of my article 'Two Distinct Boundaries for Feedback Transistor Oscillators' in the issue of January 1965, and Mr. R. H. Munro's

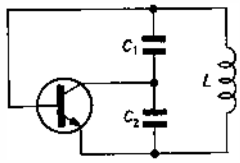


Fig. 1. Equivalent circuit

comment. I would like to emphasize again that the tank circuit in Colpitts and Hartley type oscillators can be placed only across the base and collector and not elsewhere, if the circuits are to oscillate.

This is the same as to say that Colpitts and Hartley oscillators will not work if their a.c. equivalent circuits are in common-base or in common-collector configurations[1] (Fig. 1), regardless of the arrangements for biasing and ground terminal. Then the fact that Mr. Munro's oscillator oscillates is not surprising, since its a.c. equivalent circuit is in common-emitter connexion.

Yours faithfully,

B. SHAHZADI,
U.S.A.

REFERENCE

1. REICH, H. J. Functional Circuits and Oscillators. p. 349 (D. Van Nostrand Company Inc., New York, 1961).

The U.J.T. as a Controlled Resistance

DEAR SIR,—A linear resistance having a magnitude which is a function of a control voltage or current has many applications: modulation (multiplication), gain control and frequency control are some of the obvious ones. The dynamic resistance of diodes, triodes and transistors has commonly been used for such functions.

While observing the characteristics of a type 2N2160 unijunction transistor (double-base diode) on a curve tracer it was noticed that it was possible to obtain a family of characteristics having good linearity over a useful range of voltage and current, the slope resistance being variable from about 500 to 5 000Ω.

The characteristics are shown in Fig. 1 and the mode of connexion in Fig. 2.

The positive-current part of the characteristics was first obtained with the curve tracer set to the 'npn' position and the negative with it set to 'pnp', and it will be noted that a very accurate junction of the two sets is obtained.

While the rather limited frequency range of the u.j.t. restricts the applica-

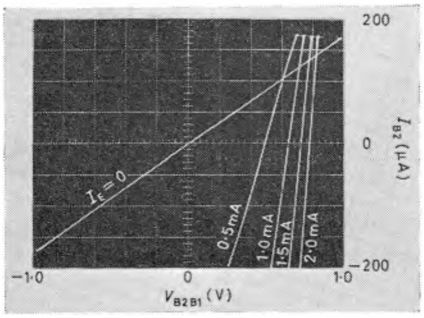


Fig. 1. Characteristics of unijunction transistor

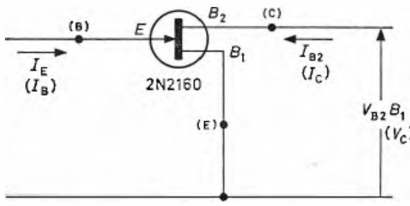


Fig. 2. Connexion to curve tracer

(The curve tracer nomenclature applicable to transistors is shown in brackets)

tion of this device as a controlled resistance, it may prove useful at audio and lower frequencies.

This property of the u.j.t. may have been described previously, but I have not found any reference to it.

Yours faithfully,

G. J. PARKER

Central Electricity Research Laboratories,

Leatherhead.

Frequency Control of Astable Transistor Multivibrator Circuits

DEAR SIR,—I read with interest the above article in the March 1965 issue and would like to draw your attention to frequency control of the same configuration by use of constant charge rate or base current drive. Fig. 1 shows the configuration to which I refer.

A first order approximation shows the p.r.f. to be proportional to the discharge current and the first derivative to

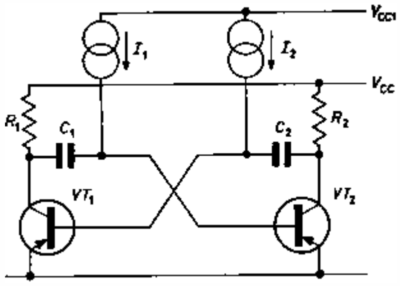


Fig. 1. Frequency control by constant charge rate

$C_1 = C_2$ $R_1 = R_2$

$I_1 = I_2 \simeq C \cdot \delta v/\delta t \propto$ p.r.f.

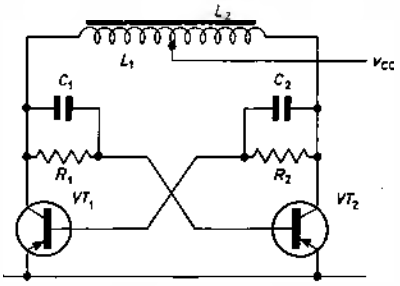


Fig. 2. Inductively coupled multivibrator

$L_1 = L_2$, $C_1 = C_2$, $R_1 = R_2$

$V_{CC} = L_1 \cdot \delta\phi/\delta t \propto$ p.r.f.

be linear. The limiting factors of thos variables which were considered in th article apply equally here.

By use of an inductively couple multivibrator a similar relationship ma be obtained, see Fig. 2. With these th applied voltage is proportional to p.r. which effect with square loop materia has found applications in fields othe than those commonly associated wit the circuit.

Yours faithfully,

H. H. A. BATH

Edwards High Vacuum Internation Ltd.

The author replies:

DEAR SIR,—We are indebted to M Bath for bringing these alternati circuits to our attention. The circuit Fig. 1 would theoretically appear t provide a more linear frequenc adjustment than the 'wide range circuit discussed in our article, bu realization of this in practice woul be dependent upon the accuracy of th constant current generator circui which control I_1 and I_2.

The interesting circuit of Fig. 2 woul seem to be a rather more difficult pro position to design to give a predete mined performance than other circuit but, as implied to Mr. Bath, may hav valuable advantages in specific appl cations.

Yours faithfully,

S. L. HURST

Bristol College of Science an Technology.

BOOK REVIEWS

Photoelectric Effects in Semiconductors

ly S. Ryvkin. 402 pp. Royal 8vo. Consultants Bureau Inc. 1964. Price $22.50

PHOTOCONDUCTIVITY in semiconductors at first glance seems to ›e a basically simple phenomenon: on llumination with radiation of suitable vavelength, infra-red or visible, 'bound :lectrons' in the 'valence band' of a emiconductor are lifted into the conduction band' where they are free o move under the influence of an elecric field, to carry electric current. Cadnium sulphide, for instance, a typical ›hotoconductor, is a fairly good nsulator in the dark, of a few megohms' esistance; when illuminated, its resistınce will drop by several orders of nagnitude. The actual phenomena in'olved in this apparently simple process ıre, however, quite complex, and Ryvkin's book gives an excellent and uthoritative treatment of this and some losely related subjects.

The first few chapters give a clear yet oncise description of the basic phenonena involved, no more than elemenary mathematics being used. The main nethods and techniques of measurement equired for the study of photoconducivity and for a detailed evaluation of uch measurements for the determinaion of the two fundamental parameters, he 'yield' and the 'life-time' of the xcited electrons, are described. Some f the major pitfalls frequently enountered in such measurements are iscussed: uneven illumination of the pecimen and non-ohmic contacts. Throughout the book the emphasis of he treatment is on the kinetics of the arious phenomena involved rather han on the static characteristics of hotoconduction. Sine-wave or pulse nodulation of the illumination is necesary to cover the very wide range of fetimes encountered in photoconducors, and the corresponding techniques re described in great detail.

The main chapters of the book deal ith the processes of generation of the harge carriers, their diffusion in the onduction band under a concentration radient and drift in an electrical potenal gradient (field), their trapping at arious metastable states ('trapping entres'), and finally with the various ecombination processes. The features eated in these chapters, particularly ıose dealing with excitation and recomination, are of vital importance, not nly in photoconductivity but also for ıser action, and a careful study of ıese chapters will pay ample dividends › the reader working in these fields. The last chapter of the book deals with the creation of a photo-e.m.f. across a pn junction, as well as with photo-diodes with their higher sensitivity and faster response.

It is perhaps regrettable that the crystal structure of photoconductors and their electronic band structures are not discussed. In spite of the vast amount of detailed information available in the literature on the effects of defect centres in certain crystals, their relation to the main crystal structure still remains largely unknown. Current work on laser crystals is bound to yield pertinent information in this respect and it is to be hoped that a second edition of the book in a few years' time will include a chapter on this aspect.

Very few mistakes were found in the book; the awkward statement in the footnote on page 75 $\lambda = 2\mu$ (meaning wavelength equals 2×10^{-4}cm) could have been avoided; also the value of the momentum of the photon in the example cited is not $1{\cdot}87 \times 10^{-29}$ but $3{\cdot}31 \times 10^{-23}$g. cm. sec^{-1}.

There is no doubt that the book represents a milestone in the study of photoconductivity. Professor Ryvkin is not only one of the most outstanding workers in this field but he also has the gift of 'putting things over' with a minimum of specialist's jargon. The translation from the Russian has obviously been prepared by one of that rather rare species—an expert in the field who is also completely bi-lingual.

E. BILLIG

Nonlinear-Magnetic Control Devices

By W. A. Geyger. 406 pp. Med. 8vo. McGraw-Hill Book Co. 1964. Price £5

IT is not often that a book is concerned with devices which may take currents of a few milliamperes or a few tens of kiloamperes, whose voltages may be a few millivolts up to a few hundreds of kilovolts, or whose powers may vary from a few milliwatts up to 1MW in the largest ratings. Such are the ranges covered by the various electromagnetic devices surveyed by Dr. Geyger and which all depend for their operation on the utilization of the non-linear magnetic saturation characteristic of 'soft' or easily magnetized ferromagnetic materials. All of them are concerned with control, and by this the author means that they are controlled in some way by electric or magnetic quantities to provide automatic regulation, magnetic modulation or amplification, frequency multiplication, static d.c. to a.c. power conversion or the measurement of direct current. Magnetic logic circuits, magnetic-tape and similar equipments are excluded.

After giving a very comprehensive historic review, the book describes the materials used and their magnetic properties. It then repeats a regular pattern of developing the basic principles of a group of devices, followed by descriptions of their applications in industrial, nuclear, military and aerospace engineering. The approach is essentially graphical and descriptive, but design aspects are omitted entirely, as is the extended use of mathematics. The groups covered are a.c. saturating non-linear inductors, saturable reactors, frequency multipliers, multivibrators, modulators and flux-gate magnetometers and include combinations of magnetic cores with transistors, silicon controlled-rectifiers and other semiconductor devices.

The author has paid detailed attention to terminology and carefully defines his terms, while giving the alternatives used in U.S., British and German literature. The references, too, are extensive and include the major British and Continental contributions in this field, but the use of the unrationalized c.g.s. system of units is to be deprecated in an otherwise up-to-date and commendable book.

J. T. HAYDEN

Electronic and Hybrid Computers

By G. A. Korn and T. M. Korn. 584 pp. Demy 8vo. McGraw-Hill Co. 1964. Price £7

THIS book succeeds the authors' well-known 'Electronic Analog Computers' reviewed in this journal in 1957. The material in the earlier book has been compressed and brought up to date and information added about recent hybrid computers. The new information on the analogue side concerns transistorized computing amplifiers and improvements to non-linear devices such as multipliers, function generators, limiters etc., in respect of speed and accuracy.

The final third of the book is principally about new developments in analogue computer control and information storage, which have added a new dimension to the analogue computer. Two kinds of store are described. There is the storage of single voltages, using track-hold circuits, which makes it possible to solve difference equations. Function storage, which is the storage of voltages varying with time on magnetic tapes or (after conversion of the analogue signal to digital form) on digital delay lines is described though rather too briefly. Hybrid computing, in which digital techniques (involving a digital clock, binary counters, logic elements etc.) are used to control high-speed analogue computers and their stores, has greatly extended the range of problems which can be solved by an analogue computer. The account of digital control elements is, however, too brief for readers not already versed in the techniques. Hybrid computers can change parameters automatically between computing runs, and can calculate by successive approximations so that optimization of a solution can be gradually achieved over a succession of runs. The applications of this technique include the automatic solution of ordinary differential equations with *two*-point boundary conditions, the solution of eigenvalue problems, the optimization of control systems, and the solution of partial differential equations and of integral equations.

There are full details of many circuits, and descriptions of recent American computers, and also large collections of references. The book, which is intended both for users and designers of computers is a welcome reference text on these recent developments, and an immense amount of information has been compressed into the one volume.

J. R. BARKER

Untersuchungen auf dem Gebiet der praktischen Mathemetik

(Investigations in the field of Practical Mathematics)

By F. Reutter and D. Haupt. 85 pp. Med. 8vo. Westdeutscher Verlag. 1964. Price DM.53.50

THIS research report deals with several subjects. Reference is made to previous reports on the possibility to present in nomographical form systems of two functions of two variables. Provided the conditions stated there are fulfilled, a system of four differential equations of the second order can define the scale functions of a system. Now an integration method has been developed for the determination of the scale functions which is particularly suitable for electronic calculations. It follows the considerations for a useful method of calculating the function values of elliptic functions of real variables by means of a computer. Further applications of this method of calculation are described and the necessary considerations given. The subject matter of the report is said to be of considerable practical value in various fields.

E. R. FRIEDLAENDER

Principles of Transistor Circuits

By S. Amos. 293 pp. Demy 8vo. Iliffe Books Ltd. 1965. Price 35s.

This is the third edition of the book originally published in 1959 and has been considerably enlarged.

Among the new subjects included are d.c. stabilization of amplifiers by direct coupled feedback, phase shift and Wien bridge oscillators, blocking oscillators and transistor sawtooth generators. Other additions include sections on emitter-coupled multivibrators, the Darlington circuit, complementary amplifiers, d.c. amplifiers, heat sinks and the unijunction transistor. The chapter on pulse amplifiers has been expanded and more information has been included on field-effect transistors.

Handbook of Electron Beam Welding

By R. Bakish & S. S. White. 269 pp. Med. 8vo. John Wiley & Sons. 1965. Price 87s.

This book deals with the theoretical and practical aspects of electron beam generation and describes the methods for proper tooling.

Thrusters and Sleepers

A P.E.P. Report. 295 pp. Demy 8vo. George Allen & Unwin Ltd. 1965. Price 35s.

This is a study on attitudes in industrial management made by four members of the research staff of P.E.P. and is the result of a two-year research project financed by a grant from the Nuffield Foundation.

Electromagnetic Aspects of Hypersonic Flight

Edited by W. Rotman, H. K. Moore and R. Papa. 364 pp. Med. 8vo. Macmillan & Co. 1965. Price 120s.

This book contains the proceedings of the unclassified sessions of the Second Symposium on the Plasma Sheath—Its Effect upon Re-entry Communication and Detection held at Boston, Mass., in April 1962 under the sponsorship of the Electromagnetic Radiation Laboratory of the American Air Force Cambridge Research Laboratories.

Principles and Methods of Measuring Humidity in Gases Volume I

By R. E. Ruskin. 704 pp. Crown 4to. Reinhold Publishing. 1965. Price $30.00

This is the first of a four-volume series dealing with humidity and moisture—measurement and control in science and industry. The subject of an international symposium held at Washington, D.C., in 1963.

Conference Proceedings Vol. 26. Pt. 1. 1964 Fall Joint Computer Conference

By A.F.I.P.S. 745 pp. Demy 4to. Macmillan & Co. 1964. Price £7 10s.

This book contains the proceedings of the 1964 Fall Joint Computer Conference organized by the American Federation of Information Processing Societies (AFIPS) at which 56 papers were presented.

Digest of Literature on Dielectrics Vol. 27. 1963

255 pp. Demy 4to. National Academy of Sciences-National Research Council. 1963. Price $15.00

This volume has been prepared by the Conference on Electrical Insulation Division of Engineering and Industrial Research for the National Academy of Sciences at Washington D.C.

It contains 11 chapters each with a bibliography and a critical review of developments described in publications appearing in 1963 and dealing with a wide range of dielectric materials.

European Miniature Electronic Components and Assemblies Data Pt. 1. 1965-66

By G. Dummer, J. Mackenzie Robertson. 1193 pp. Demy 4to. Pergamon Press. 1965. Price £12 10s.

This second European book in the Electronics Data Annual Series is being published in two parts. Part 1 covers the electronic products of West Germany and Italy and Part 2 those of France, the Netherlands, Scandinavia and Switzerland.

In addition to a six-language glossary of component titles is another glossary of microelectronic terms together with some 250 abstracts of articles relating to the components and assemblies field.

Instruments Electronics Automation Year Book and Buyers' Guide

Edited by T. G. Williams. 568 pp. Demy 4to. Morgan Brothers (Publishers) Ltd. 1965. Price 50s.

This comprehensive guide to the instrument, electronic and automation industries is divided into five thumb indexed sections.

The first section contains the names and addresses of the various associations, institutions and societies connected with the industries; a 27-page 'who's who' in which the career details of prominent people in the relevant industries are listed; and a list of people concerned with the procurement of supplies for Public Services in the U.K.

The second section gives manufacturers names and addresses.

The third section is a comprehensive buyers guide classified by subject. A list of trade names is included.

Section four is an illustrated products section consisting of advertisements arranged in alphabetical order.

The last section consists of 19 equipment surveys written by leading authorities in their respective fields and provides technical background information relating to equipment which is commercially available.

The Goonhilly Project

By F. Taylor. 152 pp. Demy 8vo. The Institution of Electrical Engineers. 1964. Price £3

'The Goonhilly Project' is a detailed account of the design, construction and operation of the General Post Office satellite communication radio station at Goonhilly Down, Cornwall.

The book is a collection of papers describing various facets of Goonhilly and of the results of experiments using the Telstar 1 satellite and its immediate successors Relay 1, Telstar 2 and Relay 2. In general the papers are those produced as contributions to the I.E.E. International Conference on Satellite Communication that was held at Savoy Place in November 1962, but opportunity has been taken to bring them up to date in certain respects and in particular, to enlarge on the original description of results of experiments.

Television Engineering: Television Electronics

By P. Neidhardt. 340 pp. Med 8vo. Pergamon Press. 1964. Price £7.

This dictionary contains some 3 500 terms in English, French, German and Russian associated with television engineering and electronics.

The terminology covers general television studio equipment, industrial, satellite and colour television and picture tubes etc.

The Radio Amateur's Handbook 42nd Edition

By the American Radio Relay League. 700 pp Med 8vo. A.R.R.L. 1965. Price $5.50

This is the 42nd edition of this handbook originally published in 1926.

Radio Receiver Design Part 1

By K. R. Sturley. 937 pp. Demy 8vo. Chapman & Hall. 3rd edition. 1965. Price 105s.

This is the third edition of the book originally published in 1943 and has been considerably enlarged to deal with the application of transistors in radio receiver design.

ELECTRONIC EQUIPMENT

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

(Voir page 417 pour la traduction en français; Deutsche Übersetzung Seite 424)

ELECTRONIC TIMER

:ircuitron Ltd, 476 Coventry Road, Small Heath, Birmingham, 10

Housed in a robust sheet steel case, he standard timer is offered with a 'ange of adjustable delays from 1sec ip to 4min, after which a P.O. type elay operates a set of changeover con-acts which can switch circuits at up o 440V a.c. Infinitely variable adjust-nent over the entire time range is given y two front mounted controls.

The timer is designed to operate from :00 to 250 or 380 to 440V but other upplies can be accommodated. A feature f the design is that the printed circuit iase, carrying all components can be emoved on a 'plug-in' basis, making naintenance and servicing extremely asy.

A number of extra features are avail-ble to meet special requirements such s the fitting of stabilizers to deal with ride fluctuations in the supply voltage, nd when the timing cycle is initiated y an impulse signal only, an additional naintaining relay can be incorporated.)n the output a variety of switching ontacts is possible to meet particular .eeds.

EE 82 751 *for further details*

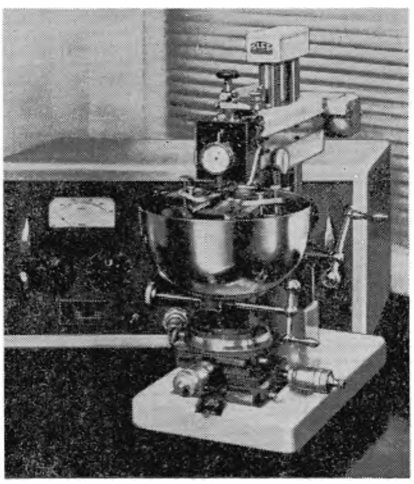
MICRO EROSION MACHINE

South London Electrical Equipment Co. Ltd, Lanier Works, Hither Green Lane, London, S.E.13

(Illustrated below)

While the technique of spark erosion ; quite well established, its application ɔ the machining of extremely small omponents in both metal and semi-onductor materials is of every recent ate, and is the subject of a number of atents.

The 'Arcotron' is a small compact ench-mounted machine constructed to 1e closest limits of accuracy, and capable of cutting slots to a thickness of approximately 0·00035in wide. Of particular interest is the servo-control which comes into operation immediately the arc is short-circuited; a feedback system causes the forward feed to reverse at high speed until the short is cleared, whereupon the forward feed once more takes over and upon the striking of the arc the cutting speed recommences.



Alignment is to the order of 0·00002in with feed rates down to 0·0002in/min. The spark rate is approximately 1Mc/s, and a surface finish of approximately 3 microns is obtainable.

Principal applications for this machine have so far been in the manufacture of evaporation masks, thin film resistor patterns, cryotron masks, microwave generators and circuits, thermo bonding tools, punches and dies, etc.

EE 82 752 *for further details*

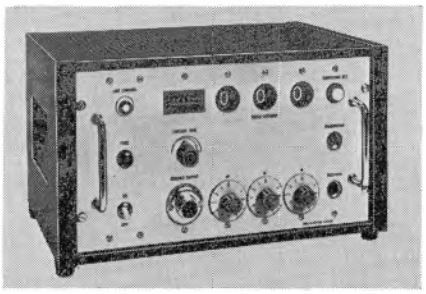


PHOTO-ELECTRIC COUNTERS

Simmonds Relays Ltd, South Road, Harlow, Essex

(Illustrated above)

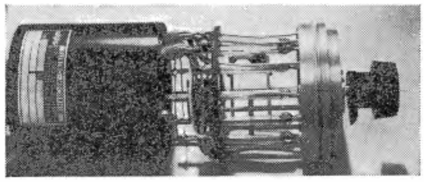
A complete range of Visolux photo-electric counters is now available from Simmonds Relays Ltd. It covers a wide variety of counting duties including pre-selection of definite numbers of items, unit counting of items on conveyor belts, counting into definite batches in con-tinuous flow, and simultaneous counting of the batches, and counting by weight.

