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Commentary

THE Economics Development Committee for Electronics has now been in existence for just over two years, having held its first meeting in April 1964: it has recently issued a report on its work during this period. The main aims of the Report are to inform industry about the work of the E.D.C., to promote comment and action on the conclusions and recommendations that have arisen as a result of this work and to put together in one place information about the industry for the use of those working in it. While much of the information in the Report is already known and has previously been given in this journal and elsewhere, it is, as a whole, a satisfactory document and in the last named aim it is singularly successful for it presents a more complete set of statistics concerning the industry than has hitherto been easily available.

The E.D.C. is interested in the electronics industry mainly from the point of view of its effect on this country's problem of balance of trade: that is, how can the industry maintain its record of rapid growth and increasing exports while at the same time restraining imports. While fully recognizing the dominance of the U.S.A. the E.D.C. emphasizes its confidence in the British industry and in its ability to maintain a strong position in world markets.

In the Report each sector of the industry is individually analysed and specific recommendations are made.

So far as capital goods are concerned the overall picture is reasonably satisfactory; but not entirely so. For 1965 the total output of this sector is given as £265M with exports at £63M, but against this, imports were at a level of £39M. Estimated figures for 1970 are £395M, £100M and £71M.

Computers form an increasingly important part of the capital goods sector and, while the U.K. has the only independent computer industry operating internationally, outside the U.S.A., our performance here is not outstanding. In fact, Britain is a net importer of computers and peripheral equipment on a growing scale. Half of all machines installed have been imported: these imports grew from an estimated £3M in 1961 to £18½M in 1965 and may reach £40M in 1970. The 'R. & D. threshold' for computers, that is, the R. & D. expenditure necessary to keep a firm competitive, is very high and is only likely to be reached by a much greater degree of collaboration between firms. The Government can give this part of the industry a great deal of help by buying British wherever possible and by encouraging other organizations to do likewise.

The sub-division dealing with radar and navigational aids shows Britain in a much better light: it is the largest category of capital goods exported. In 1964 the value of U.K. exports was £22M, compared with a world total of about £75M. Probably about three-quarters of all ships with marine radar use British equipment and so do most of the world's civil airports outside the American continent.

The U.K. position in radio communication equipment is also good; about 40 per cent of output being exported. In 1964 this amounted to £12M compared with a world total of about £95M. However, in this field competition comes not only from America but also from West Germany and Japan, each of which exports about the same amount as Britain.

The next sector of the industry dealt with by the Report is 'consumer goods' and this makes rather gloomy reading. The U.K. output for 1964 was £127M, exports were £6M and imports £12M; the provisional figures for 1965 are, output £96M, exports £6M and imports £9M, forecast figures for 1970 are £127M, £10M and £17M respectively. Of the total sales of consumer goods manufactured in the U.K. in 1965, exports of television receivers accounted for 4 per cent, radios and radiograms 3 per cent and complete gramophones 12 per cent; the only shaft of light is turntable units where exports accounted for 83 per cent of total sales. The main difficulties facing this sector of the industry are the instability of the home market which is largely due to uncertainty as to the Government's long term intentions for the future of television, and the problems of incompatibility for, owing to the dissimilarity between British home market requirements and those obtaining in countries overseas, most British home market models of radios and virtually all television receivers are unsuitable for export markets. The position is further aggravated by low cost competition particularly from Hong Kong and Japan: this, fortunately, is likely to be fairly short term for as the living standards of these countries rise their labour costs rise in step and this is now happening with fair rapidity. The E.D.C. does not have any very firm recommendations for this sector of the industry, but stresses the need for firm Government decisions on the long-term policy for both television and sound broadcasting.

The final sector of the industry to be dealt with by the E.D.C. Report is 'components.' This perhaps is the least glamorous division of the industry but it is, of course, the key sector, for the competitiveness of the whole electronic industry relies upon the ability of the component manufacturers to keep technically ahead and to produce, in sufficient quantity, the types of components that will be required for the sophisticated equipments of the immediate future. Particular emphasis is laid on semiconductors and microelectronics. This is an area where the U.S.A. has a considerable lead: it is also one where success depends on a very high rate of expenditure on both R. & D. and production processes and if Britain is to stay with the leaders considerable rationalization and regrouping of resources is urgently needed.

A Multiplex System for Acoustic Recording

By R. W. Procunier,* Ph.D.

A technique has been introduced for transmitting data from acoustic detectors to a recording centre in the rocket grenade experiment. The system comprises seven control frequencies in the range of 595 to 2 975c/s which are amplitude modulated with pressure variations and two recording systems (1) ultraviolet pen, and (2) magnetic tape. This has been shown to have the advantage of removing electrical noise encountered over long transmission lines and capability to electronically reproduce signals. Operated in the field it has been successful in extending the maximum altitude of detection of 355g grenades to 107km altitude.

(Voir page 762 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 769)

ROCKET firings for temperature and wind measurement by acoustical propagation have been carried out successfully from a number of geographical locations. In these experiments grenades are ejected and detonated at height intervals of a few kilometres as the vehicle ascends and the sound waves produced are received at an array of ground-based microphones. The detection of acoustic energy as it is received at ground level from a rocket launched grenade limits the maximum altitude of measurement and possibly gives rise to the major error in this experiment. The problem is one of receiving the signal and identifying it in the midst of natural pressure fluctuations.

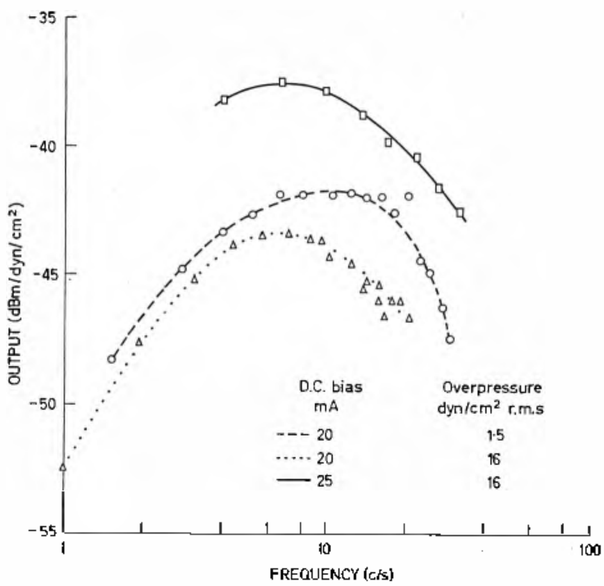

Fig. 1. Frequency-pressure response dependence on bias current and over-pressure

Seven hot-wire microphones are spaced out in an array under the bursts in accurately surveyed positions up to 30km from a central recording point and used to determine the time when the pressure deviates from the ambient at each detector. This information along with the initial co-ordinates of the burst and time of detonation is sufficient to determine the mean temperature and winds in a layer between successive bursts.

Previous instrumentation used was considered inadequate and development of a new system was undertaken with the idea of reducing extraneous noise generated in transmission and recording equipment, and improving the frequency response to achieve the maximum altitude of acoustic detection.

System Requirements

The detector of acoustic energy is a hot-wire microphone comprising a Helmholtz resonator, with a 6μ platinum wire in the neck coupling the enclosed volume and ambient air. This element, used to sense velocity changes, is kept just below red heat by passing a d.c. bias of about 30mA through it and readily changes temperature and resistance when the air in the neck of the resonator is in motion. As a non-linear detector, it has a frequency response dependent upon bias current and overpressure according to Fig. 1. The voltage output indicated corresponds to the resistance change in the element when the appropriate d.c. bias from a constant current source is applied. Pressure variations of Fig. 1 were obtained in a pistonphone of $10^6 cm^3$ volume

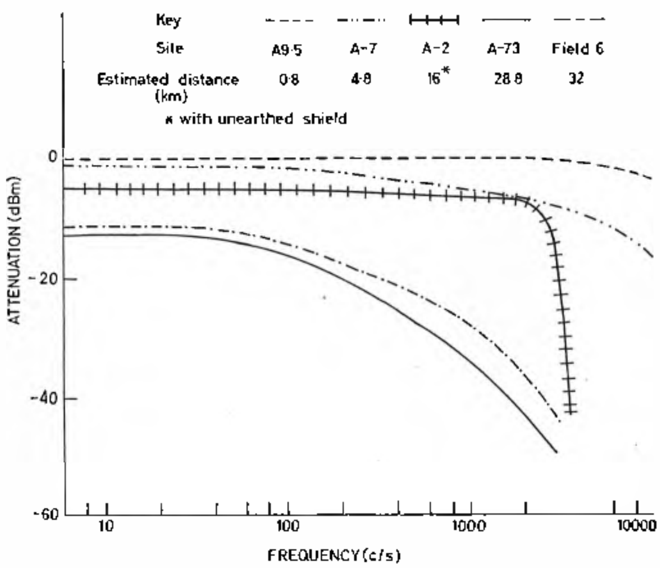

Fig. 2. Transmission characteristics of communication lines at Eglin Air Force Base

Assuming that it is desired to monitor 1 dyne/cm² signals over a chosen area and record this information on a single recorder, it is necessary to transmit −50dBm signals (in the frequency range of 1 to 100c/s) a distance

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up to 30km. In addition, 25mA bias will have to be provided at each microphone. Although in the rocket grenade experiment only three microphones are required to determine temperature and two horizontal wind components, seven were incorporated in a single system as being a number sufficient to ensure reliability and a more precise fit of data.

Two wire telephone lines were selected as the method of communication between the detecting sites and the recorder, providing the simplest and most reliable link. Microphone sites are usually in remote areas suitable for rocket launches and it is desirable if these sites are located away from man made activity and visited only on a minimum number of occasions. Permanent installations of two wire lines are usually available for a good part of the distance to the recorder or if not twisted military cable may be used. Noise levels encountered on normal communication circuits are of the order of −35dBm primarily at power generation frequencies where the reference level of 1mW in 600Ω (0dBm) is the preferred signal level. To avoid interference with power frequencies, amplitude modulation of seven carrier frequencies is used within the frequency spectrum available.

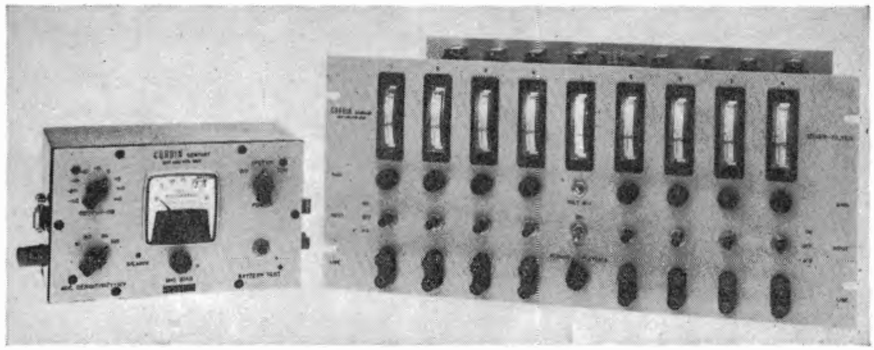
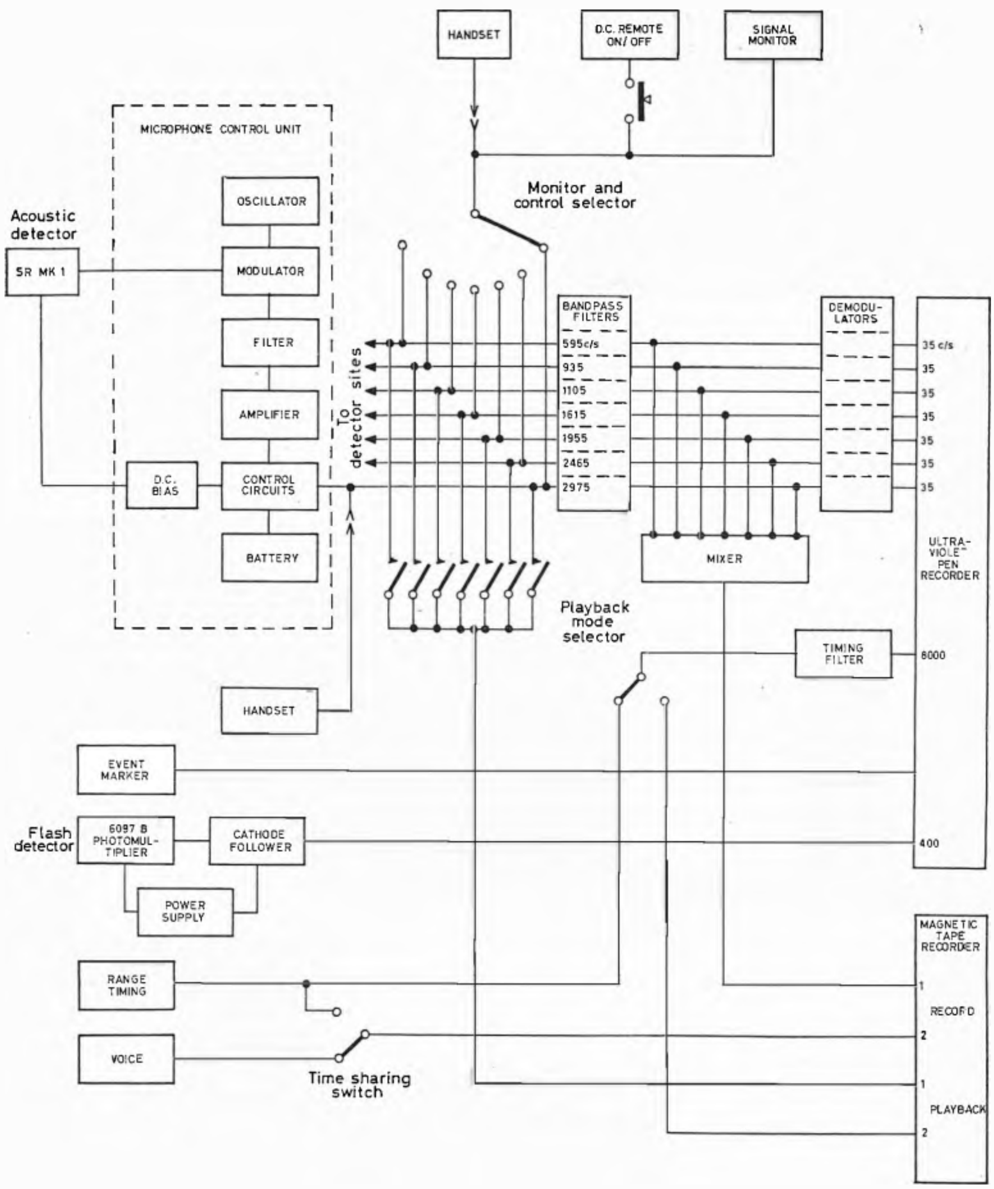


Fig. 4. (a) Microphone control unit. (b) Demodulation and control unit

Fig. 3. Arrangement of multiplex system



The relative attenuation of various line lengths is illustrated in a series of measurements made at Eglin Air Force Base, Florida. Line attenuation as a function of frequency was measured using a 600Ω oscillator and voltmeter and these characteristics are depicted in Fig. 2. Approximate lengths are given, consisting of telephone circuits for a majority of the length sometimes passing through one or more exchanges and field wire for the last few hundred metres. One site (A-2) used a shielded line with the effect of greater attenuation at the higher frequencies and without benefit of reduced line noise. It is observed that the longer lines in general have the greater attenuation particularly at higher frequencies.

Utilizing the spectrum available while allowing each site a unique frequency, thus minimizing the number of tape re-

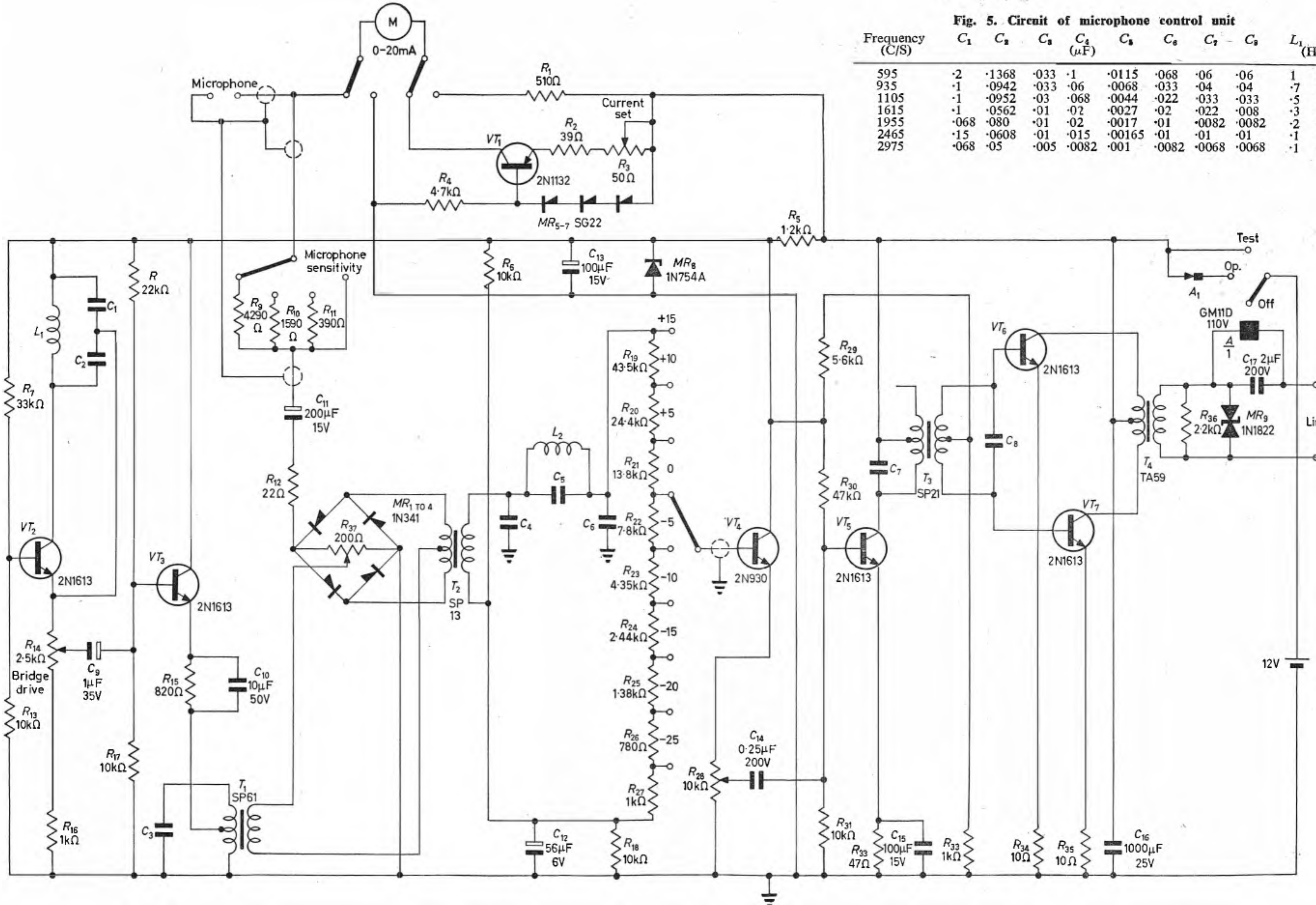


Fig. 5. Circuit of microphone control unit

Frequency (C/S)	C_1	C_2	C_3	C_4 (μF)	C_5	C_6	C_7	C_9	L_1 (H)	L_2
595	·2	·1368	·033	·1	·0115	·068	·06	·06	1	1·5
935	·1	·0942	·033	·06	·0068	·033	·04	·04	·7	1
1105	·1	·0952	·03	·068	·0044	·022	·033	·033	·5	1
1615	·1	·0562	·01	·02	·0027	·02	·022	·008	·3	·7
1955	·068	·080	·01	·02	·0017	·01	·0082	·0082	·2	·7
2465	·15	·0608	·01	·015	·00165	·01	·01	·01	·1	·5
2975	·068	·05	·005	·0082	·001	·0082	·0068	·0068	·1	·5

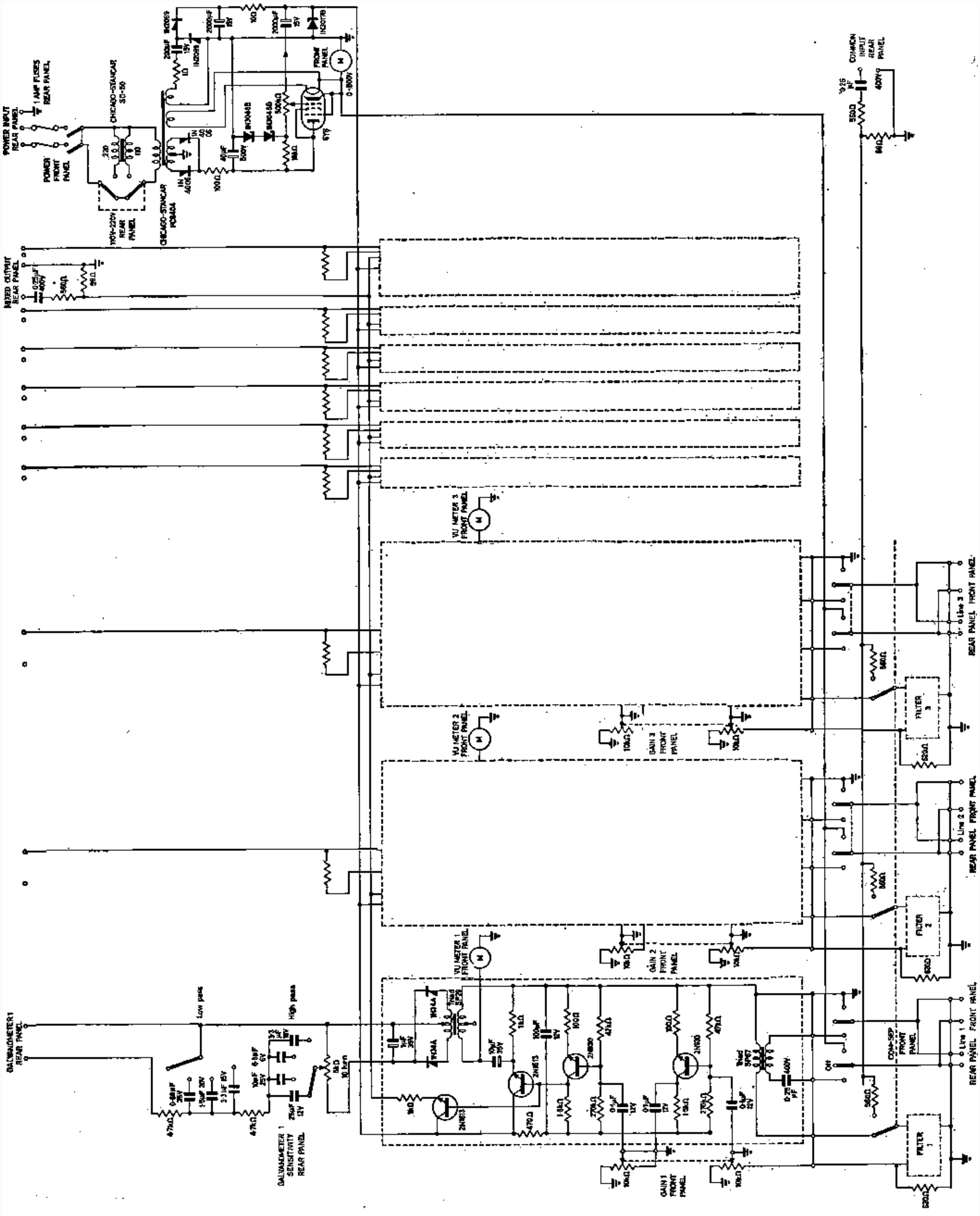


Fig. 6. Circuit of demodulation and control unit

corder channels, is best accomplished with an amplitude modulated system. Transmission noise is reduced when the modulation is accomplished at the microphone and a modulator with self-contained battery (which also supplies bias current) was decided upon. This unit is remotely operated by a stepping relay actuated with a d.c. potential across the line. It has a 0dBm output modulated with pressure variations for transmission to the recorder.

One system requirement was to produce a paper record of pressure variations at all sites simultaneously with timing and the initial time of detonation as determined by a photomultiplier. These last two channels increase the frequency response requirements and ultimately an ultraviolet pen recorder was selected with response up to 5kc/s. The acoustic data is demodulated before recording. Electronic reproduction was also desirable so that various filtration techniques might be employed for weak signal recovery and this led to the selection of a parallel magnetic tape recorder. Here the modulated information from all seven microphones is mixed and recorded on a single tape channel, separation being accomplished during playback.

Description of Equipment

The multiplex system comprises seven microphone control units, a demodulation and control unit, an ultraviolet pen recorder and a magnetic tape recorder. A block diagram of the system is shown in Fig. 3.

The microphone control unit produced in the final version by the Cordin Company of Salt Lake City, Utah may be seen in Fig. 4(a) and the circuit in Fig. 5. The constant current amplifier for microphone bias uses a 2N1132 and is adjustable from 15 to 30mA indicated on a front panel meter. Power is provided by ten manganese or rechargeable nickel cadmium cells, size C whose voltage may be observed by pressing the battery monitor switch. The unit is operated either manually or if the power switch is left in the operate position by a 100V d.c. pulse stepping relay across the line.

A 2N1613 as an oscillator followed by a 2N1613 buffer provides the control frequency input to the modulator of 595, 935, 1105, 1615, 1955, 2465 or 2975c/s. The microphone output arrives at the modulator via a four step attenuator corresponding to one order of magnitude reduction of peak signal required for 100 per cent modulation. The modulator consists of four matched diodes. The balance control is normally slightly off-centred thus operating in a carrier present mode. After the modulator a low-pass filter with strong rejection at the second harmonic of the control frequency is inserted followed by a nine step attenuator. Audio amplification follows culminating in two 2N1613's in class-B to provide output levels of −25 to +15dBm and is transformer coupled to the line.

The Cordin Co. demodulation and control unit (Fig. 4(b)) combines the functions of d.c. remote on/off, band-pass filter, mixer, demodulators and playback mode selector as shown in Fig. 3. The circuit may be seen in Fig. 6. Audio amplification is provided before demodulation or mixing and the output of each channel is monitored by a front panel meter. Additional monitoring may be accomplished with the use of a headset or by observing the waveform on an oscilloscope. Field phones may be used to communicate with a microphone site when it is manned.

An adjustable supply to 300V d.c. may be paralleled with any line by depressing the appropriate spring return switch. A manual pulse of about 0·5sec is sufficient to trigger a microphone control unit in this way or lines

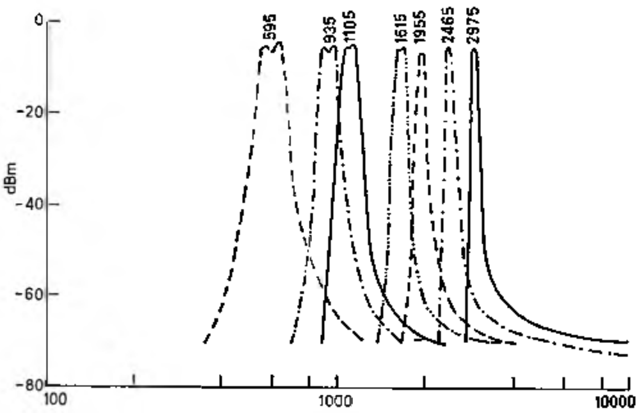


Fig. 7. Band-pass filter characteristics

may be connected to recording and monitor circuits using this switch.

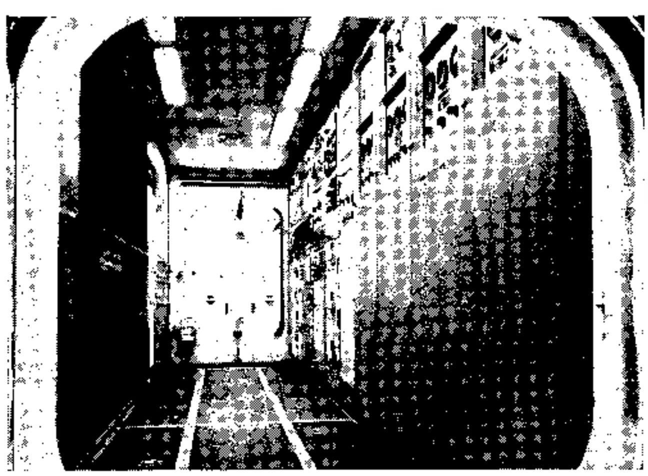
In the record operation each control frequency is separately filtered before mixing to a single magnetic tape channel or demodulated for individual ultraviolet pen recorder channels. Filtration is done to remove transmission line noise. In the playback mode these band-pass filters separate the seven control frequencies from a single magnetic tape channel. United Transformer Corporation TGR series filters are used and have the measured characteristics shown in Fig. 7.

Although seven frequencies are used, provision is made for eight demodulation channels each with a mixing level control on the front panel. In addition a separate adjustment is provided for the demodulated output consisting of amplitude, low frequency cut-off and high frequency cut-off.

The paper record is produced on an S.E. Laboratories type SE2800 ultraviolet pen recorder. This direct writing oscillograph uses up to 25 interchangeable moving-coil galvanometers covering the frequency ranges 0 to 35c/s to 0 to 5kc/s. Four widths and fifteen paper speeds may be used. For acoustic measurements 6in paper at a speed of 10cm/sec has been used with galvanometers of 35, 100 and 160c/s. A timing channel is recorded simultaneously and the arrivals of acoustic energy at each site are read to the nearest millisecond.

An AKAI model 345 tape recorder has been used with ¼in magnetic tape to simultaneously record the information for reproduction purposes. At 7½in/sec the response

Fig. 8. Interior view of recording centre



mixed microphone control frequencies and another for a modulated timing reference.

Field Use

The multiplex system has been used in various forms for a number of field trials commencing with Kronogard, Sweden and including Woomera, South Australia, Eglin Air Force Base, Florida, and most recently in Sardinia, Italy.

In the Sardinia campaign of October 1965 the recorders for acoustic information and flash times were housed in a two axle, 6·7m long trailer. The interior of this unit showing multiplex equipment, test instruments and service facilities is shown in Fig. 8. Microphone control units were at the detection sites for a four week period and, although subject to a rigorous environment, operated 20 hours using manganese cells without any difficulties encountered. Data acquisition during the rocket flight for a period of about 500sec was achieved with 100 per cent reliability. A sample record 269sec after launch (SE09) showing returns from a 25g grenade at 66km is shown in Fig. 9.

At Woomera previous acoustic instrumentation detected high altitude grenades to a 79km average (21 firings). Using nearly identical acoustic sensors with the multiplex system it was possible in Sardinia to detect a similar grenade (355g charge) to 107km altitude. A paper on this work is in preparation[1].

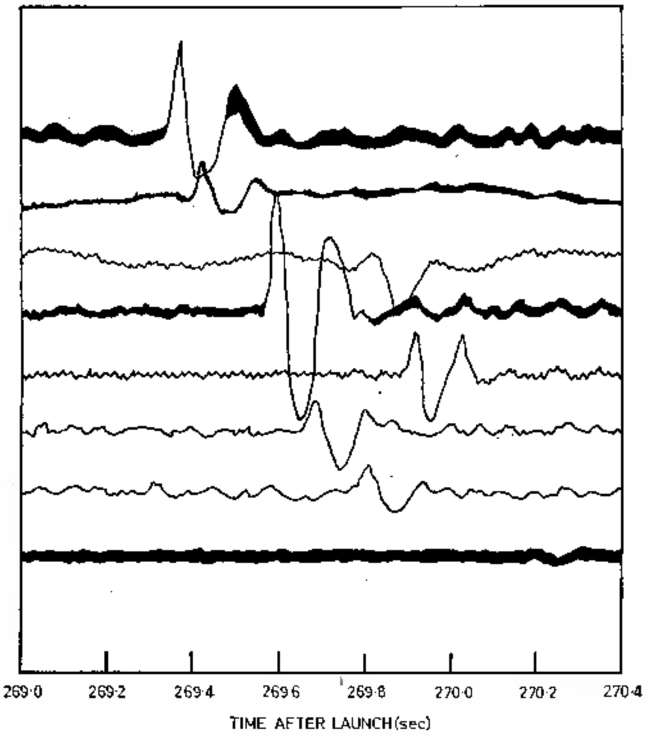


Fig. 9. Sample record showing acoustic detections

of this unit is 40c/s to 21kc/s. It has 80dB separation between channels one of which is used for the seven

REFERENCE

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Detection of Pseudo Random Binary Sequence Cycle Completion

By J. Kontos*, Ph.D., and G. Philokyprou*, Ph.D.

A method is proposed for the detection of p.r.b.s. cycle completion by using information from only one point of the p.r.b.s. generator. This is accomplished by serially recognizing a section of the p.r.b.s. of length equal to the number of stages of the p.r.b.s. generator.

(Voir page 762 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 769)

When a p.r.b.s. generator is used as a part of a larger system it is often desirable to have means of obtaining a signal informing the rest of the system of the completion of a whole cycle. The problem arises because a p.r.b.s. generator, in contrast to an ordinary counter, does not allow the detection of its cycle completion by monitoring a single transition of its last flip-flop. In three cases cited in the literature[1,2,3] the problem was solved by the two most straightforward methods available to the logic designer. These two consist of shift pulse counting[1] and state recognition by gate[2,3]. A different method is proposed here which, similarly to the method employed by Hogg[1] uses information from one point of the p.r.b.s. generator only, but with considerable reduction in the equipment required. In the case of a p.r.b.s. generator with a large number of stages the present method proves more economical even than the methods of Gardiner[2] and Smith and Hamilton[3]. Further advantages resulting from the flexibility of the present method, are shown below.

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Method

The present method is based on the detection of the occurrence of one of the p.r.b.s. generator states by recognizing the corresponding p.r.b.s. section. Any p.r.b.s. generator state can serve for this purpose since such a unit passes only once during its cycle through each one of its states.

From the fact that a p.r.b.s. generator is an N stage feedback shift register with feedback to its first stage only, it follows that every binary word representing each of its states appears as a section of length N of the binary sequence obtained from any of its stages. Therefore, it is

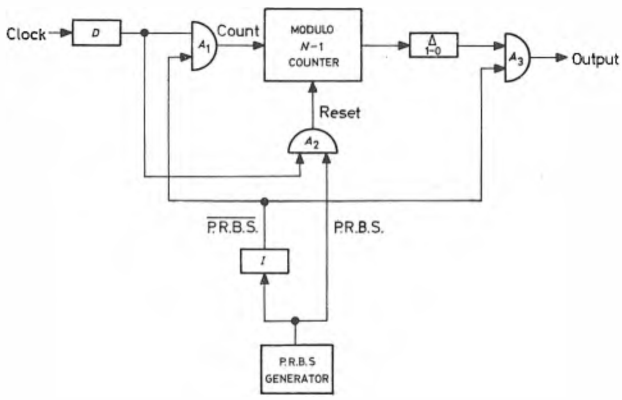

Fig. 1. Arrangement of system

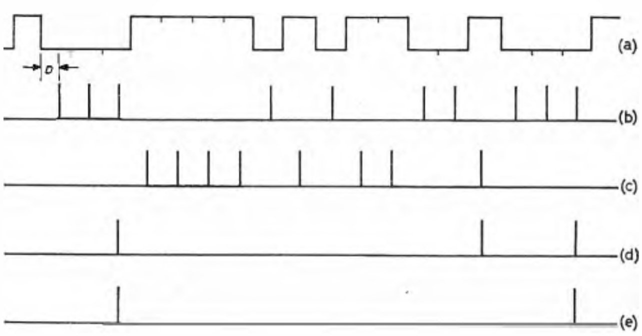

Fig. 2. Waveforms at various points in system

(a) *P.R.B.S.*

(b) *Count pulses*

(c) *Output of* Δ_2

(e) *Output*

possible to detect the occurrence of a certain state, and hence the completion of a cycle, by recognizing the corresponding p.r.b.s. section of length N.

Three easily recognizable sections of length N are: that consisting entirely of ones and the two consisting of N-1 consecutive zeros. The recognition of these sections can be accomplished by simply counting either N consecutive ones for the first section, or N-1 consecutive zeros for the other two. In the case of the latter sections it should be noted that their N-1 consecutive zeros constitute the same and only block of N-1 zeros of a single p.r.b.s. cycle.

Realization

The arrangement of a system detecting the occurrence of a section containing N-1 consecutive zeros is given in Fig. 1. The main part of the system is a modulo N-1 counter. This receives the clock pulses (which are the same as the clock pulses of the p.r.b.s. generator) either at its count or reset input. Certain of the 1-0 transitions of the last stage of this counter mark the beginning and the end of the p.r.b.s. cycle.

The instantaneous value of the p.r.b.s. determines both whether the clock pulses will be counted or will reset the counter, and selects the overflows. Thus the clock pulses delayed by D, so as not to coincide with the corresponding transitions of the p.r.b.s., are counted every time the p.r.b.s. has the value 0. In this case AND gate A_1 is opened by the output of invertor I, while AND gate A_2 is closed. When the p.r.b.s has the value of 1, gate A_1 closes and the delayed clock pulses are now gated through gate A_2 resetting the counter.

Now when N-1 consecutive zeros appear in the p.r.b.s. the modulo N-1 counter will overflow. This overflow can be detected by the 1-0 transition of the last stage of the counter with the use of the 1-0 step differentiator Δ, and marks the beginning and the end of a p.r.b.s. cycle. The last stage of the modulo N-1 counter, however, produces 1-0 transitions not only when the counter overflows but also when the counter is reset, by a clock pulse passing through gate A_2, from a state at which this last stage contains a 1. Thus unwanted pulses appear at the output of differentiator Δ. Having now in mind that whenever these unwanted pulses appear the value of the p.r.b.s. is 1, it may be seen that these can be eliminated by gating the differentiator output via AND gate A_3 governed by the output of invertor I. Thus the pulses appearing at the output of the arrangement coincide only with overflows of the modulo N-1 counter and mark the beginning and the end of the p.r.b.s. cycle.

The signals at various points of the arrangement of Fig. 1 are given in Fig. 2, for a p.r.b.s. of length 15 (N=4).

The same arrangement may be used for detecting the occurrence of the section of length N consisting entirely of ones. In this case the corresponding arrangement would be that of Fig. 1 but with the modulo N-1 counter replaced by a modulo N counter and the invertor I transferred to the branch leading from the output of the p.r.b.s. generator to the input of gate A_2. In certain cases the thus modified block diagram may prove simpler to put into hardware.

Discussion

The p.r.b.s. cycle completion detector described has proved a useful and flexible device in the design of systems involving a multitude of mutually delayed p.r.b.s.'s The most useful feature of the device seems to be the fact that, in contrast to the recognition by gate method, it detects the completion of the p.r.b.s. cycle instead of the generator cycle. Thus its single input can be any p.r.b.s. in a system. Moreover this feature enables the system to recognize more than one word by looking at suitable delayed versions of the p.r.b.s.

A single detector unit can be used to monitor a number of p.r.b.s.'s provided that they are mutually delayed by more than N clock steps. This time sharing property results from the fact that this detector is used only during a small interval compared to the length of the p.r.b.s. in contrast to the shift pulse counting method[1].

Acknowledgments

Thanks are due to Mr. J. Karakatsanis for the experimental work.

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A Transistorized Power Supply for an Ultra-violet Discharge Lamp

By J. Watson*, Ph.D., A.M.I.E.E.

A power supply is described which will operate a Flood-Hilger deuterium discharge lamp, which emits a continuous spectrum from the visible to below 2 000Å. The lamp filament is energized for 90sec and after the first 60sec, a 300V striking pulse is applied. The arc is then stabilized at a predetermined current in the range 0·35 to 0·55A, the load stability being better than 18 000:1. Semiconductor devices are used throughout.

(Voir page 762 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 769)

MANUAL and automatic spectrophotometers designed to operate in the ultra-violet region have become common in analytical laboratories and in industry[1], and it is normal practice to use an electrical discharge in hydrogen—or, more recently, deuterium—to provide a continuous ultra-violet source spectrum. Such discharge lamps work at quite high voltages which are subject to very wide variations from unit to unit. This article

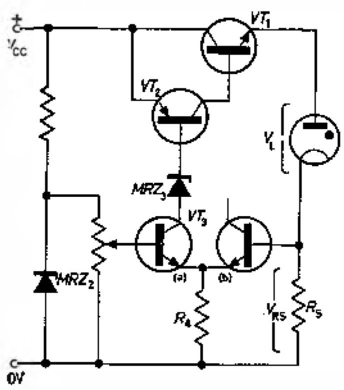

Fig. 1. Basic current stabilizer

describes a fully transistorized power supply designed to operate the Flood-Hilger deuterium discharge lamp—a source which will provide a continuous spectrum ranging from the visible down to wavelengths below 2000Å.

The Flood-Hilger lamp has the following striking sequence and operating characteristics:

(1) Filament ' on ' for 90sec at 4V 8A r.m.s.

(2) Striking pulse of not less than 300V to be applied 60sec after filament is switched on.

(3) Arc current to be stabilized within the range 0·35 to 0·55A d.c. The drop across the lamp lies between 40 and 90V.

The basic stabilizing loop will be seen from Fig. 1 to be entirely conventional. However, only with the recent introduction of high-voltage transistors at reasonable prices has it become possible to use this type of circuit without including a thermionic valve as the series element.

If a Zener diode is to be used as a reference element, it is convenient to choose, where possible, a 5·6V unit so that the temperature coefficient is minimal. This is possible in the present case by making the value of $R_S = 10\Omega$ so that the voltage drop across it will not exceed 5·5V. This implies that R_S must be capable of dissipating at least 3W continuously without a significant change in resistance. A contact-cooled, metal cased 5W unit is excellent for the purpose, for it is of small size and can be screwed to the chassis for cooling purposes.

To determine the minimum supply voltage required, maximal voltage drops around the load circuit may be summed:

$$V_{CC(min)} = V_{CE1(min)} + V_{L(max)} + V_{RS(max)}$$
$$= 3{\cdot}5 + 90 + 5{\cdot}5$$
$$= 99\text{V}$$

Here, 3·5V has been assumed to be the minimum permissible value of V_{CE1}.

In a real circuit, the change in V_{CC} due to mains variations is usually taken as +10, −15 per cent, which means that, neglecting transformer regulation, the nominal value of V_{CC} will be:

$$V_{CC} = \frac{99}{(1 - (15/100))} = 116{\cdot}5\text{V}$$

and $V_{CC(max)} = 116{\cdot}5\,(1 + (10/100)) = 128\text{V}$.

It is now possible to determine the maximum value of V_{CE} with which VT_1 must cope:

$$V_{CE1(max)} = V_{CC(max)} - V_{L(min)} - V_{RS(min)}$$
$$= 128 - 40 - 3{\cdot}5$$
$$\doteq 84{\cdot}5\text{V}$$

VT_1 must also dissipate a maximum power of:

$$P_{diss(max)} = 82{\cdot}5 \times 0{\cdot}55 \simeq 45\text{W}$$

These factors lead to a choice between several transistors, and taking cost into account, the optimal unit at the time of writing is the Silicon Transistor Corp. 2N3234 which has the following characteristics:

$$V_{CEM} = 160\text{V} \;;\; P_{tot} = 60\text{W} \;;\; h_{FE} = 18 \text{ to } 40$$

Note that in the event of a short-circuit fault developing in the load, this transistor would not be immediately damaged by the application of almost the whole of V_{CC}, but would survive until thermally destroyed by the resultant maximum dissipation of 66W, which is the power corresponding to the 0·55A current level.

The pnp half of the stabilizing pair, VT_2, must also cope with almost the whole of V_{CC}, and must be capable of dissipating a power given by:

$$P_{diss(max)} = V_{CE2(max)} \,.\, I_{C2(max)}$$
$$= (82{\cdot}5 - V_{BE1}) \,.\, (0{\cdot}55/18)$$
$$= 81{\cdot}5 \times 0{\cdot}03 \simeq 2{\cdot}5\text{W}$$

A unit fulfilling these requirements is the Motorola 2N3635, which has the following characteristics:

$$V_{CEM} = 140\text{V} \;;\; P_{tot} = 5\text{W (with heat sink)} \;;\; h_{FE(min)} = 80$$

The comparator/amplifier is a dual npn transistor, a choice which minimizes the number of resistors by virtue of accepting the base current of VT_2 as its collector current;

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and which makes for excellent stability. The device in question will have a maximum I_C in its left half of:

$$I_{C3(a)(max)} = \frac{I_{C2(max)}}{h_{FE2(min)}}$$
$$= \frac{0.55}{18 \times 80} = 0.38\text{mA}$$

By reason of its low cost and high V_{CEM} (60V), the Fairchild 2C425 is eminently suitable here. However, since the base of VT_2 can approach 128V, a series Zener diode, MRZ_3, must be included in the collector lead as shown.

The worst case situation is where $VT_{3(a)}$ approaches cut-off, and little voltage is dropped in R_4, when, if $V_{CE3(a)}$ is not to exceed 60V:

$$V_{Z3(min)} = V_{CC(max)} - V_{CEM3}$$
$$= 128 - 60$$
$$= 68\text{V}$$

A suitable Zener diode is consequently the 1N1792, which has a nominal Zener voltage of 75 ± 10 per cent; that is, $V_{Z3(min)} \simeq 68\text{V}$ and $V_{Z3(max)} \simeq 82\text{V}$.

If a 'maximum' 1N1792 is fitted, then the lowest possible value for $V_{CE3(a)}$ is:

$$V_{CE3(a)(min)} = V_{CC(min)} - V_{Z3(max)} - V_{R4} - V_{BE2}$$
$$= 99 - 82 - 5 - 1$$
$$= 11\text{V}$$

The circuit of Fig. 2 shows how this basic current stabilizing loop has been incorporated into the complete system. Here, the reference Zener diode, MRZ_2, has itself been current stabilized by the regulator MRZ_1 and the resistor R_2. The actual load current is adjusted by RV_1, the lower limit being determined by R_3.

The remainder of the circuit accomplishes the striking sequence as follows:

At switch-on, the discharge lamp heater is fed from the filament transformer T_2 via the normally-closed contacts 5 and 6 of relay A. This transformer also supplies the heater of the 90sec thermal delay relay B, which upon

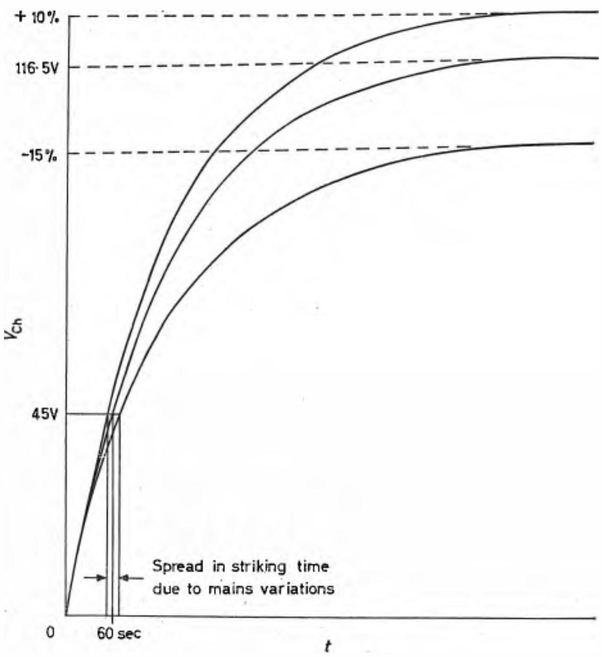

Fig. 3. Charging exponentials for C_h
(Shockley diode 1N3836 breaks over at 45V ±4V)

operation, energizes relay A, which is then held on by its own contacts 11 and 9.

However, the lamp is scheduled to strike 30sec prior to the operation of the relays, and this operation is initiated by the firing of the Shockley diode D_h. The capacitor C_h is charged via R_h from the nominal 116V line. It will be noticed that this charging current is derived from the lower end of the relay A coil, which, after relay operation, reverts to zero potential so that C_h does not continue to charge.

The time-constant $R_h . C_h$ is so arranged that at

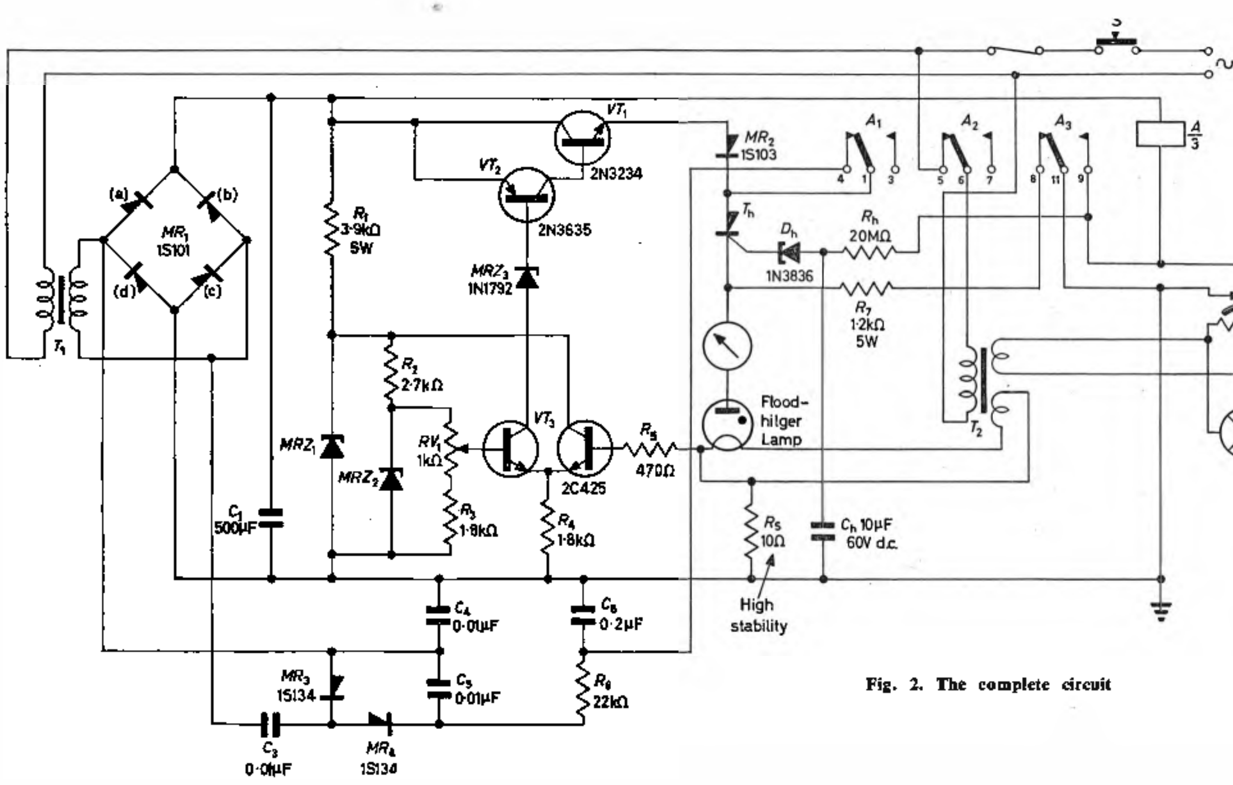

Fig. 2. The complete circuit

$t = 60$sec, the firing voltage of D_h is reached. It is convenient to choose a Shockley diode whose firing voltage is on the more linear part of the charging exponential (as shown in Fig. 3), for this ensures accurate timing.

The thyristor T_h is in turn fired by the discharge of C_h into its gate via D_h. This applies a 300V pulse to the lamp, which strikes and so completes the main stabilizing loop. The striking voltage is generated by a tripler circuit of the form shown in Fig. 4. When applied to the main circuit, one of the diodes, MR_{1c}, becomes one of the main rectifier diodes, with the result that not only is a component saved, but the negative end of the tripler output is automatically connected to the common line. The +300V end is now applied to the junction of the thyristor and the isolating diode MR_3 via contacts 4 and 1 of relay A.

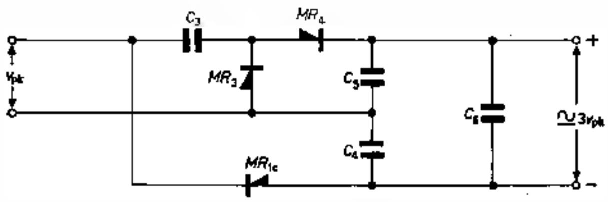

Fig. 4. Basic tripler circuit

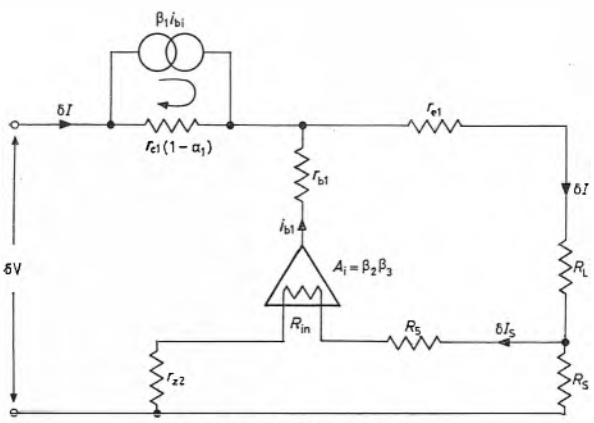

Fig. 5. Circuit for analysis

It will be noticed that R_7 has been included as a return path for the thyristor firing pulse, which would otherwise be connected only to the lamp, which is an open circuit prior to striking. R_7 must have quite a low value to ensure reliable striking, which means that it must be uncoupled from the circuit during normal operation, otherwise it would affect the stability by shunting the lamp and R_S.

This is accomplished by contacts 8 and 11 of relay A and is one of the five functions of that relay which, summarized, are:

(a) Self-latching
(b) De-energization of T_2 (filament switch-off at 90sec)
(c) Removal of C_h charging current
(d) Removal of lamp striking voltage
(e) Uncoupling of thyristor striking pulse return path.

The priming and striking functions are now completely isolated from the main stabilizing loop and will remain quiescent until the mains switch is manually switched off, then on again. This will be so even though the lamp may become extinguished, or be **unplugged.**

The analysis of the circuit can be most easily carried out by inserting the T-parameter equivalent of VT_1 as shown in Fig. 5. Summing voltages round the output loop gives:

$$\delta V = (\delta I - \delta I_S)\, R_S + \delta I\, [R_L + r_{e1} + r_{c1}(1-\alpha_1)] - \beta_1 i_{b1} r_{c1}\,(1-\alpha_1)$$

If r_{e1} is small and $\delta I_S \ll \delta I$, this reduces to:

$$\delta V = \delta I\,[(R_S + R_L + r_{c1}\,(1 - \alpha_1)] - \alpha_1 i_{b1} r_{c1}$$

Now:

$$i_{b1} = \beta_3\beta_3 \delta I_S = \beta_2\beta_3\,\frac{\delta I\ .\ R_S}{R_{in}}$$

where $R_{in}\,(\gg R_S)$ = input resistance of the long-tailed pair.

$$R_{total} = \delta V / \delta I = R_S + R_L + r_{c1}\,(1 - \alpha_1) - \alpha_1\beta_2\beta_3\,\frac{R_S\ .\ r_{c1}}{R_{in}}$$

The effective resistance of VT_1 is therefore:

$$R_{eff} = R_{total} - R_L = r_{c1}\,(1-\alpha_1) - R_S\,(1 - \alpha_1\beta_2\beta_3\,(r_{c1}/R_{in}))$$

If $\alpha_1 \rightarrow 1$, this approximates to:

$$R_{eff} = \beta_2\beta_3 r_{c1}\,(R_S/R_{in}) \quad \ldots\ldots\ldots\ldots \quad (1)$$

This expression can be solved only if r_{c1} is known, and neither this nor the equivalent h-parameters appear in the published data for any of the transistors usable in the VT_1 position. Also, R_{in} is dependent upon the position of the slider of RV_1. If this is at the top of the track:

$$R_{in} = R_5 + 2r_{b3} + 2r_{e3} + r_{z3} \quad \ldots\ldots\ldots\ldots \quad (2)$$

where r_{z3} is the incremental resistance of MRZ_2

(This expression, however, is very approximate, for R_4 cannot be considered large in relation to R_5 and r_{z3}.)

If R_{in} is assumed to be about 5kΩ and r_{c1} is estimated at 10kΩ, then R_{eff} is 15kΩ.

R_{eff} is clearly the resistance involved when both load and mains stability are being considered, and in fact, these parameters were measured and over much of the working range R_{eff} was found to be of this order.

The mains stability, $\delta V/\delta I$, was always better than 12 000:1 while the load stability was better than 18 000:1. Knowing that $V_{CB(VT1)}$ was required to range from 3·5 to 84V, it would be expected that the value of r_{c1} would change significantly, leading to a wide variation in stability.

The temperature performance of the power supply depends upon the temperature coefficient of MRZ_2, and since this can be a selected unit, the performance can be made very good. Using an unselected Texas 2056A, the regulated current was found to have a maximum slope of only 10μA/°C over the range 25° to 50°C ambient

When VT_1 and VT_2 are types 2N3234 and 2N3635 respectively, no high-frequency oscillation is observed because of their widely differing frequency responses. However, should alternative devices be used and such oscillation occurs, a small capacitor connected between the VT_2 collector and base will damp it successfully by reducing the high frequency loop gain around the VT_1 and VT_3 circuit.

The performance of this power supply makes it suitable for use in both double and single beam optical instruments, but should an even higher order of stability be required, the long-tail resistor, R_4, could be taken down to a negative line. Also, a second differential stage could be added to supplement the gain of VT_3.

Acknowledgments

Thanks are due to Messrs. Hilger and Watts Ltd (for whom the supply was developed), for their permission to publish this article. The author would also like to acknowledge the valuable assistance of Mr. A. Sanghvi who carried out much of the initial experimental work at Swansea.

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The Generation of Hyperbolic Waveforms

By R. D. McDonald*, M.Sc.

In the measurement of low frequency events such as heart rate, it is often necessary to measure the instantaneous frequency between successive events. If the output of the measuring device is to be linearly related to frequency it must be hyperbolic with respect to time. The generation of hyperbolic waveforms by means of exponential waveforms is discussed and design equations are derived.

(Voir page 762 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 769)

IN the investigation of low frequency events, for example heart rate or respiration rate, it is often required to measure the 'instantaneous frequency', which is defined as the reciprocal of the time interval between two successive events. This information may be displayed on a meter, a chart recorder, or on some form of digital indicator, but in most cases, ease of interpolation

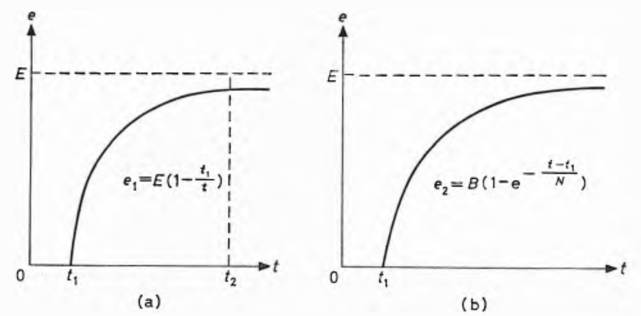

Fig. 1. Graphs of hyperbolic and exponential functions commencing at $t = t_1$, and asymptoting to E and B respectively

dictates a linear scale. Therefore it is required that the output voltage of the measuring device be linearly related to frequency.

i.e.:

$$e = Af = A/t \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

This means that e must be a hyperbolic function of time. If the frequency range to be covered is f_1 to f_2, where $f_1 > f_2$, then the hyperbola to be generated must start at $t_1 = 1/f_1$ and end at $t_2 = 1/f_2$. Fig. 1(a) shows the graph of a hyperbola which starts at t_1 and asymptotes to the value E. The equation of this hyperbola is:

$$e_1 = E\,(1 - (t_1/t)) \quad \ldots\ldots\ldots\ldots\ldots (2)$$

A method of obtaining this hyperbola over the required range (t_1, t_2) is to approximate it by a series of a more easily produced function. The two most common waveforms are the linear and exponential functions. Of these, the easiest to produce is the exponential, since the method of producing linear waveforms is itself an approximation, whereas the exponential waveform is a fundamental property of resistance-capacitance networks. Fig. 1(b) shows the graph of an exponential starting at t_1 and asymptoting to the value B. The equation of this exponential is:

$$e_2 = B\left[1 - \exp\left(-\frac{t - t_1}{N}\right)\right] \quad \ldots\ldots\ldots\ldots (3)$$

where N is the time-constant.

The aim is to find the range over which this exponential can be fitted to the hyperbola with a given accuracy. The method of least squares may be used to determine the exponential of best fit over a given range, but the method is extremely cumbersome, and does not readily apply to the case of successive approximations required here. In the following text a graphic-analytic approach is used. Two initial conditions will be imposed.

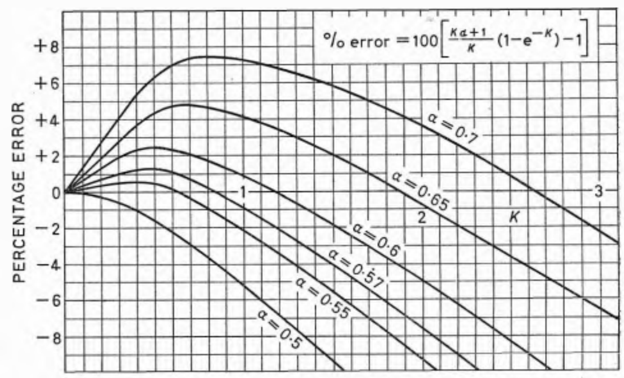

Fig. 2. Graph of X_1 with K as variable and α as parameter.
From this graph α and K may be chosen to give the desired degree of approximation

$$\left.\begin{array}{ll} e_1 - e_2 = 0 & \text{at } t = t_1 \\ \text{and} \quad de_1/dt = de_2/dt & \text{at } t = t_1 \end{array}\right\} \ldots\ldots\ldots\ldots (3a)$$

From the second condition:

$$E/t_1 = B/N \quad \text{giving} \quad B = NE/t_1$$

By putting $N = \alpha t_1$ where α is a new variable, then $B = \alpha E$

$$\therefore\ e_2 = \alpha E\left[1 - \exp\left(-\frac{t - t_1}{N}\right)\right] \quad \ldots\ldots (4)$$

The percentage error X_1, between e_1 and e_2 is given by:

$$X_1 = 100\left(\frac{e_2 - e_1}{e_1}\right)$$

$$= 100\,\frac{\alpha t\,[1 - \exp\,(-(t - t_1)/N)] - (t - t_1)}{(t - t_1)}$$

By putting $T = (t - t_1) = KN = K\alpha t_1$ where K is a new variable:

$$X_1 = 100\left[\frac{1 + K\alpha}{K}(1 - e^{-K}) - 1\right] \quad \ldots\ldots (5)$$

Fig. 2 shows the graph X_1 with K as variable and α as parameter. From this graph it is possible to choose values of α such that X_1 will be less than, or equal to, a given error. For example, suppose that for a given error the value $\alpha = \alpha'$ is obtained from Fig. 2. Along the curve $\alpha = \alpha'$, X_1 will be within the required accuracy over a range of values of K. However, if the same value of α' is to be used for each exponential segment the initial conditions (3a) must be satisfied at the end point of each segment. Thus the value of K' is given by the intersection of the curve $\alpha = \alpha'$ with the K axis. The required time-

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constant will be given by $N = \alpha' t_1$ and the duration over which it will be within the required accuracy is $T = K' N$. In the second segment the new initial value of t will be:

$$t_1 + K' \alpha' t_1 = t_1 (1 + K' \alpha')$$

The new time-constant will be:

$$\alpha' t_1 (1 + K' \alpha')$$

and the new duration will be:

$$K' \alpha' t_1 (1 + K' \alpha')$$

Similarly, in the third segment the initial value of t will be:

$$t_1 (1 + K' \alpha')^2$$

The time-constant will be:

$$\alpha' t_1 (1 + K' \alpha')^2$$

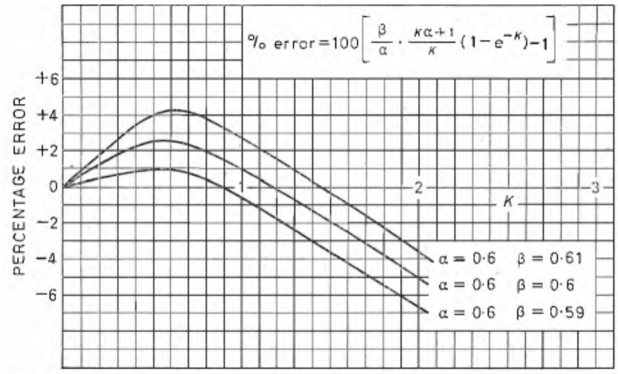


Fig. 3. Graph of X_2 demonstrating the effect of variations in β and a fixed value of α

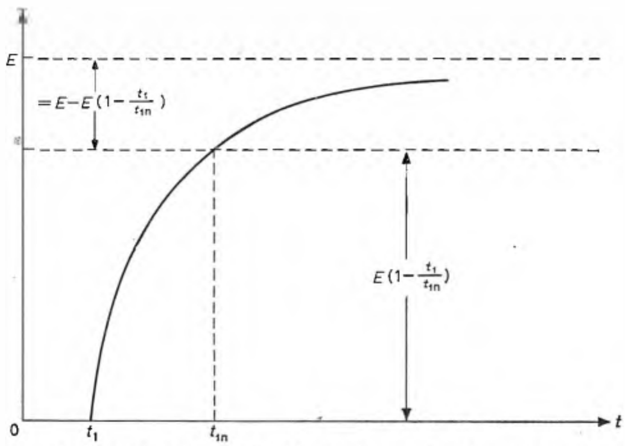


Fig. 4. Graph of hyperbola showing the start of segment voltage $E\,(1 - (t/t_{1n}))$

and the duration will be:

$$K' \alpha' t_1 (1 + K' \alpha')^2$$

By mathematical induction the following results are obtained:

Time-constant in n^{th} segment is:

$$N_n = \alpha' t_1 (1 + K' \alpha')^{n-1} \quad \ldots\ldots\ldots\ldots \quad (6)$$

Initial value of t at start of n^{th} segment is:

$$t_{1n} = t_1 (1 + K' \alpha')^{n-1} \quad \ldots\ldots\ldots\ldots\ldots \quad (7)$$

Duration of n^{th} segment is:

$$T_n = K' \alpha' t_1 (1 + K' \alpha')^{n-1} = K' N_n \quad \ldots\ldots \quad (8)$$

The number of segments required for a given accuracy is found by determining when the initial value of t in the $(m + 1)^{th}$ segment is greater than or equal to t_2.
i.e. when:

$$t_1 (1 + K' \alpha')^m \geqslant t_2$$

where m is the number of segments.

$$\therefore m \geqslant \frac{\log t_2/t_1}{\log (1 + K' \alpha')} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

As an example of the use of equation (9) let the required accuracy be $\pm 2{\cdot}5$ per cent.

If accumulative errors are to be avoided X_1 must be zero at the end of each segment since the design procedure implies that $X_1 = 0$ at the start of each new exponential segment.

Referring to Fig. 2 and choosing $X_{1(max)}$ to be 5 per cent one obtains $\alpha' = 0{\cdot}66$ and $K' = 2$, giving a maximum positive error of 5 per cent and a zero negative error. A linear scale calibration will then give an accuracy of $\pm 2{\cdot}5$ per cent. Thus to obtain an accuracy of $\pm x$ per cent, $X_{1(max)}$ is chosen as $2x$ from Fig. 2. A typical frequency range in a cardiotachometer would be from $f_1 = 200$ to $f_2 = 20$ cycles per minute giving $t_1 = 0{\cdot}3$sec and $t_2 = 3$sec.

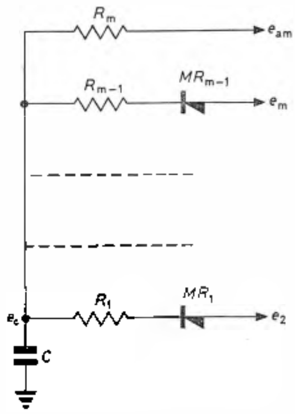


Fig. 5. An m section parallel shaping circuit

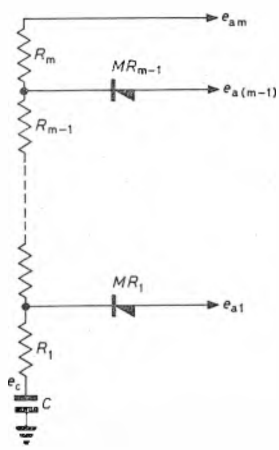


Fig. 6. An m section series shaping circuit

Substituting for t_1, t_2 α' and K' in equation (9):

$$m \geqslant \frac{\log 10}{\log\ 2{\cdot}3} = 2{\cdot}7$$

In this case the number of segments will be three, but only a portion of the segment will be used.

For an accuracy ± 1 per cent, $\alpha' = 0{\cdot}59$ and $K' = 1{\cdot}0$ giving $m = 5$.

From equation (4) the asymptote voltage e_a of the exponential is given by:

$$e_a = \alpha' . \text{(asymptote of hyperbola)}$$

If t_n is the start of an exponential segment, then from Fig. 4 it can be seen that with respect to the start point of the segment the asymptote of the exponential is:

$$\alpha' [E - E\,(1 - (t_1/t_{1n}))]$$

However, $E\,(1 - (t_1/t_{1n}))$ must be added to this in order to obtain the correct value with respect to the original reference voltage at $t = t_1$. In most cases this will be zero voltage.

$$\therefore\ e_{an} = E - E\,t_1/t_{1n}\,(1 - \alpha') \quad \ldots\ldots\ldots \quad (10)$$

Substituting for t_{1n}, the asymptote voltage in the n^{th} segment is:

$$e_{an} = E\left(1 - \frac{(1 - \alpha')}{(1 + K' \alpha')^{n-1}}\right) \quad \ldots\ldots\ldots \quad (11)$$

For each value of t_{1n} a new exponential segment is started. The voltage at this instant is the break point e_{bn} and is given by:

$$e_{bn} = E\,(1 - (t_1/t_{1n}))$$

Substituting for t_n, the break point voltage, with respect to the reference voltage at $t = t_1$, at the start of the n^{th} segment is:

$$e_{bn} = E\left(1 - \frac{1}{(1 + K'\alpha')^{n-1}}\right) \quad \ldots\ldots\ldots (12)$$

Consider the circuit shown in Fig. 5, where e_{an} is the asymptote voltage of the n^{th} segment and e_n is the break point voltage at the start of the n^{th} segment. The diodes are assumed to be perfect, the use of real diodes will be discussed later. With this circuit it is not possible to choose the time-constants, break point voltages and asymptote voltages independently. If the break point voltages are set as determined by equation (12) the asymptote will be βE and not αE as before. The percentage error will then be given by:

$$X_2 = 100\left[(\beta/\alpha) \cdot \frac{1 + K\alpha}{K}(1 - e^{-K}) - 1\right] \ldots. (13)$$

Fig. 3 shows the graph of X_2 and demonstrates the effect of variations in β for a fixed value of α. It can be seen that unless $\beta = \alpha$, x_2 will depart considerably from the required value of X_1. In order to avoid this error it is necessary to set the asymptote voltages as determined from equation (11). This will alter the effective value of K' and thus change the segment size. In order to examine this further it is necessary to derive the design equations for the circuit of Fig. 5. In Fig. 5 the capacitor C is initially uncharged and at $t = t_1$ commences to charge with a time-constant given by:

$$C \cdot ((1/R_1) + (1/R_2) + \ldots\ldots + (1/R_m))^{-1}$$

As each break point e_n is reached the resistor associated with this break point is disconnected. The time-constant of each section can be adjusted by suitable choice of resistors.

In the m^{th} segment the time-constant will be $N_m = R_mC$

$$\therefore R_m = N_m/C \quad \ldots\ldots\ldots\ldots\ldots (14)$$

In the $(m - 1)^{th}$ segment:

$$N_{m-1} = C \cdot \frac{R_m \cdot R_{m-1}}{R_m + R_{m-1}}$$

which gives:

$$R_{m-1} = R_m/\alpha'K'$$

similarly:

$$R_{m-2} = \frac{R_m}{\alpha'K'(1 + K'\alpha')}$$

and:

$$R_{m-3} = \frac{R_m}{\alpha'K'(1 + K'\alpha')^2}$$

Hence by indication:

$$R_n = \frac{R_m}{\alpha'K'(1 + K'\alpha')^{m-n-1}}$$

where $n = 1, 2, 3 \ldots\ldots (m - 1)$.

For brevity put:

$$A = (1 + K'\alpha')$$

$$\therefore R_n = \frac{R_m}{\alpha'K'A^{m-n-1}} \quad \ldots\ldots\ldots\ldots\ldots (15)$$

From equation (11) the asymptote voltages for this circuit will be:

$$e_{an} = E - \frac{E(1 - \alpha')}{A^{n-1}}$$

In practice it is difficult to set these voltages without the use of a high impedance voltmeter, and it would be easier to set the values for the break point voltages e_n, to give the correct asymptote voltages.

The equation for e_n can be shown to be:

$$e_n = E - \frac{E(1 - \alpha')(2 + K'\alpha')}{A^{n-1}} \quad \ldots\ldots\ldots (17)$$

where $n = 2, 3, \ldots\ldots m$.

The value of e_n given by equation (17) differs from the required break point voltages e_{bn} given by equation (12). e_n will be less than e_{bn} if $(1 - \alpha')(2 + K'\alpha') > 1$.

In fact, this is true for all values of K'.

The effective value of K will therefore always be smaller than the value selected from Fig. 2. In general this will not significantly alter the value of m as calculated from equation (9). However, X_1 should be at or near zero at the end of each segment. From Fig. 3 it can be seen that X_1 can be adjusted over a wide range by small variations in β; that is, by variation of the asymptote voltage. Using this fact X_1 can be set at, or near zero, at the end of a segment. An alternative circuit is shown in Fig. 6. Capacitor C is initially uncharged and asymptotes towards e_1 with a time-constant given by:

$$N_1 = R_1C$$

$$\therefore R_1 = N_1/C \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (18)$$

Before e_c reaches e_1, diode MR_1 will cut off and disconnect e_1: C will then asymptote towards e_2 with time-constant:

$$N_2 = (R_1 + R_2)C$$

Continuing in this way the time-constant in the n^{th} segment will be:

$$N_n = (R_1 + R_2 + \ldots. + R_{n-1})C + R_nC$$

$$= N_{n-1} + R_nC$$

$$\therefore R_n = \frac{N_n - N_{n-1}}{C}$$

Substituting from equation (6):

$$R_n = K'\alpha'R_1A^{n-2} \quad \ldots\ldots\ldots\ldots (19)$$

where $n = 2, 3, \ldots\ldots m$

As in the circuit of Fig. 5, the asymptote and break point voltages cannot be set independently. In this case, however, the asymptote voltages can be set directly. The actual break point voltages e_n, are given by equation (17).

Summarizing, the design equations are as follows:

Number of segments $= m$

$$= \frac{\log\ t_2/t_1}{\log(1 + K'\alpha')}$$

For the parallel circuit of Fig. (5):

$$e^n = E - \frac{E(1 - \alpha')(2 + K'\alpha')}{A^{n-1}}$$

$$R_m = Nm/C = \frac{\alpha' t_1 A^{m-1}}{C}$$

$$R_n = \frac{R_m}{K'\alpha' A^{m-n-1}}$$

$$e_{am} = E - \frac{E(1 - \alpha')}{A^{m-1}}$$

and for the series circuit of Fig. 6:

$$e_{an} = E - \frac{E(1 - \alpha')}{A^{n-1}}$$

$$R_1 = N_1/C = \alpha' t_1/C$$

$$R_n = K'\alpha' R_1A^{n-2}$$

Practical Example

Let the required accuracy be $\pm 2{\cdot}5$ per cent. From Fig. 2, $\alpha' = 0{\cdot}66$ and $K' = 2$.

A frequency range of $f_1 = 200$ cycles per minute to $f_2 = 20$ cycles per minute gives $t_1 = 0{\cdot}3$sec and $t_2 = 3$sec.

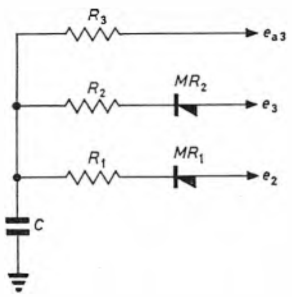
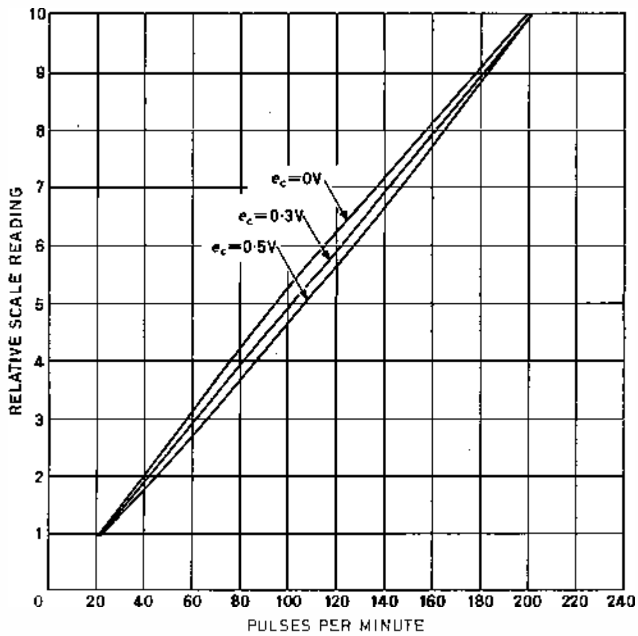


Fig. 7 (left). A three section parallel shaping circuit. *The calculated component values and voltages are given in the text*

Fig. 8 (below). Graph of linearity obtained with three section circuit showing the effect of variations in the diode correction voltage



For practical reasons take $t_1 = 0{\cdot}25$ and $t_2 = 3$ giving:

$$m = \frac{\log 12}{\log 2{\cdot}3} = 2{\cdot}9$$

Thus three segments will be required to achieve the desired accuracy. The circuit of Fig. 5 will be used and a value of $E = 6$V will be assumed. For three segments the circuit will be as shown in Fig. 7.

From the design equations:

$$e_{a3} = 5{\cdot}62\text{V}$$

$$e_2 = 3{\cdot}08\text{V}$$

$$e_3 = 4{\cdot}74\text{V}$$

$$R_3 = \frac{0{\cdot}8875}{C}$$

$$R_2 = \frac{0{\cdot}6725}{C}$$

$$R_1 = \frac{0{\cdot}290}{C}$$

Taking $C = 0{\cdot}22\mu$F the following circuit dimensions are obtained:

$R_3 = 4{\cdot}04\text{M}\Omega$	$e_{a3} = 5{\cdot}62$V
$R_2 = 3{\cdot}06\text{M}\Omega$	$e_3 = 4{\cdot}74$V
$R_1 = 1{\cdot}32\text{M}\Omega$	$e_2 = 3{\cdot}08$V

In the discussion it has been assumed that the diodes were perfect. In practice it is necessary to take into consideration the forward voltage drop e_d, of the diodes. This is done by adding the forward voltage drop to the voltage setting to which the diodes are returned, in this case e_2 and e_3. The voltage to be added will depend upon the current through the diode, but will normally be in the range 0·3 to 0·6V. If a real diode could be regarded as a perfect diode in a series with a battery, this adjustment would not affect the error of approximation.

In fact, the voltage drop across the diode is not a constant but decreases until $e_d = 0$ when $\lambda_n = 0$.

Provided that E is not too large this fact can be used to improve the accuracy of approximation. Let the correction voltage be e_c. Referring to Fig. 3 it can be seen that if $\beta < \alpha$ the error is less than for $\alpha = \beta$, but the range of approximation K', is also smaller. With the diode in the circuit it is possible to adjust e_c so that $\alpha < \beta$ initially, and then increases until $\alpha > \beta$ at the instant the diode cuts off.

Fig. 8 shows the linearity obtained with this circuit for different values of e_c.

When $e_c = 0{\cdot}3$V the error is approximately ± 1 per cent. The use of real diodes thus leads to a more accurate approximation than indicated by the theory, despite the fact that the asymptote and break point voltage adjustments are not independent. It is possible to devise circuits in which the asymptotes, break points, and time-constants can be chosen independently.

However, these circuits will be complex and have little to recommend them other than their ease of adjustment. The circuits of Fig. 5 and 6 are simple to construct, easy to adjust, and have predictable accuracy.

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A New Submarine Cable for Channel Islands

The Post Office is laying a new submarine cable to Jersey which, over the next few years, will increase by three times the number of telephone circuits at present provided to the Channel Islands. The system is of advanced design and will have four times the capacity of any cable system of its size currently in use in the world. The project is under contract to Submarine Cables Ltd.

The cable will be about 160 miles long, between Christchurch, Hampshire, and St. Helier, Jersey, and will require 18 sea-bottom transistor amplifiers every $8\frac{1}{2}$ miles to boost the 480 simultaneous conversations that the system will ultimately carry. The terminal stations will be in the Post Office Repeater stations in St. Helier and Tuckton Bridge, Bournemouth. Connexion to the main trunk circuit network will be in Bournemouth.

The most suitable available landing-site for the submarine cable is an area between Hengistbury Head and Christchurch Harbour. The sea approach is not a direct one and is rocky; consequently the approach cable will be double-protected with the heaviest armouring wires yet used in this country.

Because of the fairly shallow water off this part of the coast, even the smallest Post Office cable ships could not approach in-shore. At the same time the great weight of the shore sections of the cable precludes the use of local small vessels. Consequently, the Dutch cableship *Poolster* which is eminently suitable for this type of work, has been chartered to collaborate with H.M.T.S. *Iris* on the project. The St. Helier shore-end presents a different problem as the large sandy beaches are surrounded by extensive areas of rock; but *Poolster* can, if necessary, 'take the bottom' to permit the cable to be taken ashore at low tide. The main section of the cable, about 130 miles long, complete with the 18 submerged amplifiers, will be ready early in 1968. It will be laid by H.M.T.S. *Monarch*.

A Fast Integrator Resetting Switch

By M. H. McFadden*, B.Sc., and W. J. Niblock*, B.Sc.

In recent years, development work on analogue computers has been directed towards increasing the speed of operation. One of the obstacles has been the problem of devising a means of resetting integrators in very short periods without introducing serious errors. Many of the high speed resetting circuits which have evolved do not operate satisfactorily at low speeds or in a single shot fashion and some are hybrid arrangement of electronic switches and electromechanical relays to combine the advantages of both. The semiconductor switch described in this article operates accurately both as a single shot device and at high repetition rates.

(Voir page 763 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 769)

IN analogue computer integrators, electromechanical relays are employed in the resetting circuits to switch between the normal compute mode and a reset mode in which initial condition voltages are established. By the use of guard-ring techniques and connecting the contacts through separate flying leads to avoid base leakage the drift and other spurious errors caused by the relays can be made immeasurably small. They are therefore very satisfactory for single shot and low speed repetitive operation. Present day machines, however, are required to work at much higher repetition rates which demand switches capable of very short switching times and initial condition circuits which can reset the integrators very much faster. The latter feature also enables the integrators to be used as track-hold units by applying the varying voltage to be tracked to the initial condition input.

The switch described was developed to replace the relays in a general purpose computer. The machine can still operate in a single shot fashion as with the relays but of course with much more precise timing and improved reliability. The only measurable error introduced by the switch when operating in this fashion is a very small error in initial conditions. The increased switching speed and the fast track-hold feature has extended the operation into the field of iterative computation.