The range also covers electromagnetic and electronic counters to count at speeds of up to 10kc/s. Predetermining batch facilities can be provided on certain of the counters and up to five selected batches. Initiation of the counters is normally by interruption of the light beam by the pieces to be counted; this brings the photo-electric receiver into operation.

Sensing heads can be provided to operate for distances up to 30ft between receiver and light beam transmitter. Compressed air fans can be provided for dusty atmospheres, so that the lenses of sensing heads can be kept clean. Flame-proof units are also available.

Other means of initiating the counting operation are by galvanic contact, in-ductive transmitters, magnetic scanning heads and impulse generation.

EE 82 753 *for further details*



ROTARY REED SWITCHES

Distributed by: Kynmore Engineering Co. Ltd, 19 Buckingham Street, London, W.C.2

(Illustrated above)

EMS Rotireeds are available in five basic types, with sealed reed contacts arranged radially or axially around a cylindrical or rectangular body. Switch-ing is controlled by an electromagnetic or permanent magnet armature driven by a shaft. Permanent magnet armatures are used in the majority of cases, a number of permanent magnets being mounted on the same armature when multi-pole switching is required. Alter-natively, multiple switches with a common spindle may be used. Where a large number of contacts must be con-fined in a very small space, electro-magnetic switching is preferred. The coils of the electromagnetic armature are supplied through sliprings.

Since the gold-plated contacts of the reeds themselves are sealed in an inert atmosphere, they are unaffected by the external environment. Rotireeds may therefore be mounted in any desired attitude, in dust-laden, damp or other-wise aggressive atmospheres. As with all reed switches, the contacts remain free from dirt, corrosion or appreciable mechanical wear.

Normal or miniature contacts may be used in the standard types of Rotireed, the choice depending on the load to be switched and on the speed of operation required. Normal contacts are rated at 15W, 1A, with a reaction time of 3msec. At 26V, 0·25A, operating life is 10^8 operations. Miniature contacts are rated at 6W, 0·3A, with a reaction time of 1msec. At 26V, 0·1A, operating life is again 10^8 operations. For maximum reliability the switching cycle should be two or three times the reaction time for both types of contact, and armature speed of rotation for particular Rotireed assemblies must be limited accordingly. Some types may be driven satisfactorily at up to 5 000 rev/min.

The five main types of Rotireed offered are as follows:

Type RR is fitted with a permanent

magnet armature and ball bearing shaft for pulse generation from an external drive.

Type RH is fitted with a permanent magnet armature and rachet-controlled shaft for manual operation, with click stop positions clearly marked on the front panel.

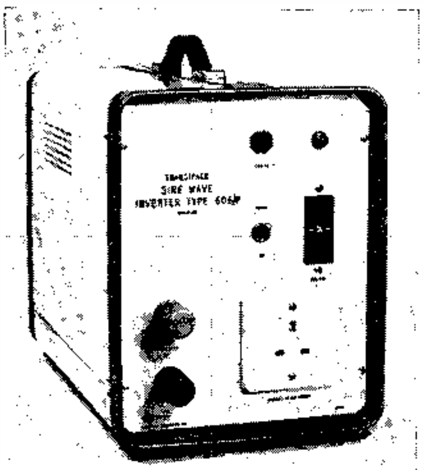
Type RM is fitted with a permanent magnet armature and built-in synchronous motor for clock pulse applications.

Type RS is similar to type RM with addition of a position-holding circuit.

Type RK is fitted with an electromagnetic armature and synchronous motor drive, with switch positions marked on the front panel.

All types can be supplied as standard in single- and multi-pole, and multi-position versions, some with as many as 100 separate sets of contacts. All types may be fitted with soldered, clamped or plug-in type connexions at the customer's discretion, and special configurations can be supplied to customers' requirements. Dimensions depend on the choice of configuration.

EE 82 754 *for further details*



STATIC INVERTORS

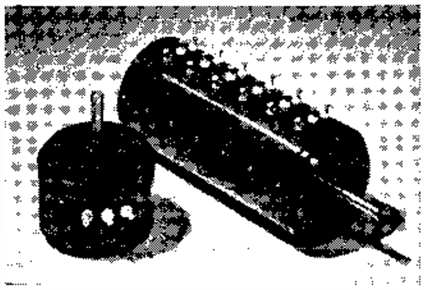
Industrial Instruments Ltd, Stanley Road, Bromley, Kent

(*Illustrated above*)

These invertors employ semiconductors as switching elements and are designed for d.c. inputs of 12, 24, 48, 110 and 220V. The sinusoidal output is either 115, or 230V r.m.s. and the frequency 50c/s. The power output varies according to model from 110W to 6kW. The invertor is protected against input voltage polarity reversal and also incorporates electronic protection against overload and short-circuits.

The invertor is tolerant of wide load power factor changes and models are available for energizing motors, such as are used in large recording machines, or portable electric tools, e.g. hand drills. The circuit enables extremely compact and inexpensive design; e.g. a 1kW unit is mounted in a portable case. Despite its comparatively small size, the invertor incorporates an automatic voltage regulator, which compensates for changes in load and d.c. input voltage. A frequency control unit is provided, which is capable of holding 50c/s to better than 1 per cent, regardless of d.c. input and load changes.

EE 82 755 *for further details*



MULTI-GANG POTENTIOMETERS

Standard Telephones & Cables Ltd, West Road, Harlow, Essex

(*Illustrated above*)

Now available from STC/P. X. Fox is a range of precision potentiometers with choices from multi-gang and multi-tap construction. Typical of the range is the *S11* International frame size, illustrated, which has a 1·062in outside diameter. This unit has a torque value of 1g/cm per section and an operating life of 3 million cycles.

The *S11* range offers a linearity of 0·1 per cent at 5kΩ and above. The potentiometers are available with up to 10 gangs per unit and with a maximum of 10 taps per gang. The unique Fox potentiometer contact, while giving extremely long life and low torque, achieves noise values as low as 10Ω.

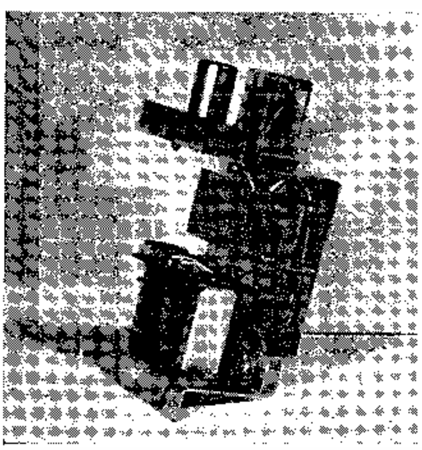
EE 82 756 *for further details*

PHOTO RELAY

Hird Brown Ltd, Flash Street, Bolton, Lancashire

(*Illustrated below*)

Hird-Brown Ltd has introduced a new chassis mounting for the photo-relay type PS1. The new chassis has three keyhole slot fixing holes so that it can quickly be fitted into its case or inserted into new or existing electrical control cabinets. The PS101 photo-relay operates two sets of relay contacts when its beam(s) is interrupted (or restored). All power supplies for the relay, photocell(s) lamp(s) are provided and the unit can be connected to any standard mains supply.



Positive relay operation is always achieved whenever the light path is broken, whatever the ambient lighting conditions.

The photo-relay may be housed in standard Hird-Brown sheet steel cases, size 9in × 6in × 4in, 10in × 6in × 4in, 12in × 9in × 5in or up to three at a time in size 18in × 12in × 5in cases.

A choice of 30 different types of projector and receiver is available for use with the PS101 photo-relay.

EE 82 757 *for further details*

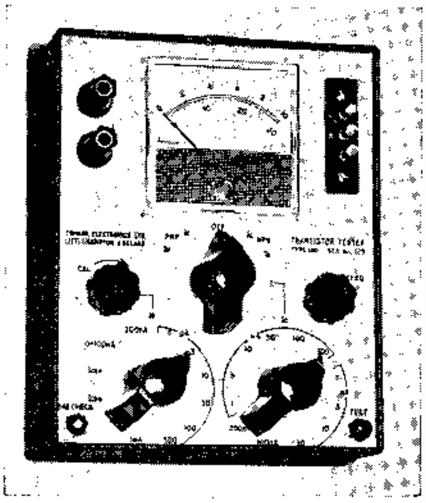
TRANSISTOR TESTER

Comark Electronics Ltd, Gloucester Road, Littlehampton, Sussex

(*Illustrated below*)

On the transistor tester type 180 d.c. gain of both npn and pnp transistors can be measured at collector currents as low as 10nA, and leakage down to 1nA can be detected.

Collector current may be set at any value up to 30mA, and measured with a transistor-chopper nano-ammeter in 12 ranges down to 100nA f.s.d. Collector test voltage is 4V. Terminals are available for external use as a nano-ammeter. Accuracy: 2 per cent.



Base current is continuously variable from zero to 1mA in nine ranges, and is measured directly with the nano-ammeter; auto-ranging for ease of use. Nine pre-set base currents give direct-reading gain scales of 0-30, 0-100 and 0-300.

The instrument is powered by long-life mercury batteries. Overall dimensions are 6·25in × 5in × 3·5in.

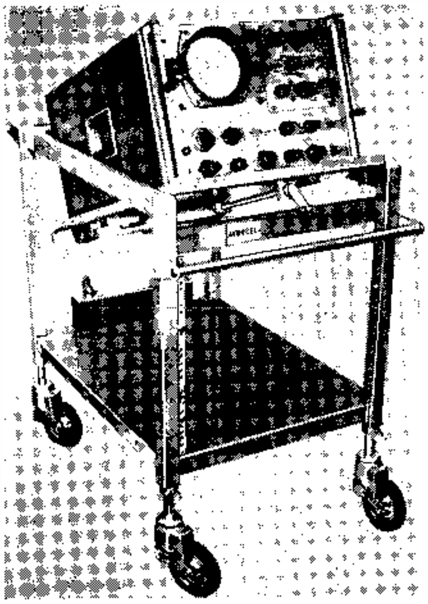
EE 82 758 *for further details*

OSCILLOSCOPE TROLLEY

Avon Communications & Electronics Ltd, 16a High Street, Christchurch, Hants

(*Illustrated on page 410*)

The TM11, with its adjustable top shelf, has been designed to provide a satisfactory mobile mounting for the new style of wide fronted oscilloscope. A new feature is the inclusion of rack bars for standard G.P.O. 19in panels to provide mounting facilities for the



stand-by plug-in units associated with many modern instruments.

This new trolley maintains the characteristic sturdiness of construction associated with the other models in the range produced by this company. Strongly welded 12 gauge square and rectangular section steel tubes form a unit construction frame for the adjustable top shelf 19in wide by 28½in deep and the fixed position bottom shelf is 22in wide by 30in deep. Both shelves are of ¼in steel plate and are fitted 20in apart. The top shelf adjustment is achieved by a winding handle mounted at the front of the trolley through 0 to 20° and can be held at any intermediate angle. Variable position locators for the rear of the oscilloscope are fitted to the top shelf. The rack bars for direct bolting of G.P.O. 19in panels are fitted below the shelf adjustment handle. Height of the trolley is adjustable in 1in steps from 30in to 36in; push bars are provided at either end. The unladen weight is approximately 85 lb.

Castors are supplied to suit varying conditions. Heavy duty 5in industrial type rubber-tyred castors with ball bearing swivel are fitted as standard. Brake assemblies may also be supplied at extra cost. Using standard castors, the TM11 has a safe load capacity of some 900 lb.

Where the trolley is required to carry highly delicate instruments, 5in spring-loaded castors with cushion-tyred wheels are fitted and can be supplied instead of the standard type, at extra cost. Using the spring-loaded castors restricts the safe load capacity to 200 lb. For travel over rough floor or road type surfaces, the TM11 may be equipped with special 8in by 2in pneumatic-tyred castors, again in lieu of the standard fitting and at extra cost.

EE 82 759 *for further details*

DIGITAL METER READER

Distributed by: Thorn Electronics Ltd, Wellington Crescent, New Malden, Surrey

A new digital meter reader (analogue to digital convertor) is to be marketed by Thorn Electronics. This instrument was developed by Automatique Electrique S.A. of Antwerp, for whom Thorn will act as agents.

Although the conversion of analogue quantities into digital can be achieved with shaft recorders, or the conversion of d.c. voltages, etc., the digital meter reader (d.m.r.) operates with greater precision and efficiency.

The d.m.r. converts the angular deflexion of a needle instrument or a shaft into an equivalent number of pulses. These are read from a previously calibrated magnetic drum starting from a point corresponding to the zero of the instrument up to a point determined optically by the actual instrument reading.

A thousand or more pulses corresponds to full-scale deflexion so that the conversion accuracy is 0·1 per cent or better, with the result that the conversion is as exact as the analogue indication. The magnetic drum is set to rotate continuously at one revolution per second, although faster speeds are possible.

An optical system mounted on the drum produces a rotating beam which determines the needle position. A mirror is mounted on the needle shaft with two photo-electric cells. As soon as the needle position has been determined, the photocell signal stops the pulse count of the pulses read off the magnetic drum.

The rotating beam is produced by a fixed light mounted in the axis of the drum and an optical system mounted on it. This optical system consists of a flat mirror inclined at 45° to the axis of the drum, and a concave mirror which focuses the beam on to the instrument mirror.

The conversion accuracy is independent of the drum speed, and the use of the magnetic drum allows the use of non-linear conversions—hence it is possible to use a.c. inputs and obtain directly digital outputs without an a.c./d.c. convertor. On the other hand, the magnetic drum allows correction of transducer errors or non-linear lanes. This can be very useful for flow measurements, etc.

The initial development of d.m.r. was aimed at telemetry, although it has since proved valuable in many fields.

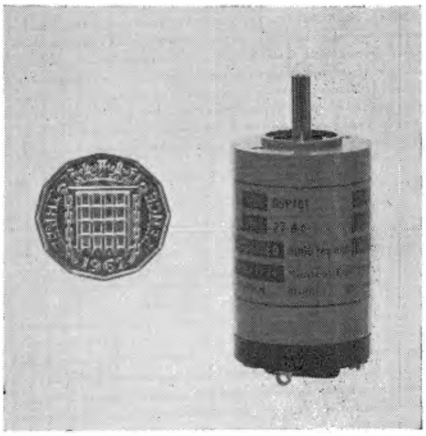
EE 82 760 *for further details*

MINIATURE D.C. MOTOR

Vactric Control Equipment Ltd, Garth Road, Morden, Surrey

(Illustrated above right)

Recently introduced by Vactric Control Equipment Ltd is a new low-cost miniature precision-built permanent magnet d.c. motor designed to have a long trouble-free life under adverse environmental conditions. Known as type 09P, the motor is considerably shorter in length than others in a similar category and has an overall housing diameter of 0·880in. Various shaft-end configurations



are available and provision has been made in the design for a double-ended shaft, if required. When fitted with a pinion it is suitable for connecting to a precision reduction gearhead. For vibrationless operation, it has a balanced armature running on miniature stainless steel ball bearings.

With a nominal voltage of 28V d.c., the motor has a rated torque of 30g.cm at 6 000 rev/min. with an input current of 0·25A. Its minimum stall torque is 65g.cm and no load current 100mA. Its weight is 45g and it is suitable for operating in the ambient temperature range −55° to +85°C. The motor is mounted by two threaded holes in the front face of the housing.

EE 82 761 *for further details*

A.C.-D.C. DIGITAL VOLTMETER

Digital Measurement Ltd, Salisbury Grove, Mytchett, Aldershot, Hampshire

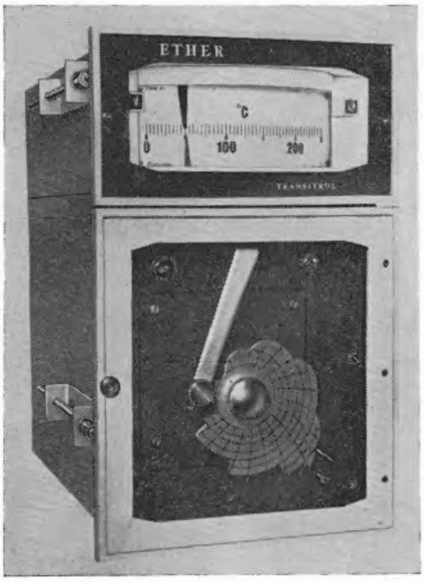
(Illustrated above)

Digital Measurements Ltd has added the DM2003 a.c.-d.c. digital voltmeter (NATO No. 6625-99-104-6993) to its range of high performance digital instrumentation.

The DM2003 measures d.c. voltages from 1mV to 1kV with an accuracy of 0·05 per cent f.s.d. ±0·1 per cent of reading, and a.c. voltages from 2V to 700V r.m.s. with an accuracy of 0·25 per cent f.s.d. ±0·25 per cent of reading over the frequency range 50c/s to 5kc/s. The scale of 1999 gives a best resolution of 1mV d.c. and 10mV a.c.

The instrument has a high impedance fully-floating input giving a d.c. common mode rejection better than 120dB with up to 1 000V isolation from earth. The measurement is displayed on numerical indicator tubes with automatic indication of decimal point. Modes of operation include (a) auto follow, (b) manual trip, (c) hold reading. A polarity switch enables bi-polar operation so that d.c. measurements of either polarity can be made without the need to reverse the signal input leads.

EE 82 762 *for further details*



TEMPERATURE CONTROLLERS

Ether Ltd, Caxton Way, Stevenage, Hertfordshire

(Illustrated above)

A new series of potentiometric programme temperature controllers known as the 12-94 has been announced by Ether Ltd.

A potentiometric indicating temperature control unit (available in a variety of types) is combined with a time/temperature programme unit to indicate and control temperature, to a close accuracy, over a wide range. Solid state construction throughout ensures high reliability under widely varying conditions over a long working life. It can also control any process where the signal can be converted into a direct current or voltage. Housed in a welded steel case the equipment is fully sealed against dust and moisture.

Programme cams can be supplied cut to an accuracy of ±1 per cent of the scale range. Any errors in cam cutting can be corrected by a vernier screw on the control arm. An involute cam can be used for fixed temperature control.

At any given time or temperature the programme motor or fuel can be switched off by use of the limit switch. One or two auxiliary switches can also be fitted to initiate external circuits.

EE 82 763 *for further details*

HIGH POWER AUDIO OSCILLATOR

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

(Illustrated above right)

A high-power audio oscillator giving very low distortion has been introduced by Dawe Instruments Ltd. Designated the type 440B, it comprises a two-stage oscillator section feeding a selective *RC* network, the output of which is taken through an amplitude control to a buffer amplifier feeding a phase splitter and balanced push-pull output stage.

Each section has been designed to operate so that its valves work well within their linear regions; this, together with selective feedback and a generally high standard of construction, ensures that the oscillator provides a high power (6W) output with virtually no distortion over the range 20c/s to 20kc/s. The output transformer is matched for a load of 3·75, 15 or 600Ω impedance but the effect of mismatch is negligible.

Frequency is continuously variable through a ratio of ten to one by a ganged variable capacitor coupled through a precision-geared drive to a frequency scale calibrated over 333° of arc. Three decade ranges provide the full 20c/s to 20kc/s coverage in a total scale length of 60in.

At 3W output, amplitude is constant to within ±0·5 dB over the whole frequency range. Typical harmonic content at 400c/s is 0·02 per cent second harmonic and 0·12 per cent third harmonic, with less than 0·01 perc cent hum and spurious signal. Amplitude is stabilized to within ±1 per cent and frequency to within 0·05 per cent within 30min of switching on.

The instrument is simple to operate and needs no special care to achieve consistently good results. It is powered by a 50c/s or 60c/s mains supply. The compact bench-mounting cabinet (8¼ × 13 × 12½in) ensures proper ventilation.

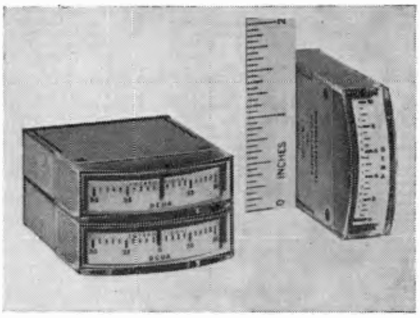
EE 82 764 *for further details*

MINIATURE PANEL METERS

Distributed by: Leland Leroux Ltd, 145 Grosvenor Road, London, S.W.1

(Illustrated above right)

International Instruments Inc of Connecticut, U.S.A., has developed a new precision miniature meter—the model 1122—which satisfies many needs for tight-space applications. In addition to the basic advantages of edgewise meters the model 1122 has several additional features. They are completely flat from scale to terminals; there is no barrel projecting from the meter, and the back



of panel volume is only about 1·5in³.

The new type patented meter movement has, unlike most permanent magnet moving-coil movements, only one air-gap, rather than two. This single gap magnetic circuit is so arranged that the available space is utilized in a highly efficient way. As a result the 1122 movement produces as much magnetic field strength as was possible with conventional two-gap movements. Since there is only one air-gap the coil can be pivoted from an arm attached to the non-cutting side on the moving-coil. This long movement arm multiplies the force produced by the movement to give a high torque output. In addition, because the coil's pivot axis is offset from its centre, a single-shaft, through pivot can be used instead of individual pivots on each side of the coil, thus completely eliminating pivot misalignment problems and helping to maintain linearity and repeatability.

The model 1122 miniature panel meters are especially suitable for check-out and monitoring consoles where multi-channel indication is required. Their compact profile makes these meters suitable for use in miniature process instruments, and as tuning meters or v.u. indicators in audio systems. An optional centre zero arrangement allows their use for null indication.