General Description

A typical integrator circuit using a high speed relay for resetting the initial condition voltage is shown in Fig. 1. During the reset period the relay L is in the condition shown, the normal input V_i is disconnected and the capacitor C is charged to the initial condition voltage $-V_{ic}$ which appears at the integrator output. The time-constant of the charging circuit is RC so $7RC$sec must be allowed to elapse in order to achieve an initial condition voltage accuracy of better than 0·1 per cent, or $10RC$sec if 0·01 per cent is the aim. Thus a very severe limitation is imposed on the maximum repetition rate of solutions. The resistor R in the initial condition circuit cannot be reduced to meet the requirement for fast charging because of the load it would impose on the V_{ic} voltage source (which may be another operational amplifier) and of course the integrator amplifier in question also has to provide the capacitor charging current from its output. Various high speed initial condition circuits using relays have been devised usually entailing the connexion of the integrator capacitor between amplifier output and earth during the resetting period so that the full current capacity of the amplifier is available for charging the capacitor linearly[1]. The drawbacks of the relays themselves when used as high speed switches then become apparent. This

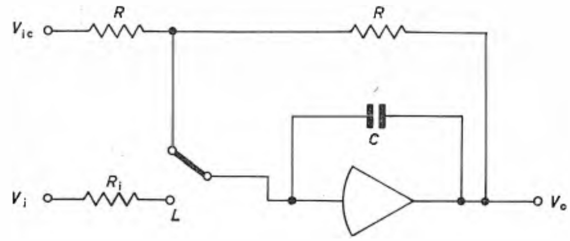
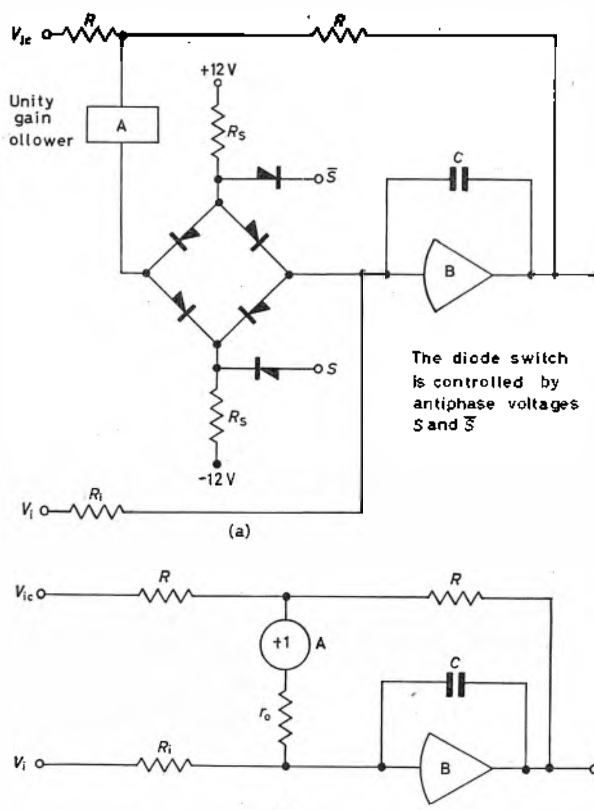


Fig. 1. Integrator with a high speed electromechanical relay for resetting

Fig. 2 (a). A track-hold unit with electronic switching
(b). Skeleton diagram of the track-hold unit to illustrate the significance of r_0



* *Short Bros. & Harland Ltd, Belfast.*

has prompted the development of electronic switches in which the greatest problems are associated with the elimination of current leakage, voltage offsets and switching transients. One which is capable of good performance in a track-hold circuit[2] is shown in Fig. 2(a). When the diode switch is conducting the unit will track a voltage V_{ic} applied to the initial condition input up to a maximum rate determined by the output current limits of the unity gain follower and the diode switch. This is typically 10mA which gives a maximum tracking rate of $10^4/C$ volts per second. When the switch is non-conducting tracking stops and ideally the output voltage is held at the value it had at the instant of switching. The voltage in fact changes with time because of the amplifier input current and the capacitor leakage resistance but also because of the finite back resistance of the diodes in the switch. By using modern silicon diodes and adding leakage divider resistors (see Fig. 3) the latter source of error can be made quite insignificant. When the unit is used as a general purpose integrator, however, a serious error arises because of the magnitude of the combined diode switch output resistance, when conducting, and the amplifier output resistance. During the reset period the desired initial condition voltage should appear at the integrator output and should not be influenced by the voltage V_i applied to the integrator input. Refer to the skeleton diagram in Fig. 2(b) where r_o represents the switch resistance added to the unity gain follower output resistance. If r_o is regarded

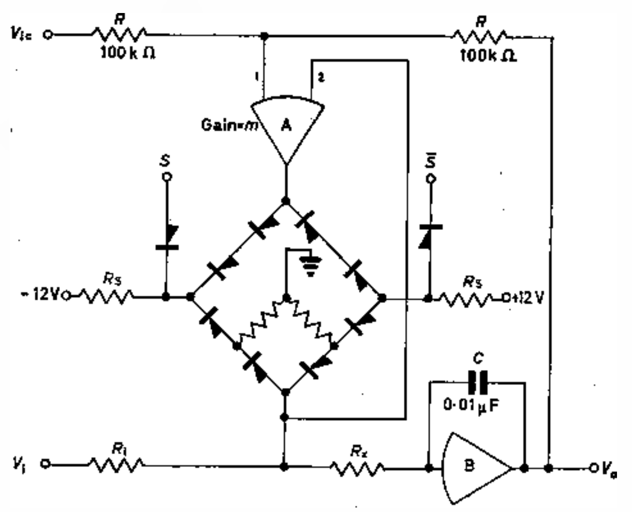
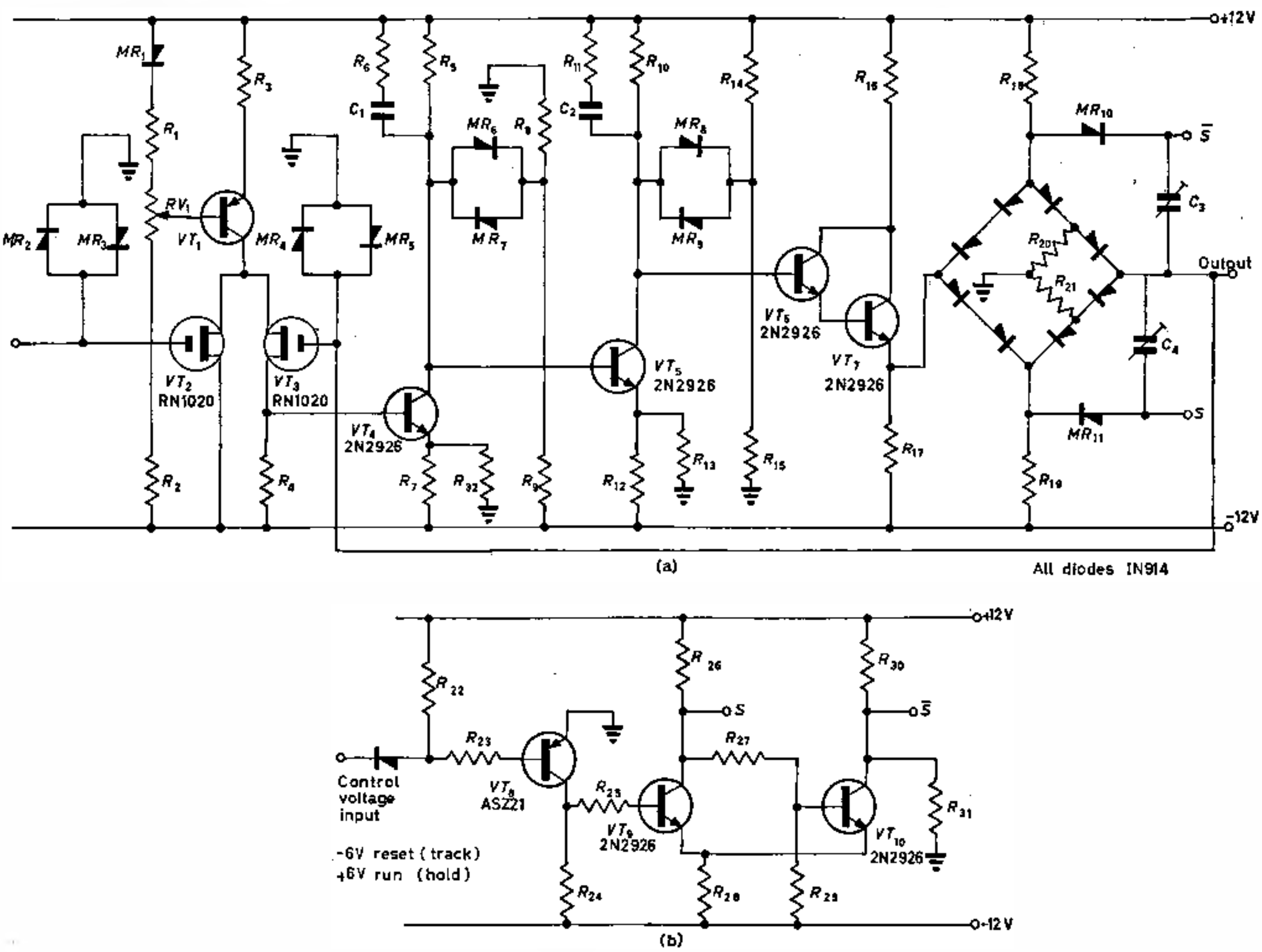


Fig. 3. An integrator with high performance electronic resetting switch

as a feedback resistor across the integrator amplifier and the unity gain amplifier in cascade (coupled by the ÷2 attenuator formed by resistors R) it is obvious that V_i causes a voltage $(2V_i \cdot r_o)/R_i$ to appear at the integrator output. In the case where $R_i = 100\text{k}\Omega$ and $V_i = 100\text{V}$, it is necessary for the output resistance r_o to be less

Fig. 4 (a). The diode switch and switch amplifier
(b). Switch control voltage generator



than 5Ω in order to produce an error of less than 0·01 per cent (i.e. 10mV). This is very difficult to achieve in practice and to cater for input resistors of 10kΩ which might be required for high speed computation or for several 100kΩ summing resistors an impracticably low switch-plus-amplifier output resistance is required. This has led to the development of the circuit shown in Fig. 3. The unity gain follower is replaced by a high gain amplifier A with two differential inputs. A negative feedback connexion is taken from the output of the diode switch to the inverting input 2 of the amplifier A which, during the reset (or track) period when the switch is conducting, fixes the gain from input 1 to the output of the switch at unity and also gives a very low output resistance. The output resistance $= \dfrac{r_A + r_s}{m+1}$ where r_A is the amplifier open loop output resistance, r_s is the switch output resistance and m is the open loop gain of amplifier A. The differential input stage consists of two metal oxide silicon transistors. These devices are field effect transistors with insulated gates giving an input resistance which is usually quoted as 'greater than $10^{12}\Omega$.' Such a high resistance is necessary since during the compute (or hold) period when the diode switch is non-conducting the connexion from the integrator summing point back to input 2 is an additional possible source of drift current. A further advantage of this circuit is that voltage offsets in the diode switch, which occur when it is conducting due to asymmetry in the switch arms, are of little significance since the switch is included in the local feedback loop. The error in initial condition or tracking voltage is $2(V_A + (V_S/m))$ where V_A is the offset in amplifier A referred to input 1 and V_S is the switch offset voltage. In practice the amplifier offset voltage completely masks the contribution from the switch (i.e. $V_A \gg (V_S/m)$) and it is not difficult to maintain $V_A < 5$mV over a period of several days giving an error of less than 0·01 per cent of full-scale.

Circuit Description

The circuit diagram of the amplifier A and switch is shown in Fig. 4(a). The amplifier first stage uses two p-channel enhancement mode, insulated gate field effect transistors to obtain the required high input impedance and low input current. As these devices have threshold voltages varying from about −2 to −8V, a constant current tail VT_1 is used in preference to a simple resistor. This also provides a convenient point to introduce a zero adjustment potentiometer. The diode MR_1 is mounted in the same heat sink as VT_1 to reduce drift due to temperature changes. The input transistors are also mounted in a common heat sink and they are matched for similar threshold voltages to prevent either one hogging all the available current. Diode clamps protect the transistors VT_2 and VT_3 against breakdown of the gate insulation by excessive voltage. The second and third stages are conventional and contribute most of the overall open loop gain of between 1 000 and 2 000. The emitter-follower provides a low output impedance and is capable of supplying 10mA of current to the integrating capacitor.

When the diode switch is non-conducting the overall feedback is removed and the amplifier output voltage goes to limits. The recovery time from this condition is normally excessively long and causes a delay in tracking of the order of 100μsec after the re-closing of the switch. To prevent this, collector catching diodes are connected to VT_4 and VT_5 so that when the feedback is removed and the amplifier tends to limit its gain is held at approximately unity. Fast recovery is achieved by using fast diodes for MR_6 and MR_9.

The resistor R_X (20Ω) shown in Fig. 3, is necessary to achieve stability in the loop containing both amplifiers.

A trigger circuit which produces anti-phase switching voltages with short rise times from the ±6V control pulses in the computer is shown in Fig. 4(b).

Performance

When used with an integration capacitor of 0·01μF the switch does not appear to contribute any drift in the hold condition. Within the accuracy of measurement the drift rate from zero remains at approximatelty 5mV/sec regardless of whether or not the switch output is connected to the integrator summing point. The drift rate from a voltage other than zero of course has an additional component due to the capacitor insulation resistance. In the track (or reset) condition a current of 5mA into the normal integrator input (i.e. $V_i = 100$V and $R_i = 20$kΩ) produces an output from the integrator of only 400μV which indicates a switch output resistance of 0·04Ω.

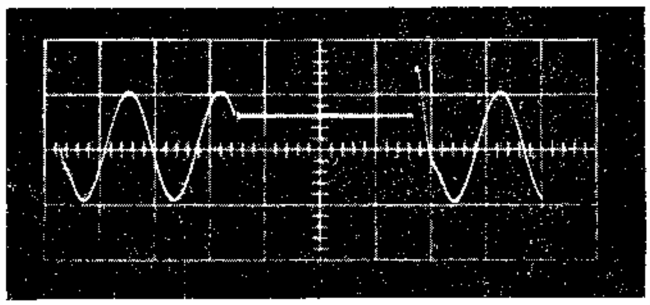


Fig. 5. Tracking and holding a 30kc/s sine wave of 1V peak amplitude
Vertical scale 1V/cm; horizontal scale 20μsec/cm

The unit is intended to work at a maximum repetition rate of 1kc/s, but in order to show more clearly the waveform as it switches from track to hold and back again the photograph in Fig. 5 shows a 30kc/s sine wave with 1·0V peak amplitude being tracked with the switch operating at 7·5kc/s and roughly unity mark-to-space ratio.

Conclusions

The switch unit described satisfactorily fulfils the requirement for a substitute for the integrator resetting electromechanical relays in a general purpose analogue computer which combines the excellent static and low speed performance of the relay with very short operating time and fast setting of initial conditions. Accurate operation is obtained up to the maximum repetition rate of 1kc/s. Higher repetition rates in the present machine are not realistic because of the restricted bandwidth of the amplifiers and phase shift caused by stray capacitances but if warranted further development could extend the upper limit of switch speed.

Acknowledgments

The authors wish to thank the Directors of Short Brothers and Harland Ltd for their permission to publish this article.

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A Silicon Controlled Rectifier Variable Voltage Power Unit

By J. L. Everett*

A variable voltage power unit is described where the conventional variable transformer has been replaced by a silicon controlled rectifier unit. With this unit it is possible to obtain the precise voltage control necessary when used in conjunction with a laser pumping system for measuring very low threshold energies. This unit has several advantages over the variable transformer, the most important being the elimination of voltage steps caused by the brushes of the variable transformer passing over the windings.

The output voltage is continuously variable over the range 0 to 2·3kV.

(Voir page 763 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 770)

THE threshold energy of a laser[1] rod is the minimum energy required to initiate oscillation.

This energy is most conveniently obtained by measuring the input energy to the flash-tube which is used to pump the laser.

The energy input to a flash-tube is given by:

$$E_t = \tfrac{1}{2} . C . (V^2 - V_r^2) \text{ Joules.}$$

where E_t is the threshold energy

C is the energy storage capacitor (Farads)

V is the voltage to which C is charged.

V_r is the residual voltage remaining on the capacitor after the flash-tube has extinguished.

As E_t varies linearly with V^2 it is essential to be able to vary the voltage in small increments in order to obtain the exact threshold energy.

Comparison of the threshold energy of several laser rods gives an indication of the quality of one rod relative to another. This is not an absolute figure of merit, as the threshold energy of a rod would be different in another type of cavity.

Variable Transformer Method of Voltage Control

The variable transformer is effectively an auto-transformer with a variable turns ratio. The output voltage can generally be varied from zero up to the full applied voltage. For any output voltage setting the waveform is sinusoidal.

The primary of the variable transformer is connected to an a.c. supply, the output being fed to the primary of a step-up transformer.

The variation of output voltage from a variable transformer is achieved by moving a brush carriage over a toroidal winding. This form of control varies the output voltage in a series of small steps.

Fig. 1 illustrates a conventional capacitor charging circuit. The resistor R is a current limiter and C is an energy storage capacitor. The capacitor C charges after a number of cycles up to a peak voltage $V_{AB(pk)}$, the variation of voltage with time following, to a close approximation an exponential law.

The variable transformer method of voltage control has an important limitation. The voltage variation occurs in small steps as a result of the brush traversing the winding. These small steps are magnified by the turns ratio of the high voltage transformer, causing considerable difficulty when it is necessary to charge the capacitor to a potential between these voltage steps. The variable transformer has the further disadvantage of being heavy and occupying a large volume of 'behind panel' space.

It was with these disadvantages in mind that the unit about to be described, was built.

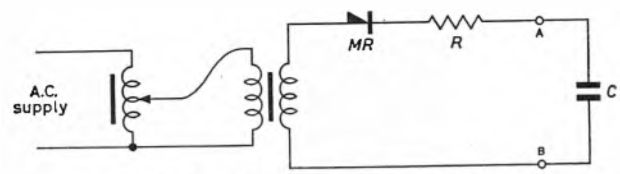

Fig. 1. Conventional capacitor charging circuit

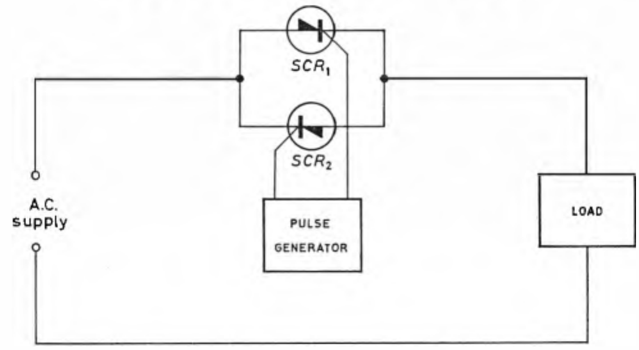

Fig. 2. S.C.R. control circuit

Silicon Controlled Rectifier Method of Voltage Control

The silicon controlled rectifier (s.c.r.) is a solid state semiconductor pnpn four-layer device. The s.c.r., in its normal state, will block an applied voltage in either direction; but when a suitable voltage pulse is applied to the gate electrode, current will flow through anode to cathode thus turning on the power to the load circuit. It is, therefore, equivalent to a diode except that the gate can control the start of conduction at a predetermined time, and once conduction starts the gate exercises no further control. The device remains in the conducting state until the current through anode to cathode is removed or drops below a minimum value known as the holding current.

An s.c.r. may be used on a.c. provided a gate pulse is applied once every cycle. The gate pulse must not be applied during the half cycle when the cathode is positive with respect to the anode, or permanent damage to the s.c.r. will result. By providing a gate pulse at different times in the positive half cycle, the s.c.r. can be switched on at any desired time during that half cycle.

Conduction angle control of two s.c.r.'s may be ob-

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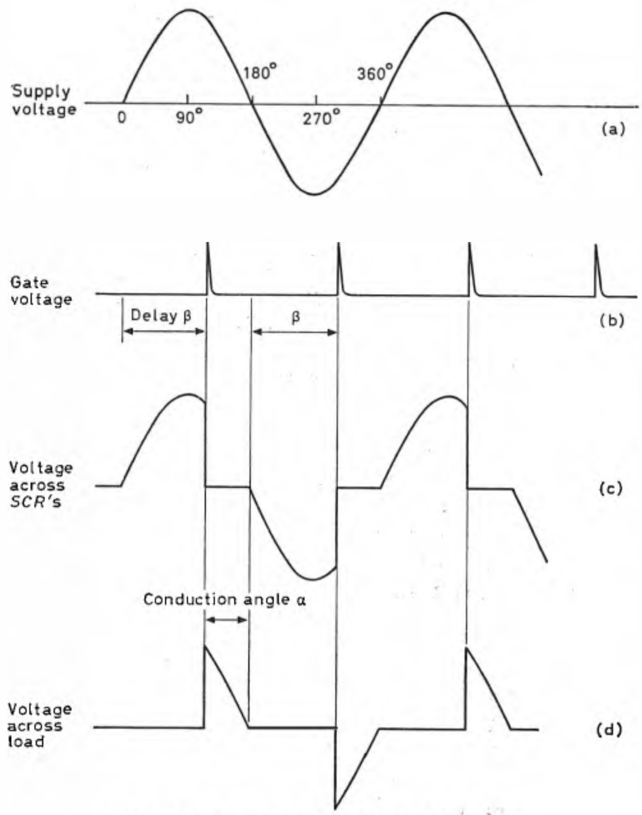


Fig. 3. Waveforms at several points in the circuit

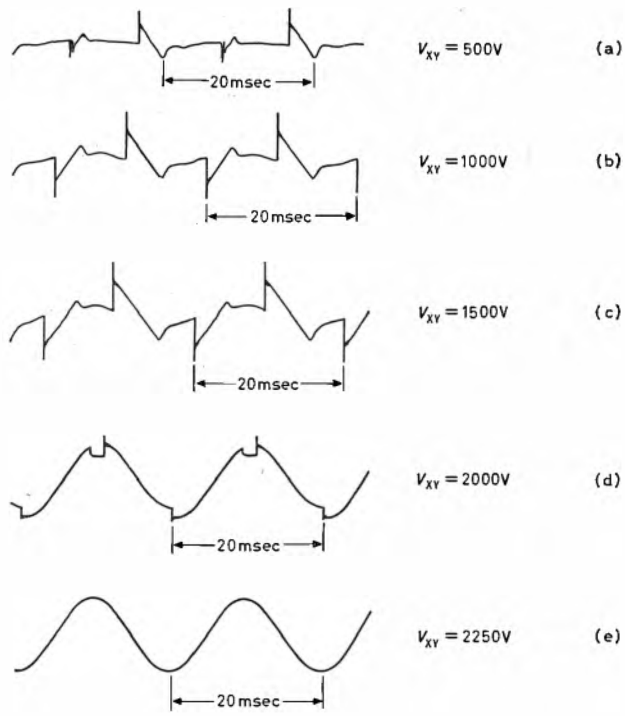


Fig. 6. Waveforms across secondary of transformer

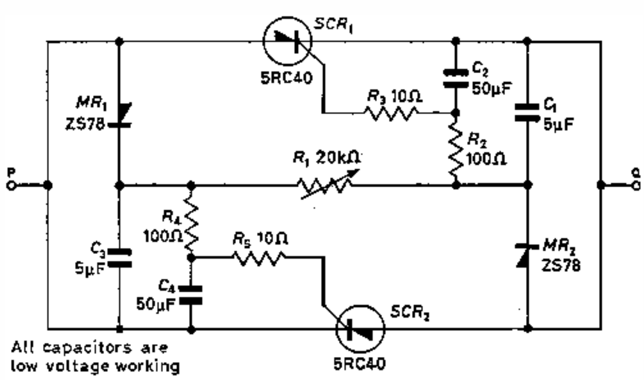


Fig. 4. Original control circuit

tained by using a circuit similar to that illustrated in Fig. 2. In this circuit a pulse generator supplies a pulse to each s.c.r. gate in turn, the pulse appearing on the respective gate when the supply voltage waveform has reached some arbitrary delay angle β. Fig. 3 shows the voltage waveforms occurring at several points in the circuit.

The s.c.r. control circuit in its final form is shown in Fig. 4.

When the circuit was set up the voltage waveform across points PQ was monitored. The value of resistor R_2 required slight adjustment to ensure that the conduction angle was the same for both SCR_1 and SCR_2.

The delay angle β is varied by the potentiometer R_1. The gate pulses are obtained as follows [2, 3]:

Positive half cycles are applied via diode MR_1 to R_1 and C_1 in series, giving an attenuated and retarded voltage across C_1. R_2 and C_2 attenuate and retard the voltage across C_1 so that the voltage across C_2 is lagging still further. Finally, R_3 in combination with the gate impedance further attenuates the voltage to the gate.

The load in the original circuit is the primary of a high voltage transformer (230/2 000V).

Fig. 5 illustrates the complete circuit, and Fig. 6, the waveforms obtained across the secondary of the transformer. The waveforms of the ripple superimposed on the d.c. output voltage are shown in Fig. 7.

The time taken to fully charge a 32μF

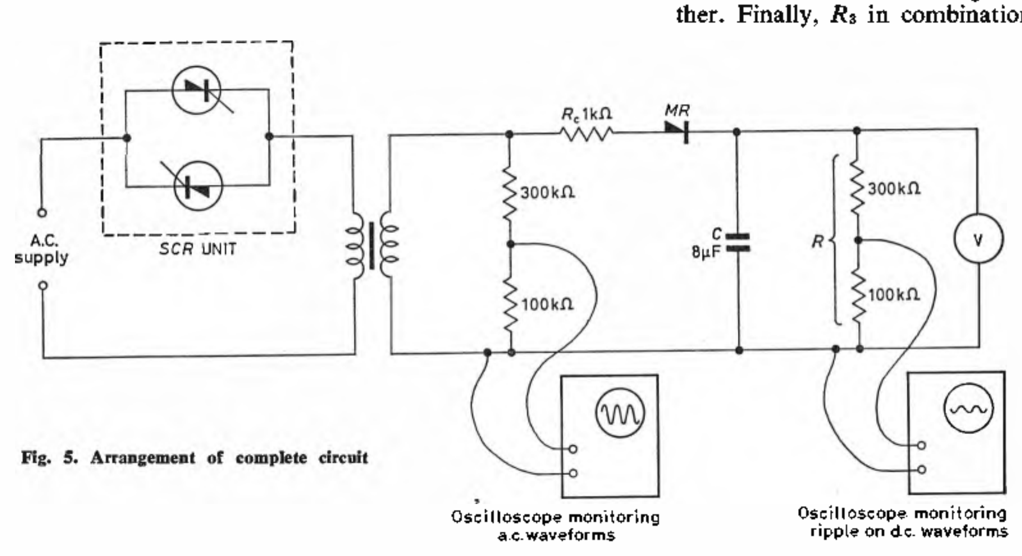


Fig. 5. Arrangement of complete circuit

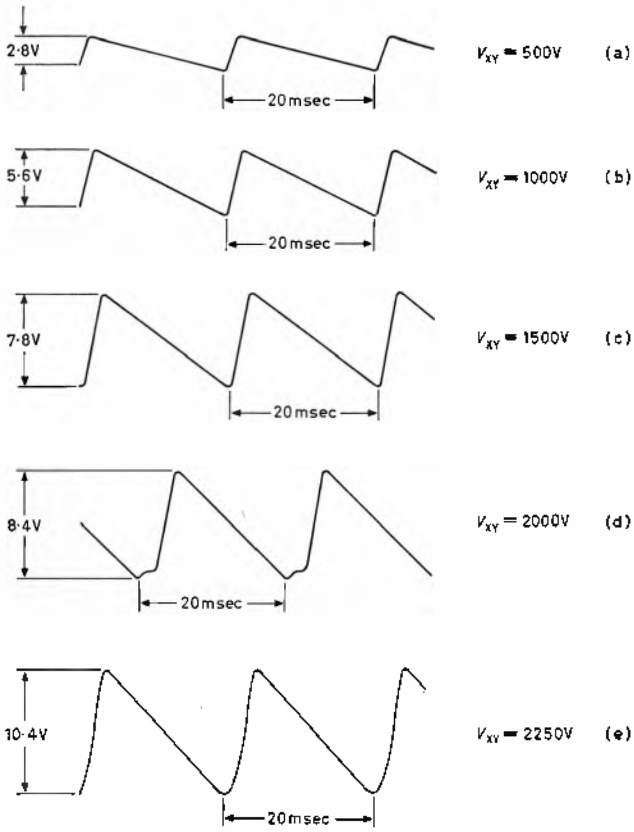


Fig. 7. Waveforms of ripple superimposed on d.c. output voltage

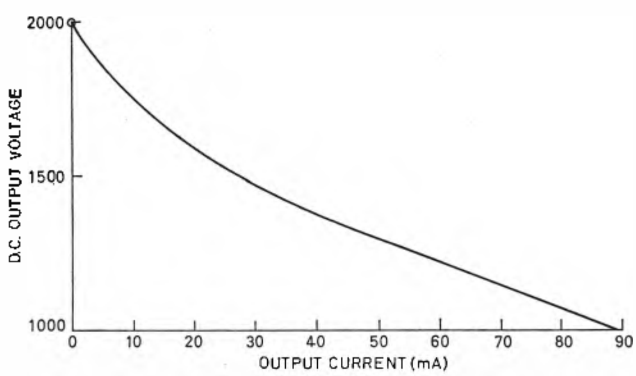
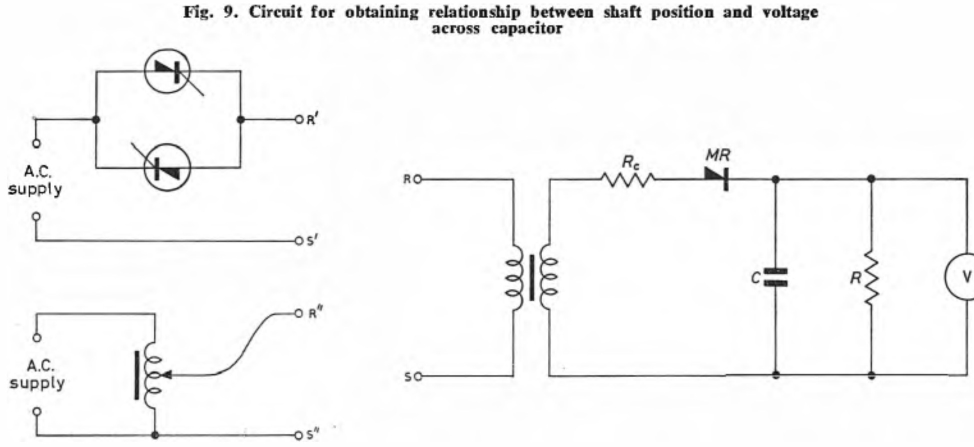


Fig. 8. Regulation curve

Fig. 9. Circuit for obtaining relationship between shaft position and voltage across capacitor



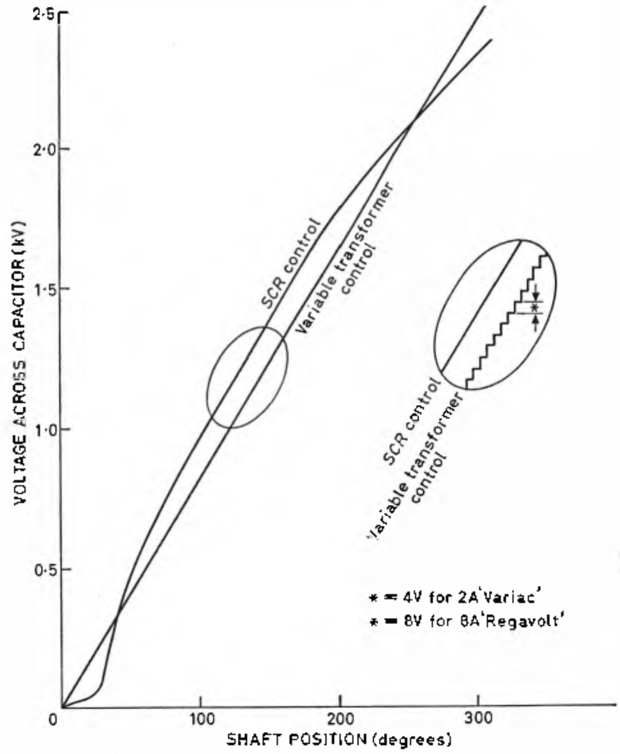


Fig. 10. Relationship between shaft position and voltage across energy storage capacitor

capacitor up to 2kV was approximately 10sec.

A regulation test was carried out to give an indication of the output impedance of the unit. The regulation curve is shown in Fig. 8. The output impedance, over the linear region, was estimated to be 7kΩ. The maximum current drawn from the unit was 89mA. This was determined by the wattage rating of the 1kΩ current limiting resistor. The circuit employed for the regulation test is shown in Fig. 5.

The relationship between shaft position and voltage across the energy storage capacitor was investigated for both the variable transformer and s.c.r. voltage control methods. The circuit used is shown in Fig. 9 and the relationship in Fig. 10.

The complete unit, as built, also incorporated a high voltage trigger circuit (for ionization of the flash-tube), and a 24V d.c. 5A supply.

Conclusions

The main advantage of s.c.r. control is the elimination of voltage steps (Fig. 10). The 20kΩ wirewound potentiometer (R_1 in Fig. 4) introduced small voltage steps, but these were reduced significantly when a 1kΩ potentiometer was connected in series with R_1, and extremely smooth voltage control was obtained.

The unit was initially designed to charge energy storage capacitors up to any potential in the range

0 to 2·3kV. The regulation curve suggests that the unit may also be used as a continuous current power supply. The ripple on the output voltage waveform increases as the load increases, but if a ripple free output is not of prime importance, this unit may suffice.

No stabilization against mains fluctuations has been incorporated in this unit, but no difficulty has been experienced in this respect.

A 2A variable transformer is about six times as heavy as the unit described, and occupies twice the volume of the unit. In applications where these considerations are important, it would be advantageous to use this form of voltage control.

A more rigorous treatment of the s.c.r. control circuit is given in the Westinghouse S.C.R. Designers' Handbook. This article indicates how the control circuit may form the basis of a variable voltage power unit.

Acknowledgments

The author wishes to thank Dr. D. Findlay and Mr. P. Baxandall for advice and encouragement in the preparation of this article.

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A Precision Oscillator Based on an Operational Amplifier

By E. J. Brach*

A precision oscillator generating frequencies ranging from 1c/s to 10kc/s, with an accuracy of 3 cycles per 1 000, is described. The basis of the design is a novel application of an operational amplifier, resulting in an inexpensive laboratory standard.

(Voir page 763 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 770)

OPERATIONAL amplifiers, originally developed for analogue computers, are used for signal conditioning, impedance transformation, servo and process control. Their application is extended here to a precision oscillator.

For development of sinusoidal output a resistance-capacitance bridge network is used (Fig. 1). The voltage developed across the load resistance R_L is fed back to the bridge. Part of this voltage is applied to the negative input of the amplifier (A), to provide degeneration. Regeneration is provided by the parallel circuit C_2, R_2, connected to the positive input. These voltages are in phase at only one frequency, due to the combined parallel and series RC networks. The voltages vary in opposite directions with frequency changes. At resonant frequency the phase shifts to zero. R_b and MRZ, a voltage divider, is chosen so that the negative feedback determined by R_b exceeds the positive feedback, ensuring oscillator stability. To stabilize the oscillator output, a Zener diode MRZ is placed in the degenerative path of the feed back voltage. The resonant frequency of the circuit is:

$$f_o = 1/2\pi(R_1 R_2 C_1 C_2)$$

but $R_1 = R_2 = R$ and $C_1 = C_2 = C$

therefore $f_o = 1/2\pi RC$

To vary f_o, either component of the two RC combinations can be changed.

The Amplifier

The oscillator (Fig. 2) is an operational amplifier and a bridge network (R_1, C_1, R_2, C_2 R_b, MRZ). The operational amplifier has a differential input stage VT_1 and VT_2 which are pnp germanium, alloy type transistors, followed by a second differential amplifier VT_3 and VT_4, having a constant current regulator VT_5. The second stage transistors are npn rate grown germanium devices with a high beta characteristic. The output stage VT_6 is connected as an emitter-follower.

The transistors of the differential amplifiers were selected so that their h_{fe} and I_{cbo} values are identical, to ensure minimum drift. Values for each pair of transistors are:

VT_1 and VT_2, $h_{fe} = 155$, $I_{cbo} = 6\mu A$

VT_3 and VT_4, $h_{fe} = 35$, $I_{cbo} = 1\mu A$

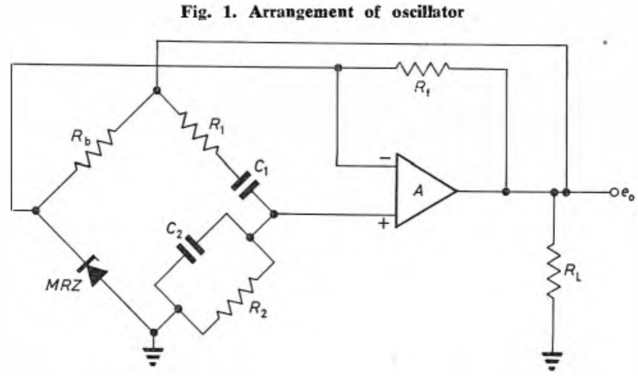
Analysis of oscillator

The circuit (Fig. 1) is redrawn (Fig. 3) with the bridge (B), the frequency determining network, in the feedback path. The output of the amplifier (A) is connected to (B), and the input of (A) is connected to the output of (B). The transfer function of this arrangement is:

$$e_o/e_i = A/1 \pm AB \text{ where}$$
$$e_o = A\ e_s, \text{ and } e_s = e_i \pm B\ e_o$$

If the feedback path to the summing point (s) is broken and the input signal e_i introduced, it is amplified by A

Fig. 1. Arrangement of oscillator



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and fed back to B, where the gain is less than unity. Due to the reactive elements, the phase of the output (e_o) is shifted with respect to the input (e_i). The output voltage from B is:

$$e_B = AB\, e_i$$

the differential voltage e_d is $e_i - e_B$

therefore $e_d = e_i\,(1 - AB)$

If e_i is unity, e_d is the denominator of the transfer function. For stable oscillation e_d must be zero. Substituting this value in the denominator shows that the overall amplifier gain is infinite, causing instability and oscillation in the system. If e_d is zero e_i must equal e_B. That is, the input voltage is regenerated through path A B.

When the amplitude and phase of e_B is identical to e_i, the system oscillates at its resonant frequency f_o. For self-sustained oscillation, the feedback path is reconnected to the summing point and the input signal removed.

The voltage required to initiate oscillation is supplied by the noise present in the amplifier circuit. This contains energy at all frequencies in the spectrum and therefore contains f_o to initiate oscillation.

ANALYSIS OF AMPLIFIER

The amplifier (Fig. 2) feeds a total load of 15kΩ, that is, R_L in parallel with feedback resistance R_f and the resistance of the bridge. The maximum output voltage e_o is 1·0V and the current through R_L is 6·0μA. The emitter current of VT_6 is:

$$I_o = \frac{V_{BB} + I_{co} R_8}{(1 - \alpha) R_8 + R_{13}} = 4{\cdot}15\text{mA}$$

Where V_{BB} is the base voltage, R_8 the resistance in the base circuit and β is 140. The differential amplifier in the second stage provides the drive current for the base of VT_6. The current generator VT_5 supplies bias current to VT_3 and VT_4 and increases the common mode rejection ratio of this stage. The emitter voltage of VT_5 is determined by the voltage divider R_{10} and R_{11}. The impedance of the current regulator is the effective emitter resistance for VT_3 and VT_4. Therefore, the emitter resistance of VT_5 (R_{12}) determines the currents of VT_3 and VT_4.

By selecting $R_{11} = 2{\cdot}2\text{k}\Omega$:

$$V_{B5} = \frac{(V_o + V_E)\, R_{11}}{R_{10} + R_{11}} \simeq 9{\cdot}6\text{V}$$

$$\text{and } R_{12} = \frac{V_{B5}}{I_{c3} + I_{c4}} = 4{\cdot}8\text{k}\Omega$$

where $I_{c3} = I_{c4} = 1\text{mA}$.

The bases of VT_3 and VT_4 are driven from the collectors of the input stage.

To reduce the common mode effects R_4 is large. The optimum collector currents for VT_1 and VT_2 are 300μA. This low I_c improves stability at this stage, reducing the drift to a minimum. Lower collector currents were tested but resulted in decreased gain and increased drift in the first stage.

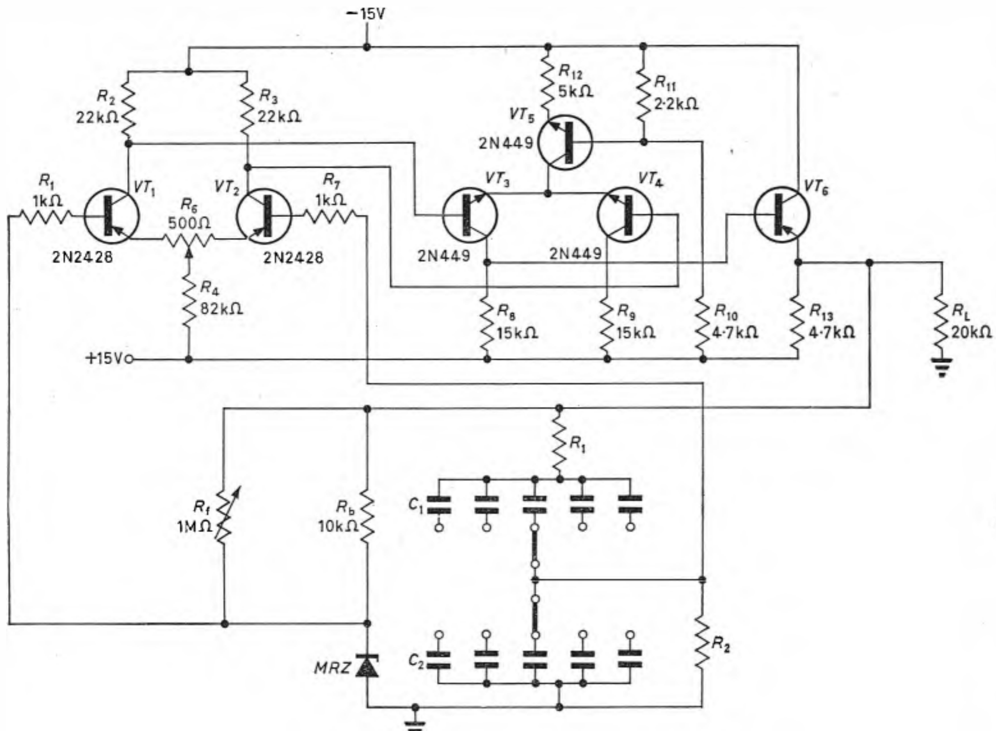

Fig. 2 (left). The oscillator circuit

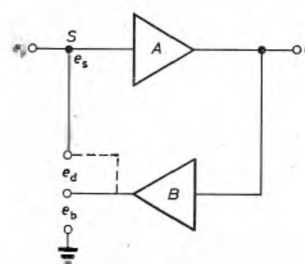

Fig. 3 (below). Transfer function circuit

The open loop gain of the amplifier is 5 000, the first stage is 250, the second stage is 21 and the output stage is 0·95. By introducing feedback resistor R_f the total gain is reduced to 500.

The capacitors in the bridge are polystrene with 0·5 per cent accuracy providing the temperature does not exceed 70°C and the bridge resistors have a 1 per cent accuracy.

The oscillator frequency changes 3 cycles per 1 000 over the temperature range 15° to 40°C. The distortion of the oscillator at a load resistance (R_L) of 20kΩ and 1V output is 0·2 per cent. A change of 10 per cent in R_L distorts the output by 8 per cent.

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A Tunnel Diode Peak and Valley Current Measuring Set

By J. B. Earnshaw*, M.Sc., Ph.D., and Z. C. Tan*, M.Sc.

The simple equipment described below enables accurate measurements of the peak and valley currents of tunnel diodes to be made rapidly. It is particularly suitable for determinations of the relative values of these currents for batches of similar type tunnel diodes.

(Voir page 763 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 770)

THE d.c. parameters of a tunnel diode are indicated on the typical $I_a - V_a$ characteristic in Fig. 1.

Fig. 2 shows the basic circuit for measuring I_p and I_v for any tunnel diode. V is a variable d.c. voltage, I is a variable d.c. current, and S is an oscillating switch.

For the measurement of I_p, I is initially set to zero and V is increased from zero until the tunnel diode, which is initially in the low ($V_a < V_p$) state, just begins to switch, i.e. forward switch when S closes and reverse switch when S opens. At this point:

$$I_p = (V - V_p)/R \quad \ldots\ldots\ldots\ldots\ldots (1)$$

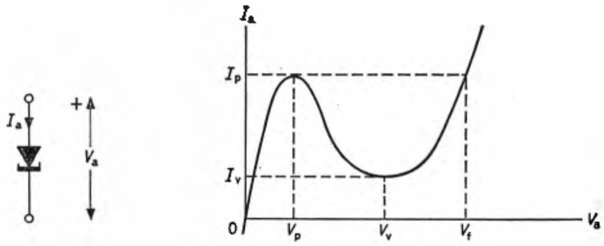

Fig. 1. Definition of the d.c. parameters of a tunnel diode

For the subsequent measurement of I_v, I is then increased until switching just ceases, i.e. the tunnel diode no longer reverse switches when S opens but remains in the high voltage ($V_a > V_v$) state as S continues to oscillate.

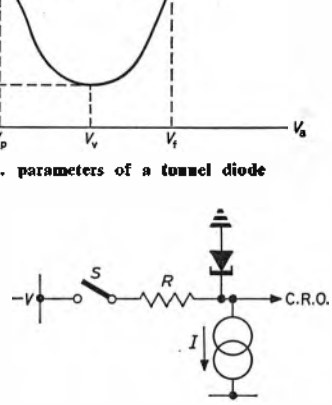

Fig. 2. Basic measuring circuit

At this point:

$$I_v = I \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

While it is important that I be set to zero for the measurement of I_p, V may be set† to any value greater than $V_p + R.(I_p - I_v)$ for the measurement of I_v.

Actual Circuit Arrangement

The actual circuit used to measure I_p and I_v is shown in Fig. 3, with component values suitable for 5mA tunnel diodes. The design and operation of this circuit are explained as follows.

When the input potential is raised above 0·3V the current of 4·5mA, defined by R_1, is conducted by MR_3. This means that the emitter potential of VT_1 is clamped at 0·3V. In these circumstances the collector current through VT_1 is cut-off and the current of 2mA, defined by R_2, is connected by MR_4. The potential drop across MR_4 reverse biases the emitter-base junction of VT_2 by 0·3V, so that the collector current through VT_2 is also cut-off. Since VT_2 functions as the switch S, this situation corresponds to the switch position S—open.

When the input potential is lowered below −0·3V VT_1 conducts the current of 4·5mA, defined by R_1. Since only 2mA of the collector current of VT_1 is demanded by R_2 the remaining 2·5mA is supplied to the base of VT_2 causing this transistor to saturate with its collector clamped at the potential $-V$ given by:

$$-V = -V_e + V_{cs} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

where V_{cs} is the collector-emitter saturation potential. This corresponds to the switch position S—closed.

Switch S can be made to oscillate between 'open' and 'closed' at any convenient frequency, say 100kc/s, by an

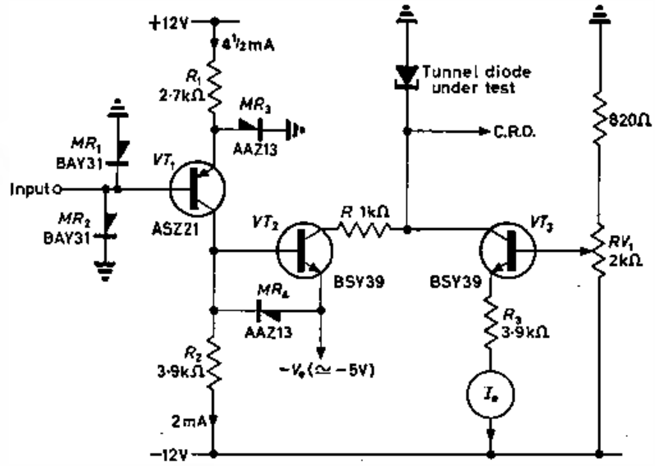

Fig. 3. Actual measuring circuit with component values suitable for 5mA tunnel diodes

alternate input voltage of greater than 0·3V amplitude. The purpose of the silicon diodes MR_1 and MR_2 is to limit the input voltage to approximately ±0·7V.

Transistor VT_3 acts as the current source I demanding a current determined by its base potential and R_3. This current is monitored in the emitter circuit as I_e, and it can be cut-off by setting the base potential to −12V.

Writing equations (1) and (2) in terms of the measured voltage V_e, and the measured current I_e, and including the appropriate collector leakage currents .... equation (1) becomes:

$$I_p = \frac{V_e - V_{cs} - V_p}{R} + I_{co3}$$

$$= (V_e/R) - \left[\frac{V_{cs} + V_p}{R} - I_{co3}\right] \quad \ldots\ldots\ldots (4)$$

and equation (2) becomes:

$$I_v = \alpha_3 I_e + I_{co2} + I_{co3}$$

$$= I_e - [(1 - \alpha_3) I_e - I_{co2} - I_{co3}] \quad \ldots\ldots (5)$$

where the suffices 2 and 3 refer to the transistor notation.

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† *In practice V is usually equal to $V_p + R.I_p$, i.e. the value at which switching commences when I is equal to zero.*

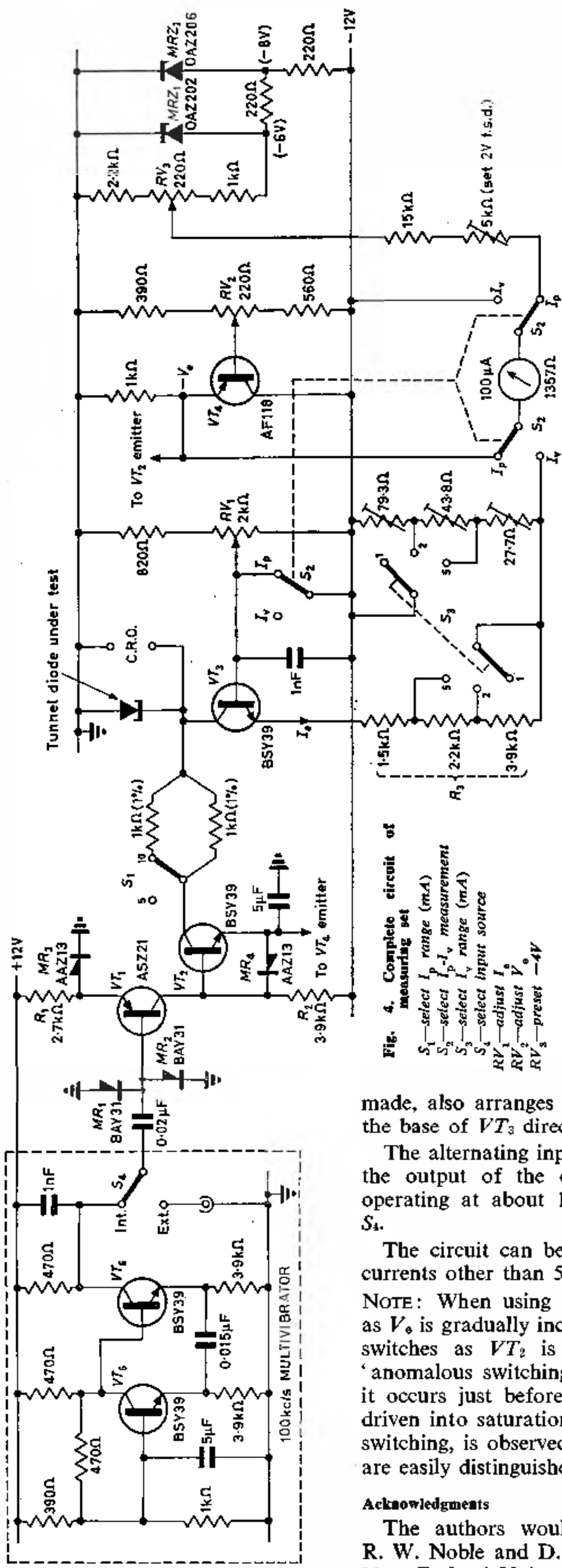

Fig. 4. Complete circuit of measuring set
S_1—select I_p range (mA)
S_2—select I_p-I_v measurement
S_3—select I_v range (mA)
S_4—select input source
RV_1—adjust I_e
RV_2—adjust V_e
RV_3—preset −4V

For accurate measurements the values of α_3 and V_{e3} can readily be determined. The value of V_p can be estimated at 60mV for germanium tunnel diodes and 150mV for gallium arsenide tunnel diodes. By using silicon transistors for VT_2 and VT_3 the leakage currents can be ignored in most cases.

For many measurements, particularly where relative values of I_p and I_v for a batch of similar tunnel diodes are required, the correction terms in square brackets in equations (4) and (5) can be neglected.

To obviate erroneous measurements the coupling of spurious signals to the tunnel diode must be eliminated, and for this reason it is preferable for the resistor which constitutes R to be inductive rather than capacitive.

Clearly the oscilloscope which is used to observe the onset and cessation of switching does not need to have a rise-time that is anywhere near comparable with the tunnel diode switching time.

Complete Circuit of Measuring Set

Fig. 4 shows the complete circuit of the measuring set which is designed specifically for measurements on tunnel diodes with peak currents in the 4 to 6mA or 8 to 12mA ranges and valley currents of up to 5mA.

For the 4 to 6mA range ($I_p \simeq 5$mA nominal) the value of R is 1kΩ and this is reduced to 500Ω by switch S_1 for the 8 to 12mA range ($I_p \simeq 10$mA nominal).

V_e is supplied from the d.c. emitter follower VT_4, and can be varied over the range 4 to 6V by the setting of RV_2. It is monitored, during measurements of I_p, by a 100µA meter calibrated as a voltmeter (2V f.s.d.) and arranged to read from 4 to 6V. This meter is backed-off by a potential of −4V obtained from the double Zener diode (MRZ_1 and MRZ_2) network, and preset by RV_3. The double Zener diode action adequately stabilizes the backing-off potential against small changes in the −12V supply line.

I_e is varied by the setting of RV_1, and this current is also monitored, during measurements of I_v, by the 100µA meter calibrated as an ammeter with three ranges, viz. 0 to 1mA, 0 to 2mA and 0 to 5mA. The appropriate range is selected by switch S_3 which also changes the value of R_3 to maintain similar RV_1 setting sensitivities on all ranges.

The $I_p - I_v$ switch S_2, in addition to selecting the function of the meter according to the measurement to be made, also arranges that I_e is set to zero for measurements of I_p by connecting the base of VT_3 directly to the −12V supply line.

The alternating input voltage applied to the base of VT_1 is supplied either from the output of the conventional emitter-coupled multivibrator (VT_5 and VT_6) operating at about 100kc/s, or from an external source, as selected by switch S_4.

The circuit can be modified for use with tunnel diodes having nominal peak currents other than 5mA and 10mA simply by changing the value of R.

NOTE: When using this measuring set to determine I_p, it will be observed that as V_e is gradually increased, a value is reached at which the tunnel diode forward-switches as VT_2 is brought out of saturation prior to being cut off. This 'anomalous switching' is due to a capacitive base-collector current in VT_2, and it occurs just before V_e is large enough to cause forward-switching as VT_2 is driven into saturation. A somewhat similar phenomenon, associated with reverse switching, is observed during measurements of I_v. In both cases these phenomena are easily distinguished from 'normal switching' and should be ignored.

Acknowledgments

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Cryogenic Regenerative Hall Effect Devices

By D. Midgley*, B.Sc. (Eng), Ph.D., A.M.I.E.E.

The advantages of a disk (Corbino disk) in solid-state electronics are discussed in comparison with a rectangular slab (Hall plate), when practical application requires currents to be driven by the Hall effect. Suggestions are made for the application of regenerative principles to active printed circuits for digital computers. Refrigeration to temperatures near absolute zero may or may not be required; in any case the devices compare favourably as regards linearity and active symmetrical bistable operation with some other cryotrons. For a bismuth disk in liquid helium, experimental results are given in terms of modification to the hysteresis loop of a contorted magnetic feedback circuit.

(Voir page 763 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 770)

A HALL plate is usually a rectangular slab of semi-conducting material; current is supplied and flows at first uniformly over the length of the slab; a uniform magnetic field is applied across two faces at right-angles to the current and, because lateral movement of the slab is prevented, forces act directly on the current carriers to produce the lateral Hall-effect e.m.f. at the remaining pair of faces. When output is drawn at these terminals a complex current distribution appears in the slab[1] and this renders it relatively inefficient. However, sufficient current has been drawn in one output circuit to feed coils supplying the magnetic field and so to achieve a regenerative amplifier, which can drive itself to either of two limiting conditions corresponding to regenerative growth of the magnetic field in each polarity[2]. As bistable trigger circuits, the early versions of regenerative Hall amplifier were not competitive in speed of operation with valve and transistor circuits due to the inductance of the magnetizing winding; however, the speed of passive ferrite cores has recently been so improved by miniaturization that equally fast active devices should be realizable by the same technique.

The Corbino disk is a cylindrical variant of the Hall plate; the supplied current both initially and finally flows radially in the disk; the magnetic field is axial; the Hall e.m.f. is, so to speak, used up as fast as it is generated in driving circulating currents in the disk itself. If the object is to drive such currents, then this is clearly more efficient than having a separate source and load; moreover, the current distribution maintains axial symmetry and this simplifies the calculation of the magnetic field caused by the circulating currents[3]. Depending on the direction of the radial current, this self-magnetic field may either assist or oppose the applied field. In a plain disk, however, it can never entirely supplant the applied field because each elemental ring of circulating current causes a field within itself, but is caused by the fields of other larger rings. The spiral path of the resultant currents is tight or loose according as the applied field is aided or opposed; this leads to different resistances for the two possible directions of the radial current and thus to action as a rectifier in that circuit[4].

In the present application the radial circuit is used simply as the power supply. The fundamental difficulty about regenerating the magnetic field from the circulating component of current is solved by elaborating the magnetic circuit. A hole in the centre of the disk is threaded by the magnetic circuit, which loops around all the circulating currents at least once in the path between the two pole faces, which provide the axial field[5].

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Cryogenic Experiments

The material bismuth was selected for construction of the disks on the ground that it possessed the longest known mean free path; this is equivalent to selecting the material with the best combined Hall coefficient and conductivity. A still better criterion would be to include permeability among the attributes of an ideal material; on this score electrolytic iron at high temperatures is a candidate, but its Corbino effect is anomalous and reverses at low field strengths; again, it is difficult to avoid unwanted magnetization of a magnetic circuit without a gap, for instance, by the leads required to feed the radial current for the disk.

Fully superconducting materials are incapable of exhibiting a Hall effect because they exclude magnetic fields. To this extent they are less useful than materials which admit a magnetic field and so allow control of the current flow to be retained from remote sources. Thus an efficient low temperature amplifier is possible so long as the Hall effect exists in a material; the power input is that required for the applied current; the signal input is to the applied magnetic field; the power output is the product of Hall e.m.f. and currents with positive or negative feedback available from the fields of those currents; the Hall effect is linear, being directly proportional to both the applied field and current; the material is active in the same sense that a valve or transistor makes a circuit active by amplification and the conversion of power. By contrast a superconductor is passive; it imposes a new boundary condition on the magnetic field; it is only different from a highly permeable material in that it imposes the opposite boundary condition of parallel instead of perpendicular lines of force at its surface; it is thus only useful in the same fashion to give shape to a magnetic field by its passive presence.

The highest electron mobilities are to be found in single large crystals of bismuth; these would be suitable for rectangular Hall plates. Relatively high mobilities remain in the non-crystalline material, which is more suited to the construction of a disk. In order to prevent crystallization, an ultrasonic vibration was applied as the bismuth cooled from the liquid state. Copper, which does not become superconducting, was chosen for connectors at the inside and outside radius of the disk. Direct castings of the bismuth into copper moulds failed due to differential contractions, but satisfactory joints were made with ordinary solder. The joints did not fail when subjected to extreme temperature changes, but they caused some doubt as to whether supercurrents were induced in them.

The magnetic circuit was constructed from lengths of soft iron wire (15cm 20 S.W.G.) bent into the shape shown in Fig. 1. In the figure a second wire of the same shape can be imagined to complete the magnetic circuit as a figure of eight, which links some of the circulating currents twice and links all of them once. Such wires were interleaved with each other and packed into the central hole until 110 were accommodated, the ends being trimmed and spread uniformly as pole surfaces in contact with the flat surfaces of the bismuth disk.

Meanwhile magnetizing and search coil windings of ten turns each were put around the central core and eight evenly spaced leads to carry the radial currents were connected to the inner and outer rings of the disk. The whole was less than $2\frac{1}{2}$in in diameter and could be lowered into a glass liquid helium vessel by its leads. The disk itself was $\frac{1}{8}$in thick with inner diameter $\frac{1}{2}$in and outer diameter 1in. The source of radial current was a single-phase full-wave

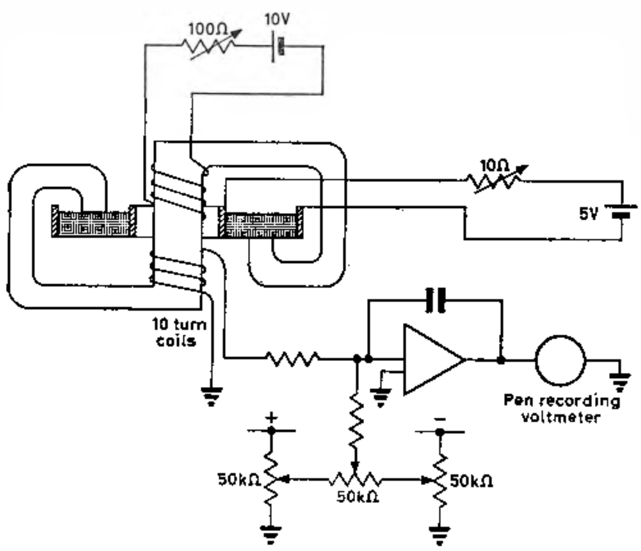


Fig. 1. Arrangement of Corbino disk, magnetic feedback circuit segment and circuit for measurement of flux density

rectifier with two-stage open-loop control of constant current output from magnetic amplifiers with no smoothing circuit.

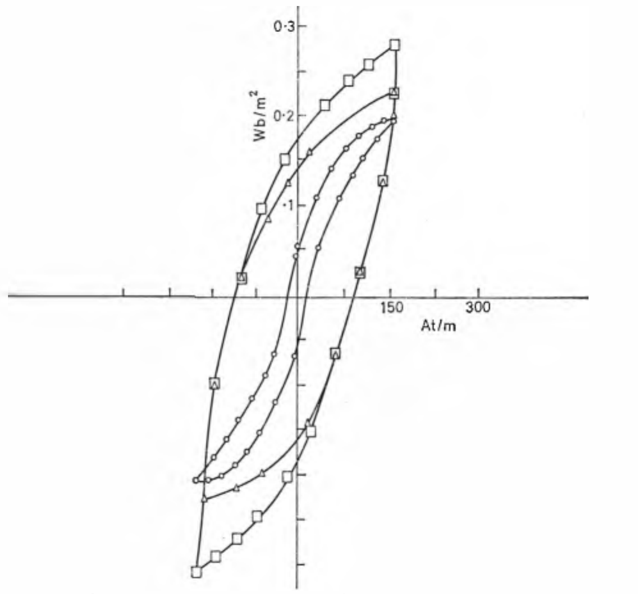
Fluxmeter Measurements with Operational Amplifier

An ordinary fluxmeter is insufficiently sensitive and is not conveniently adapted to record the measurements speedily. Each hysteresis loop was completed in about 20sec as the liquid helium boiled rapidly after immersion of the current-carrying disk. An integrator of an analogue computer was therefore used to integrate the e.m.f. induced in the search coil. The output of the integrator is proportional to the flux and can drive a pen recorder. In order to attain sufficient sensitivity the feedback capacitor was 0·1μF associated with an input resistor of 2·6kΩ; the amplifier gain was 3.10^7. To compensate against stray e.m.f.'s of thermal or chemical origin in the input circuit, a second input was applied to the summing junction of the integrator to act as a coarse and fine zero set. Imbalance of the input circuit is indicated by constant drift of the output, with striking resemblance to a non-level fluxmeter.

Stepped changes in the magnetizing current were recorded simultaneously with the flux recordings. At room temperature and again at the temperature of liquid nitrogen the fluxmeter response to stepwise change in current was virtually instantaneous. In marked contrast at liquid helium temperatures the time-constant apparent in the fluxmeter circuit was of the order 1sec. This is tentatively attributed to the L/R ratio of the copper and solder rings, which surround the core and act like short-circuited secondary turns.

Experimental Results

On first switching on the radial current after the disk had been immersed in liquid helium, the pen recorder was immediately driven off scale at its maximum speed of response. This was dismissed as a nuisance, associated with similar experiments on all-iron constructions: the familiar remedy of re-balancing the fluxmeter and radial



o Hysteresis loop for the soft iron magnetic circuit at room temperature
△ Hysteresis loop at liquid helium temperature with 110A inward radial current
□ Hysteresis loop at liquid helium temperature with 110A outward radial current

Fig. 2. Hysteresis loop for the soft iron magnetic circuit at room temperature

current circuits was applied and experiments were re-started. The effect was not repeated. It may nevertheless have been the first and best manifestation of the regenerative action under investigation, as was ultimately realized, when room temperature tests at leisure established that with the bismuth disk no measurable coupling to the search coil could arise from the radial current circuit. The non-repetition of the effect is tentatively attributed to its having established a supercurrent in the ring of solder and the persistence of that supercurrent through the remaining experiments.

The separate recordings of total flux and magnetizing current are combined in Fig. 2 into effective hysteresis loops for each direction of radial current. These are compared with a loop for the soft iron magnetic circuit taken by the same method but at room temperature.

Discussion and Recommendations

No special significance is given to the change in height from the room temperature loop, since permeability is not independent of temperature. The difference in height of the two loops taken at liquid helium temperature for inward and outward radial current is attributed to the Corbino currents, which have hitherto usually been measured by less direct methods involving alternating quantities. For the taller loop, the Corbino currents act so as to assist the magnetizing current, and increasingly so as one proceeds for intance from left to right over the lower curve; the curve continues to become steeper, as, due to the regenerative feedback in the magnetic circuit, the Corbino currents take over an increasing proportion of the total magnetizing force. The room temperature loop is opposite in this respect; both of the curves comprising the loop have steadily diminishing gradient as B and H increase towards the tips of the loop.

The apparent increase in hysteresis for both directions of the radial current is more difficult to explain. There are certain affinities between ferromagnetism and supercurrents in that the atomic currents, which are responsible for ferromagnetism are in themselves a form of supercurrent, whose very persistence is manifest in hysteresis. An absolutely persistent supercurrent would have the effect of a bias on the H axis and would cause a minor loop to be encountered by the cycling of external magnetizing current. An effect like hysteresis itself, however, requires for its explanation a current, which changes after the stimulus is removed. In the present

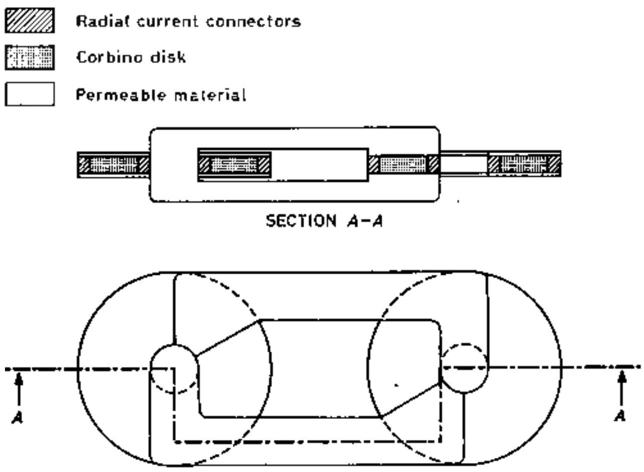


Fig. 3. Proposed three-ply printed circuit arrangement for a bistable device

example, a temporary persistence of the circulating Corbino currents could account for some of the apparent increase in hysteresis; they move around a path of very low but not zero resistance; in consequence, the effects of electron inertia and of effective viscosity between layers of electrons moving in parallel paths could cease to be negligible. The argument that a Corbino disk cannot supply its own magnetic field in the absence of feedback would no longer apply if there were sufficient viscosity for the inner orbiting electrons to carry the outermost with them. These speculations and possibilities are sufficient to show the need for further investigations into the fundamentals of the subject, which is fertile ground for fresh discovery.

As regards practical application, the experimental model has demonstrated a significant effect of Corbino currents, which can be applied to a symmetrical bistable device. Symmetry is a desirable property of bistable circuits, since it ensures that the same triggering signal applies equally to each stable state. Those cryotrons, which depend for their effect upon changing from a superconducting to a normal condition, do not possess this symmetry. Regeneration and a cumulative effect arising from positive feedback are also desirable properties of bistable circuits; with this property the circuit proceeds of its own accord to the alternate state after the minimum trigger has been removed; valve and transistor multivibrators behave in this way, but ferrite cores and other passive elements do not.

A suggested printed circuit version of a Corbino disk bistable arrangement is shown in Fig. 3. It is reminiscent of the multivibrator in that two disks are used, such that each supplies the magnetizing current for the other. This leads to rather simpler magnetic field configurations than when one disk must supply its own field. The assembly is conceived as a three-ply; in the central layer are the disks and radial current connectors, which should either be slit to avoid unwanted supercurrents or be of a material having some resistivity. The flat surfaces of the disks are coated with permeable material and the holes are plugged similarly. The outer layers of the three ply are of permeable material shaped to convey the flux from the core of one disk to the pole faces of the other. Since the Hall e.m.f. is directly proportional to the radial current, it follows that the latter controls the Corbino currents, hence the magnetic field strength and the feedback factor of the whole circuit. Thus after the radial currents have been increased until the feedback factor exceeds unity, the circuit becomes regenerative. A magnetic field initiated in either direction will continue to grow in that direction until saturation again reduces the feedback factor to less than unity. Triggering to the alternate state of reversed magnetization is achieved by applying an external field momentarily and of sufficient strength to cancel the existing field.

Acknowledgements

Facilities for the experiments were provided by the Department of Electrical Engineering, Bradford Institute of Technology and cryostats were loaned by the British Oxygen Company Ltd.

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Selective Moving Target Indication

A new radar development for Air Traffic Control equipment has been announced by The Solartron Electronic Group Ltd. This new technique, known as Selective Moving Target Indication (s.m.t.i.), has been developed by Solartron in collaboration with the Ministry of Aviation. Prototype s.m.t.i. equipment has been undergoing operational trials at the London Air Traffic Control Centre for the past two months.

With the introduction of remote radars, air traffic controllers have found the phenomena of tangential fade an increasing problem: s.m.t.i. is claimed as the answer to this problem. A radar distinguishes between ground clutter and aircraft echoes by seeing whether the radar return is moving or not. Unfortunately, it has no ability to distinguish movement unless it is towards or away from the radar aerial. In the area where normal m.t.i. is operating, aircraft flying tangentially will disappear completely from the screen.

The development of s.m.t.i. allows the moving target indication facility to be limited to those areas where it is required—where there is actual ground clutter. It does this by using a photographic plate on which there is a picture of the permanent echo pattern of the particular radar. It scans this with a flying spot scanner so that the amount of light passing through the plate at any point will depend on whether there is ground clutter or not. The light which passes is converted to a varying voltage by means of a photomultiplier and used to operate a switching circuit. The switching circuit determines whether uncancelled video (raw radar) or cancelled video (m.t.i.) should be used at any point on the face of the radar screen.

The switching cycle is very fast, and a complete on-off operation may take only a few microseconds. The switching circuit is entirely solid state.

A Million Megohm Solid State Dielectric Amplifier

By G. M. Ettinger*, Ph.D.

Following a short review of methods of measuring currents in the nanoampere and picoampere ranges, a solid state dielectric amplifier is described which has a d.c. input resistance of a million megohms. The operation of this amplifier is based on the low leakage properties of certain semiconductor diodes operated in a varacter mode. Finally, a true dielectric amplifier for high voltages is mentioned which is based on the ferro-electric properties of ceramic capacitors.

(Voir page 763 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 770)

THE requirements for direct current measurements in the nanoampere and picoampere range in insulation research, pH apparatus, nucleonic instrumentation and other fields have been discussed by Hitchcox, Taylor *et al*[1]. The older devices for low current measurements include galvanometers with photo-electronic amplification, electrometer valves, vibrating capacitors and, ultimately, electroscopes. Some of these devices have disadvantages such as lack of ruggedness, lack of long-term stability, electrical noise, appreciable power consumption, slow response, size or cost. Shonka, Failla and Rose[2] overcame several of these difficulties in a sensitive vibrating fibre electrometer for suppressed zero applications.

Among solid state devices for low current d.c. amplification may be mentioned low level balanced silicon junction transistors which can readily detect some tens of nanoamperes direct current above noise[3] and junction field effect transistors which are capable of operating with gate currents of a few hundred picoamperes. A method of operating junction field effect transistors with gate currents of some tens of picoamperes is described elsewhere[4].

Similar input currents can also be obtained with optimized transistor choppers using, for example, double emitter transistors. The extensive literature on low level d.c./a.c. convertors up to 1961 has been covered by Komolibus[5].

For picoampere operation, however, the only solid state device so far considered has been the insulated-gate enhancement mode field effect transistor (m.o.s.f.e.t.—Metal-Oxide Silicon Field Effect Transistor). This type of transistor may generate appreciable channel noise[6] and has not yet been established as a fully reliable device.

Principle Employed in Solid State Dielectric Amplifier

The dielectric amplifier to be described employs the varactor characteristics of silicon pn junctions in contradistinction to the conductance modulation techniques employed by Moody[7] in silicon diode modulators for low current measurements. Appreciable d.c./a.c. conversion power gain is obtained in the varactor mode. Power gain is further enhanced by operating the varactor diodes in a non-linear twin-T network similar to that described by Lion[8] rather than in a resonant circuit or a.c. bridge circuit[9,10]. Voltage degeneration is employed to maintain a nearly constant working point for the diodes; this degeneration may be adjusted to achieve sensibly infinite input resistance. The working point is chosen to obtain zero standing input current. In practical amplifiers, input current variations of ± 1pA have been obtained for input changes of ± 1V, yielding an input resistance of the order of a million megohms.

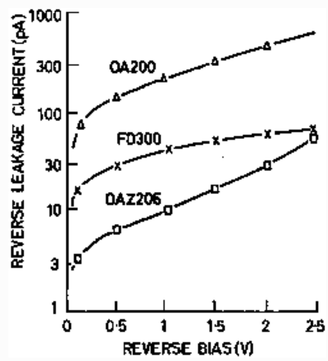


Fig. 1. Current-voltage characteristics of diodes with small reverse bias

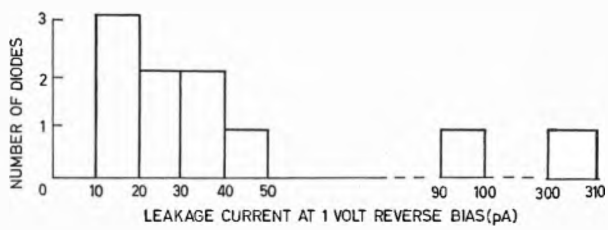


Fig. 2. Distribution of reverse leakage for ten Zener diodes (5 type OAZ206: 5 type OAZ207)

Characteristics of Silicon Junction Diodes

Leakage Properties

Fig. 1 shows the experimental current-voltage curves for three silicon diodes, respectively a silicon alloy junction diode (OA200), a low leakage planar diode (type FD 300), and a Zener diode (OAZ 206). It is seen that, up to approximately 2·5V reverse bias, the leakage current of the Zener diode was smaller than that of the planar low-leakage diode. Up to 1V bias the leakage of the Zener diode at 20°C did not exceed 11pA. Fig. 2 is a histogram which indicates the variation of reverse leakage found at 1V for ten Zener diodes (five type OAZ 206, nominally 8V, five type OAZ 206 nominally 9V). It is seen that a significant yield of Zener diodes drawing less than 50pA at 1V reverse bias was obtained. The temperature variation of reverse leakage, measured on one Zener diode only, was such that leakage current doubled for approxi-

* *Formerly G. and E. Bradley Ltd, now at Rotax Ltd.*

mately 10°C increases of temperature, as expected for a silicon pn junction.

Variable Capacitance Performance

Published data on Zener diodes indicate that junction capacitance variations with varying bias of some hundreds of picofarads are readily obtained, compared to a variation of a few picofarads only for fast low leakage diodes. Fig. 3 shows experimental capacitance/voltage curves for several Zener diodes. All the curves followed closely a $-1/2{\cdot}4$ exponential law.

Leakage Current/Capacitance Correlation

No significant correlation was found between capacitance of the Zener diodes when reverse biased and their corresponding leakage currents.

Design of Million Megohm Dielectric Amplifier

Fig. 4 shows the basic circuits employed in the dielectric amplifier. Fig. 4(a) is the Lion non-linear parallel-T network[8] which has the following properties:

(a) D.C. output is obtained as a function of differential changes of the capacitors C_1 and C_2.

(b) The null point is independent, to a first approximation, of frequency and a.c. drive level.

(c) The sensitivity varies slightly with frequency, exhibiting a maximum at the frequency.

$$f = \frac{0{\cdot}57\,(R + R_L)}{R(C_1 + C_2)(R + 2R_L)}$$

In the solid state dielectric amplifier to be described, the capacitors C_1 and C_2 are replaced by reverse biased Zener diodes, as shown in Fig. 4(b). The characteristics of

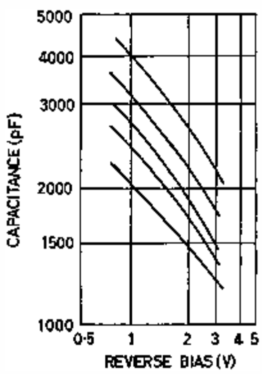
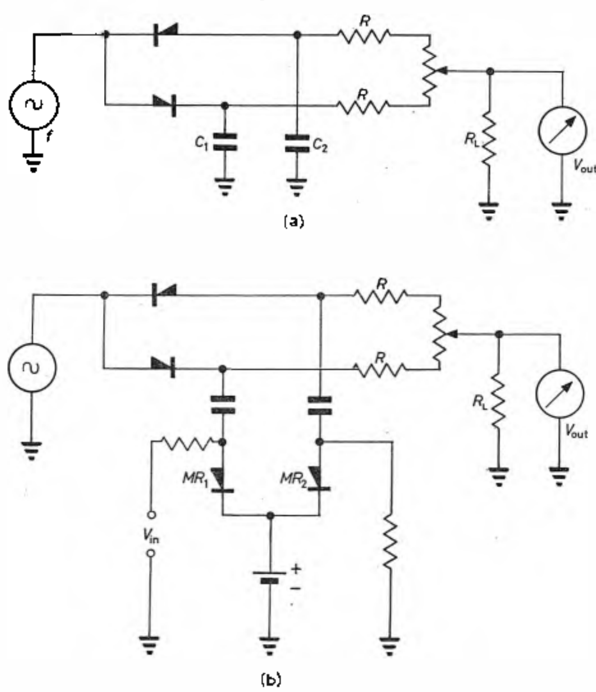


Fig. 3 (right). Variation of capacitance with reverse bias for five Zener diodes type OAZ206
The two diodes having lowest capacitance exhibited lowest leakage in a solid state dielectric amplifier

Fig. 4 (below). (a) Non-linear parallel-T circuit *(after Lion[8])*
(b) Basic solid state dielectric amplifier



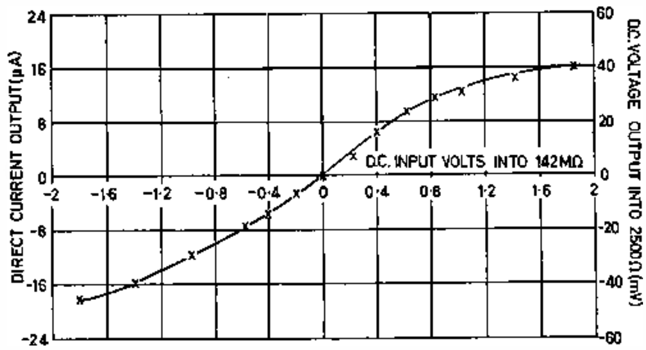


Fig. 5. Performance of solid state dielectric amplifier of Fig. 4(b)

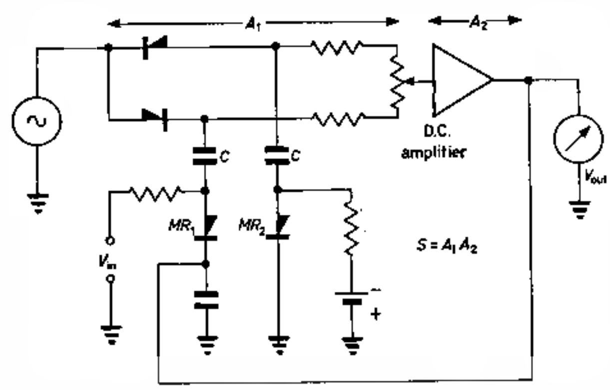


Fig. 6. Solid state dielectric amplifier with voltage feedback

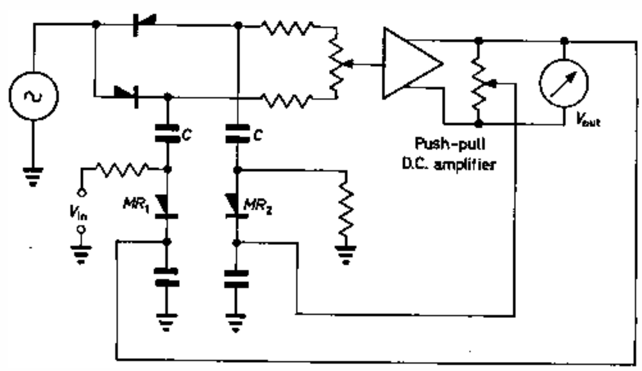


Fig. 7. Solid state dielectric amplifier with push-pull voltage feedback, exhibiting sensibly infinite input resistance

this circuit are shown in Fig. 5. They indicate a d.c. voltage attenuation, from input to output, of approximately 30 to 1. The current gain of this simple circuit, however, is approximately 1700 (12μA output for 7nA input). Thus the parametric power gain is 1700/30 or 57. The input sensitivity (10nA full scale input) is not particularly good and can readily be equalled by other known transistor circuits. Fig. 4(b) and its characteristics are shown merely to illustrate the principle of operation of the solid state dielectric amplifier.

Now consider the arrangement of Fig. 6 where voltage feedback is applied from the output of a transistor amplifier which has good voltage zero stability but relatively low input resistance. Let the forward voltage gain of the system be S. Thus, for 1V input at the 'anode' of diode MR_1 (Fig. 4(b)), S volts will be fed back to its 'cathode'. Correspondingly, the input current drawn is reduced by a factor S. In practice, S may approach a value of 1000, when the 10nA full scale input current is reduced to 10pA. Further increase of input resistance is achieved by push-pull negative voltage feedback (Fig. 7) where the diode MR_2 need not have low leakage properties. The feedback to diode MR_2 may be made adjustable as shown. As feedback is increased, infinite input resistance, or stable negative input resistance, are obtained. An input current variation of one picoampere per volt input has been achieved in practice.

Practical Million Megohm Dielectric Amplifier

Fig. 8 is the complete circuit of a million megohm dielectric amplifier. The a.c. supply is obtained from a 50kc/s multivibrator delivering a square wave of 40mV amplitude to the commutating diodes MR_3, MR_4. The diodes employed as d.c. varactor amplifiers (MR_1 MR_2) were Zener diodes type OAZ 206, chosen to have less than 20pA leakage at 1V reverse bias. No capacitance matching was carried out.

The transistor amplifier employed a push-pull pair of matched npn silicon planar transistors, type BCY 55, in a long tailed pair configuration, followed by a pair of unmatched 2N930 transistor emitter-followers. Potentiometer RV_1 is employed to null the dielectric amplifier proper, potentiometer RV_2 sets the operating point for minimum leakage and RV_3 sets the positive feedback level to obtain sensibly infinite input resistance.

Fig. 9 shows voltage and current transfer curves for the dielectric amplifier. Nearly linear voltage transfer characteristics (gain $\simeq 2$) for inputs up to ± 1V are obtained. Fig. 9(b) indicates the input current drawn; it is seen that this varies approximately ± 1pA for an input change from zero to 1V. The input current includes the leakage current contributed by the polystyrene blocking capacitor C of Fig. 8.

The amplifier was housed in a case of dimensions 1¼in by 4in by 6in. The total current drawn from the 22V dry battery (type 155) was 8mA. Using standard monolithic

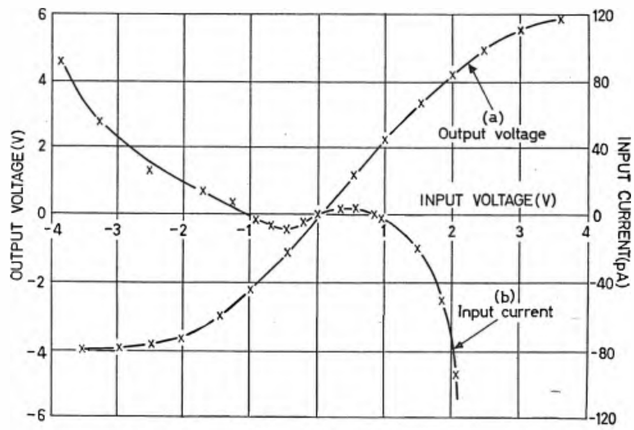


Fig. 9. Performance of amplifier of Fig. 8

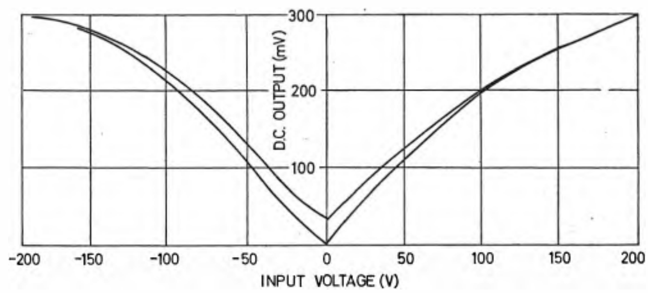


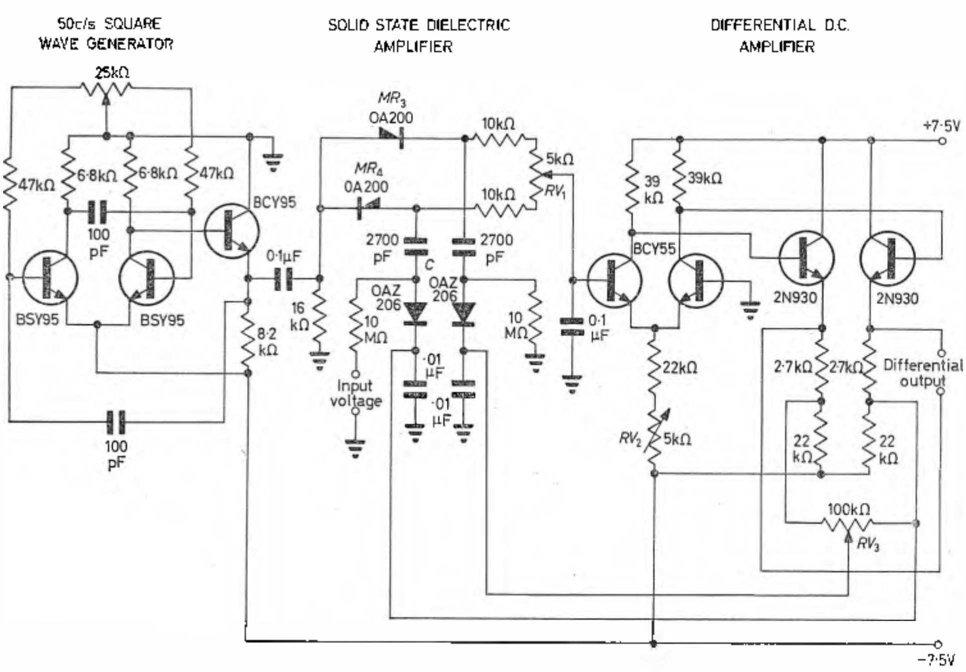
Fig. 10. Characteristics of true dielectric (ferro-electric) amplifier of Fig. 11

integrated circuits for the multivibrator and d.c. amplifier of Fig. 8, it is possible to reduce the volume of the complete amplifier to less than 1in^3.

Comparison With True Dielectric (Ferro-Electric) Amplifier

Fig. 10 shows the transfer curve for a dielectric amplifier, basically that of Fig. 4(b), with the Zener diodes replaced by 470pF ceramic capacitors. Circuit values are given in Fig. 11. This circuit, useful for high voltage d.c. measurements, suffers from the effects of dielectric hysteresis, so that the output does not fully return to zero after input voltage is removed. However, the ferro-electric circuit provides a simple method of measuring voltages up to, say, 200V directly without loading. Higher d.c. voltages can be measured by this technique if a number of capacitors in series is employed. D.C. input current of the ferroelectric dielectric amplifier was about ± 100pA for ± 100V input, corresponding to

Fig. 8. Circuit diagram of million megohm solid state dielectric amplifier



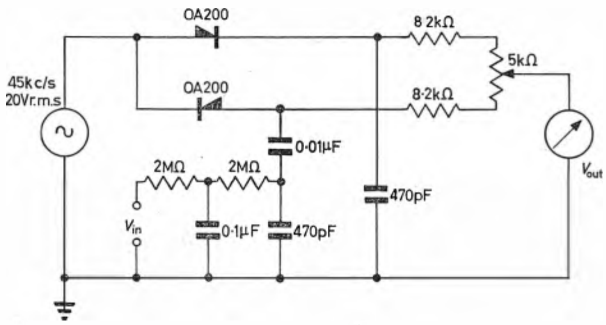


Fig. 11. Dielectric amplifier using ferro-electric properties

an input resistance of one million megohms.

Conclusions

A low-cost solid state dielectric amplifier having a million megohm d.c. input resistance has been described. This amplifier uses robust conventional components. The high input resistance is due to the low d.c. leakage obtainable with Zener diodes operated in a varactor mode. The ferro-electric amplifier described also exhibits a million megohm d.c. input resistance.

Acknowledgments

Thanks are due to G. and E. Bradley Ltd for permission to publish this article, and also to S. A. Husain for his co-operation in circuit construction and development.

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A Clinical Electromyograph with Improved Recall Facilities

By C. K. Battye*, L. D. Kitchen* and A. E. Pastellopoulos*

The article describes a new electromyograph design, using fully transistorized amplifiers, which allows the contents of a 1sec magnetic memory to be rapidly scanned and individual action potentials to be quickly measured.