Since there is no barrel, the 1122 meters can be stacked one on top of another or side by side without limit. The new magnetic circuit design precludes any magnetic interaction problems.

The 1122 is available in 27 standard ranges, with sensitivities from 100μA or 50mV f.s.d. in vertical or horizontal reading format, with various zero positions, plus special scale arrangement, v.u. meters, decibel meters, etc. Higher sensitivities to special order.

Initial accuracy is ±2 per cent of full-scale value for d.c. (±3 per cent for a.c.); response time is 2·5sec maximum; scale length is 1·24in. Overall measurements are 1·600in wide by 2·350in deep by 0·515in high, and the weight is approximately 4 oz.

EE 82 765 *for further details*

MINIATURE ELECTROLYTIC CAPACITORS

Plessey-UK Ltd, Capacitor Division, Kembrey Street, Swindon, Wiltshire

A new range of miniature electrolytic capacitors with very low series resistance is announced by Plessey-UK Ltd.

Designated type LSR, the capacitors were originally developed for use in transistorized computer circuits but are expected to find many other applications.

By using highly conductive electrolytes, internal resistance has been reduced to a fraction of its usual value—a figure as low as 0·05Ω has been confirmed on some samples, using a pulse measurement technique.

A property of ordinary aluminium electrolytic capacitors which limits their performance and thus restricts their use at audio and higher frequencies and under rapid discharge conditions, is their high internal resistance. This high resistance arises from two causes: the use of high boiling point electrolytes, based on boric acid, which are only moderately conducting, and the need to make the capacitor small.

If operating conditions are realistically assessed, the designer of computer and communications equipment will often find that the use of electrolytic capacitors constructed to work in an ambient temperature of say 70°C is quite unnecessary and that a capacitor with an upper ambient temperature limit of 40° or 50°C could well be used.

At these more moderate temperatures a choice between several, more conducting, electrolytes may be made, the electrolytes being based on the more soluble, and almost neutral, ammonium salts of acids other than boric. For 50°C working, it is thus possible to formulate film forming electrolytes which are about five times more conducting than those normally used, while for 40°C working, electrolytes as much as fifty times more conducting may be used.

Aluminium electrolytic capacitors, either of the etched foil or plain foil types, impregnated with these more conducting electrolytes give greatly improved performance at high frequencies, under pulse conditions, or in decoupling applications, and their behaviour at low temperatures in the range 0°C to −40°C is outstanding in comparison with normal electrolytic capacitors.

LSR capacitors cover a range from 1 to 1 000μF, at working voltages up to 150V. Operating temperature range is −30°C to +40°C or +50°C, according to type. They are available in plain or etched foil type with or without an insulating sleeve.

There are two case diameters, $\frac{3}{8}$in and $\frac{1}{2}$in, and four case lengths, $\frac{3}{4}$in, $1\frac{1}{8}$in, $1\frac{1}{4}$in and $1\frac{3}{8}$in.

EE 82 766 *for further details*

VARIABLE RESISTOR

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

(Illustrated right)

An inexpensive variable resistor now available from Mullard has completely noise-free control. It is therefore particularly suitable for controlling video and audio signal currents. The device, type number ORP39, comprises a cadmium sulphide cell and a 12V filament lamp encapsulated in a plastic block measuring 17 × 17·5 × 22mm. The block has four lead-out pins and is suitable for standard printed circuit mounting.

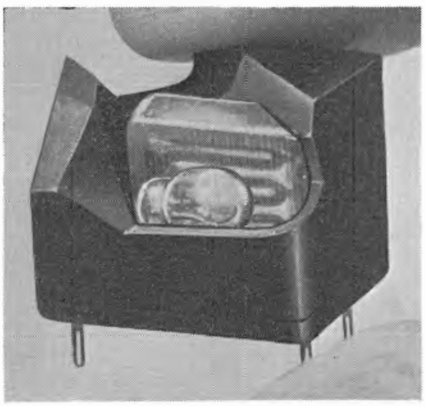
The ORP39 has been specifically designed for use as a remotely controlled variable resistor in television cameras to control brightness (beam current) and black-level clamping. It can also be used as a feedback element in audio circuits for overall gain control, as a remotely controlled brightness/contrast control for television receivers and for remote control in video tape-recorders, video signal repeater stations and television translator equipment. It could also find application in medical electronics.

By varying the brightness of the lamp the resistance of the cell can be controlled over at least three decades (say from 100Ω to 10kΩ).

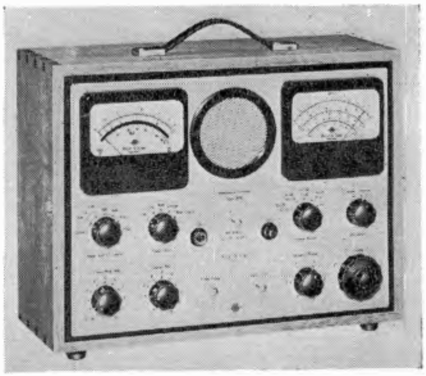
The adjustment of the resistance is completely free of noise and there is no electrical connexion between the control and the output. This results in good electrical insulation and isolation and also permits long leads to be used from the remote controlling point to the equipment with no interference to the controlled circuit.

The capacitance between the controlling and controlled circuits is of the order of 2pF. The device is resistive and does not become reactive over the video signal range. It is not, however, recommended for use with intermediate frequencies (i.e. of the order of 10Mc/s). It has a fast response time—far faster than the operation time of a manual control and is inexpensive when compared with any other similar high-quality device capable of remote control. The ORP39 is particularly suitable for use in circuits where any interaction between control and controlled circuit is undesirable, as a rheostat with no contact noise or, in general, as a transducer, converting a voltage input to a resistance output with complete electrical isolation between input and output.

As the impedance and phase angle of the cell vary with its resistance and the frequency applied to it, the useful upper frequency limit of the output resistor depends on the tolerance of the application to the changes and is probably a few megacycles per second.



EE 82 767 *for further details*



HETERODYNE VOLTMETER

Distributed by: B & K Laboratories Ltd, 4 Tilney Street, Park Lane, London, W.1

(Illustrated above)

The Brüel & Kjær heterodyne voltmeter type 2006 is fully transistorized and is designed for measurements in the radio frequency and v.h.f. ranges. It is a battery-operated, light weight unit capable of selective measurements at all commonly used a.m., f.m. and television frequencies.

Not only the amplitude of high frequency signals can be measured, but it is also possible to determine the frequency as well as the percentage modulation. The measured frequency is indicated on a meter scale. A second meter indicates the amplitude of the measured r.f. voltage and the modulation, and a loudspeaker provides an audible signal check.

The voltmeter is provided with a direct input terminal and the impedance at this terminal is 75Ω. However, by fitting this terminal with a special probe a high impedance input is obtained. The input probe is connected to the voltmeter by means of a 1·5m long flexible cable.

To extend the voltage range of the instrument the input probe is supplied with a removable voltage divider having similar dimensions to the probe. The attenuation of the voltage divider is 60dB.

A built-in stabilized reference oscillator supplies a reference voltage for calibration of the instrument.

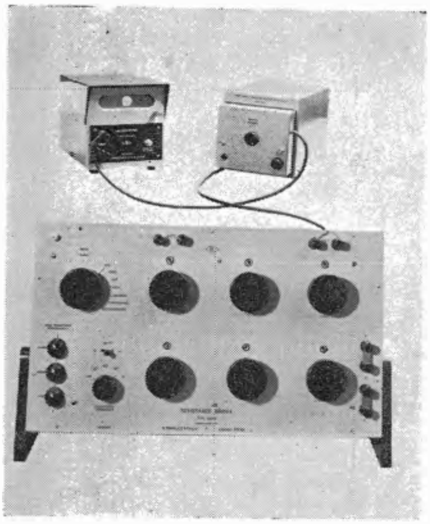
EE 82 768 *for further details*

HIGH PRECISION RESISTANCE BRIDGE

H. Tinsley & Co. Ltd, Werndee Hall, South Norwood, London, S.E.25

(Illustrated on page 413)

The high precision resistance bridge, type 5577, recently introduced by H. Tinsley & Co. Ltd, claims the elimination of switching errors usually associated with the Wheatstone-bridge type of measuring instrument, together with a reduction of possible errors, or damage, due to excessive current in one or more coils. These advantages are attributable to circuit design. The variable arm incorporated in the bridge is constructed of conductance elements, built-up in binary increments, and covers a million steps. Six coils only are used on each of six decades; a total number of 36 instead of the 60 coils normal to



a conventional Wheatstone-bridge circuit. Ratios are changed by means of a rotary switch.

In a conventional Wheatstone-bridge all the switch contacts are in series and this limits the possible accuracy to the sum of the contact errors. In the new design this problem is entirely eliminated as all the contacts are in parallel. The worst case is when the 50Ω resistance coil is in series with a $25\mu\Omega$ switch contact; the effect of the latter obviously being negligible.

A further feature of the bridge is that it can be used as a four terminal bridge which enables long leads to be used and their effect compensated in the bridge reading. The total measuring range is from $0{\cdot}0001\Omega$ to $100M\Omega$, with bridge voltages of 2 to 60V respectively. The instrument may be expected to operate with a limit of error no greater than 0·01 per cent within the lower extreme, and 0·1 per cent within the upper extreme measuring ranges. For intermediate measurements it is 0·001 per cent at 100Ω to $10k\Omega$, 0·005 per cent at $10k\Omega$ to $100k\Omega$ and 0·01 per cent at $100k\Omega$ to $10M\Omega$.

EE 82 769 *for further details*

INSTRUCTIONAL SERVO SYSTEM

Feedback Ltd, Crowborough, Sussex

(Illustrated below)

The instructional servo system type ES130 is a general purpose d.c. position control designed to illustrate all important aspects of closed loop system theory.

The initial approach is to explore the characteristics of a simple second order system and proceed to problems of stabilizing higher order systems involving non-linear elements and compliance-inertia resonance. In this way, student technicians from industry or post-graduate specialists may use the equipment with equal facility.

Among the practical features are:

The provision of continuously rotatable input and resetter potentiometers. The input may be driven by its own motor speed controller to enable steady state following characteristics to be investigated.

An operational amplifier in addition to the servo amplifier with appropriate components for compensating networks.

Addition of predetermined amounts of backlash, inertia and friction when required.

Indication of continuous and impulsive overloading of the system. Monitor meter to read potentials throughout the system.

The internal $\pm 300V$ stabilized power supplies are available for operating associated units from the Feedback analogue range to provide analogues and relay control.

A comprehensive course of theory and experimental work is included.

EE 82 770 *for further details*

STABILIZED POWER SUPPLY

A.P.T. Electronic Industries Ltd, Chertsey Road, Byfleet, Surrey

(Illustrated above right)

A.P.T. Electronic Industries Ltd announce the addition to their T.C.U. series of the T.C.U. 1050.

The T.C.U. series of power supply units is a range of compact laboratory instruments of high performance and attractive styling, incorporating a number of features which result in an excellent specification in an exceptionally small size.

In common with the rest of the series, the T.C.U. 1050 is variable over the range 0 to 50V with an output current of 10A. The protection system is designed to prevent damage to the unit under overload conditions by limiting the current drawn and, after a delay, clamping the output to zero. Transient overloads having a duration shorter than the delay permit the unit to restore to its normal operating conditions. A stepped control is provided to set the level at which the protection will operate, and a push-button is mounted on the front panel for resetting.

Five switched steps and a fine control allow the output control to be varied over the range 0 to 50V, while the trip level is selected on a six-position switch, having steps of 120 per cent, 100 per cent, 80 per cent, 60 per cent, 40 per cent, or 20 per cent of the maximum rated load current.

Terminals are provided for remote sensing, and the output is isolated from the chassis, so that by earthing one side or the other the voltage may be made

positive or negative with respect to earth, and units may be series connected to give higher voltages, subject to the limitation of 500V d.c. between the terminals and the chassis.

The design of the rectifier circuits, which use silicon controlled rectifiers, results in operation at high efficiencies with the peak current drawn from the mains supply kept to its lowest practical limit.

The mains and d.c. fuses are mounted at the rear of the units together with the mains tapping panel and the mains cable, all other controls and terminals are at the front together with the large, easily read, meter.

EE 82 771 *for further details*

GAS LASER

G. & E. Bradley Ltd, Electrical House, Neasden Lane, London, N.W.10

(Illustrated below)

G. & E. Bradley announce the release of a new helium-neon gas laser especially designed for educational establishments. It has a 28in tube, is r.f. excited with separate drive unit. The drive unit has an output of 60W at 27·12Mc/s, is crystal-controlled, and can be modulated for simple communication experiments.

The standard output frequency is 6 328Å and the mirror system is confocal. The output power is 5mW. Alternate output frequencies and mirror systems are available. The cover of the laser head is easily detachable for servicing and adjustable mounts can be supplied for fitting the head on an optical bench.

EE 82 772 *for further details*

Short News Items

Cossor Electronics Ltd has recently concluded negotiations in Moscow with the State Trading Organization V/O Aviaexport for the supply of 50 aircraft systems based on the Cossor SSR.1600 a.t.c. airborne transponder. A number of the equipments will be installed in aircraft of the Soviet Airline Aeroflot for air traffic control purposes on international air routes; the remaining units will be fitted into aircraft manufactured by the Soviet constructors Ilyushin, Antonov and Tupolev for supply to various air lines outside the U.S.S.R.

The order for the transponder systems, which is worth more than £80 000, is coupled with an option for the further supply of a substantial quantity of transponders together with back-up spares and test equipment.

The Fourth International Aerospace Instrumentation Symposium (formerly Flight Test Instrumentation) will be held at the College of Aeronautics, Cranfield on 21 to 24 March, 1966.

The Symposium is sponsored by the College of Aeronautics and the Aerospace Division of the Instrument Society of America.

Papers are invited for presentation at this symposium and authors are requested to submit a 300 to 500 word summary for consideration by the organizers.

Appropriate subjects in the applied science and technology of instrumentation of aerospace vehicles may be chosen but papers which are concerned with new measurement techniques and the application of computers to large scale data handling problems are particularly welcome.

For further information write to; Michael A. Perry, Symposium Organizer, The College of Aeronautics, Cranfield, Bedford, England, or E. K. Merewether, Chairman, International Affairs Committee, I.S.A. Aerospace Division, 4515 Canoga Avenue, Woodland Hills, California, U.S.A.

Racal Communications Ltd is supplying a number of 1kW single sideband mobile radio stations to the Republic of Ireland, Department of Defence.

The installations set in a standard military 3 ton 4 × 4 truck, are intended for service in any part of the world and the electrical installation includes a refrigerated air conditioning unit.

The radio installation which is specially designed to withstand severe bumbs and vibration comprises: a 1kW TA.127 single sideband transmitter, two receiving terminals embodying the RA.17 receiver, a comprehensive telephone system enabling the radio station to be connected to any public telephone network and aerial systems with automatic switching. The station is equipped with the latest type of teleprinters to permit full duplex operation. Radio facilities provided by the station are f.s.k. (teleprinter) s.s.b., and c.w.

The Computing Devices Co. Ltd. has introduced a new, compact and lightweight system which projects symbols from a cathode-ray on to a flat surface. Designed to display tactical situations or navigational information on a plotting board, chart or similar surface the new equipment has been named Tactical Display System (TDS) and is the end unit or read-out device of a complete tactical and navigation computing system.

It is small and light enough to be fitted in fixed-wing and helicopter aircraft as well as in ships and hydrofoils. The system is of importance where a need exists to collect quantitative data and present it visually in a manner which allows a clear appraisal to be made of a developing situation. Examples of its uses are in tactical anti-submarine warfare plots, supply or paratroop dropping on to beacons and for displays of battlefield situations.

The inputs to TDS can be manual or automatic. They are converted to conventional, cartesian characters for display on a cathode-ray tube. Any form of plain symbol can be used such as arrows, circles, squares, crosses, letters and numbers.

A typical display could show, for example, present position, orientation, marker location, bearing information, range data, and alphanumeric symbols combined to give an up-to-date picture of a changing situation.

The Zambia Information Service has announced that G.E.C. (Telecommunications) Ltd has been awarded a contract valued at over £350 000 for a microwave radio system in Zambia. Three broadband frequency channels will be provided in each direction between the capital city of Lusaka, Broken Hill, Ndola and Kitwe via five repeaters. One channel will convey a 625-line television channel plus sound channel, a second will be allocated for 960 telephone channels and the third will act as a protection channel which will automatically replace either of the working channels in the event of a fault.

In addition to the broadband channels, an auxiliary radio channel operating in the 2 000Mc/s band and also completely semiconductored, will provide engineers order wire and remote alarm facilities linking all stations.

G.E.C. (Telecommunications) Ltd has been given an order worth £100 000 to extend two large automatic telephone exchanges in Iraq. The exchanges, which were originally supplied by G.E.C., are in the towns of Mosul and Kirkuk, to the north of Baghdad, the capital.

When the extensions are complete, Iraq will have 100 000 telephone lines. Ninety per cent of these have been supplied by G.E.C. who have been contractors to the Government of Iraq for nearly thirty years.

RENFE—the Spanish Railways System is to instal an electronic seat reservation system made by Siemens of Munich.

This system, known as SIERRA (Sistema electronica RENFE reserva asientos) not only books seats and sleeping berths but also prints seat reservations and tickets, computes ticket prices, performs accounting operations, and prints passenger lists and reservation tickets for carriage compartments. The central equipment consists of two model 3003 Siemens data processing systems with disk files and magnetic tape units. Siemens will also supply the peripheral switching, the transmission equipment, booking stations, etc., so that the entire system will have a uniform operating principle.

A Microelectronics Symposium organized jointly by the Southern Section of the Institution of Electronic and Radio Engineers, the Southern Electronics Section of the Institution of Electrical Engineers and the Department of Electronics, University of Southampton is to be held at the University of Southampton on 21 to 23 September this year at which over thirty papers will be presented.

Sessions will be held dealing with thin-film and integrated-circuit linear applications, digital-stores, computer and switching applications, the use of metal-oxide-semiconductor transistors, system design and interconnexion methods, and human and economic aspects.

It is also hoped to arrange a small exhibition to feature displays of microelectronic circuits and components in stages of development as well as those in production.

Registration forms are now available from The Symposium Secretary, Department of Electronics, The University, Southampton.

The British Radio Valve Manufacturers' Association (BVA) and Electronic Valve and Semiconductor Manufacturers' Association (VASCA) announce that the total sterling value of sales of British radio valves, tubes and semiconductor devices for 1964 shows an increase of 16·9 per cent over those for 1963, according to figures given below:

	1964	1963
Valves and Tubes	£48·3M	£42·7M
Semiconductor devices	£23·7M	£18·9M
	£72·0M	£61·6M

The figures for the last quarter of 1964 were:

Valve and Tubes	£12·1M
Semiconductor devices	£ 6·2M
	£18·3M

Of the total for 1964, according to figures previously released, export sales accounted for £11 392 584, approximately 15·8 per cent.

The Nippon Electric Company of Tokyo has received a contract from the Ministry of Iranian Posts, Telegraphs and Telephones for the supply of three 100kW and eight 10kW medium wave radio broadcasting transmitters. The contract includes the supply of aerial systems and tower, and power supply equipment.

The South African Air Force has ordered a precision approach radar simulator type SY.2022 from Solartron Electronic Group Ltd, of Farnborough, Hampshire, England. The simulator will be installed early next year at the South African Air Force Base, Langebaanweg, Cape Province, where it will be used for air traffic control training.

Feeding into Standard Telephones and Cables SLA 3C display equipment, the simulator realistically represents on azimuth and elevation displays the radar responses of aircraft from their turning on to final approach right down to touch-down on the runway. The controllers under training pass instructions to the 'pilots' over a simulated radio-telephone link as they would do operationally, and additional features such as wind gusting effects are provided so as to create maximum authenticity and training value.

The Home Office has placed an order with G.E.C. (Electronics) Ltd, for 400 LANCON pocket-sized radio transmitter-receivers for use by police forces throughout the country.

The LANCON set, which is the smallest and lightest v.h.f. packet set to be granted G.P.O. and Home Office approval, has been in operational use by the Lancashire Constabulary for more than 12 months.

The LANCON is a three-channel set, powered by a 12V rechargeable battery housed in its case, fitting conveniently into a pocket inside a policeman's tunic.

Thorn-AEI Radio Valves and Tubes Ltd has received an order from West Germany for television picture tubes to a value of more than £250 000. These tubes are basically the same as those used in the majority of British television sets but have been specially tailored to the needs of the German customer. This is believed to be the first order of this size received from a West German television setmaker for British picture tubes.

The Government of Bermuda has now approved the application by Cable and Wireless (West Indies) Ltd, for a cable-laying licence for an 80-channel telephone cable between Bermuda and Tortola, British Virgin Islands.

The inter-island scheme of tropospheric links is now under construction and the islands involved are: Trinidad, Antigua, Barbados, St. Lucia, Grenada, St. Kitts, St. Thomas, St. Vincent, Montserrat, Dominica and British Virgin Islands.

The 900 nautical mile cable link to Bermuda will provide high quality telephone, telex and telegraph services to the United States and via the Commonwealth telephone cable system to most countries of the world.

Submarine Cables Ltd has received a contract for the supply of the 900 nautical mile cable and Standard Telephones and Cables Ltd will supply thirty repeaters, three equalizers in demountable housings for adjustment of the electrical characteristics of the cable during the laying process and special terminal apparatus including power feeding equipment for providing power to the electronic circuits of the repeaters and equalizers.

The Posts and Telegraphs Administration of Denmark is to place an order worth nearly £500 000 with Submarine Cables Ltd (owned jointly by AEI and BICC) for a submarine telephone cable to be installed in the Baltic between Nykobing (Falster) and Ronne on the island of Bornholm.