(Voir page 763 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 770)

IN clinical electromyography the electrical potentials generated by the contraction of muscle fibres are picked up from the tip of a needle electrode inserted into the muscle, amplified, and observed on a cathode-ray oscilloscope. These 'action potentials' often occur at random, sometimes infrequently, and normally it is required to examine their shape and to record the potentials occurring during a given short interval of time and to recall some or all of them later for measurement. Two main types of recording have been in common use. Early apparatus made use of a closed loop of magnetic tape on which the incoming signals were continuously recorded. After one revolution of the tape, the recorded signal was erased and the cycle repeated. The time for one revolution, i.e. the memory capacity, was usually one or two seconds, and on switching to 'memory' the contents could be replayed repeatedly and examined at leisure. As each potential lasted for only a few milliseconds and was repeated only once every few seconds, the scanning of the memory contents and strobing of the selected impulse was a slow process. Later apparatus incorporated a Skiatron tube on which the signal was displayed during several scans across the tube face. A compromise must be made here between the scan speed, and consequently the size of the action potentials on the tube face, and the total capacity of the memory which was usually limited to about 0·05sec. The system described here was developed to give the larger information content of the closed loop magnetic tape system but with a much more rapid presentation of the results. The size of the observed potentials on the tube face can be made as large as required and, in addition, the whole of the recorded information is available at the end of the examination for further inspection, if necessary.

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Description of Memory

The signal picked up by the needle electrode is amplified before being monitored on a cathode-ray oscilloscope. At the same time it is recorded on a length of magnetic tape which is carried past the low impedance recording head at 7½in/sec by a standard commercial tape deck mechanism. When it is necessary to recall for measurement signals observed on the monitor, the tape drive is stopped, and the 7½in length of tape adjacent to the recording head is scanned by a replay head mounted on a revolving drum, around which the tape passes (Figs. 1 and 2). The signal picked off the tape is displayed on an oscilloscope (Telequipment D55A) with two channels so arranged that the first channel is strobed by the second. The time-base is triggered by a shaped pulse induced in a pick-up coil by a rotating magnet attached to the replay drum. The drum rotates at approximately 12rev/sec producing a steady trace showing the entire contents of the memory (i.e. 1sec recording) on one channel. On the second channel any action potential, selected on the first channel by a trace brightener, may be expanded to a convenient size for measurement. A picture of the display is shown in Fig. 3. The commercial direct recording amplifier and bias circuits are conventional. The replay amplifier, however, has a frequency response equalized to provide a pass-band extending from 800c/s to 100kc/s, which corresponds to a single pass-band of 40c/s to 5kc/s when the increased playback speed (approximately 20 times the recording speed) is taken into account. Some difficulty was experienced with spurious signals due to 'drop out' caused by imperfections in the tape. This was remedied by the use of high-grade instrumentation tape.

E.M.G. Pre-amplifier

The pre-amplifier used to detect the signals was a modified version of a circuit described by Knowles[1]. Silicon planar transistors are used to obtain high input impedance and low noise level. The measured rejection ratio was 10^4

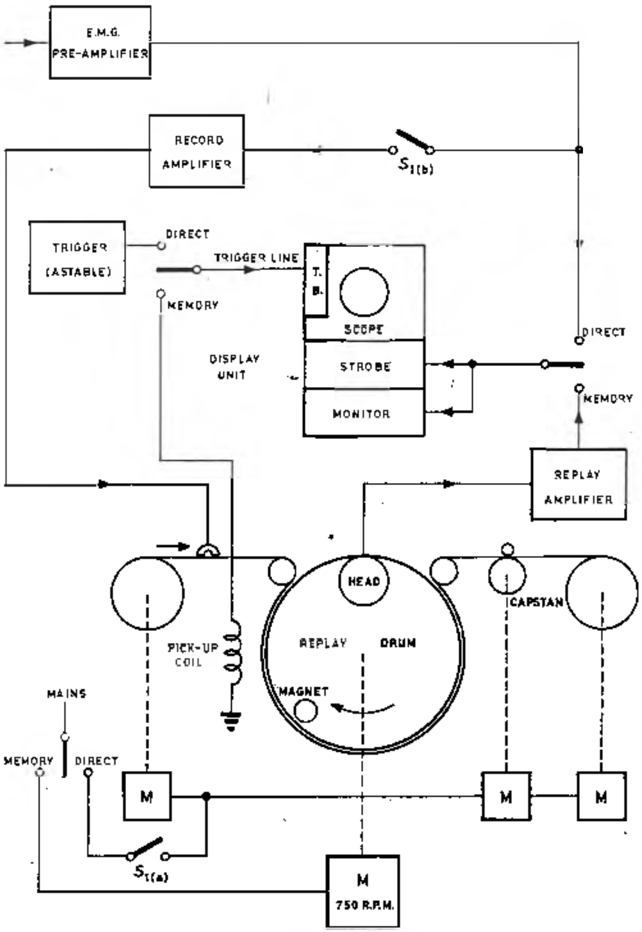

Fig. 1. Arrangement of apparatus

Fig. 2. Tape deck and scanning wheel

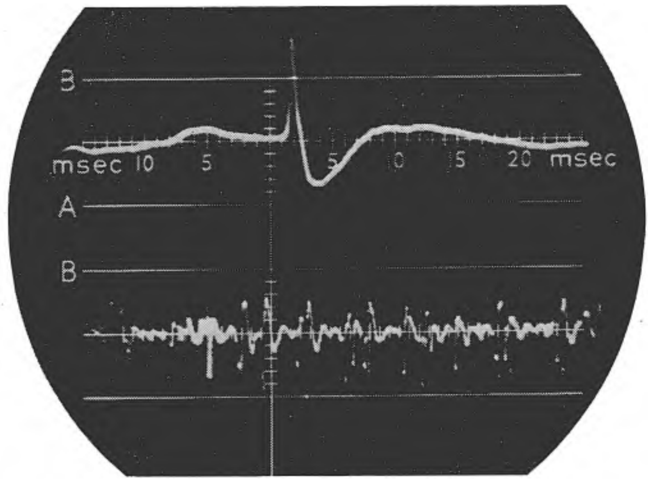

Fig. 3. Display showing memory contents
A—Strobed action potential
B—Memory contents

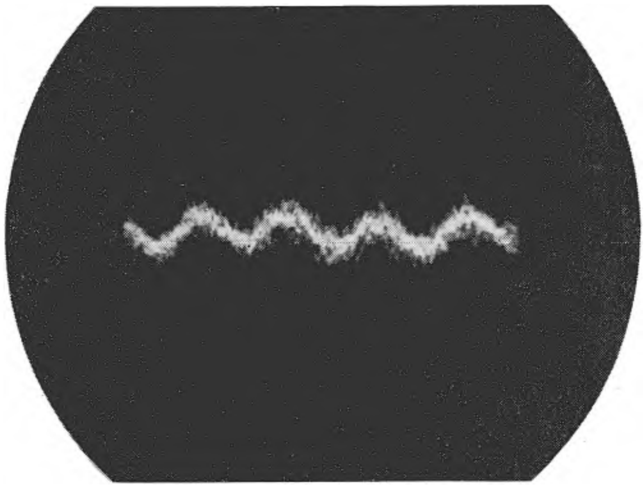

Fig. 4. 3μV r.m.s. sine wave and noise

and the noise level (see Fig. 4) was approximately 2μV r.m.s. with a source resistance of 15kΩ in a band similar to that of the recording system. The block diagram of the apparatus (Fig. 1) shows the pulse width modulated audio amplifier which completes the equipment.

Considerable importance was attached to the simplification of the controls and it was found possible to arrange these so that in practice it is necessary to manipulate only three press-buttons, the strobe control, and the gain control. The press-buttons control the change over from direct observation of the signals at the input to examination of the memory contents, all switching being as far as possible carried out by relays working from the press-buttons.

Acknowledgments

The authors are grateful to Messrs. Epsylon Industries Ltd for their help and for supplying the recording modules, recording heads, and prototype scanning drum and to Mr. R. E. George for the design and construction of the main amplifier and calibrator. Thanks are also due to Mr. W. Smith of the Photographic Department, King's College Hospital, for the reproductions.

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An Audio-frequency Waveform Synthesizer

By A. Horsman*

An oscillator is described which produces a sequence of sixteen rectangular pulses, each of independently variable amplitude, but of equal width. Synthesis is effected by adjusting the amplitudes so that the sequence of pulses approximates to the required waveform. The circuit described will do this over the audio-frequency range, and has an output whose amplitude and harmonic content are almost completely independent of the fundamental frequency.

(Voir page 763 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 770)

CONVENTIONAL methods of producing complex waveforms either involve the use of waveshaping circuits or the superposition of two or more sinusoidal oscillations. Since the response of most waveshaping circuits is frequency dependent, a change in input repetition rate results in a change in the harmonic content of the output waveform. The superposition method produces an output waveform, the stability of which depends on the frequency and amplitude stability of every input. The oscillator which is described below can produce an infinite variety of complex waveforms of continuously variable repetition rate. Its stability depends only on the stability of a driving multivibrator, and the harmonic content of the output is, ideally, independent of repetition rate.

Description

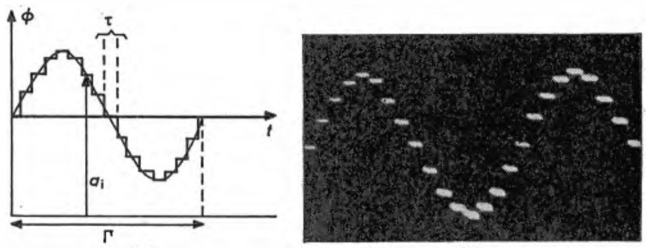
The oscillator generates a sequence of N rectangular pulses each of independently variable amplitude. All the pulses have the same duration τ, determined only by the time-constants of the driving multivibrator, which is therefore independent of pulse amplitude. Thus a change in the overall repetition rate $\Gamma = 1/N\tau$ is not accompanied by a change in the relative strengths of the harmonics. The synthetic waveform is an approximation by the sequence of pulses to the required function, the degree of approximation depending on N. The number N reflects the degree of control obtained over higher harmonics; in the design described, control is lost at the 7^{th} harmonic, since N was chosen to be 16; the strengths of harmonics higher than the 7^{th} are fixed by the use of rectangular pulses.

Consider for example the synthesis of a sinusoid. Fig. 1(a) shows the sequence of step functions by which this is to be represented. The i^{th} pulse is adjusted so that its amplitude a_i is the same as the ordinate of the sinusoid at the centre of the pulse. Fig. 1(b) is a photograph of the actual output generated by an oscillator of this type at a repetition rate of 5kc/s. Fig. 2 shows the synthesis of a sawtooth function at the same repetition rate.

Circuit

The oscillator circuit for the case $N = 16$ is shown in Fig. 3. A multivibrator M of variable repetition rate drives a chain of four binaries, $B_{1\text{-}4}$. The square wave outputs from the binaries are fed after clipping to a diode network.

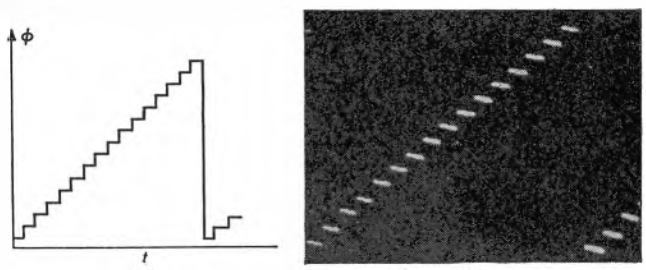
The multivibrator and bistable circuits are conventional and do not require further description. The diodes MR_1 are added to square the outputs fed to the diode matrix. The diodes in the matrix are arranged to connect the outputs from the collectors of the transistors in the binaries to the sixteen output lines $L_{1\text{-}16}$, so that a square pulse is produced on only one of these lines at any one time. The line bearing the pulse changes sequentially with each cycle of M. The amplitude of each pulse is adjusted by the linear potentiometer RV on the respective line, and the sixteen outputs added together, so that the final output is the required sequence of sixteen rectangular pulses. Any load connected to the output line should present an impedance of at least 200kΩ; otherwise the output waveform will be distorted.



(a) (b)

Fig. 1. Synthesis of a sinusoid

(a) Ideal waveform, and sequence of step functions
(b) Oscillator output at 5kc/s



(a) (b)

Fig. 2. Synthesis of a sawtooth function

(a) Sequence of step functions
(b) Oscillator output at repetition rate of 5kc/s

In a design which does not include feedback in the binary chain, N is necessarily 2^n, when n is the number of binaries employed. Designs may be envisaged for $N=64$ requiring six binaries and an extended network. However, in order to maintain the same range for Γ, the response of the binaries must be improved by a factor 4; furthermore, the driving multivibrator repetition rate must also increase by the same factor. Using the same multivibrator and binaries necessarily results in a lower value for the maximum repetition rate; also, the larger the diode network, the slower will be its switching speed and the greater the cross-channel interference, due to the parallel connexion of diodes of finite back resistance. Despite these limitations, the method has distinct advantages over a method described previously[1] which used a ring of N

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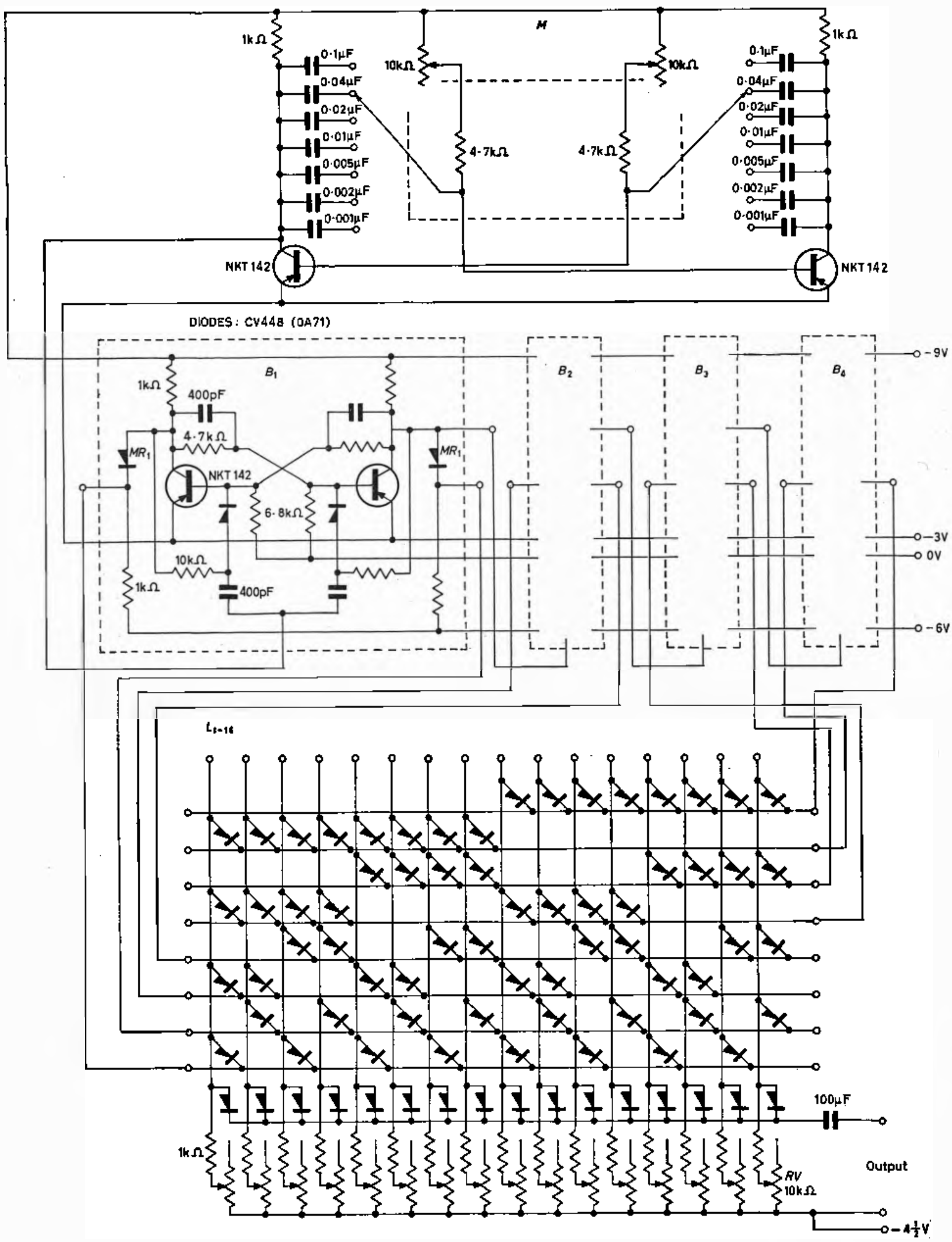

Fig. 3. The oscillator circuit for the case $N = 16$

binaries. The method of replacing the extra N-n binaries with a diode matrix results in a device which, as well as being simpler to construct and consuming much less power, is far more economical in both space and cost. In addition, no resetting is necessary, and the oscillator functions immediately the supply is connected.

Acknowledgments

The author would like to thank Dr. W. S. C. Williams and Dr. G. W. Series for their help and useful criticism during the preparation of this article.

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An Active Filter for Low Frequency Noise Power Spectra Measurement

By K. F. Knott*, B.Eng. and J. S. Bowman*, A.M.I.E.R.E.

A constant Q active filter is described which is suitable for narrowband noise measurements in the frequency range 1c/s to 10kc/s. The frequencyrange is covered in nine steps viz. 10^0, $10^{1/2}$, 10^1, $10^{3/2}$ . . . . . 10^4*c/s.*

It is shown that if Q is chosen to give a fractional 3dB bandwidth of 0·15 no serious error is introduced when a transit counting method is used to measure r.m.s. noise voltages.

(Voir page 763 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 770)

EXPERIENCE of noise power spectra measurement in the frequency range 1c/s to 10kc/s has shown that a narrowband filter with fixed centre frequencies is quite adequate. Suitable centre frequencies are 1, 3·16, 10, 31·6 . . . . . . 10 000c/s.

At low frequencies the disadvantages of passive filters are well known and one is usually confined to active types of filters. The filter described in the following text consists of two single tuned stages in cascade. Each stage consisting basically of a frequency sensitive passive network whose effective Q is increased by the application of positive feedback.

Before designing the filter thought has to be given to the kind of amplitude response and bandwidth required.

Amplitude Response and Bandwidth Requirements

Amplitude Response

The ideal amplitude response is that of a rectangular band-pass filter, however, the response given by two identical single tuned filters in cascade gives sufficient attenuation outside the 3dB points to prevent errors in measurements when dealing with non-uniform power spectra. The required transfer function is therefore:

$$A(\omega) = \frac{k^2}{1 + (Q\delta)^2} \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

where A = filter amplification
k = scaling constant
Q = effective Q-factor of a single tuned stage
$\delta = \omega/\omega_0 - \omega_0/\omega$

The 3dB bandwidth is equal to $(0{\cdot}645/Q)\,f_0$ and the equivalent rectangular bandwidth is equal to $(0{\cdot}785/Q)\,f_0$.

Bandwith

When measuring noise at low frequencies the length of observation time required to make measurements with a given statistical standard deviation increases as the bandwidth decreases[1]. Therefore in order to reduce the observation time to a minimum the largest bandwidth possible should be used. However, if a transit counting method[1] is used to obtain the r.m.s. output of the filter serious error can be introduced as the bandwidth increases. This is because the filter output departs from a quasi-sinusoidal waveform and tends towards a white noise waveform as the bandwidth is increased.

An experiment was carried out to determine the magnitude of error introduced in measuring the r.m.s. value of a filtered white noise source. The block diagram of the experiment is shown in Fig. 1. A white noise source is fed into a cascade filter whose Q could be varied. The centre frequency was maintained at 100c/s, while the 3dB bandwidth was varied up to 60c/s. The filter output r.m.s. voltage was measured simultaneously with a thermo-junction voltmeter and a transit counting voltmeter. The thermo-junction voltmeter reading was averaged over 200sec using a digital voltmeter to record the reading every 5sec. The transit counting method is inherently adapted to average over long periods.

The results of the experiment are shown in Fig. 2. The r.m.s. value σ_1 indicated by the transit counting voltmeter is compared with the true r.m.s. value σ_2 as indicated by the thermo-junction as the bandwidth is varied.

It is seen that little error is introduced if the fractional bandwidth is kept below 0·2.

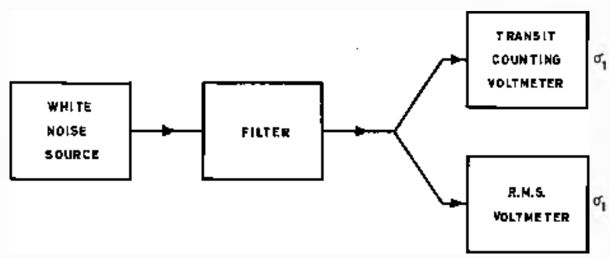
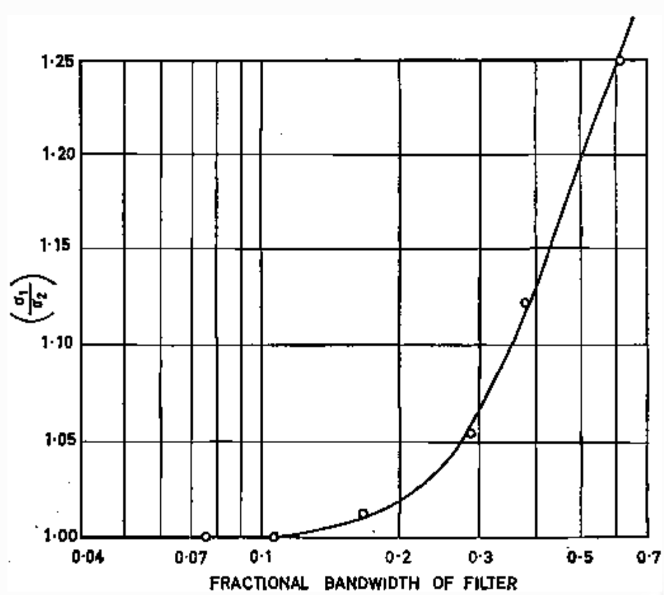


Fig. 1. System for determining maximum allowable bandwidth

Fig. 2. Transit Counting Voltmeter errors as a function of fractional bandwidth



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Design of Single Tuned Stage

Basic Circuit

One of the simplest frequency sensitive networks which has a band-pass characteristic is shown in Fig. 3.

Fig. 4 shows the circuit arrangement employing two transistors in which positive feedback is introduced, also the equivalent circuit assuming that the transistors are ideal. A valve version of this circuit is described by Klein *et al*[2].

For the case when $R_1 = R_2 = R$ and $C_1 = C_2 = C$ the phasor relationship between i and v_o in Fig. 4 is given by:

$$V_o = \frac{IR}{3\,(1 + (j\delta/3))} \quad \ldots\ldots\ldots\ldots \quad (2)$$

which is that of a single tuned circuit, but with a figure of merit of only $\frac{1}{3}$.

Considering now the combination of input and feedback signals:

$$\mathbf{I} = g_1\,\mathbf{V}_{in} + g_2\,\mathbf{V}_o$$

and:

$$\mathbf{V}_o/\mathbf{V}_{in} = \frac{g_1 R}{3 - g_2 R}\left[\frac{1}{1 + j\,(1/(3 - g_2 R))\delta}\right] \ldots\ldots \quad (3)$$

where $g_1 = (1/R_2) + (1/R_f) \quad g_2 = (1/R_f)$

This equation is again that of a single tuned circuit, but now the effective Q is given by:

$$Q = \frac{1}{3 - (R/R_f)} \quad \ldots\ldots\ldots\ldots \quad (4)$$

Practical Design

For this application it is important to maintain a quasi-sinusoidal output from the filter when the input is wide-band noise. It was therefore decided that the fractional bandwidth of the two tuned stages in cascade should not exceed 0·15. A Q per stage of 5 was chosen making the ratio R/R_f required equal to 2·8.

Perhaps the most important consideration was the physical size of the capacitors required at 1c/s, such that $C_1R_1 = C_2R_2 = 1/2\pi$.

A suitable value of capacitor was chosen to be 2·2μF, this made R_1 and R_2 = 72·5kΩ.

It was decided that the circuit should have the same impedance at all frequency settings. The capacitors were therefore switched and the resistors were common to all settings. In this case the frequency setting 10^0, 10^1, 10^2 etc. required capacitors 2·2μF, 0·22μF etc. and the frequency settings $10^{1/2}$, $10^{3/2}$ etc. required capacitors 0·696μF, 0·0696μF etc. The nearest standard capacitor to 696 is 680. This together with the tolerance would produce a small error in frequency. It was therefore decided to make part of the resistor R_2 variable so that this error could be compensated during the setting up.

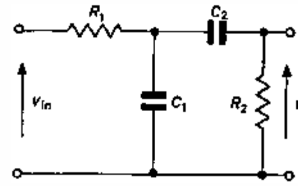
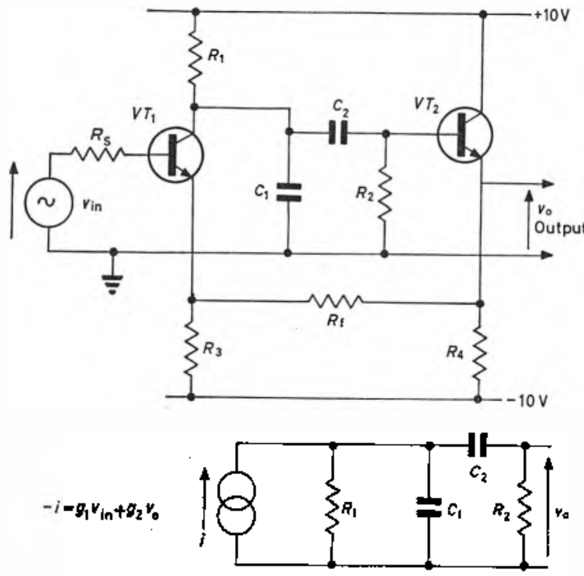


Fig. 3 (right). Basic frequency sensitive network

Fig. 4 (below). Circuit diagram and equivalent circuit of a single tuned stage



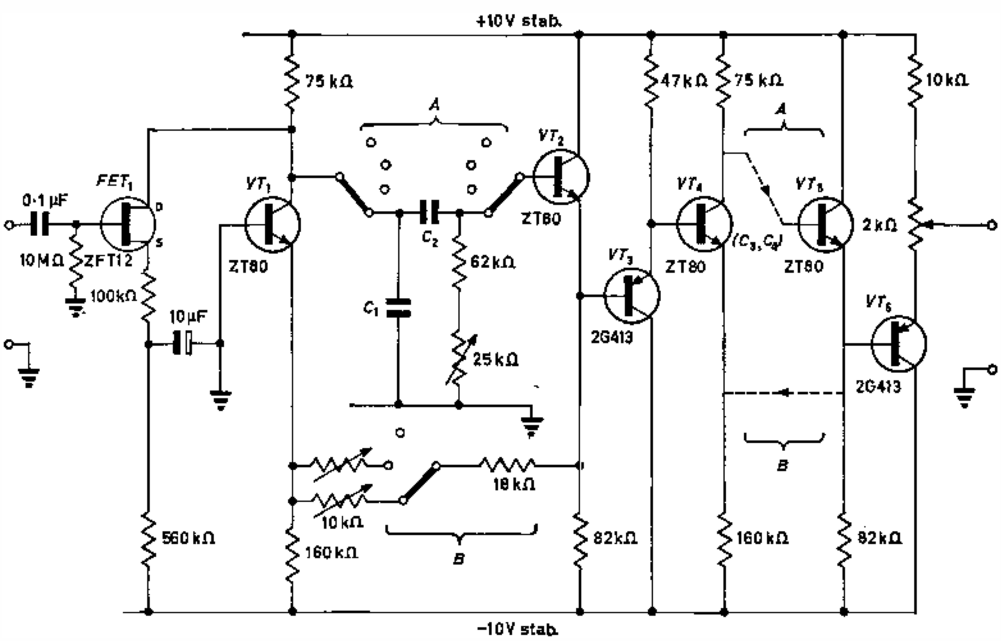
The input impedance of the transistor VT_2 is in parallel with R_2 and should therefore be large compared to R_2. This input impedance is given approximately by:

$$R_{in} = \beta\left[\frac{R_f R_4}{R_f + R_4}\right]$$

where β is the current gain of VT_2. For a single stage Q of 5 the feedback resistor $R_f = R_1/2{\cdot}8 = 26\text{k}\Omega$. Taking R_4 as say 100kΩ the magnitude of R_{in} would be approxi-

Fig. 5. Circuit diagram of cascaded two stage filter

Frequency (c/s)	1	$\sqrt{10}$	10	$10^{3/2}$	10^2	$10^{5/2}$	10^3	$10^{7/2}$	10^4
C_1, C_2, C_3, C_4 (μF)	2·2	0·68	0·22	0·068	0·022	·0068	·0022	·00068	·00022



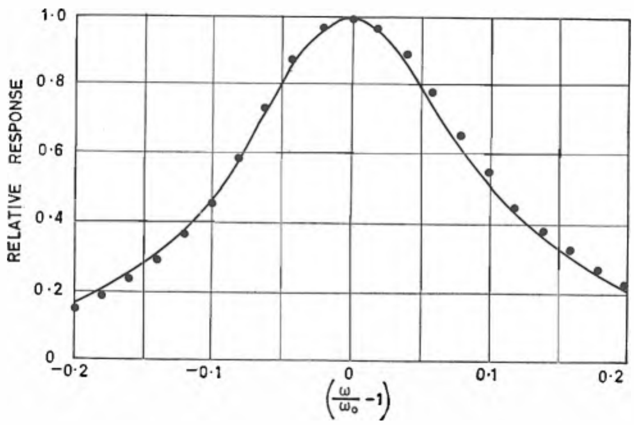


Fig. 6. Theoretical and experimental response
——— *Theoretical*
. . . . *Experimental points*

mately 600kΩ for a β of 30. This is only 8 times the value of R_2, and would therefore tend to increase the tuning frequency. But as R_2 has been made adjustable this error also can be cancelled during the setting up.

The value of g_2 is less than $1/R_f$ because of the impedance presented by VT_1 at the emitter, i.e. $1/g_m + R_s/\beta$ where g_m is the transconductance of VT_1. The value of g_2 is modified further by the output impedance of VT_2. If the β's are, say, 30 and the g_m of VT_1 is, say, 2·5mΩ^{-1} the impedances in series with R_f presented by VT_1 and VT_2 are approximately 500Ω and 2kΩ respectively. This represents about 10 per cent increase in the feedback resistance which may be cancelled by making R_f adjustable.

It is seen from equation (4) that the Q-factor is very dependent on the ratio R/R_f. This ratio can be affected by both source resistance and output loading. Steps have to be taken therefore to ensure that the source resistance and loadings are sufficiently isolated.

Cascading Stages

Two tuned stages in cascade are shown in Fig. 5. In order to isolate the input and output circuits of each stage it was necessary to incorporate a buffer stage in the form of an emitter-follower between the two stages. A further emitter-follower at the output provides a low output impedance and the potentiometer a means of adjusting the output d.c. level about the common line potential.

It was considered desirable that the complete filter should have an input which is high impedance and which is sufficiently isolated for the filter characteristic to remain unaffected by the input signal source impedance. A field effect transistor stage drawing its drain current via the collector of the first stage gives an input impedance of 10MΩ in parallel with 20pF. Isolation is achieved also by this configuration in which the base of VT_1 is connected directly to the common line. It was shown experimentally that source impedances between 0 and 10MΩ have negligible effect on the Q-factor or the tuned frequency except for the lag introduced by the input impedance.

In designing the f.e.t. stage the quiescent drain current was determined by the source resistors and the negative line potential such that, the voltage drop resulting across the VT_1 collector resistor did not reduce the possible excursion of the collector potential by more than 10 per cent.

The overall transfer characteristic of the final circuit was obtained experimentally. Fig. 6 shows the results plotted against a theoretical amplitude response.

In this circuit the minimum input signal is determined mainly by the ripple on the positive supply line. This is particularly acute when the ripple frequency is the same as the tuned frequency. For this case the hum is 60dB below the maximum output signal.

Discussion

The filter described has been found very reliable and useful in practice. No close tolerance components are required because of the ease with which the frequency and Q-factor can be set up. The basic design does not limit the use of the filter to noise measurements. The frequency of 1c/s is about the practical lower limit of this design using transistors. Any extension would require larger capacitors and these would probably have to be electrolytics. The experimental results for the effect of bandwidth on white noise are very interesting. At present there is no clear definition as to what is meant by 'narrowband noise'. The results shown in Fig. 2 might be taken as a means of distinguishing between narrowband and broadband noise.

Acknowledgments

The authors wish to thank Mr. H. Sutcliffe of the Royal College of Advanced Technology, Salford, for his suggestions and the results shown in Fig. 2.

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Manufacturing and Test Facilities for Plastic Encapsulated Transistors

A new production line has recently been installed by Texas Instruments Ltd, Bedford, for manufacturing silicon epitaxial planar transistors in the SILECT plastics package.

The SILECT package differs from earlier plastic encapsulated devices in that it employs a single block of silicone-plastic compound instead of the epoxy/ceramic compound that tended to suffer cracking with heat, encourage surface contamination, and generally exhibited low reliability.

Properties of the encapsulating compound used in the SILECT process ensures that the device is:

(a) Impervious to moisture
(b) Heat resistant up to and above soldering temperatures
(c) Moisture-proof sealed to lead material
(d) Free from contaminants liable to affect the transistor element
(e) Protected against ageing and shrinkage, even long-term.

The leads are formed in such a manner that, when they are embedded in the encapsulant, they cannot rotate and open-circuit, or otherwise damage the device.

Texas Instruments has now accumulated 2 million hours of life test data on SILECT plastic encapsulated transistors which show that they are as reliable as their counterparts in metal cans tested under the same conditions. These tests will be continued until 15 million device test hours have been completed.

Because of the larger number of parameters, the differing specifications involved, the testing and categorizing of transistors is an extremely complex operation.

The Super-CAT (Continuous Automatic Tester) designed by Texas Instruments to perform this operation, and recently installed at Bedford, is one of the first machines of its kind to be employed in Europe.

With a throughput of 9 000 units per hour, the Super-CAT is equipped to test 54 different parameters (46 at ambient temperature and 8 at elevated temperatures) and to categorize the transistors into 24 different types according to individual customer needs. Every transistor produced is tested to each of the specifications on the data sheet.

The varying customer specification outlines are read into a computer which controls the testing and sorting. In addition, this computer runs hourly check tests on the parameters under observation to ensure that each of the 54 test stations is functioning correctly.

Local Feedback Stages of Non-Minimum Phase-Shift Networks

By V. Mosca* and A. Rimondini†

Complete non-approximated formulae are given for voltage transfer function, input and output impedances of local and internal feedback stages of non-minimum phase-shift networks, calculated on well-known equivalent circuits of the linear lumped parameters type valid for valves, transistors and f.e.t. in the common cathode, common emitter and common source configuration.
Numerical examples, illustrating the presence of right-hand zeros are investigated, together with their influence on the behaviour of closed loop systems in which they are included.

(Voir page 763 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 770)

ANALYSIS of linear feedback amplifiers has attained a high degree of accuracy. On the other hand, owing to practical considerations, more or less approximated minimum phase-shift equivalent circuits are generally used to describe the single stages; in particular, the Miller approximation is extensively used to achieve easy separation between input and output circuits.

The thought that the use of non-approximated formulae might lead to results rather different from those usually obtained induced the authors to undertake their calculation.

The analysis shows that in some practical cases the non-minimum phase-shift structure of the stages considered leads to a different behaviour when they are included in a closed loop.

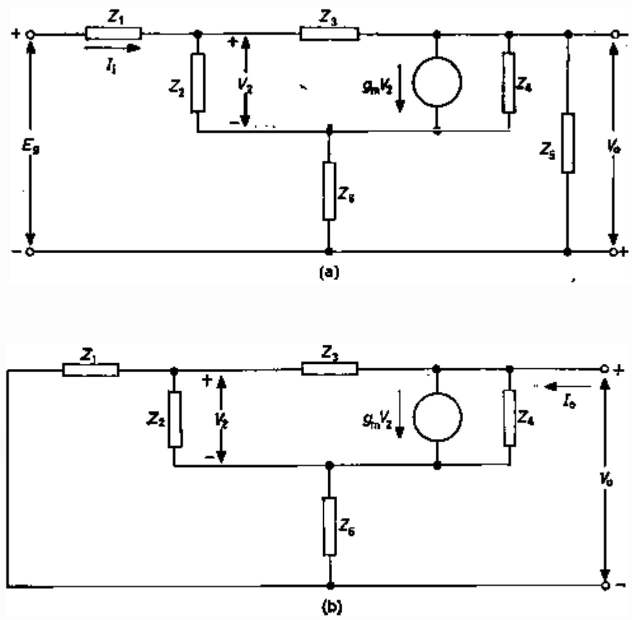

Fig. 1. Circuits for the evaluation of (a) voltage transfer function and equivalent input impedance and (b) equivalent output impedance

Analysis of the Equivalent Circuits

Fig. 1 shows typical equivalent circuits which have been used for the calculation of the desired expressions. For the sake of generality, parameters which will in turn be specified, whenever referring to a particular amplifying device, have been labelled as generic impedances.

Table 1 yields an example of such special parameters using the symbols by which they are most commonly designated.

By means of the usual methods of analysis, after some unwieldy algebra, the following formulae have been obtained. For the voltage transfer function:

$$V_o/E_g = Z_5\frac{Z_2Z_4[g_m(Z_3-Z_6)-1]-Z_6(Z_2+Z_3+Z_4)}{(g_mZ_2Z_4+Z_2+Z_4)(Z_3Z_6+Z_5Z_6+Z_1Z_6+Z_1Z_5)+Z_3(Z_4+Z_5)(Z_1+Z_2)+(Z_1+Z_5)(Z_2Z_4+Z_3Z_6)} \quad \ldots\ldots\ldots\ (1)$$

For the equivalent input impedance:

$$E_g/I_1 = Z_{ei}$$
$$= \frac{Z_2(g_mZ_4+1)(Z_1Z_6+Z_1Z_5+Z_3Z_6+Z_5Z_6)+Z_1(Z_2Z_4+Z_3Z_6+Z_3Z_4+Z_3Z_5+Z_4Z_5+Z_4Z_6)+(Z_2+Z_6)[Z_3(Z_4+Z_5)+Z_4Z_5]}{Z_2Z_4[1+g_m(Z_5+Z_6)]+Z_3Z_4+(Z_5+Z_6)(Z_2+Z_3+Z_4)} \quad \ldots\ldots\ldots\ (2)$$

For the equivalent output impedance:

$$V_o/I_o = Z_{eo} = \frac{Z_2(Z_1+Z_3)[Z_6(1+g_mZ_4)+Z_4]+Z_3Z_6(Z_1+Z_4)+Z_1Z_4(Z_3+Z_6)}{(Z_1+Z_6)[Z_2(1+g_mZ_4)+Z_3+Z_4]+Z_2(Z_3+Z_4)} \quad \ldots\ldots\ldots\ (3)$$

Reduced formulae, related to typical particular cases, originate from the foregoing:

(a) If $Z_4=\infty$; $Z_6=0$, then:

$$V_o/E_g = Z_5\frac{Z_2(g_mZ_3-1)}{Z_1Z_5(g_mZ_2+1)+(Z_1+Z_2)Z_3+(Z_1+Z_5)Z_2} \quad \ldots\ldots\ (4)$$

$$Z_{ei} = \frac{Z_1Z_5(g_mZ_2+1)+(Z_2+Z_3)Z_1+(Z_3+Z_5)Z_2}{Z_2(g_mZ_5+1)+Z_3+Z_5} \quad \ldots\ (5)$$

$$Z_{eo} = \frac{Z_1Z_2+Z_1Z_3+Z_2Z_3}{Z_1+Z_2+g_mZ_1Z_2} \quad \ldots\ldots\ (6)$$

(b) If $Z_4=\infty$; $Z_3=\infty$, then:

$$V_o/E_g = Z_5\frac{g_mZ_2}{Z_1+Z_2+Z_6(g_mZ_2+1)} \quad \ldots\ldots\ (7)$$

$$Z_{ei} = Z_1+Z_6+Z_2(g_mZ_6+1) \quad \ldots\ldots\ (8)$$

As can be seen, some of these expressions differ from those currently used.

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TABLE 1

	VALVE	TRANSISTOR	F.E.T.
Z_1	R_s	$R_s + r_{bb'}$	R_s
Z_2	$R_g // c_{gk}$	$r_{b'e} // c_{b'e}$	$R_b // c_{gs}$
Z_3	$c_{ag} //$ e.e.f.n.	$c_{b'c} // g_{b'c}$	$c_{gd} //$ e.e.f.n.
Z_4	$r_a // c_{gk}$	$h_{oe} // c_{ce}$	$r_d // c_{ds}$
Z_5	Z_L	Z_L	Z_L
Z_6	Z_k	Z_e	Z_s

'e.e.f.n." stands for 'eventual external feedback network'

For instance, expression (4) should be compared with the voltage transfer function yielded by the Miller approximation:

$$V_o/E_g = Z_5 \frac{g_m Z_2 Z_3}{Z_1 Z_2 (g_m Z_5 + 1) + Z_3 (Z_1 + Z_2)} \quad \text{.........} \quad (9)$$

Discussion of Numerical Examples

To test the character of the pole-zero configuration of the following stages, with regard to stability, the assumption has been made that they are inserted in a closed loop. The latter is formed by the stage under test and by another ideal stage having an infinite bandwidth and supposed to have variable gain. The loop is closed through a unity feedback path (Fig. 2).

EXAMPLE 1

As an example concerning expression (4), consider a simplified f.e.t. in a circuit as in Fig. 3. The parameters are:

$$Z_1 = 10^6\Omega \qquad Z_2 = \frac{1}{p\,1{\cdot}4\,.\,10^{-12}}\Omega$$

$$Z_3 = \frac{1}{p\,10^{-12}}\Omega \qquad Z_4 = 33\text{k}\Omega \qquad g_m = 2\,.\,10^{-4}\ \text{A/V}$$

The voltage transfer function is then:

$$V_o/E_g = 6{\cdot}6\,\frac{1 - p\,0{\cdot}005\,.\,10^{-6}}{(1+p\,0{\cdot}0051\,.\,10^{-6})\,(1+p\,9{\cdot}001\,.\,10^{-6})} \quad .. \quad (10)$$

On neglecting the zero and the pole at the higher frequencies (they do not eliminate each other, because they are situated on opposite sides of the imaginary axis), one finds an expression practically identical to that which could be found through the Miller approximation.

EXAMPLE 2

A capitance of 10pF has been added in parallel to the load resistance of 33kΩ in the circuit of Fig. 3, to investigate the most frequent case in which the stage is loaded by a following one, presenting an input capacitance to which the capacitance of the wiring must be added. Thus:

$$Z_5 = 33\,.\,10^3/1 + p\,33\,.\,10^{-8}\,\Omega$$

Then:

$$V_o/E_g = 6{\cdot}6\,\frac{1 - p\,0{\cdot}05\,.\,10^{-7}}{(1+p\,0{\cdot}646\,.\,10^{-7})\,(1+p\,78{\cdot}8\,.\,10^{-7})} \quad \text{......} \quad (11)$$

Owing to the insertion of the stage in the loop, the foregoing expression has to be re-arranged in the form suitable for the use of the root locus method:

$$KGH = -K_2\,65\,.\,10^3\,\frac{p - 20\,.\,10^7}{(p + 1{\cdot}548\,.\,10^7)\,(p + 0{\cdot}0127\,.\,10^7)} \quad .. \quad (12)$$

where $K = K_1 K_2$.

The locus is given in Fig. 4, according to the rules established in the appendix.

The right-hand zero, by bending the locus towards the right-half plane, generates an early intersection with the imaginary axis, which happens already for K_2 slightly greater than 23.

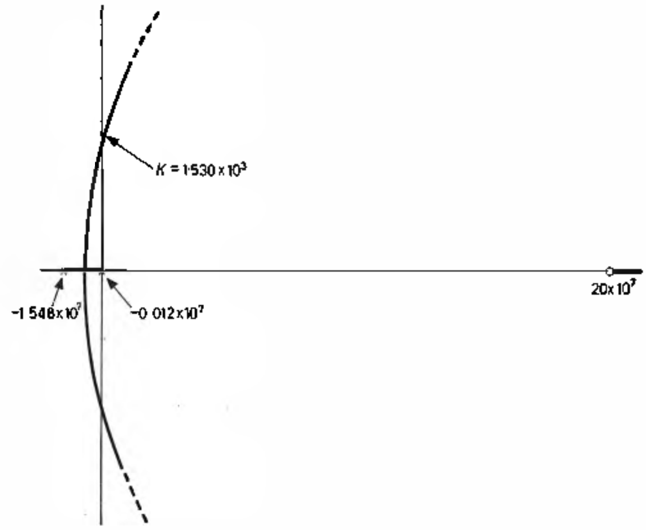


Fig. 4. Root locus for example 2

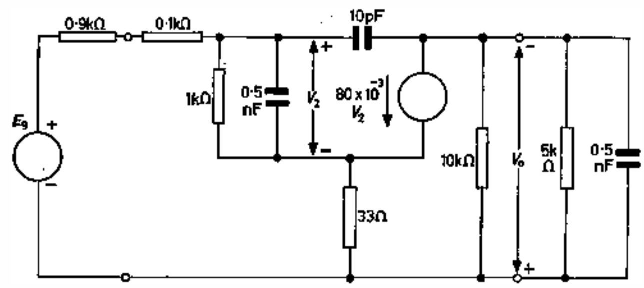


Fig. 5. Differential amplifier stage

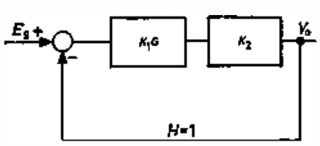
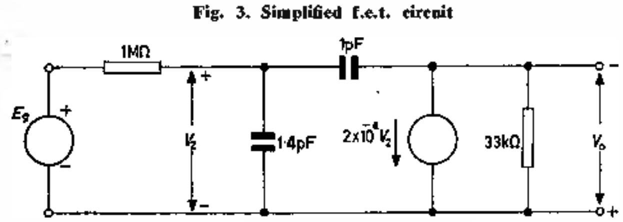


Fig. 2. Arrangement of test loop

Fig. 3. Simplified f.e.t. circuit



EXAMPLE 3

To investigate a more general example, consider now the case of a transistor connected in a differential amplifier stage loaded by a parallel *RC* network.

As is known, in such stages it is common practice to insert a small resistance in series with the emitter of each transistor to achieve a better balance. In the evaluation of the differential mode, it may be shown (for instance, by means of the bissection theorem) that those resistances cannot be eliminated from the equivalent circuit.

Consider therefore the circuit diagram of Fig. 5.

$$Z_1 = 10^3\Omega \qquad Z_2 = \frac{10^3}{1+p\,5\,.\,10^{-7}}\Omega \qquad Z_3 = \frac{1}{p\,10^{-11}}\Omega$$

$$Z_4 = \infty \qquad Z_5 = \frac{3{\cdot}3\,.\,10^3}{1+p\,1{\cdot}65\,.\,10^{-6}}\Omega \qquad Z_6 = 33\Omega$$

$g_m = 80\,.\,10^{-3}$ A/V

Expression (1) yields directly the voltage transfer function in the form suitable for the root locus plot:

$$KGH = -K_2\,2{\cdot}01\,.\,10^6 \frac{(p-10^3)(p+220\,.\,10^6)}{(p+0{\cdot}46\,.\,10^6)(p+18\,.\,10^6)(p+2222\,.\,10^6)} \quad \ldots\ldots\ldots\ldots\ldots\ldots (13)$$

The significant part of the locus is given in Fig. 6.

Again, the destabilizing effect of the right-hand zero is clearly noticeable. On following the same concepts as in example 2, it is found that, for $K_2 > 8$, instability will certainly arise.

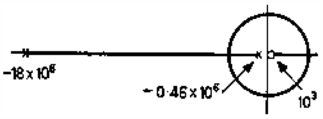


Fig. 6. Root locus for example 3

Conclusions

Some examples have been worked out, which clearly show the insufficiency of the usual approximation methods when dealing with local feedack stages (valve, transistor or f.e.t. stages), which are inserted in feedback loops.

It has been verified that the related equivalent circuits are of non-minimum phase shift structure and it has been shown that the existence of right-hand zeros may, under some circumstances, lead to instability.

Appendix

Variations to the Rules for the Construction of Root Locus Diagrams When the Transfer Function Contains Zeros with Positive Real Part

(a) *Analysis of the structure of K*

$$K = K_1 \frac{T_1\,T_3\,.\,.\;T_5^2\,.\,.}{T_2\,T_4\,.\,.\;T_6^2\,.\,.} \quad \ldots\ldots\ldots\ldots\ldots (14)$$

where: K_1 = gain of the open loop function

$T_1, T_3, .\,., T_5, .\,.$ = numerator time-constants of the same

$T_2, T_4, .\,., T_6 .\,.$ = denominator time-constants of the same.

The sign of K is positive if the number of time-constants affected by a minus sign is even; it is negative if this number is odd (obviously, factors like $T_5, T_6, .\,.$ in expression (14) do not affect the sign of K because they are present with exponent 2).

For instance, suppose $T_1 < 0$. Then:

$$KGH = K_1 \frac{(1-pT_1)(1+pT_3)\,.\,.\,(1+2\zeta T_5 p+p^2T_5^2)\,.\,.}{p^n(1+pT_2)(1+pT_4)\,.\,.\,(1+2\zeta T_6 p+p^2T_6^2)\,.\,.} \quad (15)$$

Re-arranging equation (15) for root locus analysis:

$$KGH = -K_1 \frac{T_1T_3\ldots T_5^2}{T_2T_4\ldots T_6^2}\;\frac{(p-1/T_1)\ldots}{\ldots\ldots\ldots\ldots}\ldots (16)$$

Thus:

$$K = -K_1 \frac{T_1T_3\ldots T_5^2}{T_2T_4\ldots T_6^2} \quad \ldots\ldots\ldots\ldots\ldots (17)$$

K is now affected by a minus sign.

(b) *Variations to the rules for the construction of the diagram*

From the fundamental relation[1,2]:

$$1 + KGH = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots (18)$$

and from the related angular equation:

$$\arg(KGH) = (2n+1)\,180° \quad \ldots\ldots\ldots (19)$$

it is found that, when $K < 0$, equation (19) becomes:

$$\arg(KGH) = 2n\,180° \quad \ldots\ldots\ldots\ldots\ldots (20)$$

From equation (20) arises the fact that some among the rules of construction of the locus must be varied. They are:

(1) The locus exists at any point along the real axis where no singularities or an even number of singularities is found to the right of the point.

(2) For large values of gain, the locus is asymptotic to the angles:

$$\frac{2n\,180°}{P'-Z'}\;;\text{ for } n = 0, 1, 2, \ldots.$$

where P' is the number of poles and Z' is the number of zeros.

(3) The angle of departure from complex poles and the angle of arrival to complex zeros are found by summing the angles to all the singularities.

REFERENCES

1. Savant, C. J. Basic Feedback Control System Design, p. 85 (McGraw-Hill, 1958).
2. Truxal, J. G. Control System Synthesis, p. 227 (McGraw-Hill, 1955).

An Acoustic Traffic Detector

A simple type of traffic sensor which detects from overhead, vehicles passing a point on a road, has been developed by The Marconi Co. Ltd. The device can be easily mounted on lamp standards, bridges or any other convenient structure over a traffic lane and uses radar-like principles to detect objects travelling underneath. It provides a cheap and accurate method of monitoring the passage of vehicles for use in the simplest traffic light system or in complex computer-controlled schemes.

The sensor can be installed on lamp standards, gantries or bridges at any height above the road in the range 5 to 10 metres. A strong fibreglass case ensures complete protection of the electronic circuits from the most adverse weather conditions and further reliability is ensured by the use of printed circuits.

The method of operation of the sensor is simple and extremely effective. Bursts of ultrasonic energy are emitted from a transducer and reflected from the road surface or the roof of a passing vehicle. Reflections from the top of a vehicle arrive before those travelling the maximum distance to and from the road. This difference in time caused by a vehicle passing through the beam is detected and a reed relay is energized, closing a pair of contacts. This can be used to operate counters, monitoring units or chart recorders, positioned, if necessary, long distances away.

The sensor can be adjusted so that vehicles above a certain height will operate a different relay, allowing, for example, cars and lorries to be monitored separately. This is achieved by using two gating circuits each sensitive to reflections from different levels above the road.

By assuming that each vehicle passing beneath the sensor is an average length, it is also possible to obtain a rough indication of its velocity, which is then inversely proportional to the length of time that it remains in the beam. This is only a very approximate measurement and more accurate information can be obtained by using two sensors, positioned at a set distance apart. The speed is then exactly a function of the time taken for a vehicle to pass between the two.

The sensor, employing silicon transistors, consists of a transmitter, a receiver and processing unit. The transmitter has a drive unit powering a transducer which emits pulses of ultrasonic waves at a repetition rate of 20-25 times per second. A similar transducer receives the returning beam and the signal is amplified before entering a processor where special circuits ensure that noise, undesired reflections and direct transmitter breakthrough do not cause inaccurate readings.

SHORT NEWS ITEMS

'Numerical Control of Production Processes' is the title of a one-day conference to be held at the University of Aston in Birmingham on 30 November. The conference has been organized by the Society of Instrument Technology under the aegis of the United Kingdom Automation Council. The object of the conference is to focus attention on the newer and less well-known uses of numerical control in production processes.

The first two papers will be devoted to the background and basic technique. The remaining papers will be devoted to the specialities of particular applications of numerical control to production processes; and it is hoped that they will stimulate other industries to consider the adoption of numerical control in relation to their own problems.

Further details and registration forms are available from The Secretary, The Society of Instrument Technology, 20 Peel Street, London, W.8.

'Industrial Design in Engineering' is the subject of two more courses which are being arranged by the Council of Industrial Design this autumn. The first, from 20 to 25 November, is for the engineering staff, while the second, from 28 November to 2 December, has been planned for senior management. Both courses are residential and will be held at the Prince of Wales Hotel, Kensington, London; the inclusive fee for each course is 45 guineas per person.

Further information about the courses can be obtained from W. H. Mayall, Course Controller, Council of Industrial Design, 28 Haymarket, London, S.W.1.

Thomson Regional Newspapers are to install at their Hemel Hempstead plant, early in 1967, two Elliott 903 computers for computer-aided typesetting.

This plant will be used to produce the two new Thomson evening papers, the Watford Evening Echo and the Luton Evening Post.

These new orders for Elliott-Automation follow the successful experience of computer-aided typesetting gained by Thomson Regional Newspapers with the Reading Evening Post. A National-Elliott 803 computer has been in use at Reading since July 1965 and two Elliott 903 computers will be installed there shortly.

In these on-line systems, a keyboard operator transmits copy to the computer. Typographic programs held in the computer's memory produce a corrected tape output for operation of the typesetting plant. The operator is able to insert hyphens as necessary, to check that input is correct and to confirm that appropriate instructions have been fed to the typesetting machinery by the computer.

S.T.C. Semiconductors Ltd has been granted full approval by the Electrical Inspection Directorate (E.I.D.) of the Ministry of Aviation, to carry out Qualification Approval specification tests on semiconductor devices manufactured at the company's Footscray, Sidcup, Kent, factory.

The company is believed to be the first to receive such approval since the general requirements for Qualification Approval of semiconductor devices were published by the Ministry of Aviation in March this year.

The approval means that specification tests on new semiconductor devices submitted by the company for qualification approval can now be carried out by the company's own inspection organization under the supervision of E.I.D. inspectors.

British Rail's North Eastern Region is to install a computer-type electronic memory system covering eight important signal boxes in the Leeds area. The system, which is being supplied by Elliott Traffic Automation, will remember the position and identification of trains in each sector of the track and will present this information to the signalman in the form of a cathode-ray display.

This is the second Region of British Rail to order advanced train describer equipment from Elliott Traffic Automation. The Southern Region is currently installing similar equipment in three busy signal boxes on the London-Bournemouth line.

The central train describer, situated in the main Leeds Signal Box, will have an 18-bit, core-store memory of over 8 000 words—the same as a computer—and the rest of the system incorporates solid-state silicon transistor logic.

This new approach is not only compatible with the requirements of full computer control of railway signalling, but it is cheaper, inherently more reliable, and occupies a fraction of the space required by conventional equipment. Power consumption is also much less, an important consideration in a system which has to be kept operating in the event of a power failure.

Kelvin Electronics Company, a Division of Smiths Industries Ltd, has been appointed exclusive, U.K. and Eire, sales and service agents for Princeton Applied Research Corporation of Princeton, New Jersey. The products to be marketed are precision instruments for research and development. They include a range of lock-in amplifiers for the measurement of extremely weak signal intensities in the presence of noise, waveform educators which extract repetitive waveforms or transients from noise, low-noise, high-gain amplifiers ideally suited to many small signal processing applications requiring a high quality pre-amplifier. Precision voltage-current reference sources, spinner magnetometers, and many other high precision instruments.

Electronic traffic control equipment worth over £40 000 has been ordered from Elliott-Automation by the Prague city authorities for the first stage of a new traffic modernization scheme. The equipment, which includes solid-state local controllers, vehicle-detection devices and traffic lights, will be used to control ten of the busiest road intersections in the city.

The local traffic controllers ordered for Prague are a new development of Elliott Traffic Automation and provide a form of transistorized traffic light control which can be used either as a completely autonomous device or which can be linked to an Elliott on-line computer for full traffic automation systems.

The BBC-2 service from Pontop Pike will start on Saturday, 5 November, on Channel 64 with horizontal polarization. Test transmissions began on 22 October.

Pontop Pike will bring BBC-2 to some 1 700 000 people in the north-east of England, including Newcastle upon Tyne, Gateshead, Jarrow, Tynemouth and North Shields, Durham and parts of Bishop Auckland, Sunderland and Middlesbrough.

NCR 315 computers have been ordered by the Toronto-Dominion Bank of Canada and the Mexican Federal Electricity Commission.

In Montreal, the 315 will be used to handle the bank's increasing volume of business while, in Mexico, the Commission will use a 315 system to control customer accounting and electricity generation.

The Toronto-Dominion Bank already has two NCR 315 computer systems in operation at its data processing centre in Toronto. The new equipment configuration, which is due for delivery in October, will include, in addition to the central processor, three CRAM (Card Random Access Memory) units, a high-speed printer, paper tape reader and punch, a punched card reader, a high-speed document sorter, and other peripheral units.

Texas Instruments Ltd announce that silicon diode production capacity for UNI/G computer and general purpose diodes at their Bedford plant has now been trebled.

Immediate benefit is that availability is greatly increased, but TIL also expect that increased production will enable them to reduce prices progressively over the coming months.

As part of a mechanization programme, new equipment has been installed to improve diode sealing and to speed testing. The new facility is capable of assembling and testing more than $1\frac{1}{2}$ million silicon diodes per month.

Muirhead and Co. Ltd has returned from Moscow with a signed contract for all the document transmission machines on their stand at the Moscow Interorgtechnika-66 Exhibition, the first international exhibition in the U.S.S.R. of business equipment.

The equipment, the Mufax Courier 900/901, was demonstrated in the 'British Office Complex', part of the British feature at the exhibition.

The system allowed for two-way communications between a central station and five out-stations. Pages of 'Pravda' were transmitted from the stand and were showing on all five receivers while parties of Soviet and other East European specialists and representatives of foreign trade organizations toured the exhibition.

Litton Precision Products International Inc., Hayes, Middlesex, a subsidiary of Litton Industries, has appointed Walmore Electronics Ltd exclusive distributors in the U.K. for the industrial range of transformers, inductors and other wound components manufactured by the Triad Division of Litton Industries.

The Triad range includes audio and miniature transformers, pulse transformers, plug-in telemetry filters, geoformers with special low frequency characteristics and sub-miniature toroids. Many of the Triad components meet the requirements of MIL-27-A.

Welwyn Electric Ltd has signed an agreement with Micro Measurements Inc. of Romulus, Michigan, U.S.A., giving Welwyn exclusive rights to market the M.M. range of precision foil strain gauges and associated products. The territories covered by this agreement include the U.K., Scandinavia, Holland, and all countries of the British Commonwealth, past and present, excluding Canada.

Micro Measurements Inc. is a company formed with the objective of producing the highest quality gauges with an associated programme of continuous development. As it is not part of a larger company with other interests, all the available effort is concentrated on this one objective.

The range of strain measurement products will be handled by a new London-based Strain Gauge and Equipment Division (70 High Street, Teddington, Middlesex), where large stocks will be held in order to give rapid delivery to customers.

S.G.S. Fairchild, Fairchild Camera & Instrument Corp., and Texas Instruments Inc. have entered into a cross-licence agreement for the patents belonging to each in the field of semiconductor devices and related manufacturing equipment. The agreement, extending for ten years, covers patents throughout the world except Japan. Included in the grants are licences under the Fairchild patents on the planar process and under Texas Instruments covering integrated circuits.

The Hawker Siddeley Group Ltd has entered into an agreement with American Bosch Arma Corporation for the purchase of the latter's 49 per cent interest in S. G. Brown Ltd. As a result of this agreement S. G. Brown will become a wholly-owned Hawker Siddeley company.

Licence arrangements additional to those which have been operated with success for the past nine years are being negotiated between American Bosch Arma and S. G. Brown, and liaison on the present licences is being further strengthened.

A new microelectronic computer, sufficiently adaptable and low in cost for use in many different types of civil and military automation schemes, has been announced by The Marconi Co. Ltd. The new machine, called Myriad II, is a simpler version of the ultra-high speed Myriad I, which was the first commercially available integrated circuit computer, and one of the world's most powerful microminiature machines. Myriad II is an extension to the Marconi range; a basic instrument using modular construction techniques which can be built up by adding extra units into a computer with any or all of the Myriad I facilities.

Myriad II is a parallel computer using a 24-bit word and an order code which is in a simple, single address form, the orders being obeyed sequentially. This simplifies operation and gives a choice between several different methods of arranging the main programme.

Two sizes of store unit are available with either 4 096 or 16 384, 24-bit words, providing storage capacity up to a maximum of 32 768. The stores are coincident current, ferrite core types with a cycle time of 1·5 microseconds and an access time of 0·5μsec. If required, magnetic disk or drum stores with average access times of 85 and 10msec respectively can be added and a maximum capacity of 2 million words is then available.

Myriad II is designed to form the heart of complex data-handling systems in industrial process control and all types of traffic control. Systems can be provided for small control centres which can be built up, as the degree of automation is increased, into a highly sophisticated system as versatile as the Myriad I itself. Myriad I will still be more suitable for those applications where the ultimate in high speed is an important requirement and where rigorous environmental conditions have to be met.

Redifon Ltd, the principal manufacturing company of the Rediffusion Group, has obtained a £70 000 contract for re-equipping communications networks at Lungi Airport in Sierra Leone. The order is for the supply of communications equipment and navigational aids for the airport, which is being developed to international standards by the Government of Sierra Leone.

The Redifon equipment will be used to link Lungi Airport with air traffic centres in Robertsfield, Liberia and Dakar, Senegal, and for upgrading national and international ground-to-air communications facilities. Lungi's navigational aids will be extended, some existing navigational facilities being overhauled and re-installed. Redifon will also re-design the airport's receiving and transmitting aerial installations.

Main contractors for the reconstruction of Lungi Airport are Whatlings (Overseas) Ltd, with Pye Telecommunications Ltd as the principal electronics sub-contractors.

The Ascension Island earth station, built for Cable and Wireless Ltd by The Marconi Co. Ltd as a vital communications link for the U.S. Apollo man-on-the-moon project, has been completed on schedule and handed over to Cable and Wireless Ltd.

The earth station, costing £1M, is now available for operation. It will communicate to the Goddard Space Flight Centre in Maryland via the Andover (Maine) earth station and the Intelsat II satellite which, it is expected, will be placed in its orbit above the Atlantic within the next month.

The contract for the Apollo communications is for a ten-year period and covers the provision of six voice data and two teletype circuits.

Cable and Wireless Ltd has received enquiries from the United States for a further twelve voice channels to operate between Ascension and North America using the same dish aerial. This will involve the installation of a further £100 000 worth of equipment. This additional requirement will not be for the Apollo project.

Automatic Punched Tape Ltd of Croydon, manufacturers of punched paper tape equipment for the computer and data processing markets, has been purchased by the Tally Corporation of Seattle, U.S.A., following negotiations recently completed between the directors and shareholders of both companies.

Tally are major suppliers of machines and equipment in the U.S.A. and the acquisition of their United Kingdom distributor marks a significant stage in their programme of expansion in the European market area.

Automatic Punched Tape will continue to import Tally products for resale in the United Kingdom for the present, although future local U.K. manufacture is planned for supplying internal requirements, and for export to European customers.

Automatic Punched Tape has developed a range of equipment complementary to that of Tally and which now, through the medium of Tally's world-wide representative organization, will be sold additionally in overseas markets.

The Medical Research Council has ordered a £280 000 high-speed scientific computer from G.E.C. Computers and Automation Ltd. It will be used by numerous M.R.C. research establishments for general computing purposes.

The order, which follows the Flowers Committee's recommendation that the M.R.C. should acquire about £0·2M worth of computer equipment a year and establish its own computing centre, is one of the largest yet placed with G.E.C. for off-line general purpose computers.

The system will be installed next spring at the Council's new Computer Unit in North London, and will consist of a G.E.C. Series 90 Model 300 computer and a range of peripheral items such as magnetic tape units, rapid access magnetic disks, line printers, and card and paper tape readers and punches.

The Model 300 is the most powerful computer in the G.E.C. Series 90 range and has a 32 000-word memory store, 24-bit word length, and a memory cycle time of 1·75μsec. It has a multiplication speed of 7μsec and can therefore multiply numbers with up to eight decimal places at a rate of 150 000 a second.

Morganite Resistors Ltd of Bede Trading Estate, Jarrow, one of this year's winners of the 'Queen's Award to Industry' for export achievements, has received a record order from U.S.A. for 42 million carbon resistors worth approximately £120 000. The order, secured through the company's agents, Collins and Hyde Incorporated, of Palo Alto, California, is almost double the size of any previously obtained in America.

Since 1962, when Collins and Hyde were appointed, sales of resistors have rocketed, mainly due to the rapidly increasing demands for electronic and colour television equipment. Sales to U.S.A. reached £260 000 last year and the company is confident of increasing the figure this year to over £400 000.

Two leading manufacturers of electrical and electronic control equipment, Brookhirst Igranic and Lancashire Dynamo Electronic Products, are to coordinate their activities more closely and to pool their marketing resources.

To this end the two companies, both members of the Metal Industries Group, have set up a new organization called Industrial Automation Controls Ltd.

A new method of computing to solve complex problems will be in use next year by up to 160 scientists at the United Kingdom Atomic Energy Authority Research Establishment at Harwell.

A communications system is being installed connecting individual teletypewriter stations to a high-speed AEI CON/PAC 4060 process computer which will be programmed to organize the flow of messages to and from the computer performing the calculations.

By typing out the problem and pressing a button, each scientist will send his question to the CON/PAC computer for loading on to the data processing machine. When the calculations have been completed the CON/PAC will switch the answer to the correct teletypewriter station and the details will be produced as a typed output. Considerable time will be saved by the new system, and the computer workload will be mainly channelled through the CON/PAC machine.

This type of multi-access computing centre is designed to give most rapid service to the users and at the same time make good use of the work capacity of the data processing computer.

The second part of B.S.3939: *Graphical symbols for electrical power, telecommunications and electronics diagrams* Section 5, *Capacitors* and Section 6, *Inductors, transformers and transductors* has now been published. Symbols specified in B.S.3939 are identical with those agreed within the International Electro-technical Commission (IEC) except where established U.K. usage makes this impracticable at the present time. The lists of symbols and descriptions also give the general component reference (GCR) and show whether or not the symbol agrees with the IEC Recommendation.

Sections of B.S.3939 already published cover an introductory part, general symbols, unclassified symbols, conductors and connecting devices, and resistors. Further sections are in course of preparation.

Copies of B.S.3939 Sections 5 and 6 may be obtained from the BSI Sales Branch, 101/113 Pentonville Road, London, N.1. Price 10/- each (postage 9d extra will be charged to non-subscribers).

Corrections

In the article 'Low Frequency Noise Measurements on the P-Channel M.O.S.T.' by P. W. Fry, which appeared in the October 1966 issue, line 10 of the left hand column of page 650 should read:

(a) An equivalent noise voltage generator . . . Fig. 1 should be inverted.

The caption to Fig. 6 should include the following:

The solid lines are calculated curves for $C_G = 11$pF.

Experimental points: $\Delta = R_S = 1000$MΩ; o $= R_S = 100$MΩ

The caption to Fig. 7 should include:

Dotted lines are theoretical curves for $C_G = 11$pF.

Experimental points: $\Delta = R_S = 1$MΩ; o $= R_S = 5$MΩ

In the article 'Point on a Cycle Switch' by R. A. Stevens, in the May 1966 issue the lower end of capacitor C_2 in Fig. 4 should be connected to the common negative line and not to the point shown in the diagram.

In the article 'A Series Correct Regulator' by T. M. Palmer which appeared in the July 1966 issue, equation (4) should read,

$$R_{Eo} = R_o/2 \; (= R_s/2)$$

and equation (7) should read,

$$R_{To} = \frac{\beta_o \beta_3 F_o F_3 R_L}{2R_L(\beta_o F_o + F_3) + F_o F_3}$$

NEW BOOKS

Halbleiter erobern die Technik

By J. Weidel. 384 pp. Post 4to. Dr. Alfred Hüthig Verlag GmbH. 1966. Price DM.39

'SEMI-CONDUCTORS Conquer the World of Engineering'—the title together with the pleasant ornamental cover design suggest a popular science text. Nothing could be further off the mark! This encyclopaedic work is written for the advanced student and practising engineer. It is realized that nowadays some types of semiconductors come into the purview of every electrical engineer's activity. Yet the field is so vast that but a very few specialists can claim to master the subject as a whole. Nevertheless some knowledge of domains adjacent to one's own field of endeavour is not only useful in suggesting new approaches but also intellectually satisfying. Dr. Weidel is obviously one of the few masters of this enormously wide subject which he has summarized and presented in a most readable book. He neither tries to blind his readers with science nor does he underestimate their knowledge. The staggering amount of work that went into the writing of this book may be gauged by the fact that roughly 880 bibliographical references are given and these are not only quoted but mostly referred to in the text. The extent of the field is illustrated by the 30 odd separate semiconductor effects discussed in the second chapter dealing with basic physical concepts. This could so easily have turned out to make very tedious and dreary reading. The author avoided this pitfall not only by his pleasant style but by providing plenty of diversions in the way of biographical notes and references to practical applications. The first chapter, although rather short, ranges over more than 100 years of history and it may be surprising that semiconductors are as old as electrical science itself. Other chapters deal in detail with the manufacture of semiconductor materials, components using homogeneous semiconductors, photoelectronic devices, emission properties of semiconductors, covering *inter alia* barium cathodes, solid lasers and electro-luminescence, rectifiers, amplifiers,, i.e. transistors and f.e.t.'s, and a critical comparison between semiconductors and thermionic valves. An appendix lists the more common anglo-saxon terms for the benefit of German readers which is just as useful for the English reader as a check. The book can easily be read from cover to cover although the print is a few points too small for comfort, but its main value will probably be as a work of reference. This aspect is enhanced by the detailed list of contents and an adequate author and alphabetical index quite apart from the 261 clear illustrations and the 15 informative tables.

K. L. SELIG

Mathematics for Electrical Circuit Analysis

By D. P. Howson. 170 pp. Crown 8vo. Pergamon Press. 1966. Price 17s. 6d.

THE author states in his preface that this book is aimed at second- and third-year undergraduates taking light-current electrical engineering courses, and that several important topics have unfortunately had to be omitted. What a pity the price was not raised by a few shillings so that the present chapters could be broadened a little, although the 'plausible' rather than 'exact' approach to some of the proofs is to be applauded.

Well presented and easy to read, the book starts by introducing determinants and relevant differential equations (it was good to see the operator D being used, as well as Laplace transform in a later chapter) and then goes on to matrix algebra applied to combinations of networks.

Chapter 4 is a good chapter, the author giving the impression of really warming to his task; his section on topology being particularly precise. Fourier analysis and Laplace transform comprise the last two chapters and these are followed by an excellent solution section, useful graded references, and an index.

This book will be very useful to the undergraduate although parts of the text may be too abbreviated to give the value intended. Nevertheless, it can be highly recommended especially for its more than adequate supply of examples.

D. W. PORTER

Industrial Electronic Circuits and Applications

By R. R. Benedict and N. Weiner. 527 pp. Med. 8vo. Prentice-Hall International. 1966. Price 88s.

THE authors in the preface to this book describe their work as a text book for a rigorous course in industrial electronics, and in this they succeed admirably. The first 14 chapters of the book deal with the basic components, and their application to simple amplifier and oscillator circuits. Their style of presentation is excellent. With each topic discussed the reader is made fully aware of how the component or circuit functions before he is introduced to the mathematical treatment of the subject. At the end of each chapter are a series of numerical exercises covering all topics in the previous chapter.

The remainder of the book is devoted to applications and covers the cathode-ray oscilloscope, rectifiers and power conversion, induction and dielectric heating, electronic relay circuits, resistance welding instrumentation and motor control. The applications chosen are rather basic and perhaps a little outdated by modern standards. Semiconductors are given a thorough treatment both in the component and application section but there is a slightly larger coverage of thermionic valves and their application.

The only disappointing factor in this book, is that very little space has been given to the electronic techniques used today in automatic control and computers.

Although the applications are rather basic, this book can certainly be recommended to the student starting his career in industrial electronics.

W. H. ARLISS

Applied Magnetism—a Study in Quantities

By E. Olsen. 144 pp. Med. 8vo. Philips Technical Library. 1966. Price 42s.

DR. Olsen's book, the aim of which is to give a general introduction to applied magnetism, fails to find the consistency which is desirable in an introductory text. In the early chapters the style is that of a students' revision primer with short sentences and chapters, almost a glossary of magnetic terms. In particular a large number of permeability definitions are given the relevance of which is completely lost since no references to the application in which they arise are given. In later chapters dealing with the fields of microwaves and magnetostriction more complex and longer mathematical derivations of equations are given again with little reference to the relevant applications. Contrasting with this is a chapter on terms from the field of application of square loop materials which admirably deals with the characteristics of square loop ferrites as applied to computer storage without the use of any lengthy mathematical derivations.

This inconsistency appears to arise

from the pre-occupation of the author with the secondary title of the text: 'A study in quantities'. Such a study requires a knowledge of the relevant applications which must be either presented or assumed. Engineers familiar with the a.c. applications of magnetic materials for instance, might find some chapters of the book of value since a large number of terms, definitions and equations are presented. Permeability and loss are discussed, equations of conventional a.c. theory derived and the properties of the magnetic circuit with an air-gap are given. A chapter is devoted to the derivation of analytical expressions to account for losses in magnetic materials and another deals with distortion and intermodulation arising from the nonlinear character of the materials.

Students seeking an introduction to some aspects of applied magnetism, however, will only find the chapter on square loop ferrite applications of use since here the storage application is presented and the relevant terms and definitions suitably illustrated.

Two further chapters on the fields of microwaves and magnetostriction are exercises in the derivation of analytical expressions and demand a knowledge of the relevant applications which makes one doubt the usefulness of their inclusion in this text.

D. C. STAPLETON

Basic Matrix Analysis and Synthesis

By G. Zelinger. 228 pp. Demy 8vo. Pergamon Press. 1966. Price 45s.

ZELINGER'S book is primarily concerned with the analysis of linear, active circuits using matrix methods.

Some basic matrix algebra is given, the addition, subtraction, multiplication and inversion of matrices being defined and demonstrated in a practical manner. The difference between matrices and determinants is discussed at length. Five useful matrices for evaluating the performance of a two-port are defined, their use is illustrated, and the relationships between them tabulated. The performance of a number of single two-port networks when interconnected is discussed in terms of the matrix representation. A discussion on impedance transformation and image matching which follows is unfortunately rather confused by two conflicting definitions being adopted for image matching.

The final and largest section of the book deals with the analysis of valve and transistor amplifiers and oscillators. Matrix representations of the active elements are developed in terms of linear small-signal models. Matrices for single stages are then developed and these are interconnected to allow the analysis of up to three-stage amplifiers with various forms of feedback. Many of the results for gain, input and output impedance are summarized in useful tables. Finally a similar analysis of common forms of *LC* oscillators is included. The book is included. The book is complete with references and a number of examples. Hints, but no solutions are given.

The title of the book, particularly in the shortened form used on the jacket, is misleading. The work covered consists of elementary algebraic manipulation of the basic equations of amplifiers and *LC* oscillators, in order to find gain and impedance expressions. Shortened forms are given in some cases, arrived at by stating the appropriate engineering approximations. These may well be found useful by engineers working in the field, who may not be concerned whether the use of matrix methods was appropriate in their derivation. However it would not seem a suitable book for students, basically because many of the most important principles are not clearly explained.

D. P. HOWSON

Antriebstechnik in der Metallverarbeitung—Einführung in die Automatisierung (Drives in Metalworking—Introduction to Automation)

By P. Volk. 453 pp. Med. 8vo. Springer-Verlag. Berlin. 1966. Price DM.64

THE author of this book is with Siemens A.G. in Germany. Known for many decades as 'Siemens-Schuckert' and 'Siemens-Halske', these two companies have recently amalgamated to form Siemens A.G. and are, perhaps, the largest single company on the Continent manufacturing both heavy and light electrical equipment. In his capacity as Divisional Head, Dr. Volk has had the full benefit of the company's experience in electrical drive of machine tools, i.e. in power supply as well as control.

The attempt to cover all aspects of this field in one volume is an ambitious undertaking and the author has tackled this by sub-dividing the subject into two main sections. The first, on the 'flow of energy', covers the hardware of power conversion, i.e. design, construction and main operating characteristics of d.c. and of 'asynchronous a.c.' (induction) motors, 'electric shafts' (synchros) and electromagnetics, as well as the machinery required to *control* the flow of energy i.e., mechanical couplings, gears and brakes. The second and major part of the book is concerned with the 'flow of information' and its application to control. This covers the generation of signals corresponding to the measured operational quantities, their transmission, comparison with the corresponding desired values, and their feed-back for control purposes.

A large chapter deals with the necessary hardware, i.e. the components required to convert the signals in appropriate pick-up devices and electronic circuits to store the information in various types of memories (punched cards, tapes etc.), and digest it with the aid of logic elements for action by the programme. There is a special chapter dealing with the mathematical side of control, in particular with the dynamic response of control systems. The mathematics concerned is of undergraduate level and well within the scope of most electrical engineers. The last part consists of several chapters dealing with modern power drives, with particular emphasis on the machining of metals. Not surprisingly, most examples and illustrations refer to Siemens' products.

The author seems to have succeeded in his ambitious undertaking and has struck a proper balance in the difficut selection of the most important aspects of automation as applied to the control of machine tools. The book is well illustrated, containing on the average, one illustration on almost every page. The printing and general set up are of the high quality now taken for granted in scientific books published by Springer. The book will be read with interest by many control engineers who have a knowledge of German.

E. BILLIG

Introduction to the Theory of Switching Circuits

By E. J. McCluskey. 318 pp. Med. 8vo. McGraw-Hill. 1965. Price £5

IN many ways switching theory is a very suitable subject for engineering training at an advanced undergraduate or graduate level. The subject is a self-contained one and can be understood without previous attainments in any other branch of mathematics or engineering knowledge. Also the abstract relations with which it deals are valid for all types of switching hardware: relays, transistor logic circuits, magnetic covers, cryotrons and any other type of switching element which the future may bring.

The practical relay or logic circuit engineer may think the subject overrated, considering that it only enables one with the aid of several diagrams and charts and an hour's study to uncover the possibility of a malfunction which the experienced man perceives with a glance at the circuit. This view is mistaken. The newcomer to such a field would find the theoretical background given by a course in switching theory a great assistance in arriving at satisfactory practical designs.

This book is based on material used by the author for such a theoretical course in switching theory. The author's claim to having included material likely to be of practical importance to engineers and to having avoided topics of only theoretical interest is on the whole justified. The book can be read and understood without any previous knowledge of switching theory and would serve as a good introduction to current literature on the subject.

The second chapter on Number Systems and Codes is followed by chapters on Switching Algebra, Simplification of Switching Functions, Sequential Circuit Analyses, Sequential Circuit Synthesis and Transient Behaviour of Switching

Circuits. Each chapter is concluded by problems and a useful list of references.

Criticism could be directed at the first chapter. This describes, by way of introduction, typical switching devices such as relays, vacuum tubes, transistors, cryotrons and rectangular loop cores. Inevitably these are treated in such an abbreviated way that few will find this chapter of any value. The author, rightly considering that a basic knowledge of switching devices is essential to an understanding of the mathematical models, added for his own students, a parallel laboratory course on switching devices. The short first chapter cannot be a substitute for such a course, but it does serve to introduce the symbols used later in the book, and the references at the end of the chapter may well be found useful.

E. J. R. HEWITT

Topics in Advanced Mathematics for Electronics Technology

By S. Paull. 420 pp. Demy 8vo. John Wiley & Sons. 1966. Price 38s. paper; 53s. cloth

THIS book is one of a number written to provide the electronic specialist with the mathematical tools of his trade. The first chapter deals with infinite series, treating in some detail tests for convergence, and power series. It is as early as the first chapter that it can be seen that the author has an inclination to state his mathematical results, and a disinclination to prove, or justify them. This is a tendency that shows to a greater or less degree throughout the book, and occasionally leads to simple things being complicated. It surely should not have been necessary, for example, to verify the non-convergence of the infinite series $1, -1, 1, -1 \ldots$ by the use of any conditions for convergence of alternating series. On the credit side, the book is clearly written, and is a credit to the publishers, very few printing errors being detectable. There are numbers of useful examples during and at the end of the chapters, half of which are provided with solutions.

The second and third chapters deal with the elements of Fourier series and integrals respectively, commencing with a clear introduction to time domain analysis and the idea of the frequency spectrum for time functions. Surprisingly, no attempt is made to explain why an even function of time should have a Fourier series consisting of cosine terms only. A number of useful applications of Fourier theory are dealt with. Chapters on ordinary, differential equations and the Laplace transform follow in the same vein. A detailed chapter on Gamma and Bessel functions, with work on the ber, bei, ker and kei functions, includes applications to f.m., currents in wires, and fields in magnetic cores.

Simple vector analysis, Gauss's and Stokes theorems are treated together with conversion from one co-ordinate system to another. The final chapter of eighty seven pages treats determinants and matrices, with most of the chapter being spent on their applications to linear two-port analysis. The combination of two or more two-ports is discussed, as also are various valve and transistor stages.

Students are unlikely to be satisfied with this book, when so many mathematical results are merely stated without reasoning. Practising engineers, however, may well find it useful as a reference book, particularly as many engineering applications of the techniques discussed are outlined. There are a number of other books already published which cover the same ground however.

D. P. HOWSON

Plane Vector Fields

Iliffe Books Ltd. 1966. Price 45s.

Originally published in Russia in 1963, this book, now translated into English, serves as an introduction to the more complex aspects of the subject.

The first two parts of the book are devoted to a comprehensive study of vector fields including angular functions, homotopic vector fields and vector fields with a linear principal part and a principal multilinear part.

In the final part of the book an account is given of the application of plane vector fields to existence theorems in the theory of differential equations, to the problem of location of the roots of a polynomial, and the study of singular points and periodic solutions of ordinary differential equations. The critical points of harmonic and quasi-harmonic functions, and two-points boundary-value problems are also studied with the help of vector field theory.

High Power Electronics—Vol. 2

Pergamon Press. 1966. Price 50s.

This book is the second volume of the series originally published by the Academy of Sciences in the U.S.S.R., and contains 11 papers dealing with high power microwave electronics.

Elektronische Halbleiter (Electronic Semiconductors)

By Eberhard Spenke. 2nd. edition. 650 pp. Med. 8vo. Springer-Verlag Berlin. 1965. Price DM.69

This is the second edition of an introduction to the physics of rectifiers and transistors which first appeared in 1955. Its main object remains educational and nearly every one of the 12 chapters has been brought up to date by the author, who is a divisional manager with Siemens-Schuckertwerke AG.

Digitale Messtechnik (Digital Measurements)

By L. Borucki and J. Dittmann. 215 pp. Med. 8vo. Springer-Verlag Berlin. 1966. Price DM.37,50

The authors call this book an introduction to digital measurements and—addressing themselves mainly to students—start from first principles without digressing into adjoining fields. Four chapters on codes and circuits follow those on digital counting and the measurement of frequency, revolutions, time and periods. Analogue-digital convertors of various types as well as digital-analogue conversion are discussed and the problems of limiting by digital measurements described. One chapter deals with digital measuring instruments available by way of example.

Technische Elektronik 2. Band, Stromsteuernde und elektronenoptische Entladungsgeräte (Industrial Electronics) (Vol. 2. Current-Controlling and Electron-Optical Discharge Devices)

By M. Knoll and J. Eichmeier. 389 pp. Med. 8vo. Springer-Verlag Berlin. Price DM.42

The reading of this volume presupposes knowledge of the first, which deals with the basic principles of high volume, gas and solid state discharge devices and the more important processes used in their manufacture. This volume deals with the properties of the devices themselves in the first part, and with electron-optical devices including particle accelerators in the second part. The bibliography is intentionally selective, with emphasis on education.

Electricity and Electro-Magnetic Fields

By F. E. Dart. 101 pp. Med. 8vo. Prentice/Hall International. 1966. Price 32s. cloth, 14s. paper

This introductory textbook is one of the Physical Science Series written for physical science programmes in technical colleges.

Amplification et Mesure des Signaux de Faible Amplitude

By M. Billaroon & P. Larcher. 48 pp. Demy 4to. Editions Chiron. 1966.

This paperback book is written for electronic engineers, technicians and medical workers, and deals with low signal thermionic and transistorized amplifiers.

Multistage Transistor Circuits

By R. D. Thorton et al. 286 pp. Demy 8vo. John Wiley & Sons Ltd. 1965. Price 34s.

This book is the fifth volume in the series produced by the Semiconductor Electronics Education Committee and is intended as a textbook for teaching purposes.

Proceedings of IFIP Congress '65

Edited by W. A. Kalenich. 304 pp. Demy 4to. Macmillan. 1966. Price 67s. 6d.

The first volume contains the 49 papers presented at the general and special sessions of congress organized by the International Federation of Information Processing (I.F.I.P.) and held in New York in May 1965.

The second volume will contain other papers together with reports of the symposia and panel discussions.

Cooling Electronic Equipment

By A. D. Kraus. 390 pp. Med. 8vo. Prentice-Hall. 1966. Price 128s.

The fundamental methods of heat transfer as applied to electronic equipment by conduction, convection and radiation are discussed followed by cooling designs.

Special attention is paid to the cooling of transistors, thermionic valves, microwave components and inertial equipment. A chapter is devoted to thermal considerations for spacecraft.