The contract will include the supply and laying of about 105 nautical miles of submarine coaxial telephone cable and 13 transistorized submerged repeaters, together with the supply and installation of special terminal-station equipment.

The cable will provide 480 telephone circuits and be similar to several other systems being supplied by Submarine Cables Ltd for various North Sea routes.

Laboratoire Central de Telecommunications, Paris, has been selected by the European Space Research Organization to develop the ESRO 1 satellite. It will be the first contract that will be given to an association of leading Western European electronic companies. Subcontractors for the programme are Contraves A.G., Zurich; Bell Telephone Manufacturing Company, Antwerp, Belgium, and Standard Telephones & Cables of London.

ESRO 1 is scheduled to be launched in late 1967 by a four-stage Scout rocket from the western test range in Point Arguello, California.

The total contract will call for complete design and development of a satellite whose space mission will be to collect data on ionospheric and particle conditions in the Northern Polar Region. The satellite, whose scientific objective will require a minimum six-month operational lifetime, will have an apogee of 1 500km (930 miles), and a perigee of 275km (170 miles). Its inclination will be 90° i.e. a polar orbit and it will be magnetically stabilized by passive means.

S. Smith & Sons (England) Ltd announce the formation of a new organization to be known as Kelvin Electronics Company which will promote specialized electronic instrumentation and control systems for industrial applications.

The main products of Kelvin Electronics Company are:

Ultrasonics and other non-destructive test apparatus.

Recording and laboratory test equipment.

Boilerhouse instrumentation and controls.

Process control and data handling equipment.

The future activity of Kelvin Electronics Company will be directed towards the field of advanced industrial instrumentation and controls. To accelerate these developments the technically advanced research, engineering and production capabilities of Smiths Aviation Division will supplement the existing research and engineering facilities at present located at Smiths Hillington factory.

The English Electric Co Ltd is to form a new company—English Electric Automation Ltd—with the object of consolidating the English Electric Group of Companies to develop and market automation systems and equipment. Included in the new companies will be the Marconi Companies and the English Electric-Leo-Marconi Computer Company.

The Plessey Co. Ltd is carrying out a major reorganization scheme. The first step in this is the formation of a Components Group.

This new group represents a rationalization and concentration of the wide range of component activities currently carried on by four major Plessey subsidiaries: Plessey-UK Ltd, Garrard Engineering Ltd, Semiconductors Ltd and Ericsson Telephones Ltd.

It will comprise 22 decentralized companies and divisions producing among them thousands of different components in the electrical, electronic and electro-mechanical fields. The total work force will be over 16 000 people when the new group comes into operation and production will be undertaken at factories in nine different centres in Britain.

British Standards information on the dimensions of electronic tubes, valves and their related holders until now has been contained in a comprehensive publication, B.S. 448. Many users of the standard have commented that it would be a great convenience if dimensional information on sockets were published separately from that on tubes and valves—and this would also follow the practice in IEC Recommendations.

With the issue last month of a reprint of B.S. 448, all information on valve-holders has accordingly been removed from the standard, which now carries the changed title Dimensions of Electronic Tubes and Valves. The reprint, incorporating all 32 amendments issued since the previous edition of the standard in 1953, is published in two separate parts. In Part 1, general requirements are specified for valve bases and associated gauges and pin straightening tools. The second part contains dimensional data sheets grouped into 42 individual valve sections, laying down dimensions for the base and the associated outlines, gauges and pin straightening tools. There is also a section on valve caps.

All information on the dimensional standardization of valve sockets (valve-holders) will now be covered by the new publication, B.S. 2251 Sockets for Electronics Tubes and Valves. The first part of this, giving general requirements and methods of tests, has already been issued. Work is in hand on the article sheets which will form Part 2 of the standard. As an interim measure, pending the completion of this work, the valve socket dimensional data sheets previously included in B.S. 448 are being made available as a temporary Part X of B.S. 2251.

Copies of these standards may be obtained from the B.S.I. Sales Branch, 2 Park Street, London, W1, at the following prices: B.S. 448, Part 1: 5s. each; Part 2: £4 15s. each; binder (if required) 8s. each; B.S. 2251, Part 1: 12s. 6d. each; Part X: £2 5s. each; binder (if required) 8s. each.

A Leo 3 computer is being used for the main records of 16 million holders of Premium Savings Bonds totalling nearly £500M.

The computer's magnetic tape record will replace two document files—one in alphabetical order and the other in bond number order—each containing more than 64 million documents.

The Post Office has ordered seven LEO 326 computers worth £350 000 from English Electric-Leo-Marconi Computers Ltd. The transfer of the premium bond records is the second major computer operation by the Post Office. The first is the calculation and printing of six million telephone accounts a year in the London area.

The selection of random numbers for the prize draw will still be performed by ERNIE, but will be printed out on punched paper tape. The computer will compare the punched prize numbers against the magnetic tape records and print out notifications to the prize winners.

The divided records of Post Office Register Stocks are also being placed on the computer. These are the savings totalling nearly £1 200M of more than two million people who have invested in National Development Bonds, Defence Bonds and other Government securities.

The computer will keep the records of investments up to date (there are 750 000 changes a year of one kind or another) and arrange for the payment of about 4 500 dividends each year. For many years, punched cards and other machinery has been used for this work.

Solar cells for the European Research Organization's satellite ESRO 2 will be supplied by Ferranti Ltd.

Four satellites are to be built by Hawker Siddeley Dynamics Ltd—two flight models and two prototypes—and the total number of solar cells involved will be 16 700.

The cell, type MS21, is a modified form of the MS20 cell which will be used in the U.K.3 satellite. The MS21 will convert air mass zero sun energy (outer space energy) with an efficiency of not less than 10·5 per cent (13·5 per cent at ground level) which corresponds to an output power of 28mW at the maximum voltage point of 430mV and will withstand radiation doses estimated to be the equivalent of 12 months' operation in the inner Van Allen belt, without suffering a deterioration in the output level of greater than 25 per cent.

The Imperial College Computer Unit was inaugurated on 12 May by the Right Hon. The Earl of Halsbury. This unit, under the direction of Professor Stanley Gill, Professor of Computing Science, has been set up to co-ordinate work throughout the College in the computing field.

An IBM installation comprising a 7090 computer, a 1401 computer and ancillary punched card equipment, together with a Ferranti high-speed data link, directly attached to the London University Atlas, form the major part of the unit. In addition, facilities include a reception area where computing work is received and results distributed, a room containing card punches for preparing the programmes and data, and a Mathematical Machines Laboratory.

IBM has made its equipment available to the College free of charge under an agreement which provides for one-third of the computer time to be for the use of the College, up to one-third for other universities and colleges jointly invited to participate by IBM and the Imperial College and one-third for IBM.

The Radio Research Station, an establishment of the Science Research Council, has had its name changed to 'The Radio and Space Research Station'.

It was decided in 1959 that half the total effort of the Station should be devoted to space research. Since that time much important and successful work has been performed.

The main work of the Station continues to be at Ditton Park, near Slough, Buckinghamshire. In addition, the Station is responsible for the operation at Winkfield, Berkshire, of a minitrack installation for tracking and receiving telemetry from satellites. It also operates small research stations at Port Stanley in the Falkland Islands, at Singapore and at Lerwick, Shetland Islands.

The radio telescope under construction at Chilbolton, Hampshire, is expected to come into operation in 1966 and will be used for research into radio wave propagation and in space research. Mr. J. A. Ratcliffe, C.B.E., F.R.S., is Director of the Radio and Space Research Station. Total staff is 266.

The Home Office has ordered fifty sets of radar speed measuring equipment from The Marconi Co. Ltd. These sets, together with the thirty-four that they have already bought, will be used to augment the radar equipment already in use by police authorities throughout the country to provide an accurate, safe measurement of traffic speeds in an effort to reduce the death roll due to speeding on busy roads.

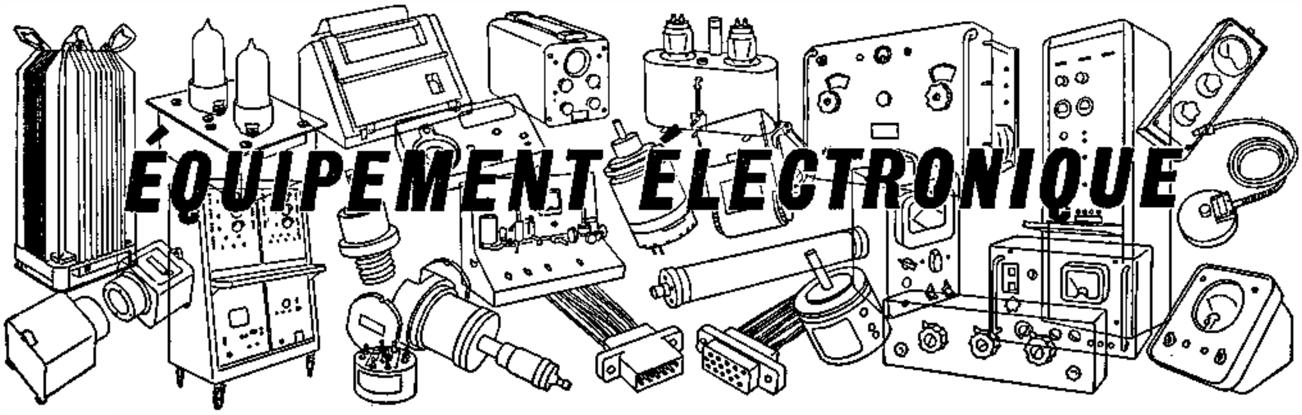
The Marconi PETA (Portable Electronic Traffic Analyser) which was designed in collaboration with police authorities, works on the Doppler principle. The basic accuracy of the equipment is better than 2 mile/h over the entire operating range. In addition, the equipment has been designed so that any fault which might occur in the system will always produce a low reading of speed or no reading at all.

Benson-Lehner Ltd, West Quay Road, in Southampton, has announced the formation of a new division. This is to be known as the Digital Systems Division, operating from the head office in Southampton.

The new division comprises of a technical advisory and design team which is integrated with technical sales. At a recently acquired building at Eastleigh the system test facility has been set up together with the main engineering unit.

The products currently being handled are high speed data acquisition systems, a range of high quality d.c. amplifiers, analogue to digital converters, digital to analogue converters and multiplexers.

ÉQUIPEMENT ÉLECTRONIQUE



Une description basée sur des renseignements fournis par les fabricants de nouveaux organes, accessoires et instruments d'essai

Traduction des pages 408 à 413

MINUTERIE ÉLECTRONIQUE

Circuitron Ltd, 476 Coventry Road, Small Heath, Birmingham, 10

Logée dans un robuste coffret en acier, la minuterie standard est offerte avec une gamme de retard réglable de 1 sec à 4 min, après quoi un relais du type de l'administration téléphonique actionne un jeu de contacts de permutation pouvant commuter des circuits jusqu'à 440 V a.c. Le réglage à variations infinies sur toute la gamme de temps est effectué au moyen de deux commandes montées à l'avant.

La minuterie a été étudiée pour fonctionner de 200 à 250 ou de 380 à 440 V mais d'autres alimentations peuvent être utilisées. Elle se distingue par sa base de circuit imprimé portant tous les composants et pouvant être retirée au moyen d'une fiche, ce qui simplifie extrêmement l'entretien et les réparations.

Un certain nombre de dispositifs supplémentaires peuvent être prévus sur demande spéciale, tels que les stabilisateurs pour parer aux fluctuations de tension d'alimentation et un relais supplémentaire utilisé lorsque le cycle de minutage est mis en train par un signal d'impulsion. A la sortie, une variété de contacts de commutation peut être fixée pour répondre à des besoins particuliers.

EE 82 751 *pour plus amples renseignements*

MACHINE À MICRO-ÉROSION

South London Electrical Equipment Co. Ltd, Lanier Works, Hither Green Lane, London, S.E.1

(*Illustration à la page 408*)

Bien que la technique d'érosion d'étincelles soit connue de longue date, son application à l'usinage de composants extrêmements petits dans les matériaux métalliques et à semi-conducteurs est relativement très récente et elle est l'objet d'un certain nombre de brevets.

"L'Arcotron" est une petite machine compacte pour montage sur banc d'essai, construite avec une précision quasi absolue et pouvant effectuer le découpage d'ouverture d'une épaisseur approximative de 0,009 mm de large. Son interêt particulier est constitué par la commande asservie qui entre en action dès que l'arc est court-circuité; un système à réaction provoque l'inversion de la marche avant à grande vitesse jusqu'à ce que le court-circuit soit éliminé. A ce moment-là, la marche avant entre en action à nouveau et lorsque l'arc est touché la vitesse de découpage recommence.

L'alignement est de l'ordre de 0,0005 mm avec des vitesses d'avance allant jusqu'à 0,005 mm/min. Le taux d'étincelles est d'environ 1 MHz, et un fini de surface d'environ 3 microns peut être obtenu.

Les principales applications de cette machine ont été jusqu'ici la fabrication de masques d'évaporation de réseaux de resistance à pellicule mince, de masques à crytron, de générateurs microondes, d'outils de liaison thermique, de poinçons, etc.

EE 82 752 *pour plus amples renseignements*

COMPTEURS PHOTOÉLECTRIQUES

Simmonds Relays Ltd, South Road, Harlow, Essex

(*Illustration à la page 408*)

La société Simmonds Relays Ltd, fournit maintenant une gamme complète de compteurs photoélectriques Visolux. Cette gamme s'acquitte d'un grand nombre d'opérations de comptage comprenant entre autre la préselection d'un certain nombre d'articles, le comptage unitaire sur courroie de transmission, le comptage par lots de manière continue, le comptage simultané de lots et le comptage suivant le poids.

Cette nouvelle gamme de compteurs comprend également des dispositifs électroniques et électromagnétiques pouvant compter à des vitesses allant jusqu'à 10 kHz. Certains des compteurs peuvent être munis de dispositifs permettant de prédéterminer les lots et ce jusqu'à cinq lots choisis. La mise en marche des compteurs s'effectue normalement par l'interruption du faisceau lumineux par les pièces devant être comptées; cette interruption met en action le récepteur photoélectrique.

Des têtes sensibles peuvent être fournies pour le fonctionnement à des distances allant jusqu'à 9 mètres entre le récepteur et l'émetteur de faisceaux lumineux. Des ventilateurs à air comprimé peuvent être fournis pour les atmosphères poussièreuses, de manière à ce que les lentilles des têtes sensibles soient gardées propres. Il existe également des éléments ignifuges.

On peut également effectuer l'opération de comptage par contact galvanique, par émetteurs inductifs, par tête de balayage magnétique et par la production d'impulsions.

EE 82 753 *pour plus amples renseignements*

COMMUTATEURS À LAME VIBRANTE ROTATIVE

Distributeurs: Kynmore Engineering Co. Ltd, 19 Buckingham Street, London, W.C.2

(*Illustration à la page 408*)

Les "Rotireeds" EMS sont fournis en cinq types de base, avec contacts à lame vibrante scellés, disposés radialement ou axialement autour d'un corps cylindrique ou rectangulaire. La commutation est commandée par un induit magnétique permanent ou électromagnétique entraîné par un arbre. Les induits magnétiques permanents sont utilisés dans la plupart des cas, un certain nombre d'aimants permanents étant montés sur le même induit lorsque la commutation multipolaire est utilisée. En variante, des commutateurs multiples avec tige commune peuvent être utilisés. Lorsqu'un grand nombre de contacts doit être confiné dans un très petit espace, la commutation électromagnétique s'avère préférable. Les bobines de l'induit électromagnétique sont alimentées à travers des bagues collectrices.

Etant donné que les contacts dorés des lames vibrantes elles mêmes sont scellés dans une atmosphère inerte, ils sont insensibles à l'ambiance extérieure. Les Rotireeds peuvent donc être montés dans n'importe quelle position voulue, dans des atmosphères poussièreuses, humides ou généralement défavorables. A l'instar de tous les commutateurs à lame vibrante, les contacts demeurent exempts de crasse, de corrosion ou d'usure mécanique appréciable.

Des contacts normaux ou miniatures peuvent être utilisés dans les types courants de Rotireeds, le choix dépendant de la charge devant être commutée et de la vitesse de fonctionnement exigée. La puissance nominale des contacts est de 15 W, 1 A, avec une durée de réaction de 3 msec. A 26 V, 0,25 A, la durée de fonctionnement est de 10^6 opérations. Les contacts miniature ont une puissance nominale de 6 W, 0,3 A, avec une durée de réaction de 1 msec. A 26 V, 0,1 A, la durée de vie de fonctionnement est encore de 10^8 opérations. Pour assurer une fiabilité maxima, le cycle de commutation doit être de deux ou de trois fois la durée du temps de réaction pour les deux types de contact, et la vitesse d'induit de rotation pour certains assemblages Rotireed doit être limitée en conséquence. Certains types peuvent être entraînés dans les meilleures conditions à des vitesses atteignant 5000 tours/min.

Les cinq types principaux de Rotireed offerts à la vente sont comme suit:

Type RR muni d'un induit magnétique permanent et d'un arbre à roulement à billes pour la production d'impulsions à partir d'un élément d'entraînement extérieur.

Type RH muni d'un induit magnétique permanent et d'un arbre à rochet pour le fonctionnement manuel avec position d'arrêt marquée distinctement sur le panneau frontal.

Type RM a induit magnétique permanent et moteur synchrone incorporé pour les applications d'impulsions minutées.

Type RS analogue au type RM, avec en plus un circuit de fixation de la position.

Type RK muni d'un induit électromagnétique et d'un moteur d'entraînement synchrone, avec position de commutation marquée sur le panneau frontal.

Tous les types peuvent être fournis comme modèle standard unipolaire et multipolaire et en version à plusieurs positions dont certaines comportant 100 jeux séparés de contact. Tous les types peuvent être munis de connexions soudées ou à fiches selon le choix du client. De plus, des montages spéciaux peuvent être fournis à la demande du client. Les dimensions dépendent du choix du montage.

EE 82 754 *pour plus amples renseignements*

INVERSEURS STATIQUES

Industrial Instruments Ltd, Stanley Road, Bromley, Kent

(Illustration à la page 409)

Ces inverseurs emploient des semiconducteurs comme éléments de commutation et sont prévus pour des entrées de tension continue de 12, 24, 48, 110 et 220 V. La sortie sinusoïdale est soit de 115 V efficaces soit de 230 V efficaces et la fréquence est de 50 Hz. La sortie de puissance varie selon le modèle de 110 W à 6 kW. L'inverseur est protégé contre l'inversion de polarité de tension d'entrée et comporte également un dispositif de protection électronique contre les surintensités et les court-circuits.

L'inverseur tolère des changements du facteur de puissance de charge et il existe des modèles pour exciter des moteurs du type utilisé dans les grandes machines enregistreuses ou dans les outils électriques portatifs, tels que les vilebrequins manuels. Leur circuit a permis une construction extrêmement compacte et peu coûteuse; ainsi un élément de 1 kW est monté dans un coffret portatif. Malgré ses dimensions comparativement réduites, l'inverseur comprend un régulateur de tension automatique qui compense les changements de charge et de tension d'entrée continue. Il est également muni d'une commande de fréquence pouvant recevoir une tension de 50 Hz à plus de 1%, quels que soient les changements de charge et d'entrée de courant continu.

EE 82 755 *pour plus amples renseignements*

POTENTIOMÈTRES COMBINÉS

Standard Telephones & Cables Ltd, West Road, Harlow, Essex

(Illustration à la page 409)

La société STC/P.X. Fox fournit maintenant une gamme de potentiomètres de précision soit du type combiné soit du type à multiprises. Le modèle S11 (format international) que l'on voit dans notre illustration a un diamètre extérieur de 26,98 mm. Sa valeur de couple est de 1 g/cm par section et sa durée de fonctionnement est de 3 millions de cycles.

La gamme S11 assure une linéarité de 0,1% à 5 kΩ et au dessus. Ces potentiomètres sont réalisés avec un maximum de 10 éléments par unité et un maximum de 10 prises par élément. Le contact potentiométrique Fox, d'un dessin inédit, est à durée de vie extrêmement longue et à couple réduit. Ses valeurs de bruit minima sont de 10.

EE 82 756 *pour plus amples renseignements*

RELAIS PHOTOÉLECTRIQUE

Hird Brown Ltd, Flash Street, Bolton, Lancashire

(Illustration à la page 409)

La société Hird Brown Ltd a mis au point un nouveau châssis pour son relais photoélectrique type PS1. Ce nouveau châssis comporte trois trous de fixation minuscules permettant de le fixer rapidement dans son coffret ou de l'insérer dans de nouveaux coffrets de commande électrique. Le relais photoélectrique PS101 actionne deux jeux de contact de relais qui interrompent ou rétablissent son faisceau. L'alimentation du relais de la cellule photoélectrique et des lampes est prévue avec l'appareil, qui peut être branché sur n'importe quel courant secteur standard.

Le relais photoélectrique peut être logé dans des coffrets en acier Hird Brown de type standard mesurant 22,86 cm × 15,24 cm × 10,16 cm; 25,4 cm × 15,24 cm × 10,16 cm; 30,48 cm × 22,86 cm × 12,7 cm. Jusqu'à trois de ces relais peuvent être logés en même temps dans les coffrets mesurant 45,72 cm × 30,48 cm × 12,7 cm.

Il existe un choix de 30 types différents de projecteurs et de récepteurs pouvant être utilisés avec le relais photoélectrique PS101.

EE 82 757 *pour plus amples renseignements*

CONTRÔLEUR DE TRANSISTORS

Comark Electronics Ltd, Gloucester Road, Littlehampton, Sussex

(Illustration à la page 409)

Le contrôleur de transistors type 180 permet de mesurer le gain en tension continue des transistors npn et pnp à des courants au collecteur minima de 10 nA. Il peut également détecter des fuites jusqu'à 1 nA.