Soviet Radio Engineering

91 pp. Demy 4to. The Faraday Press Inc. 1966. Price $35

This is a translation into English of Izvestiya VUZ Radiotekhnika, a publication of the Higher Educational Institutes of the USSR

NEW EQUIPMENT

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

(Voir page 757 pour la traduction en français; Deutsche Übersetzung Seite 764)

ELECTRONIC THERMOMETER

Protech Advisory Services Ltd, 21 High Street, Rickmansworth, Hertfordshire

(Illustrated below)

The electronic thermometer is a precision instrument using printed circuit techniques and new type semiconductors.

A choice of temperature sensing heads is connected into circuit by the operation of a rotary switch, and the temperature of the sensing head selected will be shown on the meter scale. The heads employed are high precision, close tolerance devices and are interchangeable. Sensing heads can therefore be replaced in case of damage and their readings compared without recalibration of the meter. The temperature sensing devices can be located up to 1970ft from the instrument without causing an appreciable error.

All Tele-Thermometers are designed to meet stringent industrial and research requirements for calibration accuracy and stability. Facilities are provided for

user-checking and adjustment to a maximum error of 1°C. Patents for the electronic circuit have been applied for.

The instrument is battery or mains operated and can accept up to five interchangeable sensors for the range −50°C to +150°C. 24 or more sensors may be connected via a switch unit.

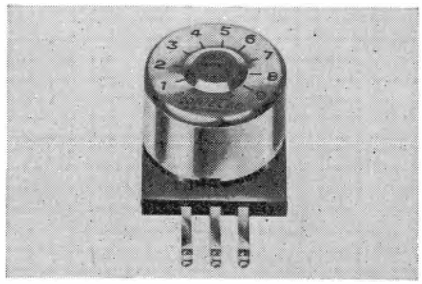
EE 99 751 *for further details*

WIREWOUND POTENTIOMETERS

Distributed by: W. Greenwood (London) Ltd, 21 Germain Street, Chesham, Buckinghamshire

(Illustrated above right)

New Swiss made adjustable wirewound potentiometers series T125S, designed for direct mounting on printed circuit boards, have been introduced by W. Greenwood (London) Ltd. They are single-turn potentiometers with outstanding humidity performance and a rating



of 1·5W at 50°C. The screwdriver adjusted units have self-locking electrical settings, precious metal contacts and gold plated terminal pins.

This competitively priced component is available in resistance values from 10Ω to 50kΩ with outside dimensions of 0·5in diameter × 0·56in × 0·395in and 3·5 grams weight. It can withstand a maximum temperature of +150°C (+302°F). The resistance tolerance is ±10 per cent, but closer tolerances can be supplied on request.

EE 99 752 *for further details*

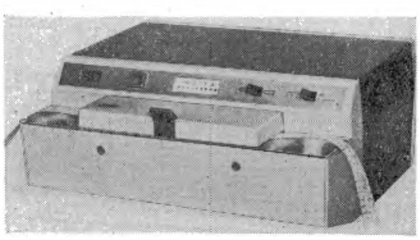
PUNCHED TAPE READER

Great Northern Telegraph Works, Copenhagen, Denmark. London office: 5 St. Helen's Place, London, E.C.3

(Illustrated below)

This contemporary styled, photo-electric punched tape reader model 4101 has an infinitely variable reading speed of between 250 and 1000 characters per second in the continuous operation mode, and of 0 to 1000 characters per second in the step-by-step mode. Forward and backward feed allows bidirectional reading with the same reading speed in either of the operating modes.

Start and stop times for the tape are very short and the tape guide is instantly adjustable to 5-, 6-, 7- or 8-channel tapes. A servo amplifier ensures constant light intensity by compensating for lamp ageing and mains fluctuations. The estimated life of the lamp is better than 1000 hours. The



error rate of the reading system is said to be less than 1×10^{-9} and a parity check can be added by plugging-in of two printed circuit boards. The unit is designed for operation over a temperature range of −10°C to +50°C and is provided with alarm facilities operating when the equipment is used under conditions which may produce errors. The reader is supplied as shown or for 19in rack mounting.

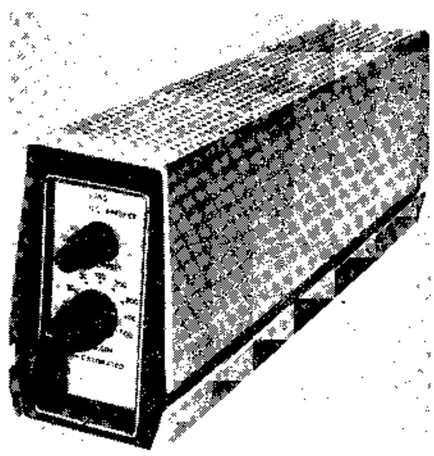
EE 99 753 *for further details*

D.C. AMPLIFIER

Consolidated Electrodynamics Division, Bell & Howell Ltd, 14 Commercial Road, Woking, Surrey

(Illustrated below)

A new high-gain differential d.c. amplifier that features the optium



combination of application versatility and low cost has been introduced by Consolidated Electrodynamics Division.

The type 1-165 d.c. amplifier is designed to drive high frequency light-beam galvanometers, as well as other floating or grounded loads, with input signals from medium to low-level sources.

A potential application exists wherever amplification and/or impedance transformation of low-level to medium-level electrical signals are desired. This situation may be encountered in dynamic or static measurement of acceleration; acoustical phenomena; displacement; force; mass flow; physiological phenomena; power, voltage, or current; pressure; rectilinear position; rotary position; strain; temperature; torque; or vibration.

Features include calibrated/vernier gain, 10 to 1000; frequency response, ±3 per cent to 15kc/s; output capability, ±10V, 100mA; plug-in galvanometer damping/protection facilities; zero offset adjustment, ±5V; input impedance, 1MΩ; and an integral power transformer within each module. Various mountings are available, including single-channel portable case, eight-channel fixed or slide rackmount, and eight-channel benchmount.

EE 99 754 *for further details*

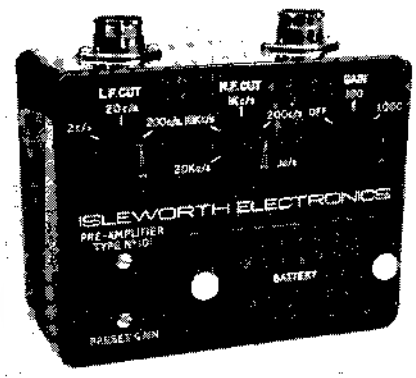
PARAMETRIC AMPLIFIER

Isleworth Electronics, Frederick Street, Waddesdon, Buckinghamshire

(Illustrated below)

The parametric input stage provided in the a.f. amplifier A101 results in a very low noise performance, especially when used with signal sources having a high impedance. The input impedance of not less than 10MΩ makes the amplifier very suitable for ceramic transducers and similar signal sources and application in physiology research.

Switched high frequency cuts are



provided to keep the noise as low as possible and to enable the user to select the lowest practicable bandwidth. In addition, three switched low frequency cuts will assist in the rejection of such remaining common mode signals as the supply frequency. Gain of either 100 or 1000 may be selected.

Isolation of the input circuit from the remainder of the amplifier gives a common mode rejection of 120dB at 50c/s. In spite of its small overall size of 4¼in × 4¾in × 3½in the unit operates from its internal mercury battery with an expected life of 40 hours. A separate power pack P101 operates up to 10 of these amplifiers. Up to three A101 amplifiers may be mounted on a standard 19in rack panel 5¼in high.

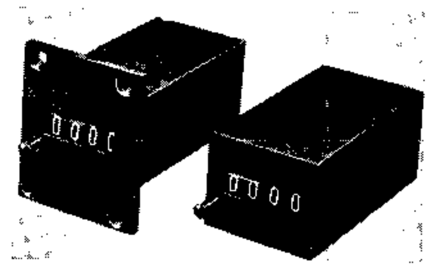
EE 99 755 *for further details*

MINIATURE ELECTRIC COUNTERS

Veeder-Root Ltd, New Addington, Surrey

(Illustrated above right)

A new range of miniature electric counters has been announced by Veeder-Root Ltd. Designed for compactness and reliability, this new range features



low power requirements (2·5W) with a high counting speed (1000 counts/min), continuous operation and long life. All versions are available in either rear or panel mountings, and all except one have push-button reset. A magnifying crystal is fitted as standard (actual figure size is 0·160in high × 0·080in wide).

Five standard models are available—4-figure reset; 5-figure reset; 5-figure 'dozens' reset, 6-figure reset and 6-figure non-reset. A new 'power-on' reset device is included in both the 5-figure models—this eliminates the danger of damage to the mechanism should 'Reset' be operated while the counter is energized and allows 'reset' to be carried out at any time.

EE 99 756 *for further details*

MINIATURE D.C. INTEGRATOR

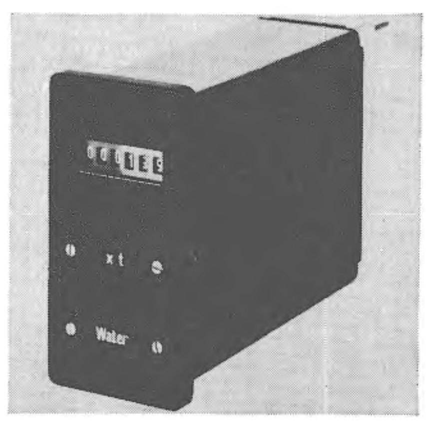
Distributed by: Universal Control Equipment Ltd, Frome Buildings, London Road, Stroud, Gloucestershire

(Illustrated below)

The 'Minigrator' type ZM/54 integrator is a new miniature version of the range of precision d.c. counters manufactured by Fernsteuergerate, c.h.g., of West Berlin.

Designed to integrate electrical values in instrumentation and process control, the 'Minigrator' has an accuracy of better than 0·2 per cent and is particularly well suited to totalizing liquid and material flows. In its standard form, the instrument is housed in a sheet steel case measuring only 2⅞in × 1 7/16in and designed for panel mounting. An alternative, unhoused, version is also available for incorporation into existing equipment such as recorders, flow-meter amplifiers, temperature measuring equipment, etc.

When used as a voltage integrator, any range between 0 to 0·3V and 0 to 5·0V can be accommodated. Current ranges of 0 to 5·0mA up to 0 to 1·0A



are also available as standard and any counting speed between 10·0 and 100·0 digits per hour can be supplied with any current or voltage range. Display is on a six digit cyclometer type counter.

EE 99 757 *for further details*

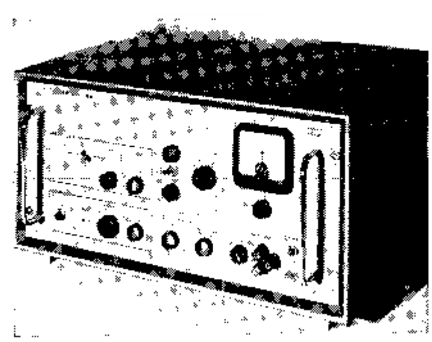
COHERENT AMPLIFIER

Caltronics Ltd, Caltronics House, Huntingate, Hitchin, Hertfordshire

(Illustrated below)

Caltronics Ltd is now manufacturing a coherent amplifier for the detection and measurement of low-level signals. The amplifier is of particular interest to engineers in such fields as radio astronomy, plasma physics, microwave spactroscopy and many other areas of small signal detection.

The frequency range is 20c/s to 15kc/s and the amplifier has a full scale sensitivity of 5μV r.m.s. Signal detection is 40dB below receiver noise and there are independent in-phrase and quadrature phase adjustments. Time-constants are selectable from 0·1 to 100sec. A high gain, low noise amplifier gives excellent stability and a synchronous detection system operates at nearly optimum detection. Detection and measurement



of low level signals is therefore possible even when they are well below the system level.

Internal or external signals may be used as a reference channel to give the frequency coverage of 20c/s to 15kc/s by selection through twin-T filters.

A low impedance is provided for galvanometer type recorders in addition to meter indication.

EE 99 758 *for further details*

COUNTER/FREQUENCY METER

Venner Electronics Ltd, Kingston By-Pass, New Malden, Surrey

(Illustrated on page 752)

A new instrument in the range of Venner frequency measuring equipment is the all-silicon TSA 6634, with a range of 10c/s to 2Mc/s. Period of signals from 10c/s to 100kc/s can also be measured, and count timing facilities are incorporated. Side view cold-cathode numerical indicators display the 4-digit read-out, and display time can be set to infinity or adjusted between 0·5 and 5sec. Provision for operation with a tacho-generator is by means of a multi-way socket.

Gating times for frequency measure-

ment are 1msec, 10msec, 0·1sec, 1sec, 10sec; sensitivity 100mV to 250V with variable sensitivity control, and input impedance greater than 200kΩ.

For period measurement, gating times are 1, 10 or 100 cycles of the input, and time units 10μsec or 1msec. Sensitivity and input impedance are as for the frequency measurement specification.

The internal standard is a 100kc/s crystal, accuracy ± 1 count, ± crystal stability, and the instrument is designed to operate in the temperature range −10°C to +60°C. Power supply is 100 to 125V or 200 to 250V, 40 to 60c/s a.c.

EE 99 759 *for further details*

DRUM PROGRAMMERS

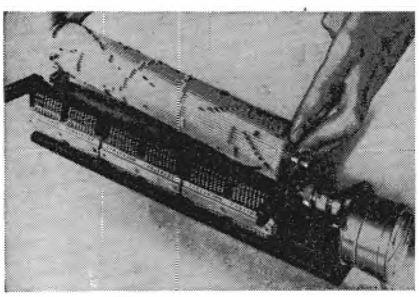
Sealectro Ltd, Farlington, Portsmouth, Hampshire

(Illustrated below)

The capability of changing programmes and drum speeds has just been introduced to the range of ACTAN drum programme switches produced by Sealectro Ltd.

With the new innovation, the programme drum can be removed from the switch assembly by the simple release of two levers and replaced by another drum with a completely different programme in less than a minute. To change speed of rotation, the timing motor can be replaced with a motor of a different drive speed with the simple removal of three screws.

The new programmer with replaceable drum and timer is available in the 60-position size and can be produced to user requirements in any size to control from 16 to 57 circuits. As with all ACTAN programmers, the colour-coded actuators on a single drum can be individually adjusted in the field. The new features will make it possible to change programmes rapidly or to eliminate down time for making field adjustments, which can now be made on a spare drum that simply replaces the one in the unit.



EE 99 760 *for further details*

MILLIVOLT RECORDER

KPE Controls Ltd, Vale Road, Tonbridge, Kent

(Illustrated below)

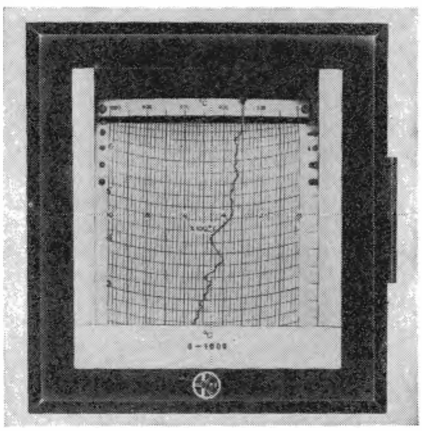
KPE has announced the availability of a 'KOM-PAC' millivolt recorder as part of its range of process measurement and control instruments.

The 'KOM-PAC' millivolt recorder has been designed and produced to meet the requirement for a highly sensitive single-channel direct-writing recorder. It is used in conjunction with the comprehensive KPE range of KOM-PAC plug-in modules which provide any additional measurement, alarm or control function that may be required for process instrumentation and control.

The instrument consists basically of the KOM-PAC transistor feedback amplifier which is used to monitor millivolt inputs and provides a standard current output for operation of a high quality moving-coil recorder mechanism. The recorder amplifier and also any additional KOM-PAC modules are self-contained.

The photograph shows a single channel KOM-PAC recorder. Continuous recording instruments up to 6-channels are available.

The KOM-PAC recorder is available



for use with a wide range of inputs, and is particularly suitable for use with low output transducers. It may be used with all standard thermocouples or resistance thermometers for temperature recording.

In conjunction with the range of KOM-PAC modules a number of self-contained additional facilities are available. These include alarm/control contacts, proportional control for external or self-contained thyristor stacks, self-contained time-delay alarms, additional output for operation of remote indicators or controllers etc.

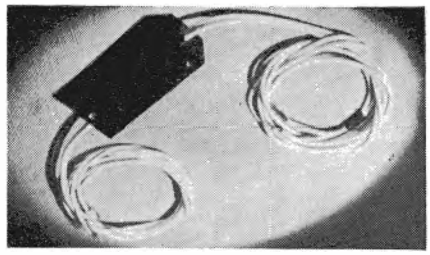
EE 99 761 *for further details*

OSCILLATOR-DEMODULATOR

S.E. Laboratories (Engineering) Ltd, Astronaut House, Feltham, Middlesex

(Illustrated above right)

S.E. Laboratories (Engineering) Ltd has introduced an encapsulated oscillator/demodulator S.E.62/12 which gives a linear output of −3V to +3V over a specified transducer pressure range.



Its small size allows it to be used in the same confined space as the transducer element.

The unit is energized from an external stabilized 12V d.c. supply and embodies a 3kc/s oscillator, an amplifier and a demodulator for use in conjunction with S.E. Laboratories variable reluctance transducers, for pressure, acceleration and displacement measurements.

Unaffected by condensation, the unit can be mounted in any attitude.

Dimensions are 3½ × 1¼ × 1in.

EE 99 762 *for further details*

ROTARY STEPPING SWITCHES

Distributed by: M.L. Industrial Products Ltd, 292 Leigh Road, Trading Estate, Slough, Buckinghamshire

(Illustrated below)

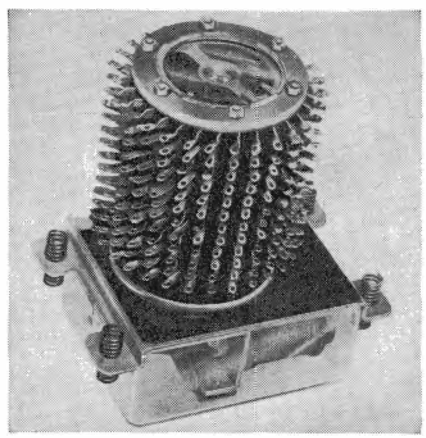
Following the agency agreement with LM Ericsson of Sweden, M.L. Industrial Products Ltd is introducing stocks of the Ericsson RVF type rotary stepping switch into Great Britain.

The switch is available with up to 6 banks of 30 contacts, and an alternative version employing two sets of wiper contacts provides the equivalent of 12 banks of 15 contacts.

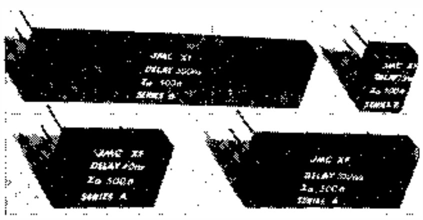
Unique design features of this uniselector, are its complete dust protection of contacts and moving components, and the ease with which parts can be replaced.

Only a minimal amount of servicing is required, if at all, and under normal operating conditions a life of 10 million revolutions is quoted.

The switch can be self-driven at speeds of up to 60 switching cycles per second by use of the interrupter contacts, and homing contacts are standard on all versions. Gold plated contacts are available both on wipers and banks.



EE 99 763 *for further details*



DELAY LINES

Johnson, Matthey & Co. Ltd,
73-83 Hatton Garden, London, E.C.1

(Illustrated above)

Johnson, Matthey & Co. Ltd. announce the introduction of Silver Star delay lines. These lumped constant *LC* units have high humidity resistance and excellent temperature stability coupled with outstanding reliability in service.

A standard range of Silver Star delay lines, each with a characteristic impedance of 500Ω, has been developed around two basic time delay increments, 10nsec and 25nsec. This range offers electronic designers and engineers not only a choice of nine basic delay times from 10nsec to 500nsec, but also a range of ratios of delay time to rise time. Without affecting the characteristic impedance of 500Ω, other delay times or other ratios of delay time to rise time can be obtained simply by cascading two or more units in a circuit.

The units are produced in four standard sizes that have the same cross-section, but different lengths. Each unit is encapsulated in an epoxy resin to give a solid, robust, hermetically sealed block. The solder-coated (electroplated) phosphor bronze terminal wires are accurately spaced to suit 0·1in module printed boards, and two common terminals are provided to simplify layout and wiring.

The base of each unit has slightly raised pads to provide a gap that eliminates any risk of moisture accumulating at the unit/board interface. The pads can be cemented to the circuit board to increase the strength of the assembly.

EE 99 764 *for further details*

TRANSDUCER AMPLIFIER

Fenlow Electronics Ltd, Springfield Lane,
Weybridge, Surrey

(Illustrated above right)

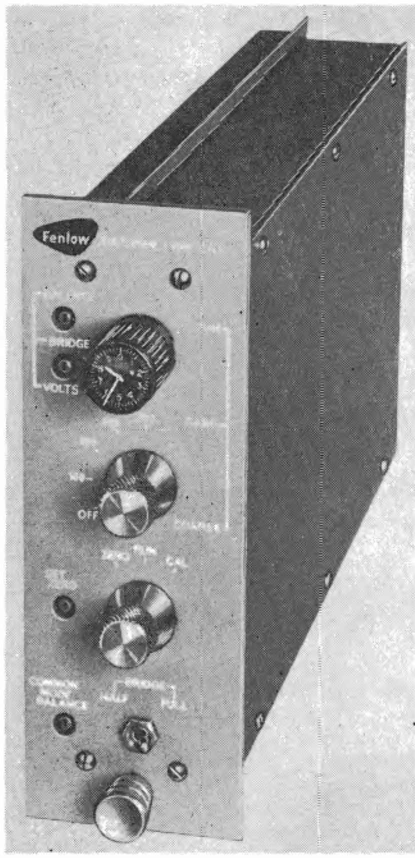
The Fenlow Amplifier ZA2 is intended for use with resistance type strain gauges, pressure transducers and accelerometers in instrumentation and servomechanism applications. All the necessary facilities for operating the above mentioned types of transducers are incorporated in one concise unit comprising the following principle components:—

Low drift d.c. differential amplifier; fixed amplifier gain steps with multi-turn dial potentiometer interpolation; stabilized mains operated power supply; variable bridge power supply; six wire shunt calibration system; precise wire-bound bridge completion resistors; multi-turn bridge balance control; multi-turn bridge voltage control; and provision for half bridge or full bridge operation.

The available output current is more than sufficient to drive loads such as Moog servo valves and high frequency ultra violet galvanometers.

It is intended that the unit is mounted in a standard rack with connexions at the rear. Seven units fit into a standard rack width. As well as use with transducers the ZA2 can also be used in impedance transforming and d.c. amplifying applications. This mode of operation is selected by means of a front panel switch.

The input impedance of the amplifier is over 2MΩ, the output impedance below 1Ω. Provision is made for coarse and fine adjustment of the gain between 100 and 800. The output current is



±36mA into 330Ω, the output voltage 40V peak-to-peak into 300Ω. The common mode rejection is 120dB at ±5V, 100dB at ±10V, and the linearity 0·01 per cent.

EE 99 765 *for further details*

TINNING SOLUTION

Shipley Chemicals Ltd, Coventry Trading Estate,
Sisken Drive, Baginton, Coventry

A new immersion tinning process, Cuposit LT27, has recently been released by Shipley Chemicals Ltd. The process produces deposits which are claimed to have exceptional solderability and corrosion resistance characteristics, even after extended periods of storage.

LT27 solutions are replenishable by adding LT.27B; the bath is extremely stable and yields of 6½mil.ft² of tin per gallon are consistently achieved. Thicknesses of 100μ in can be obtained in approximately 30min.

Tinned copper parts withstand 96 hours in salt spray without breakthrough while after exposure to 95 per cent relative humidity at 90°F for 96 hours finished parts are still readily solderable.

EE 99 766 *for further details*

SYNCHRO TRANSMITTER-RECEIVER

Aviation Division, Smiths Industries Ltd,
Kelvin House, Wembley Park Drive, Wembley,
Middlesex

(Illustrated below)

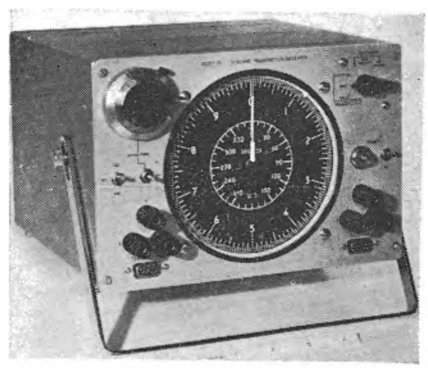
A servoed synchro transmitter-receiver has been added to the range of test equipment designed and made by the Aviation Division of Smiths Industries Ltd, for checking electromechanical servo systems and components.

Housed in a compact case measuring 8¼in wide × 5¾in high × 9¼in deep, the unit is provided with a carrying handle which can also be used as a stand when the instrument is in operation. An indicator dial with twin pointers to display the shaft angle is positioned on the front of the instrument together with all its switches and controls.

The pointers are coupled to two synchros and driven by a motor tachogenerator, all housed within the unit. One of the synchros is a controlled transformer displaying input angle in conjunction with a servo-amplifier, while the other synchro is a low impedance torque transmitter able to transmit any angle shown on the dial. Angle adjustment of the transmitter can be made by a calibrated speed control servo loop which can be used to provide either a continuous rate or any fixed angle as required.

In a further mode, the transmitter synchro position may be placed under the control of an external electrical angle standard (e.g. a delta bridge) enabling angular accuracy to be limited only by the external standard accuracy and the control loop datum error, thus eliminating errors in the transmitter synchro and display gearing.

The instrument, employing solid state circuits throughout, operates from a power supply of 115V or 200V, 400c/s but in all modes, the synchro excitation can be provided from an external source



not necessarily locked to the main 400c/s power in phase or frequency.

Accuracy is 10 minutes of arc and display resolution is 1·5 minutes but the threshold is 0·5 minutes, so that when used in the external bridge mode, accuracy is bridge accuracy ±0·5 minutes. In the rate transmission mode, slewing speed can be up to 30°/sec. A self-test facility is included.

Other similar instruments incorporating resolvers as well as three-wire machines and having higher maximum slewing speeds are also available, in addition to panel mounted synchro indicators utilizing the same read-out and with integral amplifiers.

EE 99 767 *for further details*

ELECTRONIC VOLTMETER

Marconi Instruments Ltd, St. Albans, Hertfordshire

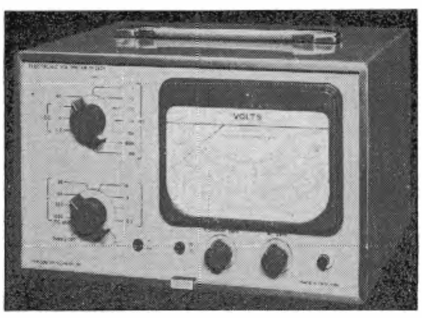
(Illustrated below)

A new electronic voltmeter combining versatility with high accuracy and stability is announced by Marconi Instruments Ltd. The instrument TF 2604, enables precise measurements of a.c. voltage from 25mV to 300V in the frequency range 20c/s to 1 500Mc/s. The d.c. voltage range is 10mV to 1 000V, and resistance can be measured from 0·2Ω to 500MΩ.

Four optional accessories still further increase the usefulness of the TF 2604. High voltages up to 30kV d.c. and 2kV a.c. can be measured with plug-on d.c. and a.c. multipliers. For measuring voltages on a coaxial line, there is a plug-on-T-connector for the a.c. probe; an accurately matched 50Ω coaxial terminating load is also available.

The good reading stability inherent in this instrument is achieved by the full stabilization of valve heaters and the h.t. line; using a series valve circuit for the h.t., and a transistor circuit controlled by a Zener diode for the l.t. supply. As a result, changes in the mains supply voltage by as much as 10 per cent will cause a deflexion change of less than 4mV at full scale on all ranges.

A well-proven push-pull circuit is used to drive the meter, each half consisting of a valve amplifier and cathode-follower. The probe used for a.c. measurements houses a disk-seal diode rectifier of an advanced type. A capacitance of only 1·5pF, short transit time, and a 3 000Mc/s resonance frequency, together with a unique probe head design, make possible the frequency response of up to 1 500Mc/s. Small and cylindrical, this light-weight probe has been designed for easy handling. A special plug-on ground connector is also supplied to facilitate the making of the ultra-short connexion necessary at the higher frequencies.



Measurements of d.c. voltage and resistance are simplified by the special dual purpose d.c. probe with its finger-tip V/Ω selector; set to V, an isolating resistor is introduced to shield the circuit under test from the effects of probe lead capacitance. For d.c. measurements the meter can be switched to give forward deflexion with positive or negative voltages; for centre zero measurements, a standing d.c. is applied to bias the meter to mid-scale.

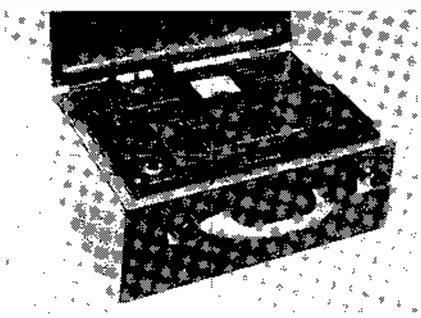
EE 99 768 *for further details*

THERMOMETER BRIDGE

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

(Illustrated below)

H. Tinsley & Co. Ltd has recently developed an instrument for measuring the change in resistance in ohms of ex-



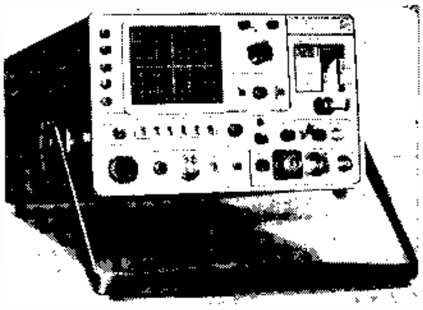
pendable thermometer elements by the four terminal method.

The unit is classified as type 5596 bridge for expendable thermometer elements and is designed for use with Tinsley four terminal expendable thermometer elements.

The resistance range covered is 75 to 165Ω readable to ±0·1Ω. The temperature range is −50°C to +150°C using 100Ω elements with reproducibility ±¼°C. The bridge is supplied by a square wave oscillator, 1 000c/s at 2·5V and the detector is a centre zero pointer meter operated from a transistorized detector amplifier. The sensitivity available allows a change of 0·05Ω to be detected.

The use of a square wave generator eliminates reactive errors, and lead errors are reduced by using the four terminal method of measurement together with high resistance ratio arms. The use of an alternating current supply reduces thermal effects to a negligible amount and the overall accuracy is normally determined by the stability of the thermometer elements.

EE 99 769 *for further details*



SPECTRUM ANALYSER

Tektronix U.K. Ltd, Beaverton House, Station Approach, Harpenden, Hertfordshire

(Illustrated above)

The Tektronix type 491 is a precision, wide band spectrum analyser designed for rugged environmental conditions, easy mobility and covering the frequency range of 10Mc/s to 40Gc/s.

A rack mounted version, the type R491 is also available which is electrically identical and occupies a rack height of only 7in.

Operation of the instrument is simple. Resolution and calibrated dispersion controls are coupled providing narrow resolution bandwidth at narrow dispersion and wide resolution at wide dispersion. Since dispersion is calibrated, frequency differences can be read directly from the c.r.t. Internal phase lock provides stable displays even at 1kc/s per division dispersion.

Other features of the type 491 are, minimum c.w. sensitivities from −110 to −70dBm depending upon frequency, display flatness of plus or minus 1·5dBm over 100Mc/s dispersion, trace intensification of high speed segments of the displayed waveform, long persistence (P7) phosphor, and d.c. coupled recorder output.

The oscilloscope-type triggering and sweep circuits enable triggering from internal, external or line sources, with sweep speeds from 10μsec/div to 0·5sec/div in a 1-2-5 sequence. The carrying handle adjusts for various tilt positions and serves as a sturdy support handle. A front panel cover acts as a storage case for all the standard accessories including adaptors, cables, waveguide mixers and coaxial attenuators.

The cabinet model is 7¼in high, 12¾in wide (including handle), 20¾in deep (including rear feet and front cover) and 22½in deep with handle extended.

EE 99 770 *for further details*

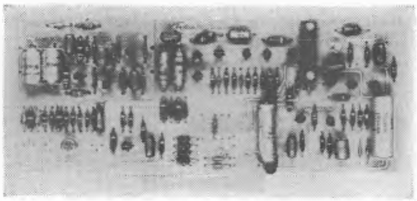
OPERATIONAL AMPLIFIER

Fenlow Electronics Ltd, Springfield Lane, Weybridge, Surrey

(Illustrated on page 755)

The Fenlow A8 is a chopper stabilized amplifier employing a field effect transistor chopper to reduce the input current drift to a very low value. The performance as an integrator is comparable with that obtained with mechanical choppers. The high gain, bandwidth and input impedance give high precision computation.

Class-A output ensures good linearity



and the elimination of crossover distortion.

The output is ±30V at 5mA and the open loop gain greater than 10^8 at d.c., 10^6 at 50c/s and 10^4 at 1kc/s. The input impedance is 200kΩ. Voltage drift is less than 1μV/°C. Wideband noise is less than 25μV peak-to-peak and from d.c. to 10c/s is less than 2μV peak-to-peak.

EE 99 771 *for further details*

THERMOCOUPLE TEMPERATURE INDICATORS

Spembly Technical Products Ltd, Trinity Trading Estate, Sittingbourne, Kent

(Illustrated below)

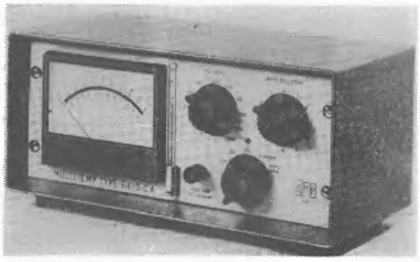
The S.T.P. 'Multitemp' model 6610 CA, illustrated, provides a quick and simple means of measuring the temperature of nickel chromium/nickel aluminium thermocouples over a wide temperature range and is virtually independent of loop resistance.

Temperature is indicated, via a small solid state amplifier, on a meter having a −120°C to 100°C scale range. A scale range selector switch, used in conjunction with the meter, enables accurate readings to be taken throughout a −120°C to 1000°C temperature range. A fast setting-up facility is provided giving the user an immediate indication of the approximate temperature of the thermocouple before adjusting to the relevant sensitive range.

The Multitemp has built-in cold junction compensation and an extension socket is provided to connect the instrument to a standard recorder.

Similar in appearance to the Multitemp, the S.T.P. Unitemp model 6650 GP is designed for use with nickel chromium/nickel aluminium, iron/constantan and copper/constantan thermocouples. The temperature scale of the meter can also be selected for use as a millivolt scale so that other combinations of thermocouple material may be measured. The Unitemp gives accurate temperature readings from −30°C to 1 000°C and has an output socket for connexion to a standard recorder.

At the rear of both instruments a terminal strip is provided for connecting up to twelve thermocouples and selection of each thermocouple is made by a 12-position switch. (Connexions 1 to 5 are duplicated and have standard Spembly sockets).



Both instruments are powered by long life mercury batteries and are fully portable.

EE 99 772 *for further details*

TELEVISION CAMERA

G.E.C. (Electronics) Ltd, East Lane, Wembley, Middlesex

A high-quality mains operated transistorized television studio camera, particularly suitable for educational television schemes, has been developed by G.E.C. Electronics' Communications Group.

A special feature of the camera, known as the type "VCT 2/S," is that it incorporates a transistorized 7in electronic viewfinder which is easily removed for use separately as a picture monitor.

The camera can be supplied with a scanning standard of either 625/50 or 525/60 lines and transmits over a bandwidth of 10Mc/s. This bandwidth is claimed to be wider than that used by competitive cameras and to give better definition.

A vidicon tube is used in the camera and a four-lens turret, which will take "C" mount or broadcast mount lenses, is fitted. A control knob at the side of the camera enables optical focus to be adjusted, or a remote control system can be fitted.

The camera has a built-in sync pulse generator and all principal electrical and electronic circuits are contained in easily-replaced printed circuit modules, thus simplifying maintenance. To minimize the length of the signal cable from the vidicon tube, the video head amplifier module is mounted directly above the vidicon focus coil.

A high signal-to-noise ratio—36dB peak-to-peak with a 0·2μA signal current—is obtained from the video head amplifier.

The 'target voltage', 'beam current', 'electrical focus' and 'black level' camera controls are normally pre-set but can be linked to a camera terminal unit to permit adjustments to be carried out remotely.

EE 99 773 *for further details*

DESK TOP COMPUTER

Cybernetics Instrumentation Ltd, 174 Glanville Road, London, N.W.2

(Illustrated above right)

LOCI-2 is a self-contained computer, consisting of an arithmetic unit, storage registers, manual programming keyboard, automatic punch-card programmer and large-size numerical ten digit output display.

The computer may be used for three specific purposes: as an extended calculator, manually or automatically pro-

grammed calculation and computation of equations and for on-line computation in a variety of control systems.

When it is operated as a manual calculator, LOCI-2 is capable of performing addition, subtraction, multiplication, division and exponention, as well as taking logarithms and extracting roots. All these basic operations may be computed within 40msec.

For programmed operation in the automatic mode, the LOCI-2 has a powerful and flexible repertoire of commands with which iterative procedures are easily and compactly coded.

An extensive library of programmes (statistical, mathematical and engineering, etc.) is available. Examples of these are: Bessel functions, polynomial, trigonometrical and logarithmic equations, variance, triangulation, catenary and stress analyses.

EE 99 774 *for further details*

FREQUENCY MULTIPLIERS

Microwave Systems Ltd, Caltronics House, Huntingate, Hitchin, Hertfordshire

(Illustrated below)

Microwave Systems Ltd is now marketing a series of solid state frequency multiplier using varactors.

The varactors enable the multipliers to achieve harmonic generation at power levels ranging from milliwatts to 5W in the 1·0 to 2·0Gc/s range, and from milliwatts to approximately 1W at C-band frequencies and 300mW at X-band frequencies. In the 300 to 1 000Mc/s range power levels range from milliwatts to 10W. Microwave Systems can also supply transistorized crystal controlled drivers to convert any multiplier into a complete solid state power source.

All the multipliers have a high spurious rejection at 60dB with output filters, are of solid aluminium block construction or aluminium castings and suitable for aircraft and missile applications.

EE 99 775 *for further details*

Meetings THIS Month

THE INSTITUTION OF ELECTRICAL ENGINEERS

All meetings will be held at Savoy Place, commencing at 5.30 p.m. unless otherwise stated.
Date: 3 November.
Lecture: The Cambridge One-mile Radio Telescope.
By: Professor Sir Martin Ryle.
Date: 4 November.
Colloquium: Optical Character Recognition.
(Joint meeting with the I.E.R.E. Computer Group at 2.30 p.m.)
Date: 7 November.
Colloquium: Instrument Transformers with special reference to B.S. 3938:1965 on Current Transformers and B.S. 3941:1965 on Voltage Transformers.
Time: 2.15 p.m.
Date: 8 November.
Lecture: Precision Temperature Control.
By: E. C. Bell and L. N. Hulley.
Date: 9-11 November.
Conference: Automatic Operation and Control of Broadcasting Equipment.
Date: 14 November.
Discussion: Market Research in Relation to Electronics Design.
Opened by: A. J. Wilson and another.
(Joint meeting with the Industrial Market Research Association.)
Date: 15 November.
Lecture: Computer Control of Scheduling and Blending in Biscuit Manufacture.
By: F. G. Helps, D. Pentelow and A. Wilkinson.
(Joint meeting with the Automatic Control Group of the I.MechE.)
Date: 16 November.
Lecture: Reflections from Thin Layers.
By: G. Millington.
Date: 16 November.
Discussion: The Use of Closed Circuit TV in Medicine and Biology.
(Joint meeting with the I.E.R.E. Medical and Biological Group at the I.E.R.E., 8-9 Bedford Square, London, W.C.1, at 6 p.m.)
Date: 21 November.
Lecture: Broad-Band Matching.
By: Dr. R. Levy.
Date: 22 November.
Colloquium: Sound on Film.
(Joint meeting with the British Kinematograph Sound and Television Society and the Television Society at 9.30 a.m.)
Date: 23 November.
Lecture: Electronically Assisted Acoustics in Concert Halls.
By: J. Moir.
Time: 6 p.m.
Date: 24 November.
Colloquium: Concepts of Systems Reliability Engineering.
(Joint meeting with the Automatic Control Group of the I.Mech.E.) (Time to be announced in IEE News.)
Date: 24 November.
Lecture: Infra-red Devices—Propagation, Generation and Reception.
By: G. Phillips.
Date: 25 November.
Lecture: X-Ray Technology.
By: F. L. Veale.
Date: 28 November.
Colloquium: The Use of Electromagnetic Waves in Distance Measuring.
Time: 2.30 p.m.
Date: 28 November.
Lecture: Elementary Particles and Resonances.
By: Dr. F. Heymann.
Date: 29 November.
Lecture: Recent Developments in Hot-Cathode Hydrogen-Filled Valves.
By: K. G. Cooke.
Date: 30 November.
Discussion: Transfer-Function Measuring Instruments.
Opened by: F. Jones and J. Kirby.
Date: 30 November.
Symposium: Numerical Control of Production Processes.
(Joint with I.Mech.E., I.Prod.E., S.I.T. and B.C.S. under the aegis of U.K.A.C. at the University of Aston in Birmingham.)

INSTITUTION OF ELECTRONIC AND RADIO ENGINEERS

Joint I.E.E.-I.E.R.E. Computer Group

Held at: The Institution of Electrical Engineers, Savoy Place, London, W.C.2.
Date: 4 November.
Time: 2.30 p.m.
Colloquium: Character Recognition.
By:

Radar Group

Held at: I.E.R.E. Lecture Room, 9 Bedford Square, London, W.C.1.
Date: 9 November.
Time: 6 p.m.
Lecture: Radio and Radar Aspects of Meteorology.

Electro-Acoustics Group

Held at: I.E.R.E. Lecture Room, 9 Bedford Square, London, W.C.1.
Date: 23 November.
Time: 6 p.m.
Lecture: Psychological Aspects of Acoustics.
By: Prof. J. T. Allanson.

Television Group

Held at: The London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.
Date: 30 November.
Time: 6 p.m.
Lecture: The Development of a Pay-Television System.
By: G. L. Hamburger.

Thames Valley Section

Held at: Lecture Theatre, School of Electronic Engineering, R.E.M.E., Arborfield.
Date: 24 November.
Time: 5 p.m.
Lecture: Digital Radar Simulator for Air Traffic Control.
By: D. Stoddart
Held at: Clarendon Laboratory, Parks Road, Oxford.
Date: 8 November.
Time: 7.30 p.m.
Lecture: Circuit Design Using Digital Computers.
By: E. Wolfendale.

East Anglian Section

Held at: Barstable Grammar and Technical School, Timber Log Lane, Basildon, Essex.
Date: 16 November.
Time: 6.30 p.m.
Lecture: Gas Lasers.
By: H. Foster.
Held at: The University Engineering Department, Trumpington Street, Cambridge.
Date: 10 November.
Time: 8 p.m.
Lecture: Some Problems in the Design of Electrical Filters.
By: J. K. Skwirzynski.
(Joint meeting with Cambridge Electronics Section of the I.E.E.)
Held at: Chelmsford Technical High School, Patching Hall Lane, Broomfield, Chelmsford, Essex.
Date: 28 November.
Time: 7 p.m.
Lecture: The Watkins-Gunn Effect: Negative Resistance in Semiconductors.
By: B. K. Ridley.