Le courant au collecteur peut être fixé à n'importe quelle valeur jusqu'à 30 mA et mesuré à l'aide d'un nano-ampèremètre à chopper de transistors en 12 gammes allant jusqu'à 100 nA de déviation sur la totalité de l'échelle. La tension d'essai au collecteur est de 4 V. Les bornes peuvent être utilisées extérieurement sous forme de nano-ampèremètres. La précision est de 2%

Le courant de base est à variation continue de 0 à 1 mA en 9 gammes et il est mesuré directement à l'aide du nano-ampèremètre. Le dispositif automatique de distance facilite l'emploi du contrôleur. Neuf courants de base préréglés donnent des échelles de gain à lecture directe de 0-30, 0-100 et 0-300.

L'instrument est alimenté par batterie au mercure de longue durée. Ses dimensions hors-tout sont de: 15,87 cm × 12,7 cm × 8,89 cm.

EE 82 758 *pour plus amples renseignements*

TROLLEY D'OSCILLOSCOPE

Avon Communications & Electronics Ltd, 16a High Street, Christchurch, Hants

(Illustration à la page 410)

Le trolley TM11 à étagère supérieure réglable constitue un chariot mobile des plus utiles pour le nouveau type d'oscilloscope frontal à grande largeur. Il se distingue par ses barreaux de bâti pour panneau téléphonique standard de 47,5 cm pour le montage des éléments à fiche auxiliaire dont sont équipés de nombreux instruments modernes.

Le nouveau trolley conserve la robustesse de construction caractéristique des autres modèles dans la gamme produite par cette société. Les tubes d'acier à sections rectangulaires et carrées solidement soudés l'un à l'autre constituent le cadre de l'étagère supérieure réglable mesurant 47,5 cm de large x 71,25 cm de profondeur et de l'étagère inférieure fixe qui mesure 57 cm de large x 75 cm de profondeur. Les deux étagères sont en acier de 0,31 cm d'épaisseur et elles sont fixées à 50 cm l'une de l'autre. Le réglage de l'étagère supérieure s'effectue au moyen d'une manivelle montée à l'avant du trolley à un angle de 0 à 20° et elle peut être maintenue à n'importe quel angle intermédiaire. Les commandes de variation de position pour l'arrière de l'oscilloscope sont fixées sur l'étagère supérieure. Les barreaux de bâti pour le boulonnage direct des panneaux du type téléphonique de 47,5 cm sont fixés au-dessous de la poignée de réglage des étagères. La hauteur du trolley est réglable par gradins de 2,5 cm de 75 cm à 90 cm; des barreaux-poussoirs sont fixés à chacune des extrémités. Le poids approximatif du trolley non chargé est de 38,6 kg.

Des roulettes peuvent être fournies selon les besoins. Des roulettes à bande de caoutchouc du type industriel de 12,5 cm à émerillon à roulement à billes sont normalement fixées. Des assemblages à freins peuvent être fournis également moyennant un supplément de prix. Lorsqu'il est muni de roulettes normales, le trolley TM11 peut porter une charge utile d'environ 409 kg.

Pour le transport d'instruments extrêmement délicats, des roulettes à ressorts de 12,5 cm avec bande de caoutchouc sont fixées. Elles peuvent être fournies à la place des roulettes du type normal moyennant un supplément de prix. L'emploi de roulettes à ressort réduit la capacité de charge utile à environ 91 kg. Pour le transport sur route ou sur surface accidentée, le trolley TM11 peut être muni de roulettes pneumatiques spéciales de 20 cm × 5 cm, une fois encore à la place des roulettes normales et moyennant un supplément de prix.

EE 82 759 *pour plus amples renseignements*

APPAREIL DE MESURE NUMÉRIQUE

Distributeurs: Thorn Electronics Ltd. Wellington Crescent, New Malden, Surrey

Un nouvel appareil de mesure numérique (convertisseur analogique/numérique) est vendu au Royaume-Uni par la société Thorn Electronics. Cet instrument a été réalisé par la société Automatique Electrique S.A. d'anvers, dont la société Thorn est l'agent.

Bien que la conversion de quantités analogiques en quantités numériques puisse être réalisée à l'aide d'enregistreurs à arbre, de même que la conversion des tensions continues, l'appareil de mesure numérique fonctionne avec une plus grande précision et une plus grande efficacité.

Il convertit en effet la déviation angulaire d'un instrument à aiguille ou d'un arbre en un nombre équivalent d'impulsions. Ces dernières sont indiquées par un tambour magnétique pré-étalonné à partir d'un point correspondant au zéro de l'instrument et jusqu'à un point déterminé de manière optique par l'indication effective de l'instrument.

Un millier d'impulsions ou davantage correspondent à la déviation sur la totalité de l'échelle de sorte qua la précision de conversion est de 0,1% ou davantage. Il en résulte que la conversion est aussi exacte que l'indication analogique. Le tambour magnétique est réglé de façon à tourner continûment à un tour par seconde, bien que des vitesses supérieures puissent être réalisées.

Un système optique monté sur le tambour produit un faisceau rotatif que détermine la position de l'aiguille. Un miroir est monté sur l'axe avec deux cellules photoélectriques. Dès que la position de l'aiguille a été déterminée, le signal de la cellule photoélectrique arrête le comptage des impulsions indiquées par le tambour magnétique.

Le faisceau rotatif est produit par une lumière fixe montée dans l'axe du tambour et un système optique est monté sur ce dernier. Ce système optique consiste en un miroir plat incliné à 45° vers l'axe du tambour et en un miroir concave qui concentre le faisceau sur le miroir de l'instrument.

La précision de conversion est indépendante de la vitesse du tambour et l'emploi du tambour magnétique permet les conversions non-linéaires. Il est donc possible d'utiliser des entrées de courant alternatif et d'obtenir directement des sorties numériques sans convertisseur de courant alternatif en courant continu. D'autre part le tambour magnétique permet la correction des erreurs de transducteur ou des bandes non linéaires. Cette particularité peut être très utile pour la mesure du flux, etc.

L'appareil de mesure numérique a été principalement conçu pour la télémesure mais il s'est avéré en outre de la plus grande utilité dans d'autres domaines.

EE 82 760 *pour plus amples renseignements*

MOTEUR MINIATURE À COURANT CONTINU

Vactric Control Equipment Ltd, Garth Road, Morden, Surrey

(*Illustration à la page 410*)

La société Vactric Control Equipment Ltd vient de réaliser un nouveau moteur miniature à courant continu et à aimant permanent construit avec précision et d'un coût réduit. Ce moteur a été étudié pour assurer un très long service sans le moindre ennui dans des conditions environnantes défavorables. Le moteur type 09P est, en effet, beaucoup plus court que d'autres moteurs de même catégorie et son diamètre hors-tout est de 23 mm. Il peut être muni de divers montages d'extrémité d'arbre ainsi que d'un arbre à double extrémité si nécessaire. Lorsqu'il est muni d'un pignon il peut être relié à une tête d'engrenage de réduction de précision. Pour le fonctionnement sans vibrations il est doté d'un induit équilibré tournant sur roulement à billes miniature en acier inoxydable.

Sa tension nominale est de 28 Vc.c. et son couple nominal est de 30 g.cm à 6000 tours/min avec un courant d'entrée de 0,25 A. Son couple de câlage minimum est de 65 g.cm et le courant de marche à vide est de 100 mA. Il pèse 45 g et peut être utilisé dans une gamme de températures ambiantes de −55° à +85° C. Il est monté au moyen de deux trous filetés sur la face frontale du logement.

EE 82 761 *pour plus amples renseignements*

VOLTMÈTRE NUMÉRIQUE C.A.-C.C.

Digital Measurement Ltd, Salisbury Grove, Mytchett, Aldershot, Hampshire

(*Illustration à la page 410*)

La société Digital Measurements Ltd vient d'ajouter le voltmètre numérique DM2003 c.a.-c.c. (Numéro de l'Otan: 6625-99-104-6993) à sa gamme d'instruments numériques à performance élevée.

Le voltmètre DM2003 mesure les tensions continues de 1 mV à 1 kV avec une précision de 0,5% de déviation sur la totalité de l'échelle à ±0,1% de l'indication, et les tensions alternatives de 2 V à 700 V efficaces avec une précision de 0,25% de déviation sur la totalité de l'échelle à ±0,1% de l'indication, et les tensions alternatives de 2 V à 700 V efficaces avec une précision de 0,25% de déviation sur la totalité de l'échelle à ±0,25% de l'indication dans la gamme de fréquence de 50 Hz à 5 kHz. L'échelle de 1999 assureune résolution optimum de 1 mV c.c. et 10 mV c.a.

L'instrument a une entrée entièrement flottante à impédance élevée donnant un rejet de mode commun de tension continue supérieure à 120 dB avec un isolement maximum de la masse de 1000 V. La mesure est affichée sur des tubes indicateurs numériques avec indication automatique de la décimale. Les modes de fonctionnement comprennent: La poursuite automatique, le déclenchement manuel et la lecture maintenue. Un commutateur de polarité assure le fonctionnement bipolaire de sorte que des mesures de courant continu de l'une ou l'autre des polarités peuvent être effectuées sans qu'il y ait lieu d'inverser les câbles d'entrée des signaux.

EE 82 762 *pour plus amples renseignements*

CONTRÔLEURS DE TEMPÉRATURE

Ether Ltd, Caxton Way, Stevenage, Hertfordshire

(*Illustration à la page 411*)

Une nouvelle série de contrôleurs de température potentiométriques, portant la référence 12-94, a été mise au point par la société Ether Ltd.

Ce dispositif comprend un contrôleur de température indicateur potentiométrique (d'une grande variété de types) allié à un élément de programme temps/température pour l'indication et le contrôle de la température à un degré élevé de précision et dans une gamme étendue. Etant entièrement composé de corps solides, ce dispositif est d'une grande fiabilité dans des conditions très diverses et pendant une très longue durée de vie. Il peut également contrôler n'importe quel processus comportant la conversion du signal en un courant ou en une tension continue. Logé dans un coffret en acier, l'appareil est entièrement scellé contre les poussières et l'humidité.

Des cames de programmation peuvent être fournies et coupées à un degré de précision de ±1% de la gamme de l'échelle. Toute erreur de coupage de la came peut être corrigée par une vis à vernier sur le bras de commande. Une came à développante peut être utilisée pour le contrôle de température mixte.

A n'importe quel moment ou température donnés le moteur ou combustible du programme peut être débranché à l'aide du commutateur de limite. Un ou deux commutateurs auxiliaires peuvent être fixés pour déclencher des circuits extérieurs.

EE 82 763 *pour plus amples renseignements*

OSCILLATEUR ACOUSTIQUE À HAUTE PUISSANCE

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

(Illustration à la page 411)

La société Dawe Instruments Ltd à réalisé un oscillateur acoustique de grande puissance donnant une très faible distorsion. L'oscillateur type 440B comprend un oscillateur à deux étages qui alimente un circuit RC sélectif dont la sortie est transmise par une commande d'amplitude à un amplificateur intermédiaire qui alimente un diviseur de phase et un étage de sortie push-pull équilibré.

Chacune des sections a été conçue pour fonctionner de manière à ce que ses tubes fonctionnent convenablement à l'intérieur de leur région linéaire; cette particularité, ainsi que la réaction sélective et un niveau généralement élevé de construction, permettent à l'oscillateur de fournir une sortie de puissance élevée (6 W) sans distorsion aucune dans la gamme de 20 Hz à 20 kHz. Le transformateur de sortie est adapté pour une charge d'une impédance de 3,75, 15 ou 600 mais l'effet d'inadaptation est négligeable.

La fréquence est à variation continue à travers un rapport de 10 à 1 grâce à un condensateur variable groupé et accouplé à travers un mécanisme d'entraînement à une échelle de fréquence étalonnée sur un arc de 333°. Trois gammes de décades fournissent une puissance complète de 20 Hz à 20 kHz sur une longueur totale d'échelle de 152,4 cm.

A une sortie de 3 W, l'amplitude demeure constante à ±0,5 dB sur toute la gamme de fréquence. La teneur en harmoniques à 400 Hz est de 0,02% pour la deuxième harmonique et de 0,12% pour la troisième harmonique, avec moins de 0,01% de bourdonnement et de signaux parasites. L'amplitude est stabilisée à ±1% et la fréquence à 0,05% 30 minutes après la mise en marche.

L'instrument est d'un fonctionnement simple et ne nécessite aucune attention spéciale pour pouvoir obtenir des résultats uniformément bons. Il est actionné par une alimentation secteur de 50 Hz ou 60 Hz. Le coffret compact pour montage sur banc d'essai mesure 20,95 cm × 33 cm × 31,75 cm et assure une ventilation appropriée.

EE 82 764 *pour plus amples renseignements*

INSTRUMENTS DE PANNEAU MINIATURES

Distributeurs: Leland Leroux Ltd, 145 Grosvenor Road, London, S.W.1

(Illustration à la page 411)

La société International Instruments Inc. of Connecticut, Etats-Unis, a réalisé un nouvel instrument de mesure miniature de grande précision, le modèle 1122, qui répond à de nombreuses applications exigeant un espace réduit. En plus des avantages de base des instruments de mesure latérale, le modèle 1112 offre de nombreux autres avantages. C'est un instrument entièrement plat de l'échelle jusqu'aux bornes; l'instrument ne comporte aucun élément en saillie et le volume de l'arrière du panneau n'est que de 24,57 cm³.

Le nouveau mouvement breveté de l'instrument de mesure, contrairement à la plupart des mouvements à cadre mobile et à aimant permanent, n'a qu'un entrefer, au lieu de deux. Le circuit magnétique à un entrefer est conçu de telle manière que l'espace disponible est utilisé de manière très efficace. Le mouvement de l'instrument 1 122 produit ainsi autant de puissance de champ magnétique qu'il était possible d'obtenir avec les mouvements classiques à deux entrefers. Etant donné qu'il n'y a qu'un seul entrefer, on peut faire pivoter le cadre à partir d'un bras fixé au côté non tranchant du cadre mobile. Ce bras à long mouvement peut donner une sortie de couple élevée. En outre, en raison du fait que l'axe du pivot du cadre est décentré, un pivot à axe unique peut être utilisé à la place de pivots individuels sur chaque côté du cadre, ce qui élimine complètement les problèmes d'alignement défectueux du pivot et contribue à maintenir la linéarité et la répétabilité.

Ces instruments de mesure miniature de panneau, modèle 1122, sont particulièrement indiqués pour les consoles de contrôle exigeant une indication multivoies. Le profil compact de ces instruments en font l'accessoire idéal pour les instruments de mesure de processus miniature, tels que les contrôleurs d'accord ou les indicateurs de systèmes acoustiques. Un dispositif facultatif à zéro central permet de les utiliser pour l'indication de zéro.

Vu que l'instrument ne comporte aucune partie protubérante, il permet l'empilement vertical ou latéral sans limite. Le nouveau circuit magnétique exclut tout problème d'interaction magnétique. Le modèle 1122 est livrable en 27 gammes standard, avec des sensibilités de 100 μA ou 50 mV de déviation sur la totalité de l'échelle, sous format de lecture vertical ou horizontal, avec diverses positions de zéro, ainsi qu'un dispositif d'échelle spécial, des V.U. mètres, des décibelmètres, etc. Des sensibilités supérieures peuvent être prévues sur commande spéciale.

La précision initiale est de ±2% de la valeur de l'échelle totale pour le courant continu (±3% pour le courant alternatif). La durée de réponse maxima est de 2.5 sec; la longueur de l'échelle est de 3.16 cm. Les dimensions hors-tout de l'instrument sont: 41 mm de large × 60 mm de profondeur × 13 mm de hauteur. Son poids est d'environ 113,36 gr.

EE 82 765 *pour plus amples renseignements*

CONDENSATEURS ÉLECTROLYTIQUES MINIATURE

Plessey-UK Ltd, Capacitor Division, Kembrey Street, Swindon, Wiltshire

Une nouvelle gamme de condensateurs électrolytiques miniature à résistance de série très réduite vient d'être créée par Plessey-UK Ltd.

Les condensateurs type LSR ont été réalisés au départ pour pouvoir être utilisés dans les circuits de calculatrices transistorisées mais ils trouvent de nombreuses autres applications dans d'autres domaines.

En utilisant des électrolytes à haute conductivité, on a pu réduire la résistance interne à une fraction de sa valeur habituelle. Ainsi on a pu vérifier une valeur minima de 0,05 Ω sur certains échantillons en utilisant la méthode de mesure des impulsions.

La haute résistance interne des condensateurs électrolytiques en aluminium de type ordinaire est une des propriétés qui limitent leur rendement et, partant, leur emploi aux fréquences acoustiques et supérieures et dans les conditions de décharge rapide. Cette résistance élevée est due à deux causes: l'emploi d'électrolytes à point d'ébullition élevé, des bases sur acide borique, d'une conductivité moyenne, et la nécessité de réduire le format du condensateur.

S'il étudie de manière réaliste les conditions d'utilisation, le réalisateur de matériel de communications et de calculatrices constatera souvent que l'emploi de condensateurs électrolytiques étudiés pour l'emploi dans une température ambiante de 70° C, par exemple, n'est pas du tout nécessaire et qu'un condensateur à limite de température ambiante maxima de 40 ou 50° C pourrait être utilisé avec profit.

A ces températures moyennes, un choix peut être effectué entre plusieurs électrolytes à conductivité plus élevée, ces électrolytes étant basés sur les sels d'ammonium, plus solubles et presque neutres, et d'acides autres que l'acide borique. Pour un régime de 50° C on peut ainsi prévoir des électrolytes à formation de pellicule qui sont environ cinq fois plus conductifs que ceux normalement employés, tandis que pour un régime de 40° C on peut utiliser des électrolytes dont la conductivité est de 50 fois supérieure.

Les condensateurs électrolytiques en aluminium, soit du type à feuille gravée soit du type à feuille ordinaire, imprégnés de ces électrolytes plus conductifs, donnent une performance nettement meilleure aux fréquences élevées, dans les conditions d'impulsions, ou dans les applications de découplage, et leur comportement aux basses températures dans la gamme de 0 à −40° C est remarquable par rapport aux condensateurs électrolytiques normaux.

Les condensateurs LSR couvrent une gamme de 1 à 1000 μF, à des tensions de régime pouvant atteindre 150 V. La gamme de température de fonctionnement est de −30° C à +40° C ou +50° C, suivant le type. Ces condensateurs sont soit du type ordinaire soit du type à feuille gravée, avec ou sans manchon d'isolement.

Deux diamètres de boîtier sont prévus: 9,5 mm et 13 mm, ainsi que quatre longueurs de boîtier: 19 mm, 29 mm, 32 mm et 35 mm.

EE 82 766 *pour plus amples renseignements*

RÉSISTANCE VARIABLE

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

(*Illustration à la page 412*)

La nouvelle résistance variable à bon marché que vient de réaliser la société Mullard Ltd est à commande entièrement silencieuse. Elle est donc particulièrement indiquée pour contrôler des courants vidéo et à signaux acoustiques. Portant le numéro de type ORP39, elle comprend une cellule au sulphure de cadmium et une lampe à filaments de 12 V encapsulée dans un bloc de matière plastique mesurant 17 × 17,5 × 22 mm. Ce bloc comporte quatre broches de sortie et il peut être utilisé pour le montage standard de circuits imprimés.

La résistance ORP39 a été spécialement conçue pour pouvoir être utilisée comme résistance variable à commande à distance dans les caméras de télévision pour la commande de brillance (intensité du faisceau) et le réglage du niveau du noir. Elle peut être utilisée également comme élément de réaction dans les circuits acoustiques pour la commande de gain général, comme télécommande de brillance/contraste pour télérécepteur et comme télécommande dans les magnétophones vidéo, comme station de répétition de signaux vidéo et comme équipement de traduction de télévision. Elle pourrait également trouver des applications dans l'électronique médicale.

En variant la brillance de la lampe on peut contrôler la résistance de la cellule pendant au moins trois décades (c'est à dire d'environ 100 Ω à 10 kΩ).

Le réglage de la résistance est entièrement silencieux et il n'y a aucune connexion électrique entre la commande et la sortie. On obtient ainsi un bon isolement et une bonne isolation électriques et l'on peut en outre utiliser de longs câbles entre le point de télécommande et l'équipement sans interférence aucune sur le circuit contrôlé.

La capacitance entre les circuits contrôleurs et les circuits contrôlés est de l'ordre de 2 pF. Le nouveau dispositif est résistif et ne devient pas réactif dans la gamme de signaux vidéo. Son usage n'est, cependant, pas recommandé pour les fréquences intermédiaires (c'est à dire de l'ordre de 10 mHz). Sa durée de réponse est rapide—beaucoup plus rapide que le temps de fonctionnement d'une commande manuelle—et c'est un élément peu coûteux par rapport a tout autre dispositif analogue de haute qualité pouvant être télécommandé. La résistance ORP39 est particulièrement appropriée pour les circuits où toute interaction entre les circuits de contrôle et les circuits contrôlés serait indésirable, ainsi que comme rhéostat sans bruit de contact ou en général comme transducteur, transformant une entrée de tension en une sortie de résistance avec isolement électrique total entre l'entrée et la sortie.

Etant donné que l'impédance et l'angle de phase de la cellule varient en fonction de sa résistance et de la fréquence qui lui est appliquée, la limite de fréquence supérieure utile de la résistance de sortie dépend de la tolérance de l'application au changement et elle est probablement de quelques mégacycles.

EE 82 767 *pour plus amples renseignements*

VOLTMÈTRE HÉTÉRODYNE

Distributeurs: B & K Laboratories Ltd, 4 Tilney Street, Park Lane, London, W.1

(*Illustration à la page 412*)

Le voltmètre hétérodyne Bruel et Kjær, type 2006, est entièrement transistorisé et il a été conçu pour les travaux de mesure dans les gammes de haute fréquence et de très haute fréquence. Il fonctionne sur batterie et son poids est réduit. Il peut effectuer des mesures sélectives à toutes les fréquences de télévision et de modulation d'amplitude/modulation de fréquence communément utilisées.

Il peut non seulement mesurer l'amplitude des signaux haute fréquence mais également déterminer la fréquence ainsi que le pourcentage de modulation. La fréquence mesurée est indiquée sur l'échelle d'un instrument de mesure. Un deuxième instrument de mesure indique l'amplitude de la tension haute fréquence mesurée et la modulation, tandis qu'un haut-parleur fournit un signal audible de contrôle.

Le voltmètre est muni d'une borne d'entrée directe et l'impédance à cette borne est de 75 Ω. Cependant, en munissant cette borne d'une sonde spéciale on obtient une entrée d'une impédance élevée. La sonde d'entrée est reliée au voltmètre au moyen d'un câble souple mesurant 1,5 m.

Pour étendre la gamme de tension de l'instrument on fixe sur la sonde d'entrée un diviseur de tension amovible ayant des dimensions semblables à celles de la sonde. L'atténuation du diviseur de tension est de 60 dB.

Un oscillateur de référence stabilisé incorporé fournit une tension de référence pour l'étalonnage de l'instrument.

EE 82 768 *pour plus amples renseignements*

PONT DE RÉSISTANCE À HAUTE PRÉCISION

H. Tinsley & Co. Ltd, Werndee Hall, South Norwood, London, S.E.25

(*Illustration à la page 413*)

Le pont de résistance à haute précision, type 5577, que vient d'introduire la société H. Tinsley & Co. Ltd, élimine les erreurs de commutation qui se produisent généralement avec les instruments de mesure du type à pont de Wheatstone. D'autre part, il réduit la possibilité d'erreur ou d'endommagement due à l'excès de courant dans une ou plusieurs bobines. Ces avantages sont dûs au modèle particulier des circuits. Le bras variable incorporé au pont est basé sur des éléments de conductance, à incréments binaires, et couvre un million de plots. Seules six bobines sont utilisées sur chacune des six décades; le pont comprend un total de 36 bobines au lieu des 60 bobines normalement employées dans un circuit ordinaire du type à pont de Wheatstone. Les rapports sont changés au moyen d'un commutateur rotatif. Dans un pont de Wheatstone du type classique, tous les contacts de commutation sont en série, ce qui limite la précision possible à la somme des erreurs de contact. Dans le nouvel appareil, ce problème est entièrement éliminé car tous les contacts sont en parallèle. Le pire des cas est celui lorsque la bobine de résistance de 50Ω est en série avec un contact de commutation de 25μ; l'effet de ce dernier est évidemment négligeable. Le pont se caractérise en outre par le fait qu'il peut être utilisé comme pont à quatre bornes. On peut ainsi employer de longs conducteurs et leur effet est compensé dans l'indication du pont. La gamme de mesure totale s'étend de 0,0001 Ω à 100 MΩ, avec des tensions de pont de 2 à 60 V respectivement. L'instrument peut fonctionner avec une limite d'erreur ne dépassant pas 0,01% dans les gammes de mesure extrêmes inférieures, et 0,1% dans les gammes de mesure extrêmes supérieures. Pour les mesures intermédiaires, la limite d'erreur est de 0 001% de 100 Ω à 10 kΩ, 0,005% de 10 kΩ à 100 kΩ et 0,01% de 100 kΩ à 10 MΩ.

EE 82 769 *pour plus amples renseignements*

APPAREILLAGE D'ASSERVISSEMENT D'INSTRUCTION

Feedback Ltd, Crowborough, Sussex

(*Illustration à la page 413*)

L'appareillage d'asservissement d'instruction, type ES130 est un instrument de commande de position universel à courant continu conçu pour illustrer tous les aspects importants de la théorie des systèmes à circuit fermé.

La première étape consiste à explorer les caractéristiques d'un système simple du deuxième ordre et de procéder au problème de stabilisation de systèmes d'un order supérieur à éléments non linéaires et à résonance d'inertie d'acquiescement. De cette manière, les techniciens de l'industrie ou les spécialistes peuvent utiliser l'équipement avec la même facilité. Ces caractéristiques pratiques comprennent:

Des potentiomètres d'entrée et de réenclenchement à rotation continue. L'entrée peut être mise en action par son propre contrôleur de la vitesse du moteur afin de permettre d'étudier les caractéristiques suivant l'état de stabilité.

Un amplificateur opérationnel s'ajoutant à l'amplificateur d'asservissement, avec les composants appropriés pour les réseaux de compensation.

L'addition de quantités prédéterminées

d'effets réactifs, d'inertie et de frottement, selon les besoins.

L'indication de la surcharge impulsive et continue du système. Un instrument de mesure pour la lecture des potentiels sur l'ensemble du système.

L'alimentation stabilisée interne de ±300 V est prévue pour la mise en oeuvre d'autres éléments connexes tels que les appareils analogiques à réaction pour fournir des données analogiques et le contrôle des relais.

L'appareillage comprend un cours complet de travaux théoriques et expérimentaux.

EE 82 770 *pour plus amples renseignements*

BLOC D'ALIMENTATION STABILISÉ

A.P.T. Electronic Industries Ltd, Chertsey Road, Byfleet, Surrey

(*Illustration à la page 413*)

La société A.P.T. Electronic Industries Ltd vient d'ajouter le bloc d'alimentation T.C.U. 1050 à sa série de blocs T.C.U.

Les blocs d'alimentation de la série T.C.U. constituent une gamme d'instruments compacts de laboratoire à haute performance. Ils sont d'une présentation élégante et comportent certaines caractéristiques leur assurant un rendement excellent, compte tenu de leur dimensions extrêmement réduites.

A l'instar des autres blocs de cette série, le T.C.U. 1050 est variable dans la gamme de 0 à 50 V, pour un courant de sortie de 10 A. Le système de protection a été étudié pour empêcher l'endommagement du bloc dans des conditions de surcharge, en limitant le courant absorbé et, après un certain intervalle, en fixant le sortie à 0.

Des surcharges transitoires d'une durée inférieure à l'intervalle, permettent au bloc de se rétablir à ses conditions normales de fonctionnement. Une commande à plots permet de fixer le niveau de protection voulu, tandis qu'un bouton poussoir monté sur le panneau frontal, permet un nouveau réglage.

Le contrôle de sortie peut être varié dans la gamme de 0 à 50 V grâce à cinq plots commutés et une commande à réglage précis. Le niveau de déclenchement s'obtient à l'aide d'un commutateur à six directions à plots de 120%, 100%, 80%, 60%, 40% ou 20% du courant de charge nominale maximum.

Des bornes sont prévues pour la perception à distance et la sortie est isolée du châssis de sorte qu'en mettant à la masse l'un ou l'autre des côtés, la tension peut être rendue positive ou négative par rapport à la masse. Les blocs peuvent être reliés en série pour produire des tensions élevées qui sont, toutefois, limitées à 500 V c.c. entre les bornes et le châssis.

La construction des circuits redresseurs, qui utilise des redresseurs pilotés au silicium, assure la grande efficacité du fonctionnement, le courant de pointe obtenu du secteur étant maintenu à son plus faible niveau pratique.

Les fusibles de courant continu et secteur sont montés à l'arrière des éléments, ainsi que le panneau de prises principales et le câble de secteur; toutes les autres commandes et bornes sont à l'avant, ainsi que le grand instrument de mesure à lecture facile.

EE 82 771 *pour plus amples renseignements*

LASER AU GAZ

G. & E. Bradley Ltd, Electrical House, Neasden Lane, London, N.W.10

(*Illustration à la page 413*)

La société G. & E. Bradley annonce la réalisation d'un nouveau laser au gaz hélium-néon spécialement conçu pour les établissements d'enseignement. Son tube de 71,12 cm est à excitation à haute fréquence et comporte un élément d'entraînement séparé. Ce dernier a une sortie de 60 W à 27,12 MHz. Il est piloté au cristal et peut être modulé pour les expériences simples de communication.

La fréquence de sortie standard est de 6 328° A et le système à miroir est à focalisation concentrée. La puissance de sortie est de 5 mW. Il comporte en outre des fréquences de sortie à alternance et des systèmes à miroir. Le couvercle de la tête du laser peut être enlevé facilement pour l'entretien et des supports réglables peuvent être fournis pour fixer la tête sur un banc optique.

EE 82 772 *pour plus amples renseignements*

Résumés des Principaux Articles

Un contrôleur de gradients actionné par la lumière: pour machines à poser des drains agricoles par G. O. Harries et D. H. Perkins

Résumé de l'article aux pages 364 à 367

Pour que les drains agricoles puissent être utilisés avec profit, il importe qu'ils soient posés avec un minimum de déviation possible du gradient voulu. Cet article décrit un dispositif automatique permettant de remplir cette condition. Le système de contrôle emploie deux faisceaux de lumière interrompus à différentes fréquences, ainsi qu'un détecteur photoélectrique. Les circuits électroniques employés sont décrits en détail.

Le M.3 : Une petite calculatrice numérique transistorisée par A. D. Booth et K. Cameron

Résumé de l'article aux pages 368 à 374

Les auteurs examinent les circuits logiques de contrôle et les sections arithmétiques d'une nouvelle petite calculatrice numérique universelle. Cette machine comporte un tambour d'emmagasinage magnétique pour 8192 mots de 32 binaires et elle fonctionne à une fréquence numérique de 150kHz/sec.

Amplificateur à gain linéaire à tension contrôlée par C. I. Sach

Résumé de l'article aux pages 375 à 379

Cet article décrit un circuit utilisé pour obtenir un étage amplificateur dont le gain est proportionnel à une tension de contrôle. Une théorie simple pour le fonctionnement du dispositif est présentée de même que quelques applications.

Une source de fréquence courante par S. J. Cotton

Résumé de l'article aux pages 380 à 383

L'auteur décrit une source de fréquence courante dans aquelle une fréquence de la gamme de 40Hz, 50Hz, 80Hz, 100Hz, 200Hz, 250Hz, à 20kHz, 25kHz, 50kHz, 100kHz peut être obtenue au moyen d'un commutateur. Ce choix s'effectue à l'aide d'un oscillateur à commande par cristal et d'un certain nombre d'étages diviseurs de fréquence utilisant des circuits à diodes pnp. Après la mise en forme des impulsions, il se produit des impulsions rectangulaires dont la hauteur dépasse 50V, l'impédance de sortie du circuit demeurant basse. En mettant en oeuvre une minuterie à partir d'un courant d'alimentation de 50Hz provenant du même oscillateur de 100kHz, on peut contrôler la fréquence à long terme de la source.

Condensateurs à diélectrique à pellicule à oxyde mince par B. Walton

Résumé de l'article aux pages 384 à 387

Après avoir donné un bref aperçu des méthodes de préparation de pellicules diélectriques à oxyde mince, l'auteur arrive à la conclusion que le dépôt sous vide d'oxydes métalliques réfractaires assure les meilleurs résultats. Il décrit en détail le processus permettant d'effectuer cette opération ainsi que la production de ces condensateurs. Les propriétés de ces condensateurs sont ensuite analysées et il est démontré qu'ils possèdent de multiples avantages.

Dispositif à courbure pour instrument de finissage de surface par B. B. Trott

Résumé de l'article aux pages 388 à 391

L'auteur décrit un dispositif pour instrument de finissage de surface permettant de déterminer le deuxième différentiel et la courbure du profil de surface. Il décrit le circuit, donne des détails de l'étalonnage et indique des résultats d'essais.

Un multiplicateur de fréquence de phase pour la mesure de phase numérique par L. Molyneux

Résume de l'article aux pages 392 à 393

L'auteur décrit un multiplicateur de fréquence numérique capable de fournir un rapport de multiplication de 360 et permettant, en outre, de mesurer la différence de phase par la méthode numérique.

Un contrôleur de hauteur d'impulsion par M. Bronzite

Résumé de l'article aux pages 394 à 395

Cet article décrit un circuit qui permet de contrôler les amplitudes d'impulsions. Il s'agit d'un circuit fort simple à utiliser et pouvant recevoir une gamme étendue de formes d'ondes d'entrée dans une large bande de fréquence et dont la précision est supérieure à 1%.

Les applications de l'emmagasinage de données dans les mémoires magnétiques par D. M. Bernstein

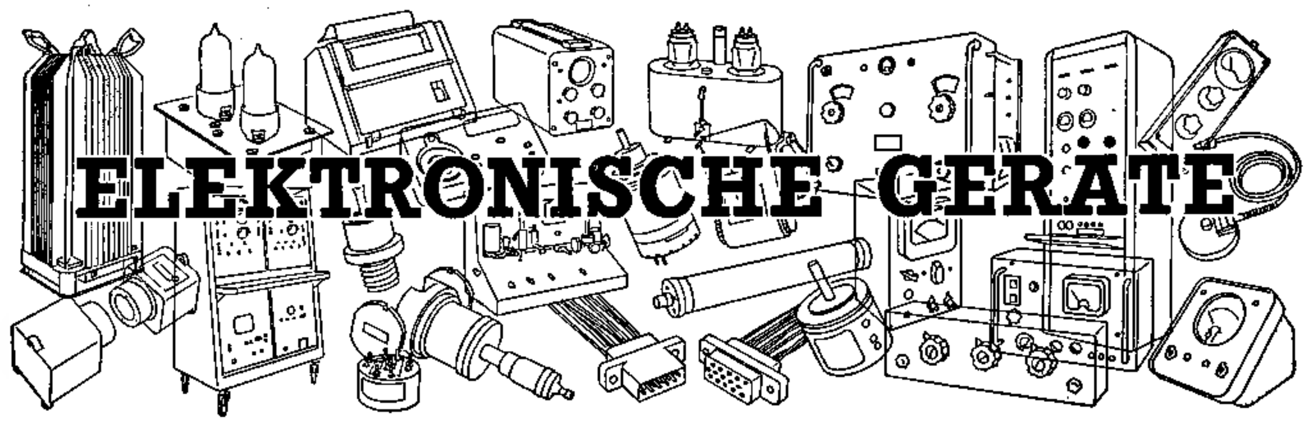
Résumé de l'article aux pages 398 à 400

On a réalisé un certain nombre de type d'analyseurs à emmagasinage magnétique pour la physique nucléaire. Certains de ces appareils sont décrits dans cet article qui indique en outre diverses possibilités d'application dans d'autres domaines de mesure.

Générateur d'impulsions à haute tension utilisant des thyratrons à commutation par T. Chan et M. W. Gunn

Résumé de l'article aux pages 401 à 403

La réalisation d'un générateur d'impulsions à haute tension utilisant des thyratrons à hydrogène dans un cycle de commutation "arrêt-marche" est décrite dans cet article. Cet appareil a été étudié de manière à pouvoir allier les avantages des générateurs du type "à ligne" et ceux du type à "tube dur" en fournissant une impulsion de sortie dont on peut varier la durée de façon continue avec une faible résistance de sortie. Ce générateur produit des impulsions rectangulaires très nettes dont l'ampleur peut atteindre 4kV et dont la longueur est à variation continue à partie de 0,2µS avec une résistance de source d'environ 13Ω. L'appareil peut être facilement conçu pour fournir des tensions de sortie d'une maximum de 16kV.



ELEKTRONISCHE GERÄTE

Beschreibung neuer Bauelemente, Zubehörteile und Prüfgeräte auf Grund der von Herstellern gemachten Angaben.

Übersetzung der Seiten 408 bis 413

Elektronischer Zeitschalter

Circuitron Ltd, 476 Coventry Road, Small Heath, Birmingham, 10

Der in einem robusten Stahlblechgehäuse untergebrachte Standard-Zeitschalter wird mit einstellbaren Verzögerungen von 1 Sekunde bis zu 4 Minuten angeboten; nach Ablauf der Zeit betätigt ein Postrelais einen Umschalterkontaktsatz, der für bis zu 440 V~ bemessen ist. Zwei Bedienelemente auf der Frontplatte gestatten stufenlose Einstellung über den gesamten Zeitbereich.

Der Zeitschalter wird mit 200 ... 250 V oder 380 ... 440 V betrieben, kann aber auch an andere Netzspannungen angepasst werden. Ein Konstruktionsmerkmal ist die Leiterplatte, auf die alle Bauelemente montiert sind; zur Erleichterung von Wartung und Service ist sie als Einsteckplatte ausgeführt.

Zur Befriedigung von Sonderanforderungen können eine Anzahl Extraeinrichtungen vorgesehen werden. Zum Ausgleich von Netzschwankungen kann man z.B. Konstanthalter oder—wenn die Zeitfolge nur durch ein Impulssignal eingeleitet wird—ein zusätzliches Haltesignal einbauen. Verschiedenen Kundenwünschen entsprechend können unterschiedliche Schaltkontakte vorgeshen werden.

EE 82 751 *für weitere Einzelheiten*

Mikro-Erodieren

South London Electrical Equipment Co. Ltd, Lanier Works, Hither Green Lane, London, S.E.13

(*Abbildung Seite 408*)

Während Funkenerosion im allgemeinen bereits gut eingeführt ist, ist ihre Anwendung auf die Bearbeitung sehr kleiner Teile aus Metall sowie Halbleitermaterial erst neueren Datums und durch eine Anzahl Patente geschützt.

Modell "arcotron" ist eine kleine, kompakte Tischmaschine, die mit äusserst engen Toleranzen konstruiert ist und etwa 0,009 mm breite Schlitze erodieren kann. Besonders interessant ist die Regelautomatik, die sofort wirksam wird, wenn der Funken kurzgeschlossen wird; ein Rückführungssystem kehrt die Vorschubrichtung mit hohen Geschwindigkeiten um, bis der Kurzschluss behoben ist; daraufhin wird der Vorschub wieder umgekehrt und die Bearbeitung fortgesetzt, sowie der Funken wieder gezündet hat.

Die Ausrichtung ist in der Grössenordnung von 0,0005 mm bei Vorschüben bis zu 0,005 mm/min herunter. Die Funkenfolgefrequenz ist 1 MHz, und Oberflächengüten von 3 Mikron sind erreichbar.

Hauptanwendungsmöglichkeiten für diese Maschine sind bisher die Erstellung von Aufdampfmasken, Dünnfilm-Widerstandsschablonen, Cryotron - Masken, Mikrowellengeneratoren und -schaltungen, Wärmeverankerungswerkzeugen, Stempeln und Matrizen usw.

EE 82 752 *für weitere Einzelheiten*

Fotoelektrische Zähler

Simmonds Relays Ltd, South Road, Harlow, Essex

(*Abbildung Seite 408*)

Simmonds Relays Ltd kann nunmehr das volle Programm der fotoelektrischen Visolux-Zähler liefern. Es umfasst Geräte für alle Zählaufgaben einschliesslich Vorwahl bestimmter Anzahlen von Gegenständen, Abzählen von Einheiten auf Förderbändern, Abzählen bestimmter Partien im laufenden Durchsatz und gleichzeitiges Zählen der Partien, sowie Zählen nach Gewicht.

Die elektromagnetischen und elektronischen Zähler des Programmes zählen mit Geschwindigkeiten von bis zu 10 kHz. An bestimmten Modellen kann man bis zu fünf eingestellte Partien vorwählen. Im allgemeinen werden die Zähler durch Unterbrechung eines Lichtstrahls ausgelöst, was den fotoelektrischen Empfänger in Betrieb setzt.

Lieferbare Prüfköpfe kann man mit 9,18 m Abstand zwischen Empfänger und Lichtquelle installieren. In staubiger Atmosphäre lassen sich die Linsen der Prüfköpfe durch Belüftung sauber halten.

Ausserdem kann die Zählung durch Schliessen von Kontakten, induktive oder magnetische Abtastköpfe oder Impulserzeugung eingeleitet werden.

EE 82 753 *für weitere Einzelheiten*

Drehzungenschalter

Vertrieb: Kynmore Engineering Co. Ltd, 19 Buckingham Street, London, W.C.2

(*Abbildung Seite 408*)

EMS-Rotireeds sind in fünf Grundausführungen lieferbar, in denen Schutzgaskontakte radial oder axial um einen runden oder viereckigen Körper angeordnet sind. Das Schalten wird über einen von einer Welle getriebenen elektromagnetischen oder Dauermagnetanker gesteuert. In den meisten Fällen werden Dauermagnetanker verwendet, und für mehrpoliges Schalten kann man eine Anzahl von Dauermagneten auf demselben Anker anordnen. Andererseits können auch Mehrfachschalter auf gemeinsamer Welle verwendet werden. Elektromagnetisches Schalten wird vorgezogen, wo eine grosse Anzahl von Kontakten in sehr kleinem Raum untergebracht werden müssen. Die Spulen der elektromagnetischen Anker werden über Schleifringe gespeist.

Da die goldplattierten Kontakte der Zungen selbst in einer Schutzgasatmosphäre arbeiten, werden sie von der Umgebung nicht beeinflusst. Rotireeds kann man daher in jeder gewünschten Lage, in staubiger, feuchter oder anderweitig aggressiver Atmosphäre einsetzen. Wie bei allen Zungenschaltern bleiben die Kontakte frei von Schmutz, Korrosion oder nennenswerter mechanischer Abnutzung.

In den Rotireed-Standardtypen kann man je nach der zu schaltenden Last und Schaltgeschwindigkeit Standard- oder Miniaturkontakte benutzen. Standardkontakte sind für 15 W, 1 A bemessen und haben eine Reaktionszeit von 3 ms. Bei 26 V und 0,25 A ist die Betriebslebensdauer 10^8 Schaltspiele. Miniaturkontakte sind für 6 W, 0,3 A bemessen und haben eine Reaktionszeit von 1 ms. Bei 26 V und 0,1 A ist die Betriebslebensdauer wieder 10^8 Schaltspiele. Die Schaltperiode soll zur Erzielung höchster Zuverlässigkeit für beide Kontakttypen zwei- oder dreimal so lang wie die Reaktionszeit sein, und die Umlaufgeschwindigkeit gewisser Rotireeds muss dementsprechend beschränkt werden. Einige Typen laufen einwandfrei mit 5 000 UPM.

Rotireed bietet folgende fünf Haupttypen an:

Typ RR ist mit Dauermagnetanker und in Kugellagern laufender Welle ausgerüstet; der Typ ist für Impulserzeugung von einem externen Antrieb gedacht.

Typ RH ist mit einem Dauermagnetanker und Sperrklinke für Handbetrieb ausgerüstet; die Rastpunkte sind auf der Frontplatte klar markiert.

Typ RM ist mit einem Dauermagnetanker und eingebautem Synchronmotor für Taktgeberzwecke ausgerüstet.

Typ RS ist Typ RM ähnlich, hat aber eine zusätzliche Positions-Halteschaltung.

Typ RK ist mit einem elektromagnetischen Anker und Synchronmotorantrieb ausgestattet; die Schalterpositionen sind auf der Frontplatte markiert.

Alle Typen können ein- und mehrpolig, sowie in Ausführung für Mehrfachposition und bis zu 100 getrennten Kontaktsätzen als Standardtypen und darüber hinaus nach Kundenwünschen entweder mit Löt-, Quetsch- oder Einsteckanschlüssen geliefert werden. Auch anderen Kundenanforderungen entsprechende Anordnungen sind lieferbar. Die Abmessungen hängen von den gewählten Anordnungen ab.

EE 82 754 *für weitere Einzelheiten*

Statische Wechselrichter

Industrial Instruments Ltd, Stanley Road, Bromley, Kent

(Abbildung Seite 409)

Diese Wechselrichter haben als Schaltelemente Halbleiter und sind für Eingangsgleichspannungen von 12, 24, 48, 110 und 220 V ausgelegt. Die sinusförmige Ausgangsspannung ist entweder 115 oder 230 V_{eff}, die Frequenz 50 Hz. Ausgangsleistungen hängen vom Modell ab und liegen zwischen 110 W und 6 kW. Der Wechselrichter ist gegen Polaritätsumkehr der Eingangsspannung geschützt und hat eingebaute elektronische Schutzschaltungen gegen Überlastung und Kurzschluss.

Der Wechselrichter toleriert grosse Leistungsfaktoränderungen in der Last, und Modelle zur Erregung von Motoren, z.B. solchen in grossen Aufzeichnungsmaschinen oder tragbaren Elektrowerkzeugen wie Handbohrern, sind lieferbar. Die Schaltung gestattet eine äusserst kompakte und billige Konstruktion; ein Gerät mit 1 kW Leistung ist z.B. in einem tragbaren Gehäuse untergebracht. Trotz der vergleichsweise kleinen Abmessungen hat der Wechselrichter eine eingebaute Spannungsreglerautomatik, die für Schwankungen in der Last und Gleichstromeingangsspannung kompensiert. Es gibt einen Frequenzregler, der die 50 Hz mit besser als 1% Unsicherheit einhalten kann, und zwar unabhängig von Schwankungen der Eingangsspannung und Last.

EE 82 755 *für weitere Einzelheiten*

Mehrgängige Potentiometer

Standard Telephones & Cables Ltd, West Road, Harlow, Essex

(Abbildung Seite 409)

STC/P.X. FOX kann jetzt ein Fertigungsprogramm von Präzisionspotentiometern in einer Auswahl von mehrgängigen Ausführungen und mit Mehrfachabgriff liefern. Typisch für das Programm ist die abgebildete internationale Aufbaugrösse S11 mit 27 mm Aussendurchmesser. Das für jeden Abschnitt erforderliche Drehmoment beträgt 1 cmp und die Lebensdauer 3 Millionen Zyklen.

Die Baureihe S11 hat bei 5 kΩ und darüber eine Linearität von 0,1 Prozent. Diese Potentiometer sind mit bis zu 10 Gängen je Einheit und bis zu 10 Abgriffen je Gang lieferbar. Die einzigartigen Fox-Potentiometerkontakte haben trotz langer Lebensdauer und niedrigem Drehmoment Rauschwerte, die so niedrig wie 10 Ω sein können.

EE 82 756 *für weitere Einzelheiten*

Lichtempfindliches Relais

Hird Brown Ltd, Flash Street, Bolton, Lancashire

(Abbildung Seite 409)

Hird Brown Ltd hat für das lichtempfindliche Relais PS1 eine neue Chassishalterung angekündigt. Das neue Chassis hat drei schlüssellochförmige Befestigungslöcher und kann in sein Gehäuse montiert oder in neue oder bestehende Kontrollgehäuse eingesetzt werden. Das lichtempfindliche Relais PS101 betätigt zwei Relaiskontaktsätze, wenn sein Strahl entweder unterbrochen oder wiederhergestellt wird. Alle Stromversorgungen für das Relais, die Fotozelle(n) und Lampe(n) sind vorhanden, und der Baustein kann an jedes Standardnetz angeschlossen werden.

Durch Unterbrechung des Lichtstrahls wird jedesmal zwangsläufig und unabhängig vom umgebenden Lichtverhältnis eine Relaisbetätigung erzeugt.

Das lichtempfindliche Relais lässt sich entweder in ein der von Hird Brown standardisierten Stahlblechgehäuse mit 228 × 152 × 102 mm, 254 × 152 × 102 mm oder 305 × 228 × 127 mm Abmessungen einbauen, oder bis zu drei Relais werden gemeinsam in ein 456 × 305 × 127 mm Gehäuse eingebaut.

Projektoren und Empfänger für das lichtempfindliche Relais PS101 stehen in 30 verschiedenen Typen zur Auswahl zur Verfügung.

EE 82 757 *für weitere Einzelheiten*

Transistor-Tester

Comark Electronics Ltd, Gloucester Road, Littlehampton, Sussex

(Abbildung Seite 409)

Mit dem Transistor-Tester 180 kann die Gleichstromverstärkung von npn- sowie pnp-Transistoren bei so niedrigen Kollektorströmen wie 10 nA gemessen werden, und Restströme sind bis 1 nA herunter nachweisbar.

Kollektorströme können auf jeden Wert bis zu 30 mA eingeregelt werden; ihre Messung erfolgt mittels eines Transistor-Chopper-Nanoamperemeters in 12 Bereichen bis zu 100 nA Vollausschlag herunter. Die Kollektor-Testspannung ist 4 V. Für externen Einsatz als Nanoamperemeter sind Klemmen vorhanden. Messunsicherheit ist 2 Prozent.

Der Basisstrom ist in neun Bereichen zwischen 0 und 1 mA kontinuierlich regelbar und wird direkt mit dem Nanoamperemeter gemessen, das zur Erleichterung der Bedienung Bereichautomatik hat. Neun vorgegebene Basisströme geben Direktanzeige der Verstärkung auf den Skalen 0...30, 0...100 und 0...300.

Das Gerät wird aus Langlebensdauer-Quecksilberbatterien gespeist. Aussenabmessungen sind 159 × 127 × 89 mm.

EE 82 758 *für weitere Einzelheiten*

Oszillografenfahrtisch

Avon Communications & Electronics Ltd, 16a High Street, Christchurch, Hants

(Abbildung Seite 410)

Das Modell TM11 mit seiner einstellbaren Tischplatte wurde hauptsächlich als nützlicher, fahrbarer Tisch für Oszillografen im neuen breiten Stil konstruiert. Ein wünschenswertes neues Konstruktionsmerkmal sind die Einrichtungen für den Einbau von 19"-Gestellfeldern für die mit vielen modernen Geräten gelieferten Reserveeinschübe.

Der neue Fahrtisch hat die robuste Bauart der anderen Modelle im Programm der Firma beibehalten. Der aus Rund- und Vierkantrohr mit 2,6 mm Wandstärke geschweisste Rahmen hält einen verstellbaren Tisch, der 483 mm (19") breit und 725 mm tief ist, und ein festes, 559 mm breites, 760 mm tiefes Zwischenblech. Beide Flächen bestehen aus 3,2 mm starkem Blech und sind mit 508 mm Abstand eingebaut. Einstellung der Tischflächenneigung erfolgt mittels einer Kurbel vorn am Wagen und kann in jeder Position zwischen 0° und 20° festgestellt werden. Veränderliche Einrichtungen auf der Tischfläche positionieren den Oszillografen von hinten. Die Gestellstangen für direktes Anschrauben der 19"-Gestellfelder sind unter der Kurbel angebracht. Die Höhe des Fahrtisches ist in Sprüngen von 25,4 mm zwischen 760 und 915 mm zu justieren, und an beiden Enden sind Schiebegriffe vorgesehen. Das unbeladene Gewicht ist etwa 38,5 kg.

Laufrollen werden entsprechend den vorherrschenden Bedingungen gewählt. Zur Standardausrüstung gehören hochbelastbare Typen von 127 mm Durchmesser mit Gummireifen und Kugellagern. Gegen Aufschlag können auch Bremsen vorgesehen werden. Mit den Standard-Laufrollen ausgerüstet hat der Fahrtisch eine Kapazität von ca. 408 kg.

Wenn der Fahrtisch für sehr empfindliche Geräte bestimmt ist, sind gegen Aufschlag gefederte 127-mm-Laufrollen mit Hochelastikreifen statt der Standard-Laufrollen zu haben, deren Einbau die Belastbarkeit auf etwa 90 kg beschränkt. Zum Fahren über unebene Fussböden oder strassenartige Oberflächen ist das Modell TM 11 gegen Aufschlag mit 203 × 51 mm Luftreifen statt der Standard-Laufrollen erhältlich.

EE 82 759 *für weitere Einzelheiten*

Digitaler Messgerätabtaster

Vertrieb: Thorn Electronics Ltd, Wellington Crescent, New Malden, Surrey

Ein neuer Digitaler Messgerätabtaster (Analog-Digitalumsetzer) wird von Thorn Electrics auf den Markt gebracht. Das Instrument wurde bei der Automatique Electrique SA in Antwerpen entwickelt, deren Vertretung Thorn übernommen hat.

Die Umsetzung analoger Grössen in digitale kann zwar durch Winkelgeber oder Umsetzung von Gleichspannungen erfolgen, geschieht jedoch über den Digitalen Messgerätabtaster mit grösserer Präzision und Leistungsfähigkeit.

Der Messgerätabtaster setzt die Winkelablenkung eines Zeigerinstrumentes oder einer Welle in eine entsprechende Anzahl von Impulsen um. Diese werden von einer vorher geeichten Magnettrommel abgelesen, beginnend mit einem der Instrument-Nullanzeige entsprechenden Punkt bis zu einem durch die Istanzeige optisch bestimmten Punkt.

Ein Tausend Impulse oder mehr entsprechen Vollausschlag, so dass die Umsetzgenauigkeit 0,1% oder besser ist und die Umsetzung genau der Analoganzeige entspricht. Die Magnettrommel läuft kontinuierlich mit einer Geschwindigkeit von einer Umdrehung je Sekunde, jedoch sind höhere Geschwindigkeiten auch möglich.

Ein an die Trommel angebautes optisches System erzeugt einen kreisenden Lichtstrahl, der die Zeigerposition ermittelt. Auf der Zeigerwelle ist ein Spiegel mit zwei Fotozellen befestigt. Sowie die Zeigerposition ermittelt ist, stoppt das Fotozellensignal das Zählen der von der Magnettrommel abgelesenen Signale.

Der kreisende Strahl wird durch eine in der Trommelachse fest eingebaute Lichtquelle und ein an die Trommel angebautes optisches System erzeugt. Dieses System besteht aus einem flachen, gegen die Trommelachse um 45° geneigten Spiegel und einem konkaven Spiegel, der den Strahl auf den Spiegel des Messgerätes fokussiert.

Die Umsetzgenauigkeit ist unabhängig von der Trommelgeschwindigkeit, und die Verwendung der Magnettrommel gestattet nichtlineare Umsetzungen. Es können daher auch Wechselstromeingänge ohne Gleichrichtung direkt in Digitalausgänge umgesetzt werden. Andererseits ermöglicht die Magnettrommel Korrektur von Messwandlerfehlern oder nichtlinearen Spuren.

Der Digitale Messgerätabtaster wurde ursprünglich für Telemetriezwecke entwickelt, hat sich seither aber auch auf anderen Gebieten bewährt.

EE 82 760 *für weitere Einzelheiten*

Miniaturgleichstrommotor

Vactric Control Equipment Ltd, Garth Road, Morden, Surrey

(Abbildung Seite 410)

Vactric Control Equipment Ltd kündigt einen neuen, preisgünstigen Miniaturgleichstrommotor mit Dauermagnet in Präzisionsausführung an, der besonders für langdauernden, ungestörten Betrieb unter ungünstigen Umgebungsbedingungen konstruiert wurde. Der Motor trägt die Typenbezeichnung 09P und ist kürzer als andere derselben Klasse; sein Gehäuse hat einen Aussendurchmesser von ca. 22,4 mm. Der Wellenstumpf ist in verschiedenen Ausführungen lieferbar, und der Motor kann gegebenenfalls auch mit doppelseitigem Wellenstumpf gebaut werden. Bei Ausrüstung mit einem Ritzel ist der Motor auch für Anschluss an ein Präzisions-Untersetzungsgetriebe geeignet. Der ausgewuchtete Anker läuft zur Erzielung schwingungsfreien Laufens in Miniaturkugellagern aus rostfreiem Stahl.

Der Motor hat bei 28 V— Nennspannung und einer Stromaufnahme von 0,25 A bei 6 000 UPM ein Nenndrehmoment von 30 cmp. Das Mindestdrehmoment, bei dem er abgewürgt wird, ist 65 cmp und der Leerlaufstrom 100 mA. Er wiegt 45 g und ist für Betrieb in Umgebungstemperaturen von −55°... +85°C geeignet. Er wird mittels zweier Gewindelöcher in der Gehäusestirnfläche angebaut.

EE 82 761 *für weitere Einzelheiten*

GW-Digitalvoltmeter

Digital Measurement Ltd, Salisbury Grove, Mytchett, Aldershot, Hampshire

(Abbildung Seite 410)

Digital Measurements Ltd hat das Fertigungsprogramm für Digitalinstrumentierung hoher Qualität durch das GW-Digitalvoltmeter DM 2003 (NATO-Nr. 6625-99-104-6993) ergänzt.

Mit dem DM 2003 können Gleichspannungen von 1 mV...1 kV mit einer Unsicherheit von 0,05 Prozent des Skalenendwertes ±0,1 Prozent der Anzeige gemessen werden und Wechselspannungen von 2...700 V_{eff} mit einer Unsicherheit von 0,25 Prozent des Skalenendwertes ±0,25 Prozent der Anzeige im Frequenzbereich 50 Hz...5 kHz. Der Skalenwert 1999 gibt ein bestes Auflösungsvermögen von 1 mV— und 10 mV∼.

Das Gerät hat einen völlig erdfreien, hochohmigen Eingang, der bei bis zu 1000 V Isolation gegen Erde eine Gleichtaktunterdrückung von besser als 120 dB gibt. Das Messergebnis wird auf Ziffernröhren mit Dezimalpunktautomatik angezeigt. Betriebsarten sind u.a.: (a) automatisch aufeinander folgend, (b) manuelle Auslösung und (c) Anzeige halten. Ein Polaritätsschalter gestattet bipolaren Betrieb, so dass sich Gleichspannungsmessungen beliebiger Polarität ohne Umpolen der Eingangssignalleitungen durchführen lassen.

EE 82 762 *für weitere Einzelheiten*

Temperaturwächter

Ether Ltd, Caxton Way, Stevenage, Hertfordshire

(Abbildung Seite 411)

Ether Ltd kündigt programmierbare Potentiometer-Temperaturwächter der neuen Baureihe 12-94 an.

Ein anzeigender Potentiometer-Temperaturwächter, der in vielen Ausführungen lieferbar ist, kombiniert mit einem Zeit-Temperatur-Programmiergerät, gibt Temperaturanzeige und -regelung über einen grossen Bereich mit hoher Genauigkeit.

Zur Gewährleistung hoher Zuverlässigkeit und langer Betriebslebensdauer ist dieses Gerät durchweg in Festköpertechnik ausgeführt. Es kann auch jeden Prozess regeln, dessen Signale sich in Gleichstrom oder Gleichspannung umsetzen lassen. Das in einem geschweissten Stahlgehäuse untergebrachte Gerät ist völlig staub- und feuchtigkeitsdicht.

Programmnocken können mit einer Toleranz von ±1 Prozent des Skalenumfanges hergestellt werden. Fehler in der Bearbeitung der Nocken sind mittels einer Feineinstellschraube am Steuerarm korrigierbar. Eine Evolventennocke kann für Feststeuerung der Temperatur eingesetzt werden.

Programmotor oder Brennstoffzufuhr kann man zu jedem beliebigen Zeit- oder Temperaturpunkt mittels eines Grenzschalters stoppen. Ein oder zwei Hilfsschalter zur Betätigung externer Schaltungen können auch vorgesehen werden.

EE 82 763 *für weitere Einzelheiten*

Leistungs-Tongenerator

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

(Abbildung Seite 411)

Ein Leistungs-Tongenerator mit sehr niedrigem Klirrfaktor wurde von Dawe Instruments Ltd angekündigt. Das Modell 440B besteht aus einem zweistufigen Oszillatorteil, dem ein selektives RC-Netzwerk nachgeschaltet ist, dessen

Ausgang durch einen Amplitudenregler einem Trennverstärker zugeführt wird, der über einen Phasenspalter eine symmetrische Gegentakt-Endstufe speist.

Jede Baugruppe wurde so entworfen, dass ihre Röhren immer innerhalb des linearen Abschnittes ihrer Kennlinien arbeiten, wodurch—zusammen mit selektiver Gegenkopplung und der allgemeinen hohen Konstruktionsqualität—ein Generator geschaffen wurde, der im Frequenzbereich 20 Hz...20 kHz praktisch ohne Verzerrung eine hohe Ausgangsleistung (6 W) abgibt. Der Ausgangsübertrager ist einer Belastung von 3,75, 15 oder 600 Ω angepasst, jedoch ist der Einfluss einer Fehlanpassung vernachlässigbar klein.

Die Frequenz ist kontinuierlich durchstimmbar; der Mehrfachkondensator ist über einen Feinantrieb mit 10:1 Untersetzung mit einer Frequenzskala gekuppelt, die über 333° ihres Umfanges geeicht ist. Drei Dekadenbereiche überstreichen den vollen Frequenzumfang von 20 Hz...20 kHz auf einer Gesamtskalenlänge von 1,52 m.

Bei 3 W Leistung ist die Amplitude über den ganzen Frequenzbereich innerhalb ± 0,5 dB konstant. Ein typischer Oberwellengehalt bei 400 Hz besteht aus 0,02 Prozent zweite Harmonische, 0,12 Prozent dritte Harmonische, mit weniger als 0,01 Prozent Brummen und Störsignal. 30 Minuten nach Einschalten wird die Amplitude innerhalb ±1 Prozent, die Frequenz innerhalb 0,05 Prozent konstant gehalten.

Das Gerät ist einfach zu bedienen und erfordert keine besondere Wartung, um laufend gute Ergebnisse zu erzielen. Es wird aus dem 50-Hz- oder 60-Hz-Netz gespeist. Das kompakte Tischgehäuse (210 × 330 × 317 mm) ist ausreichend belüftet.

EE 82 764 *für weitere Einzelheiten*

Miniatur-Einbauinstrumente

Vertrieb: Leland Leroux Ltd, 145 Grosvenor Road, London, S.W.1

(Abbildung Seite 411)

International Instruments Inc in Connecticut, USA, hat ein neues Miniatur-Präzisionsmessgerät Modell 1122 entwickelt, das vielen Ansprüchen für Anwendung in engem Raum genügen wird. Seine Gestaltung als Profilinstrument ist der Hauptvorteil des Modells 1122, der durch weitere Eingenschaften noch unterstrichen wird. Von der Skala bis zu den Anschlüssen sind diese Messgeräte völlig flach und ohne hervorstehende zylindrische Teile; das Volumen hinter der Frontplatte ist nur etwa 25 cm³.

Ungleich anderen Drehspulmesswerken hat dieses neue, patentierte Messwerk nur einen Luftspalt statt der üblichen zwei. Dieser magnetische Kreis mit Einzelspalt ist so angeordnet, dass der Raum mit hohem Wirkungsgrad ausgenutzt wird. Die vom Messwerk des Modells 1122 erzeugte magnetische Feldstärke ist daher so hoch wie die eines herkömmlichen Messwerkes mit zwei Luftspalten. Da es nur einen Luftspalt gibt, kann die Spule mit einem Arm, der an der nichtscheidenden Seite der Drehspule angeordnet ist, drehbar angeordnet werden. Die durch das Messwerk erzeugte Kraft wird durch den langen Arm multipliziert und ergibt ein hohes Ausgangsdrehmoment. Durch Versetzen der Drehzapfenachse aus der Mitte wird ausserdem die Verwendung einer durchgehenden Lagerwelle statt der einzelnen Zapfen an jeder Seite der Spule möglich, wodurch Fluchtungsfehler vermieden und Linearität sowie Reproduzierbarkeit gewährleistet werden.

Miniatur-Einbauinstrumente Modell 1122 sind besonders für Endprüf- und Kontrollpulte mit Mehrkanalanzeige geeignet. Wegen ihres kompakten Profils eignen sie sich vor allem als Miniaturinstrumente in Prozessen, Abstimmanzeiger sowie VU-Messer in Tonfrequenzsystemen. Da sie auf Wunsch auch für beiderseitigen Ausschlag zu haben sind, eignen sie sich als Nullanzeiger.

Da die Messgeräte 1122 völlig flach sind, können sie unbegrenzt übereinander oder nebeneinander gestapelt werden. Die Neukonstruktion des magnetischen Kreises schliesst jegliche magnetische Wechselwirkung aus.

Das Modell 1122 kommt in 27 Standardbereichen mit Empfindlichkeiten von 100 μA oder 50 mA Skalenendwert ab und in vertikalem oder horizontalem Anzeigeformat, mit verschiedenen Nullpositionen und Sonderausführungen für die Skala, als VU-Messer, dB-Messer usw. Höhere Empfindlichkeiten sind gegen Sonderauftrag lieferbar.

Die Anfangsunsicherheit ist ±2 Prozent des Vollausschlags für Gleichstrom und ±3 Prozent für Wechselstrom. Die maximale Einschwingzeit ist 2,5 s, die Skalenlänge 31,5 mm. Die Aussenabmessungen sind etwa 41 mm breit × 60 mm tief × 13 mm hoch, und das Instrument wiegt etwa 115 g.

EE 82 765 *für weitere Einzelheiten*

Miniatur-Elektrolytkondensatoren

Plessey-UK Ltd, Capacitor Division, Kembrey Street, Swindon, Wiltshire

Miniatur-Elektrolytkondensatoren neuer Bauart mit sehr niedrigem Serienwiderstand wurden unter Typenbezeichnung LSR von der Plessey-UK Ltd angekündigt.

Die Kondensatoren wurden ursprünglich für transistorisierte Rechnerschaltungen entwickelt, finden voraussichtlich aber viele weitere Anwendungsmöglichkeiten.

Durch Wahl hochleitender Elektrolyte wurde der Innenwiderstand auf einen Bruchteil seines üblichen Wertes reduziert; an einigen Prüflingen wurde bei Anwendung von Impulsmesstechnik ein so niedriger Wert wie 0,05 Ω festgestellt.

Eine Eigenschaft gewöhnlicher Aluminium-Elektrolytkondensatoren, die ihre Leistung begrenzt und dadurch ihre Verwendung bei Ton- und höheren Frequenzen einschränkt, ist ihr hoher Innenwiderstand. Dieser hohe Widerstand ist auf zwei Ursachen zurückzuführen, und zwar die Verwendung von auf natürlicher Borsäure beruhenden Elektrolyten mit hohem Siedepunkt und nur mittelmässiger Leitfähigkeit, sowie den Bedarf an Kondensatoren mit kleinen Abmessungen.

Bei wirklichkeitsnaher Einschätzung der Betriebsbedingungen wird der Konstrukteur von Ausrüstungen für Elektronenrechner und Nachrichtentechnik bald feststellen, dass ein für eine Umgebungstemperatur von 70° bemessener Elektrolytkondensator völlig unnötig ist und ein Kondensator mit einer oberen Grenztemperatur von 40 oder 50° C verwendet werden kann.

Bei diesen verhältnismässig niedrigen Temperaturen hat man die Wahl zwischen mehreren, besser leitenden Elektrolyten, die auf den lösbaren, fast neutralen Ammonsalzen anderer Säuren als der natürlichen Borsäure beruhen. Für Betrieb bei 50° C können schichtbildende Elektrolyte formuliert werden, die eine fünfmal höhere Leitfähigkeit haben als die üblicherweise benutzten, während man bei 40° C Elektrolyte verwenden kann, deren Leitfähigkeit fünfzigmal so hoch ist.

Mit diesen besser leitenden Elektrolyten imprägnierte Aluminium-Elektrolytkondensatoren mit geätzter oder glatter Folie haben bei höheren Frequenzen wesentlich bessere Leistungen im Impulsbetrieb oder in der Entkopplung; ihr Verhalten bei niedrigen Temperaturen im Bereich 0 ... −40° C im Vergleich mit üblichen Elektrolytkondensatoren ist hervorstechend.

Es gibt LSR-Kondensatoren im Kapazitätsbereich 1 ... 1000 μF bei Betriebsspannungen bis zu 150 V. Der Betriebstemperaturbereich ist je nach Typ −30 ... +40° C oder 50° C. Sie sind mit geätzter oder glatter Folie, mit oder ohne Isolierhülle lieferbar.

Sie werden mit zwei Gehäusedurchmessern von 9,5 mm und 13 mm und in vier Gehäuselängen von 19, 29, 32 und 35 mm geliefert.

EE 82 766 *für weitere Einzelheiten*

Regelwiderstand

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

(Abbildung Seite 412)

Ein preiswerter Regelwiderstand mit völlig rauschfreier Regelung kann nunmehr von Mullard bezogen werden, der sich somit besonders für die Steuerung von Video- und Tonfrequenzsignalströmen eignet. Der Baustein hat die Typenbezeichnung ORP 39 und besteht aus einer Kadmiumsulfidzelle und einer 12-V-Lampe, die in einen Kunststoffblock von 17 × 17,5 ×22 mm verkapselt sind. Der Block hat vier Anschlussstifte für Montage auf gedruckte Schaltungen.

Der ORP 39 wurde als ferngesteuerter

Regelwiderstand in Fernsehkameras entwickelt, hauptsächlich für die Steuerung der Helligkeit (Strahlstrom) und Austastschaltung. Er kann auch als Gegenkopplungselement zur Regelung der Gesamtverstärkung in Tonfrequenzschaltungen, als ferngesteuerter Helligkeits-Kontrastregler für Fernsehempfänger und für die Fernsteuerung von Bildbandgeräten, Videosignal-Relaisstationen und Fernsehumsetzerausrüstungen Anwendung finden.

Durch Änderung der Helligkeit der Lampe kann man den Widerstand der Zelle über mindestens drei Dekaden (etwa von 100 Ω...10 kΩ) regeln.

Das Einstellen des Widerstandes erfolgt völlig rauschfrei, und zwischen Steuerung und Ausgang bestehen keinerlei elektrische Verbindungen. Dadurch wird gute elektrische Isolierung und Trennung erzielt, wodurch wiederum lange Zuleitungen zwischen Fernsteuerungspunkt und Ausrüstung ohne Einfluss auf die geregelte Schaltung möglich werden.

Die Kapazität zwischen der steuernden und der geregelten Schaltung beträgt etwa 2 pF. Der Baustein hat einen rein ohmschen Widerstand und wird auch über den gesamten Videobereich nicht reaktiv. Anwendung für Zwischenfrequenzen in der Grössenordnung von 10 MHz wird jedoch nicht empfohlen. Die Ansprechzeit ist kurz—viel kürzer als die Betätigungszeit eines manuellen Reglers—und die Preislage im Vergleich mit anderen ähnlichen, fernsteuerbaren Elementen hoher Qualität günstig. Der ORP 39 ist vor allem für Verwendung in Schaltungen, in denen jegliche gegenseitige Beeinflussung zwischen Steuerung und gesteuerter Schaltung unerwünscht ist, geeignet, sowie als Drehwiderstand ohne Kontaktrauschen oder als Wandler zum Umsetzen eines Spannungseinganges in einen Widerstandsausgang mit kompletter elektrischer Trennung zwischen Eingang und Ausgang.

Da Impedanz und Phasenwinkel der Zelle sich mit ihrem Widerstand und der angelegten Frequenz ändern, hängt die nutzbare obere Frequenzgrenze des Ausgangswiderstandes von der Toleranz der jeweiligen Anwendung auf Änderungen ab und beträgt wahrscheinlich einige Megahertz.

EE 82 767 *für weitere Einzelheiten*

Überlagerungsvoltmeter

Vertrieb: B & K Laboratories Ltd, 4 Tilney Street, Park Lane, London, W.1

(Abbildung Seite 412)

Das Bruel & Kjaer Überlagerungsvoltmeter 2006 ist volltransistorisiert und für Messungen im HF- und UKW-Bereich ausgelegt. Es ist ein batteriebetriebenes, leichtes Gerät, das bei allen für AM, FM und Fernsehen üblichen Frequenzen selektiv messen kann.

Man kann nicht nur die Amplitude von hochfrequenten Signalen messen, sondern auch die Frequenz sowie den Modulationsgrad bestimmen; die gemessene Frequenz wird auf einer Instrumentenskala angezeigt. Auf einem zweiten Messgerät werden die Amplitude der gemessenen HF-Spannung sowie der Modulationsgrad angezeigt, und ein Lautsprecher erlaubt Hörüberwachung.

Das Voltmeter hat direkte Eingangsklemmen mit 75 Ω Impedanz. Man kann jedoch einen Spezialmesskopf anschliessen und erhält dann einen hochohmigen Eingang. Der Eingangsmesskopf wird mittels eines 1,5 m langen Kabels an das Voltmeter angeschlossen.

Der Spannungsmessbereich des Gerätes kann durch einen abrüstbaren Spannungsteiler am Messkopf erweitert werden; Spannungsteiler und Messkopf haben ungefähr gleiche Abmessungen. Die Abschwächung des Spannungsteilers ist 60 dB.

Ein eingebauter, stabilisierter Bezugsoszillator liefert eine Bezugsspannung für die Eichung des Instrumentes.

EE 82 768 *für weitere Einzelheiten*

Präzisions-Widerstandsmessbrücke

H. Tinsley & Co. Ltd, Werndee Hall, South Norwood, London, S.E.25

(Abbildung Seite 413)

Für die vor kurzem von H. Tinsley & Co angekündigte Präzisions-Widerstandsmessbrücke 5577 wird angegeben, dass sie die üblicherweise in Messbrücken des Wheatstonschen Typs beim Schalten auftretenden Fehler beseitigt und andere Fehlermöglichkeiten durch auf Überstrom zurückzuführende Beschädigung von ein oder mehreren Spulen reduziert. Diese Vorteile werden dem Schaltungsentwurf zugeschrieben. Der veränderliche Brückenzweig ist aus Leitwerten konstruiert und aus binären Inkrementen aufgebaut, wodurch sich eine Million Stufen ergeben. Für jede der sechs Dekaden sind nur sechs Spulen erforderlich, insgesamt 36 statt der 60 in einer konventionellen Wheatstone-Schaltung. Verhältnisse werden mittels Drehschalter geändert.

In einer konventionellen Wheatstoneschen Brücke liegen alle Schalterkontakte in Serie, was die erzielbare Messgenauigkeit durch die Summe der Kontaktfehler beschränkt. In der neuen Konstruktion wird dieses Problem völlig eliminiert, da alle Kontakte parallel liegen. Im schlimmsten Falle liegt die 50-Ω-Widerstandsspule mit einem 25-μΩ-Schalterkontakt in Serie, und der Einfluss des letzteren ist offensichtlich vernachlässigbar klein.

Eine weitere Eigenschaft der Brücke ist, dass man sie als vierpolige Brücke einsetzen kann, was Benutzung langer Zuleitungen erlaubt, deren Einfluss in der Brückenanzeige kompensiert werden kann. Bei Brückenspannungen von 2... 60 V ist der Messumfang der Brücke 0,0001 Ω...100 MΩ. Man kann erwarten, dass die Fehlergrenze des Messgerätes am untersten Ende des Messbereiches nicht grösser als 0,01 Prozent und am obersten Ende 0,1 Prozent ist. Für die Zwischenmessungen ist es 0,001 Prozent bei 100 Ω...10 kΩ, 0,005 Prozent bei 10...100 kΩ und 0,01 Prozent bei 100 kΩ...10MΩ.

EE 82 769 *für weitere Einzelheiten*

Schulungs-Servosystem

Feedback Ltd, Crowborough, Sussex

(Abbildung Seite 413)

Das Schulungs-Servosystem ES130 ist eine Mehrzweck-Gleichstrompositionssteuerung, die für die Erläuterung aller wichtigen Aspekte der Theorie des geschlossenen Regelkreises ausgelegt ist.

Zum Anfang werden die Eigenschaften eines einfachen Systems zweiter Ordnung untersucht, wonach man auf die Probleme der stabilisierenden Systeme höherer Ordnung übergeht, in denen es nichtlineare Elemente und Federungswiderstand-Trägheitsresonanz gibt. Auf diese Weise kann dieselbe Ausrüstung vom Industrietechniker wie auch vom Doktoranden mit gleicher Leichtigkeit benutzt werden.

Unter den praktischen Merkmalen sind zu nennen:

Kontinuierlich durchdrehbare Eingabe- und Rückstellpotentiometer. Die Eingabe kann über ihren eigenen Motordrehzahlregler getrieben werden, um den auf die zu untersuchenden Eigenschaften folgenden eingeschwungenen Zustand zu erreichen.

Ausser dem Servoverstärker gibt es auch einen Funktionsverstärker mit den entsprechenden Bauelementen für Ausgleichsnetzwerke.

Auf Wunsch lassen sich zusätzlich vorbestimmte Mengen von totem Gang, Trägheit und Reibung eingeben.

Kontinuierliche oder stossweise Überlastung des Systems wird angezeigt. Die Spannungspegel im ganzen System können mittels eines Monitorinstrumentes überwacht werden.

Die interne Konstantstromversorgung für ±300 V lässt sich zum Betrieb von angeschlossenen Geräten des Feedback-Analogprogrammes heranziehen, um Analoge und Relaissteuerung einzubegreifen.

Ein umfassender Kurs in der Theorie und praktischen Arbeiten wird mitgeliefert.

EE 82 770 *für weitere Einzelheiten*

Konstantstromversorgung

A.P.T. Electronic Industries Ltd, Chertsey Road, Byfleet, Surrey

(Abbildung Seite 413)

A.P.T. Electronic Industries hat ihre Baureihe T.C.U. durch das neue Modell T.C.U. 1050 erweitert.

Stromversorgungsgeräte der Baureihe T.C.U. sind kompakte Hochleistungs-Laborgeräte in ansprechendem Stil mit einer Anzahl von Konstruktionsmerkmalen, die ausgezeichnete technische Eigenschaften bei ungewöhnlich kleinen Abmessungen ergeben.

Genauso wie der Rest der Serie ist das Modell T.C.U.1050 bei 10 A Ausgangsstrom über den Bereich 0...50 V regelbar. Die Schutzschaltung verhütet Beschädigung, indem sie im Überlastungszustand die Stromentnahme begrenzt und nach einer Verzögerung den Ausgang auf Null klemmt. Einschwingüberlastungen von kürzerer Dauer als die Verzögerung lassen das Gerät wieder in den normalen Betriebszustand zurückgehen. Der Pegel, bei dem die Schutzschaltung wirksam wird, lässt sich durch einen Stufenschalter einstellen, und Rückstellung erfolgt über eine Drucktaste im Bedienfeld.

Die Ausgangsspannung wird mittels eines fünfstufigen Schalters und eines Feinreglers über den Bereich 0...50 V eingeregelt; der Auslösepegel der Schutzschaltung wird durch einen Schalter mit sechs Stufen für 120%, 100%, 80%, 60%, 40% und 20% der Höchstnennstromlast gewählt.

Anschlussklemmen für Fernanzeige sind vorhanden, und der Ausgang ist erdfrei, so dass die Spannung durch Erdung der einen oder anderen Seite in bezug auf Masse positiv oder negativ gemacht werden kann; ausserdem kann man Geräte in Serie schalten, um höhere Spannungen zu erhalten, wobei allerdings durch eine Höchstspannung von 500 V— zwischen Klemmen und Masse eine Grenze gesetzt ist.

Die mit steuerbaren Siliziumzellen bestückten Gleichrichterschaltungen arbeiten sehr leistungsfähig, so dass der dem Netz entnommene Spitzenstrom so klein wie praktisch möglich gehalten wird.

Netz- und Gleichstromsicherungen, Spannungswähler des Netztrafos und das Anschlusskabel sind hinten, alle anderen Regler und Klemmen sowie das grosse, leicht ablesbare Messgerät auf der Frontplatte angeordnet.

EE 82 771 *für weitere Einzelheiten*

Gaslaser

G. & E. Bradley Ltd. Electrical House, Neasden Lane, London, N.W.10

(Abbildung Seite 413)

G & E Bradley hat einen neuen, besonders für Lehranstalten entwickelten Helium-Neon-Gaslaser angekündigt. Er hat eine etwa 711 mm lange Röhre, wird hochfrequent erregt und hat einen getrennten Treiber. Der Treiber hat eine Ausgangsleistung von 60 W bei 27,12 MHz, ist quarzgesteuert und kann für einfache Nachrichtenverkehrsversuche moduliert werden.

Die Standard-Ausgangsfrequenz ist 6328 Å, und das Spiegelsystem hat denselben Brennpunkt. Die Ausgangsleistung ist 5 mW. Andere Ausgangsfrequenzen und Spiegelsysteme sind ebenfalls lieferbar. Die Abdeckung des Laserkopfes ist für die Wartung leicht abnehmbar, und für Aufbau auf eine optische Bank stehen einstellbare Halterungen zur Verfügung.

EE 82 772 *für weitere Einzelheiten*

Zusammenfassung der wichtigsten Beiträge

Eine lichtbetätigte Neigungssteuerung für landwirtschaftliche Abzuggrabenmaschinen von G. O. Harries und D. H. Perkins

Zusammenfassung des Beitrages auf Seite 364-367

Feldabzuggräben müssen mit der geringstmöglichen Abweichung von der beabsichtigten Neigung erstellt werden, damit sie fehlerfrei funktionieren. Automatische Mittel zur Lösung der Aufgabe werden in diesem Beitrag beschrieben. Das Steuersystem hat zwei Lichtstrahlen, die mit unterschiedlicher Frequenz unterbrochen werden, und einen fotoelektrischen Detektor. Die angewandten elektronischen Schaltungen werden eingehend beschrieben.

Der M.3—ein kleiner, transistorisierter Digitalrechner von A. D. Booth und K. Cameron

Zusammenfassung des Beitrages auf Seite 368-374

Die Logik und Schaltungen für das Steuerwerk und Rechenwerk eines neuen, kleinen Universal-Digitalrechners werden beschrieben. Die Anlage ist mit Magnettrommelspeicherung für 8192 Worte von je 32 Bit ausgerüstet und arbeitet mit einer Ziffernfrequenz von 150 kHz.

Ein Verstärker mit linearer[1] spannungsgesteuerter Verstärkung von C. I. Sach

Zusammenfassung des Beitrages auf Seite 375-379

Dieser Beitrag beschreibt eine für eine Verstärkerstufe benutzte Schaltung, deren Verstärkung einer Steuerspannung proportional ist. Eine einfache Theorie für die Arbeitsweise der Stufe zusammen mit einigen Anwendungsbeispielen wird gegeben.

Eine Normalfrequenzquelle von S. I. Cotton

Zusammenfassung des Beitrages auf Seite 380-383

Es wird eine Normalfrequenzquelle beschrieben, in der eine Frequenz aus dem Bereich 40 Hz, 50 Hz, 80 Hz, 100 Hz, 200 Hz, 250 Hz . . . 20 kHz, 25 kHz, 50 kHz, 100 kHz mittels eines Schalters eingestellt werden kann. Man erhält sie von einem 100-kHz-Quarzoszillator über eine Anzahl von Frequenzteilerstufen mit Diodenpumpschaltung. Nach Impulsformung werden Rechteckimpulse mit über 50 V Höhe erzeugt, während die Ausgangsimpedanz der Schaltung niedrig ist. Von demselben 100-kHz-Oszillator wird eine 50-Hz-Speisung abgeleitet, die eine Uhr teribt, damit die Langzeitfrequenz der Quelle überwacht werden kann.

Kondensatoren mit dünnen Oxydschichtdielektrika von B. Walton

Zusammenfassung des Beitrages auf Seite 384-387

Ein kurzer Überblick über Verfahren zur Aufbereitung dünner Oxydschichtdielektrika wird gegeben und daraus der Rückschluss gezogen, dass die Vakuum-Bedampfung mit schwer schmelzbaren Metalloxyden die besten Ergebnisse bringt. Das dafür benutzte Verfahren und die Herstellung solcher Kondensatoren werden eingehender beschrieben. Die Eigenschaften dieser Kondensatoren werden besprochen, und es wird gezeigt, dass sie viele wünschenswerte Qualitäten besitzen.

Krümmungszusatz zu einem Oberflächengüte-Messgerät von B. B. Trott

Zusammenfassung des Beitrages auf Seite 388-389

Ein Zusatz zu einem Messgerät für Oberflächengüte wird beschrieben, mit dem man das zweite Differential und die Krümmung des Oberflächenprofils bestimmen kann. Eine Schaltung wird beschrieben und Einzelheiten über Eichung und Testergebnisse gegeben.

Ein Impulsfrequenzvervielfacher für Digitalphasenmessungen von L. Molyneux

Zusammenfassung des Beitrages auf Seite 392-393

Ein beschriebener Analog-Frequenzvervielfacher kann ein Multiplikationsverhältnis von 360 verarbeiten, wodurch Digitalmessungen von Phasendifferenzen ermöglicht werden.

Ein Impulshöhenanalysator von M. Bronzite

Zusammenfassung des Beitrages auf Seite 394-395

In diesem Beitrag wird eine Schaltung zur Überwachung von Impulsamplituden beschrieben. Die Bedienung ist einfach; eine umfangreiche Auswahl von Eingangswellenformen kann über ein breites Frequenzband mit einer Unsicherheit unter 1 Prozent verarbeitet werden.

Anwendungsmöglichkeiten der Informationsspeicherung in Magnetspeichern von D. M. Bernstein

Zusammenfassung des Beitrages auf Seite 398-400

Eine Anzahl von Analysatortypen mit magnetischer Speicherung wurde für Einsatz in der Kernphysik entwickelt. Einige dieser Ausrüstungen werden in dem Beitrag besprochen und ihre Anwendungsmöglichkeiten in anderen Gebieten der Messtechnik angedeutet.

Ein Hochspannungsimpulsgeber mit geschalteten Thyratrons von T. Chan und M. W. Gunn

Zusammenfassung des Beitrages auf Seite 401-403

Der Entwurf eines Hochspannungsimpulsgebers mit Wasserstoffthyratrons in einem "Ein-Aus"-Schaltzyklus wird beschrieben. In der Schaltung werden die Vorteile von Impulsgebern des Leitungs- und des Hochvakuumtyps zur Erzeugung von Ausgangsimpulsen, deren Dauer kontinuierlich veränderlich ist, mit niedrigem Ausgangswiderstand kombiniert. Der beschriebene Generator erzeugt gut geformte Rechteckimpulse von bis zu 4 kV Grösse und kontinuierlich ab 0,2 μs regelbarer Dauer bei etwa 13 Ω Quellenwiderstand. Die Schaltung kann ohne Schwierigkeiten auf die Abgabe von Ausgangsimpulsen bis zu maximal 16 kV ausgebaut werden.