Southern Section

Held at: Bournemouth College of Technology, Bournemouth, Hants.
Date: 15 November.
Time: 7 p.m.
Lecture: Transistor, Sinusoidal, Stabilized Inverters
By: C. E. Ridgers.
Held at: Brighton College of Technology, Brighton, Sussex.
Date: 8 November.
Time: 6.30 p.m.
Lecture: Thin Film Microelectronics.
By: T. Cummins.
Held at: Highbury Technical College, Cosham, Portsmouth.
Date: 2 November.
Time: 6.30 p.m.
Lecture: Computer Control of a Factory.
By: P. A. Spinney.

South Western Section

Held at: Victoria Rooms, Clifton, Bristol 8.
Date: 3 November.
Time: 7 p.m.
Lecture: Chartered Engineers' Lecture on 'Recent Developments in Satellite Telecommunications'.
By: H. C. Husband.
(Admission by ticket only: obtainable from W. E. Wheeldon, Hon. Sec., I.E.R.E. South Western Section, School of Electrical Engineering, College of Science and Technology, Ashley Down, Bristol 7.
Held at: Large Lecture Theatre, University of Bristol, University Walk, Clifton, Bristol.
Date: 7 November.
Time: 6 p.m.
Lecture: Television Recording.
By: P. Leggat.
(Joint meeting with Western Centre of I.E.E. (Electronics Section).)
Held at: Plymouth College of Technology, Plymouth, Devon.
Date: 15 November.
Time: 7 p.m.
Lecture: Automatic Driving of Trains.
By: R. Dell.
(Joint meeting with the Western Centre of the I.E.E. (Electronics Section).)
Held at: The College, Swindon.
Date: 9 November.
Time: 7 p.m.
Lecture: Ballistic Missile Early Warning System.
By: B. S. Batt.
(Joint meeting with the Western Centre of the I.E.E. (Electronics Section).)

South Wales Section

Held at: Welsh College of Advanced Technology, Cardiff.
Date: 9 November.
Time: 6.30 p.m.
Lecture: Latest Developments in Radio Astronomy.
By: P. Williams.

West Midland Section

Held at: Lanchester College of Technology, Priory Street, Coventry.
Date: 28 November.
Time: 7.15 p.m.
Lecture: Electronic Exchanges.
By: E. S. Grundy.
Held at: Stafford College of Further Education, Tenterbanks, Stafford.
Date: 8 November.
Time: 7.15 p.m.
Lecture: The Application of Programmed Learning to Industrial Training.
By: K. Holme.

South Midland Section

Held at: Abbey Ballroom, Malvern.
Date: 14 November.
Time: 7 p.m.
Lecture: There is More to Colour than Wavelength.
By: R. W. Brocklebank.

Merseyside Section

Held at: Liverpool College of Technology, Byrom Street, Liverpool.
Date: 16 November.
Lecture: Stereophonic Broadcasting.
By: G. J. Phillips.

North Eastern Section

Held at: Institute of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle upon Tyne.
Date: 9 November.
Time: 6 p.m.
Lecture: Lasers and their Applications.
By: G. W. Wilson.

Scottish Section

Held at: Carlton Hotel, North Bridge, Edinburgh.
Date: 8 November.
Time: 6 p.m.
Lecture: Scanning Electron Microscope and other Electron Probe Instruments.
By: Prof. C. W. Oatley.
(Joint I.E.E.-I.E.R.E. Meeting.)
Held at: Carlton Hotel, North Bridge, Edinburgh.
Date: 24 November.
Time: 6 p.m.
Lecture: Transducers in Medical Research.
By: D. C. Thomas.
(Joint I.E.R.E.-I.E.E. Medical Electronics Meeting.)
Held at: University of Strathclyde, Glasgow, C.1.
Date: 7 November.
Time: 6 p.m.
Lecture: Scanning Electron Microscope and other Electron Probe Instruments.
By: Prof. C. W. Oatley.
(Joint I.E.E.-I.E.R.E. Meeting.)

THE TELEVISION SOCIETY

Date: 24 November.
Time: 7 p.m.
Held at: Conference Suite, I.T.A., 70 Brompton Road, London, S.W.3.
Lecture: Interference to Television in the U.H.F. Bands.
By: A. S. McLachlan (P.O. Engineering Department).
Date: 30 November.
Time: 6 p.m.
Held at: London School of Hygiene and Tropical Medicine, Keppell Street, London, W.C.1.
Lecture: Pay Television.
By: G. H. Hamburger (Sangamo Weston Ltd.) and K. A. Russell (British Relay Wireless and Television Ltd.).
(This will be a joint meeting between the Institution of Electronic and Radio Engineers and The Television Society.)

NOUVELLES Réalisations

Traduction des pages 750 à 755

Une description basée sur des renseignements fournis par les fabricants de nouveaux composants, accessoires et instruments d'essai

THERMOMÈTRE ÉLECTRONIQUE

Protech Advisory Services Ltd, 21 High Street, Rickmansworth, Hertfordshire

(Illustration à la page 750)

Le thermomètre électronique est un instrument de précision à circuit imprimé et comportant des semi-conducteurs d'un modèle nouveau.

Un choix de têtes sensibles à la température est relié au circuit à l'aide d'un commutateur rotatif et la température de la tête sensible choisie est indiquée sur l'échelle de l'instrument de mesure. Les têtes employées sont des dispositifs à tolérance restreinte et de haute précision et ils sont interchangeables. Les têtes sensibles peuvent donc être remplacées en cas d'endommagement et leurs indications peuvent être comparées sans qu'il y ait lieu de procéder à un nouvel étalonnage de l'instrument de mesure. Les dispositifs sensibles à la température peuvent être placés à une distance allant jusqu'à 600 mètres de l'instrument sans causer une erreur appréciable.

Tous les "Télé-Thermomètres" sont conçus pour répondre à des conditions industrielles et de recherche rigoureuses en ce qui concerne la précision de l'étalonnage et la stabilité. Des facilités sont prévues pour le contrôle et le réglage par l'utilisateur à une erreur maxima de 1° C. Des brevets ont été demandés pour le circuit électronique. L'instrument fonctionne sur batterie ou sur courant secteur et peut recevoir jusqu'à 5 éléments sensibles interchangeables pour la gamme de −50° C à +150° C. 24 éléments sensibles ou d'avantage peuvent être reliés au moyen d'un commutateur.

EE 99 751 *pour plus amples renseignements*

POTENTIOMÈTRE BOBINÉS

Distributeurs: W. Greenwood (London) Ltd, 21 Germain Street, Chesham, Buckinghamshire

(Illustration à la page 750)

De nouveaux potentiomètre bobinés et réglables de fabrication suisse, série T125S, conçus pour le montage direct sur plaquette de circuit imprimé, ont été introduits dans le Royaume-Uni par la société W. Greenwood (London) Ltd. Il s'agit de potentiomètres à un seul tour avec une performance d'humidité remarquable et une puissance nominale de 1,5 W à 50°C. Les éléments ajustables par tournevis comportent des réglages électriques à autoverrouillage, des contacts en métal précieux et des broches de borne dorées.

Ce composant vendu à un prix compétitif est fourni à des valeurs de résistance de 10 Ω à 50 kΩ avec des dimensions externes de 0,5 pouce de diamètre × 0,56 pouce × 0,395 pouce et d'un poids de 3,5 grammes. Il peut résister à une température maxima de +150°C (+302°F). La tolérance de résistance est de ±10% mais des tolérances plus restreintes peuvent être fournies sur demande.

EE 99 752 *pour plus amples renseignements*

LECTEUR À BANDE PERFORÉE

Great Northern Telegraph Works, Copenhague, Danemark. Bureau de Londres: 5 St. Helen's Place, London, E.C.3

(Illustration à la page 750)

Le lecteur de bande perforée photoélectrique, modèle 4101, est un dispositif de style moderne. Il a une vitesse de lecture à variation infinie de 250 à 1000 caractères par seconde en cas de fonctionnement continu et de 0 à 1000 caractères par seconde dans le cas du fonctionnement de plot à plot. L'alimentation vers l'avant et vers l'arrière permet une lecture bidirectionnelle avec la même vitesse de lecture dans l'un ou l'autre des modes de fonctionnement.

Les temps de mise en marche et d'arrêt de la bande sont très courts et le guide de la bande est à réglage intantané pour des bandes à 5, 6, 7 ou 8 voies. Un amplificateur asservi assure une intensité lumineuse constante en compensant le vieillissement de la lampe et les fluctuations du courant secteur. La durée de vie estimée de la lampe est supérieure à 1000 heures. Le taux d'erreurs du système de lecture est inférieur à 1×10^{-9} et un contrôle de parité peut être ajouté en branchant deux plaquettes de circuit imprimé. L'appareil a été conçu pour l'emploi dans une gamme de température de −10° C à +50° C et il est muni de dispositifs d'alarme fonctionnant lorsque l'appareil est utilisé dans des conditions pouvant donner lieu à des erreurs. Le lecteur est fourni tel qu'on le voit dans notre gravure ou pour montage sur bâti de 48,2 cm.

EE 99 753 *pour plus amples renseignements*

AMPLIFICATEUR DE TENSION CONTINUE

Consolidated Electrodynamics Division, Bell & Howell Ltd, 14 Commercial Road, Woking, Surrey

(Illustration à la page 750)

Un nouvel amplificateur différentiel de tension continue à gain élevé comportant une combinaison optima de souplesse d'emploi et de faible prix a été réalisé par la société Consolidated Electrodynamics Division.

L'amplificateur de tension continue type 1-165 a été étudié pour entraîner des galvanomètres à faisceaux lumineux de haute fréquence ainsi que d'autres charges flottantes ou à la terre, avec des signaux d'entrée provenant de sources de niveau moyen ou bas.

Une application potentielle existe lorsqu'il s'agit d'effectuer une amplification ou une transformation d'impédance de signaux électriques de niveau bas à niveau moyen. Cette situation peut se produire dans la mesure statique ou dynamique de l'accélération, de phénomènes acoustiques, du déplacement, de la force, du flux de masse, des phénomènes physiologiques, de la puissance, de la tension, du courant, de la pression, de la position rectilinéaire, de la position rotative, de la contrainte, de la température, du couple, ou des vibrations.

Les principales caractéristiques de l'appareil sont les suivantes: gain étalonné/Vernier, 10 à 1000; réponse de fréquence, ±3 % à 15 000 cps; capacité de sortie, ±10 volts, 100 mA; facilité de protection/atténuation du galvanomètre à fiche; réglage du zéro, ±5 volts; impédance d'entrée, 1 megohm; et un transformateur de puissance intégrale à l'intérieur de chaque module. Différents montages sont prévus, dont le coffret portatif à une voie, le montage sur bâti fixe ou glissant à huit voies et le montage sur banc d'essai à huit voies.

EE 99 754 *pour plus amples renseignements*

AMPLIFICATEUR PARAMÉTRIQUE

Isleworth Electronics, Frederick Street, Waddesdon, Buckinghamshire

(*Illustration à la page 751*)

L'étage d'entrée paramétrique de l'amplificateur A101 à fréquence acoustique donne une performance à très faible bruit, particulièrement lorsqu'il est utilisé avec des sources de signaux ayant une impédance élevée. L'impédance d'entrée de 10 MΩ au minimum rend l'amplificateur particulièrement approprié pour les transducteurs en céramique ainsi que pour les sources de signaux similaires et les applications de la recherche physiologique.

Des coupures de haute fréquence à commutation sont prévues pour maintenir le niveau de bruit aussi bas que possible et pour permettre à l'utilisateur de choisir la largeur de bande la plus basse possible. En outre, trois coupures de basse fréquence à commutation permettent le rejet des signaux de mode commun restants tels que la fréquence d'alimentation. Un gain de 100 ou de 1000 peut être choisi.

L'isolement du circuit d'entrée du reste de l'amplificateur donne un rejet de mode commun de 120 dB à 50 Hz. En dépit de ses dimensions hors-tout réduites, soit 10,79 cm × 12,06 cm × 8,89 cm l'appareil fonctionne sur sa batterie au mercure interne avec une durée de vie prévue de 40 heures. Un bloc d'alimentation à part, type P101, actionne jusqu'à 10 de ces amplificateurs. Jusqu'à 3 de ces amplificateurs 101 peuvent être montés sur un panneau de châssis standard de 48,26 cm × 13,33 cm de hauteur.

EE 99 755 *pour plus amples renseignements*

COMPTEURS ÉLECTRIQUES MINIATURE

Veeder-Root Ltd, New Addington, Surrey

(*Illustration à la page 751*)

Une nouvelle série de compteurs électriques miniature a été crée par la société Veeder-Root Ltd. Conçue de manière compacte et sûre, cette nouvelle gamme se caractèrise par sa faible consommation de courant (2,5 W), sa vitesse de comptage élevée (1000 coups/minute), son fonctionnement continu et sa longue durée de vie. Toutes les versions sont prévues soit pour montage à l'arrière soit pour montage sur panneau, et toutes sauf une comportent un réenclenchement à bouton-poussoir. Un cristal grossissant constitue un accessoire standard (dimensions effectives: 0,16 "de haut × 0,080" de large).

Cinq modèles courants sont offerts à la vente: réenclenchement à 4 chiffres; réenclenchement à 5 chiffres; réenclenchement de douzaines à 5 chiffres; réenclenchement à 6 chiffres et non-réenclenchement à 6 chiffres. Un nouveau dispositif de réenclenchement "à puissance" est inclus dans les deux modèles à 5 chiffres. Il élimine le risque d'endommagement du mécanisme au cas où l'on actionnerait le "réenclenchement" pendant que le compteur est amorcé et il permet d'effectuer le réenclenchement à n'importe quel moment.

EE 99 756 *pour plus amples renseignements*

INTÉGRATEUR MINIATURE À COURANT CONTINU

Distributeurs: Universal Control Equipment Ltd, Frome Buildings, London Road, Stroud, Gloucestershire

(*Illustration à la page 751*)

L'intégrateur type ZM/54 "Minigrator" est une nouvelle version miniature de la gamme de compteurs de précision à courant continu fabriqués par la société Fernsteuergräte de Berlin-Ouest.

Conçu pour intégrer des valeurs électriques dans la commande d'instrumentation et de processus, le Minigrator a une précision supérieure à 0,2 % et il est particulièrement indiqué pour totaliser des débits de liquides et matières solides. Dans sa forme classique, l'instrument est logé dans un coffret métallique ne mesurant que 7,30 cm × 3,65 cm et prévu pour le montage sur panneau. Il existe, en variante, un modèle sans coffret pouvant être incorporé à des appareils tels que les enregistreurs, les amplificateurs, de débitmètres, les instruments de mesure de la température, etc.

Lorsque le type ZM/54 est utilisé comme intégrateur de tension, toute gamme entre 0 et 0,3 V et 0 et 5 V peut être traitée. Des gammes de courant de 0 à 5 mA et de 0 à 1 A peuvent également être prévues de manière standard et n'importe quelle vitesse de comptage entre 10 et 100 chiffres binaires par heure peut être assurée avec n'importe quelle gamme de courant ou de tension. L'affichage s'effectue sur un compteur du type cyclomètre à six chiffres binaires.

EE 99 757 *pour plus amples renseignements*

AMPLIFICATEUR COHÉRENT

Caltronics Ltd, Caltronics House, Huntingate, Hitchin, Hertfordshire

(*Illustration à la page 751*)

La société Caltronics fabrique maintenant un amplificateur cohérent pour la détection et la mesure de signaux à niveau réduit. L'amplificateur est d'un intérêt particulier pour les ingénieurs dans des domains tels que la radio-astronomie, la physique des plasmas, la spectroscopie micro-ondes, ainsi que dans de nombreuses utilisations pour la détection de faibles signaux.

La gamme de fréquence va de 20 Hz à 15 kHz et l'amplificateur a une sensibilité sur la totalité de l'échelle de 5 μV efficaces. La détection de signaux est à 40 dB au dessous du bruit de réception et il y a des réglages indépendants en phase et à quadrature de phase. Les constantes de temps peuvent être choises entre 0,1 et 100 sec. Un amplificateur à faible bruit et à gain élevé donne une stabilité excellente et le système à détection synchrone fonctionne à une degré de détection quasi optimum. La détection et la mesure de signaux à fouble bruit est donc possible même s'ils sont bien au-dessous du niveau du système.

Des signaux internes ou externes peuvent être utilisés comme canal de référence pour assurer une couverture de fréquence de 20 Hz à 15 kHz par sélection à travers des filtres à double T.

Une sortie à faible impédance est prévue pour les enregistreurs de type galvanométrique en plus de l'indication par instrument de mesure.

EE 99 758 *pour plus amples renseignements*

COMPTEUR/FRÉQUENCEMÈTRE

Venner Electronics Ltd, Kingston By-Pass, New Malden, Surrey

(*Illustration à la page 752*)

Le fréquencemètre "tout silicium" TSA 6634 à gamme de 10 Hz à 2 MHz constitue une réalisation récente de la série des instruments de mesure de fréquence Venner. Des périodes de signaux de 10 Hz à 100 kHz peuvent également être mesurés. L'appareil permet, en outre, le minutage de comptage. Les indicateurs numériques à cathode troide et à vision latérale affichent la lecture à 4 chiffres et la durée d'affichage peut être réglée à l'infins ou ajustée entre 0,5 et 5 sec. L'emploi d'un tachygénérateur peut s'effectuer au moyen d'une douille à plusieurs directions.

Les temps de déclenchement périodique pour la mesure de fréquence sont de 1 msec, 10 msec, 0,1 sec, 1 sec, 10 sec. La sensibilité va de 100 mV à 250 V avec commande de sensibilité variable; l'impédance d'entrée est supérieure à 200 kHz.

Pour la mesure de périodes, les temps de déclenchement périodique sont de 1, 10 ou 100 cycles de l'entrée, et les minutés de temps sont de 10 μsec ou de 1 msec. La sensibilité et l'impédance d'entrée sont les mêmes que pour la spécification de la mesure de fréquence.

L'étalon interne est un cristal de 100 kHz, d'une précision de ±1 comptage et d'une stabilité de cristal plus ou moins équivalente. L'instrument a été conçu pour être utilisé dans une gamme de températures de −10° C à +60° C. L'alimentation va de 100 à 125 V ou de 200 à 250 V, 40 à 60 Hz, c.a.

Le TSA 6634 mesure 26,67 cm de large sur 13,33 cm de haut sur 21,59 cm de profondeur.

EE 99 759 *pour plus amples renseignements*

PROGRAMMATEURS À TAMBOUR

Sealectro Ltd, Farlington, Portsmouth, Hampshire

(*Illustration à la page 752*)

La pouvoir de changer des programmes et des vitesses de tambour vient d'être donné à la gamme de commutateurs de programmes à tambour ACTAN réalisée par la société Sealectro Ltd.

Grâce à cette innovation, le tambour à programme peut être retiré de l'assemblage de commutation par simple déclenchement de deux leviers et remplacé par un autre tambour avec un programme complètement différent en moins d'une minute. Pour changer la vitesse de rotateon, le moteur de minutage peut être remplacé par un moteur ayant une vitesse d'entraînement différente par simple retrait de trois vis.

Le nouveau programmateur à tambour et minuterie remplaçables est livrable dans le format à 60 positions et il peut être produit suivant la demande de l'utilisateur dans n'importe quelle dimension voulue pour pouvoir contrôer de 16 à 57 circuits. Comme pour tous les programmateurs ACTAN, les mécanismes de commande à code de couleurs sur un seul tambour peuvent être réglés individuellement sur place. Les nouvelles caractéristiques permettront de changer les programmes rapidement ou d'éliminer les pertes de temps pour les réglages sur place, ces derniers pouvant être effectués maintenant sur un tambour supplémentaire qui remplace simplement celui de l'appareil.

EE 99 760 *pour plus amples renseignements*

ENREGISTREUR DE MILLIVOLTS

KPE Controls Ltd, Vale Road, Tonbridge, Kent

(Illustration à la page 752)

La société KPE Controls Ltd vient d'annoncer la réalisation d'un enregistreur de millivolts KOM-PAC qui fait partie de sa gamme d'instruments de contrôle et de mesure de processus.

L'enregistreur de millivolts KOM-PAC a été conçu et mis au point pour répondre à la demande d'un enregistreur à lecture directe à voie unique et d'une grande sensibilité. Il est utilisé en liaison avec la gamme étendue de modules KOM-PAC à fiches de la série KPE, qui assurent toute fonction supplémentaire de mesure, d'alarme et de contrôle.

L'instrument se compose essentiellement de l'amplificateur à reaction transistorisé KOM-PAC, utilisé pour contrôler des entrées de millivolts et il fournit une sortie de courant standard pour actionner un mécanisme enregistreur à cadre mobile de haute qualité. L'amplificateur enregistreur ainsi que les modules KOM-PAC supplémentaires sont autonomes.

Notre gravure montre un enregistreur KOM-PAC univoie. Des instruments à enregistrement continu allant jusqu'à 6 voies peuvent être fournis.

L'enregistreur KOM-PAC est prévu pour l'utilisation avec une gamme étendue d'entrées et il est particulièrement recommandé pour l'emploi avec des transducteurs à faible sortie. Il peut être utilisé avec tous les couples thermoélectriques courants ou tous les thermomètres à résistance pour l'enregistrement de la température.

En liaison avec la gamme des modules KOM-PAC, il existe un nombre de dispositifs autonomes supplémentaires. Ces derniers comprenent des contacts d'alarme et de contrôle, la commande proportionnelle pour des entassements de thyristors externes ou autonomes, des alarmes de retard de temps autonomes, une sortie supplémentaire pour la mise en oeuvre de téléindicateurs ou de contrôleurs, etc.

EE 99 761 *pour plus amples renseignements*

OSCILLATEUR-DÉMODULATEUR

S.E. Laboratories (Engineering) Ltd, Astronaut House, Feltham, Middlesex

(Illustration à la page 752)

La société SE Laboratories (Engineering) Ltd a réalisé un oscillateur-démodulateur encapsulé, le modèle SE 62/12, qui produit une sortie linéaire de -3 V à $+3$ V dans une gamme de pression de transducteur déterminée.

Son faible encombrement permet de l'utiliser dans le même espace restreint que l'élément transducteur.

Il est amorcé par une alimentation en continu extérieure stabilisée de 12 V et il comprend un oscillateur de 3 kHz, un amplificateur et un démodulateur pouvant être utilisé en liaison avec les transducteurs a reluctance variable construits par la société SE Laboratories pour la mesure de pression, d'accélération et de déplacement.

Insensible à la condensation, l'appareil peut être monté à n'importé quelle altitude. Les connexions s'effectuent par des câbles volants fixés de manière permanente. Il mesure 9 cm × 2,9 cm × 2,5 cm.

EE 99 762 *pour plus amples renseignements*

COMMUTATEURS À PLOTS ROTATIFS

Distributeurs: M.L. Industrial Products Ltd, 292 Leigh Road, Trading Estate, Slough, Buckinghamshire

(Illustration à la page 752)

Conformément à son accord de représentation avec la société ML Ericsson de Suède, la société ML Industrial Products Ltd importe au Royaume-Uni des stocks du commutateur à plots rotatif Ericsson type RVF.

Ce commutateur est prévu avec un maximum de 6 banes de 30 contacts. Une autre version comportant deux jeux de contacts frotteurs fournit l'équivalent de 12 banes de 15 contacts.

Les caractéristiques exceptionnelles de cet unisélecteur sont, en premier lieu, la protection complète contre la poussière qu'il assure aux contacts et aux composants mobiles et la facilité avec laquelle les pièces peuvent être remplacées.

C'est à peine si un minimum d'entretien est exigé et, doins des conditions normales d'utilisation, la durée de vie est de 10 millions de révolutions.

Le commutateur peut être autoactionné à des vitesses allant jusqu'à 60 cycles de commutation par seconde par l'emploi des contacts d'interrupteur. Les contacts de guidage sont normalement fournis sur toutes les versions. Des contacts dorés sont fixés tant sur les frotteurs que sur les bancs.

EE 99 763 *pour plus amples renseignements*

LIGNES À RETARD

Johnson, Matthey & Co. Ltd. 73-83 Hatton Garden, London, E.C.1

(Illustration à la page 753)

La société Johnson, Matthey & Co Ltd vient d'annoncer l'introduction des lignes à retard Silver Star. Ces composants à constantes LC groupées le'moignant d'une résistance élevée à l'humidité et présentent une excellente stabilité aux changements de température, ainsi qu'une remarquable fiabilité en service.

Une gamme standard de lignes à retard Silver Star, ayant chacune une impédance caractéristique de 500 Ω, a été mise au point autour de deux incréments de ligne à retard de base, soit 10 nsec et 25 nsec. Cette gamme offre aux électroniciens non seulement un choix de neuf temps de retard de base, de 10 nsec à 500 nsec, mais également une série de rapports allant du temps de retard au temps de montée. Sans affecter l'impédance caractéristique de 500 Ω, d'autres temps de retard ou d'autres rapports de temps de retard peuvent être obtenus en mettant simplement en cascade deux ou plusieurs éléments dans un circuit.

Les éléments sont produits en quatre grandeurs standard ayant la même section mais des longeurs différentes. Chaque élément est encapsulé dans de la résine d'époxyde donnant un bloc solide, robuste et hermétiquement scellé. Deux fils métalliques terminaux en bronze phosphoreux (à revêtement électrolytique) et recouverts de soudure sont expacés avec précision pour pouvoir s'adapter à des modules de plaquettes imprimées de 0,1″, et deux bornes communer sont prévues pour amplifier la disposition et le câblage.

La base de chaque éléments comporte des patins légèrement surélevés afin de présenter un espace qui élimine tout risque d'accumulation d'humidité sur la face intérieure de l'élément et de la plaquette. Les patins peuvent être collés à la plaquette de circuit pour augmentes la solidité de l'assemblage.

EE 99 764 *pour plus amples renseignements*

AMPLIFICATEUR DE TRANSDUCTEUR

Fenlow Electronics Ltd, Springfield Lane, Weybridge, Surrey

(Illustration à la page 753)

L'amplificateur Fenlow ZA2 a été conçu pour l'emploi avec des extensomètres du type à résistance, des transducteurs de pression et des accéléromètres dans l'instrumentation et les applications à mécanisme asservi. Toutes les facilités nécessaires pour mettre en oeuvre les types précités de tranducteurs sont incorporés dans un seul élément compact comprenant les composants principaux suivants:

Amplificateur différentiel c.c. à dérive réduite; amplificateur fixe à plot de gain avec interpolation par potentiomètre à cadran à plusieurs tours; alimentation stabilisée secteur; alimentation variable de pont; 6 systèmes d'étalonnage; des résistances de pont bobinées de précision; une commande d'équilibre de pont à plusieurs tours; une commande de tension de pont à plusieurs tours et la possibilité du fonctionnement à pont entier ou à demi-pont.

Le courant de sortie prévu est plus que suffisant pour actionner des charges telles que les valves asservies Moog et des galvanomètres ultra-violets à haute fréquence.

L'appareil a été étudié pour être monté dans un bâti standard avec des connexions à l'arrière. Sept éléments peuvent être fixés dans un bâti de largeur standard. Le ZA2 peut être utilisé non seulement avec des transducteurs mais aussi pour l'amplification de la tension continue et la transformation de l'impédance. Ce mode de fonctionnement est choisi au moyen d'un commutateur sur le panneau frontal.

L'impédance d'entrée de l'amplificateur dépasse 2 MΩ, l'impédance d'entrée étant au-dessous de 1 Ω. Le gain peut être contrôlé par réglage précis ou approximatif entre 100 et 800. Le courant de sortie est de ±36 mA dans 330 Ω, la tension de sortie étant de 40 V de crête à crête dans 300 Ω. Le rejet de mode commun est de 120 dB à ±5 V, 100 dB à ±10 V et la linéarité est de 0,01 %

EE 99 765 *pour plus amples renseignements*

SOLUTION D'ÉTAMAGE

Shipley Chemicals Ltd, Coventry Trading Estate, Sisken Drive, Baginton, Coventry

Un nouveau procédé d'étamage par immersion vient d'être mis au point par la société Shipley Chemicals Ltd. Ce procédé produit des dépôts ayant des qualités exceptionnelles de soudabilité et de résistance à la corrosion, même après des périodes étendues d'emmagasinement.

Les solutions LT27 peuvent être re-approvisionnées en leur ajoutant du LT27B, ce bain est extrêmement stable et il donne une quantité abondante d'étain. Des épaisseurs de 100 μ peuvent être obtenues en une trentaine de minutes.

Des Lublots en cuivre étamé peuvent résister à 96 heures de pulvérisation de sel sans la moindre rupture tandis qu'après une exposition à 95% d'humidité relative à 90°F pendant 96 heures les parties firmes peuvent toujours être facilement soudables.

EE 99 766 *pour plus amples renseignements*

TRANSMETTEUR-RÉCEPTEUR À AUTO-SYNCHRONISATION

Aviation Division, Smiths Industries Ltd, Kelvin House, Wembley Park Drive, Wembley, Middlesex

(*Illustration à la page 753*)

Un transmetteur émetteur à autosynchronisation et à servomécanisme a été ajouté à la gamme d'instruments d'essais et de contrôle conçus et mis au point par la Division d'Aviation de la société Smith Industries Ltd. Cet appareil est prévu pour le contrôle des systèmes et composants à asservissement électromécanique.

Logé dans un coffret compact mesurant 21,59 cm de large, 14,92 cm de haut et 24,13 cm de profondeur, il est muni d'une poignée de support pouvant être utilisé également comme base lorsque l'instrument est en action. Un cadran indicateur à deux aiguilles montrant l'angle d'arbre est fixé à l'avant de l'instrument, de même que toutes les commandes et commutateurs.

Les aiguilles sont reliées aux deux dispositifs de synchronisation et entraînés par un tachygénérateur à moteur, le tout se trouvant à l'intérieur de l'appareil. L'un des deux systèmes de synchronisation est un transformateur contrôlé qui indique l'angle d'entrée en liaison avec un amplificateur à asservissement, tandis que l'autre système est un transmetteur de couple à faible impédance pouvant transmettre n'importe quel angle indiqué sur le cadran. L'angle du transmetteur peut être réglé par un circuit d'asservissement de contrôle à vitesse étalonnée qu'on peut employer pour fournir soit une vitesse continue ou n'importe quel angle fixe.

Dans un autre mode d'utilisation, la position d'autosynchronisation du transmetteur peut être placée sous le contrôle d'un étalon d'angle électrique externe (comme, par exemple, un pont delta) permettant de limiter la précision angulaire uniquement par la précision de l'étalon externe et l'erreur de donnée du circuit d'asservissement. On élimine ainsi toutes les erreurs dans le mécanique d'affichage et de synchronisation du transmetteur.

L'instrument est équipé de circuits constitués de corps solides et fonctionne à partir d'une alimentation de 115 V ou 200 V, 400 Hz, mais dans tous les modes, l'excitation de synchronisation, peut être fournie par une source extérieure qui n'est pas nécessairement verrouillée au courant secteur de 400 Hz en phase ou en fréquence.

La précision est de 10 minutes d'arc et la résolution d'affichage est de 1,5 minutes mais le seuil est de 0,5 minutes, de sorte que lorsque l'instrument est utilisé en tant que pour externe, la précision est de ±0,5 minutes. Dans le mode de transmission de vitesse, cette dernière peut atteindre jusqu'à 30 degrés par seconde. Un dispositif de contrôle automatique est incorporé à l'instrument.

D'autres appareils analogues comprenant des mécanismes de résolution ainsi que des machines à trois fils et ayant des vitesses de rotation sur elles-mêmes plus élevées, peuvent être fournis, de même que des indicateurs à autosynchronisation montés sur panneau et utilisant la même méthode de lecture et munis d'amplificateurs faisant corps avec eux.

EE 99 767 *pour plus amples renseignements*

VOLTMÈTRE ÉLECTRONIQUE

Marconi Instruments Ltd, St. Albans, Hertfordshire

(*Illustration à la page 754*)

Un nouveau voltmètre électronique alliant la souplesse d'emploi à une grande précision et à une parfaite stabilité vient d'être mis sur le marché par Marconi Instruments Ltd. L'instrument TF 2604 permet, en effet, d'effectuer des mesures précises de tension alternative de 25 mV à 300 V dans la gamme de fréquence de 20 Hz à 1500 MHz. La gamme de tensions continues va de 10 mV à 1000 V et la résistance peut être mesurée de 0,2 Ω à 500 MΩ.

Quatre accessoires facultatifs augmentent encore l'utilité du TF 2604. Des hautes tensions allant jusqu'à 30 kV et 2 kV c.a. peuvent être mesurées à l'aide de multiplicateurs de tension continue et de tension alternative à fiches. Pour la mesure de tensions sur une ligne coaxiale, un connecteur en T à fiches a été prévu pour la sonde de courant alternatif. Une charge de 50 Ω à équilibrage précis et à terminaison coaxiale est également prévue.

La bonne stabilité de lecture inhérente à cet instrument est obtenue par la stabilisation totale des éléments de chauffage des lampes et la ligne de haute tension; on utilise un circuit à lampes en série pour la haute tension et un circuit à transistors piloté par une diode Zéner pour l'alimentation en basse tension. Il en résulte que des changements dans la tension d'alimentation secteur pouvant atteindre 10 % n'occasionneront qu'un changement de déviation de moins de 4 mV sur la totalité de l'échelle et sur toutes les gammes.

Un circuit push-pull d'une qualité éprouvée est utilisé pour entraîner l'instrument de mesure, chaque moitié se composant d'un amplificateur à valve et d'un circuit à charge cathodique. La sonde utilisé pour la mesure du courant alternatif comporte un redresseur à diode à scellement à disque d'un type perfectionné. Une capacité de 1,5 pF seulement, à temps transitoire réduit et à fréquence de résonance de 3000 MHz, ainsi qu'une tête de sonde d'un dessin exceptionnel, permettent la réponse de fréquence maxima de 1500 MHz. Petite et cylindrique, cette sonde légère a été conçue en vue d'un maniement facile. Un connecteur de terre spécial à fiches est également fourni pour faciliter l'exécution de la connexion ultracourte nécessaire aux fréquences élevées.

La mesure de la tension continue et de la résistance a été simplifiée par la sonde spéciale à double usage à tension continue munie d'un sélecteur V/Ω. Une résistance d'isolement réglée en volts est introduite pour protéger le circuit soumis à l'essai contre les effets de la capacitance du câble de sonde. Pour la mesure de tension continue, l'instrument de mesure peut être commuté de manière à présenter une déviation avant avec des tensions positives ou négatives. Pour la mesure du zéro central, une tension continue constante est appliquée pour polariser l'instrument de mesure à la moitié de l'échelle.

EE 99 768 *pour plus amples renseignements*

PONT DE THERMOMÈTRE

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

(Illustration à la page 754)

La société H. Tinsley è Co Ltd a récemment mis au point un instrument permettant de mesurer les changements de résistance en ohms d'éléments de thermomètre par la méthode à quatre bornes.

Cet instrument qui porte la référence de type 5596 est un pont pour éléments de thermomètre extensibles et il a été conçu pour l'emploi avec les éléments de thermomètre extensibles à quatre bornes.

La gamme de résistance s'étend de 75 à 165 Ω pouvant être lus jusqu'à ±0,1 Ω. La gamme de température va de −50°C à +150°C, par l'emploi d'éléments de 100 Ω ayant une reproductibilité de ±¼°C. Le pont est alimenté par un oscillateur à ondes carrées de 1000 Hz à 2,5 V et le détecteur est un instrument de mesure à zéro central actionné par un amplificateur à détecteur transistorisé. La sensibilité disponible permet de détecteur un changement de 0,5 Ω.

L'emploi d'un générateur d'ondes carrées élimine les erreurs réactives, et les erreurs de câble sont réduites par l'emploi de la méthode de mesure à quatre bornes ainsi que des tras de rapport à haute résistance. L'utilisation d'une alimentation en courant alternatif réduit les effets thermiques à une proportion négligeable et la précision générale est normalement déterminée par la stabilité des éléments du thermomètre.

EE 99 769 *pour plus amples renseignements*

ANALYSEUR DE SPECTRES

Tektronix U.K. Ltd, Beaverton House, Station Approach, Harpenden, Hertfordshire

(Illustration à la page 754)

Le Tektronix type 491 est un analyseur de spectres à large bande de précision, conçu pour des conditions environnantes assez rudes, pour une grande mobilité et couvrant la gamme de fréquences de 10 MHz à 40 GHz.

Il existe également un modèle pour montage sur bâti, le type R 491. C'est uns appareil identique sous le rapport électrique et n'occupant que 13,5 cm de hauteur de bâti.

Le fonctionnement de l'instrument est fort simple. Les commandes de résolution et de dispersion étalonnée sont accouplées, donnant ainsi une largeur de bande de résolution étroite pour une dispersion étroite et une résolution étendu pour une dispersion du même ordre. Etant donné que la dispersion est étalonnée, les différences de fréquence peuvent être luis directement sur le tube cathodique. Le verrouillage de phases interne assure des affichages stables, même pour une dispersion de 1 kHz/div.

Les autres caractéristiques du type 491 sont: des sensibilités d'ondes entretenues minima allant de −110 à −70 dBm suivant la fréquence, l'affichage plat de plus ou moins 1,5 dBm pour une dispersion de 100 MHz, l'intensification de trace des segments à grande vitesse de la forme d'onde affichée, une longue persistance (P7) phosphorescente et une sortie d'enregistrement à couplage au courant continu.

Les circuits de balayage et de déclenchement de type oscilloscopique permettent le déclenchement à partir de sources internes, externes ou en ligne, à des vitesses de balayage allant de 10 μsec/div à 0,5 sec/div dans une séquence de 1-2-5. La poignée de support peut être réglée à diverses position d'inclinaison. C'est une poignée des plus robustes. Le couvercle du panneau frontal fait fonction de coffret d'emmagasinage pour tour les accessoires standard tels que les adaptateurs, les câbles, les mélangeuts de guide d'ondes et les atténuateurs coaxiaux.

Le modèle à ébénisterie mesure 18 cm de haut, 30 cm de large (poignée y compris), 52,7 cm de profondeur (y compris les pieds arrière et le couvercle frontal), et 57,15 cm de profondeur avec la poignée étendue.

EE 99 770 *pour plus amples renseignements*

AMPLIFICATEUR DE SERVICE

Fenlow Electronics Ltd, Springfield Lane, Weybridge, Surrey

(Illustration à la page 755)

Le Fenlow A8 est un amplificateur stabilisé par relais modulateur utilisant un relais modulateur transistorisé à effet de champ pour réduire la dérive du courant d'entrée à une valeur très réduite. Sa performance en tant qu'intégrateur est comparable à celle qu'on obtient avec des interrupteurs mécanique. Le gain élevé, la largeur de bande et l'impédance d'entrée donnent un calcul de haute précision.

La sortie de la classe A assure une bonne linéarité et l'élimination de la distorsion due au recouvrement.

La sortie est de ±30 V à 5 mA et le gain par circuit ouvert est supérieur à 10^8 auv cc, 10^6 à 50 Hz et 10^4 à 1 kHz. L'impédance d'entrée est de 200 kΩ. La dérive de tension est intérieure à 1 μV/°C. Le bruit de bande large est inférieur à 25 μV de crête et du couvant continu à 10 Hz il est inférieur à 2 μV de crête-à-crête.

EE 99 771 *pour plus amples renseignements*

INDICATEURS DE TEMPÉRATURE À THERMOCOUPLES

Spembly Technical Products Ltd, Trinity Trading Estate, Sittingbourne, Kent

(Illustration à la page 755)

Le "Multitemp", modèle 6610 CA, que l'on voit sur notre gravure constitue un moyen simple et pratique pour mesurer la température de thermocouples au nickel-chrome/nickel-aluminium dans une gamme étendue de températures. Il est virtuellement insensible à la résistance de circuit. La température est indiquée, à l'aide d'un petit amplificateur constitué de corps solides, sur un instrument de mesure ayant une largeur d'échelle allant de −120°C à 100°C. Un sélecteur de gamme d'échelle, utilisé en liaison avec l'instrument de mesure, permet d'effectuer des lectures rapides sur toute l'étendue d'une gamme de température de −120°C à 1000°C. Un dispositif de réglage rapide donne à l'utilisateur une indication immédiate de la température approximative du thermocouple avant réglage à la gamme sensible appropriée.

Le Multitemp comporte une compensation de jonction froide incorporée et une doille d'extension relie l'instrument à un enregistreur standard.

Semblable en apparence au Multitemp, le STP Unitemp, modèle 6650GP, a été étudié pour l'emploi avec des thermocouples au nickel-chrome/nickel-aluminium, au fer/constantan et au cuivre/constantan. L'échelle de température de l'instrument de mesure peut être utilisée également comme échelle de millivolts afin de pouvoir mesurer d'autres combinaisons de matériaux de thermocouples. L'Unitemp donnes des indications de température précises de −30°C à 1000°C et il comprend une douille de sortie pour le branchement à un enregistreur classique.

A l'arrière des deux instruments se trouve une barrette de connexion permettant d'y brancher jusqu'à 12 thermocouples. Le choix de chaque thermocouple se fait au moyen d'un commutateur à 12 directions. (Les connexions 1 à 5 se répètent et comprenent des douilles Spembly ordinaires.)

Les deux instruments sont alimentés par des batteries de longue durée et ils sont entièrement portatifs.

EE 99 772 *pour plus amples renseignements*

CAMÉRA DE TÉLÉVISION

G.E.C. (Electronics) Ltd, East Lane, Wembley, Middlesex

Une caméra de studio de télévision transistorisée de haute qualité et fonctionnant sur courant secteur, particulièrement indiquée pour la télévision éducative, a été réalisé par le groupe de communications de la société G.E.C. Electronics Ltd.

Cette caméra, type VCT 2/S, se caractérise notamment par le fait qu'elle comporte un viseur électrique transistorisé de 17,5 cm pouvant être facilement retiré pour être employé séparément comme contrôleur d'images. La caméra et le viseur ont des circuits de puissance à part.

La caméra peut être fournie avec un étalon de balayage de 625/50 lignes ou de 525/60 lignes et elle transmet sur une largeur de bande de 10 MHz. Cette largeur de bande est plus étendue que celle utilisée par des caméras concurrentes et donne une meilleure définition.

La caméra comprend un tube Vidicon et une tourelle à quatre lentilles pouvant recevoir des lentilles "C" ou des lentilles de diffusion. Un bouton de contrôle sur le côté de la caméra permet le réglage de la concentration optique ou le montage d'un système de commande à distance.

La caméra comprend un générateur d'impulsions synchronisées incorporé et tous les principaux circuits électriques et électroniques sont enfermés dans des modules à circuit imprimé facilement remplaçables, ce qui simplifie considérablement l'entretien. Pour réduire au minimum la longueur du câble à signaux partant du tube Vidicon, le module amplificateur à tête vidéo est monté directement au-dessus de la bobine de focalisation du tube Vidicon.

Un rapport élevé de signal/bruit—36 dB de crête à crête avec un courant de signal de 0,2 μA—s'obtient de l'amplificateur à tête vidéo.

Les commandes de caméra de "tensioncible", de "courant de faisceau", de "focalisation électrique" et de "niveau noir" sont normalement préréglées mais elles peuvent être reliées à un élément de bornes de caméra pour permettre les réglages à distance.

Les circuits électroniques du viseur sont également inclus dans des modules à circuit imprimé afin de faciliter l'entretien.

EE 99 773 *pour plus amples renseignements*

CALCULATRICE DE BUREAU

Cybernetics Instrumentation Ltd, 174 Clanville Road, London, N.W.2

(*Illustration à la page 755*)

La calculatrice LOCI-2 est une machine autonome, se composant d'un élément arithmétique, de registres d'emmagasinage, d'un clavier de programmation manuel, d'un programmateur à cartes perforées automatique et d'un affichage de sortie numérique à dix chiffres de grand format.

La calculatrice peut être utilisée pour trois usages particuliers: en tant que calculatrice d'appoint, pour le calcul à programmation manuelle ou automatique d'équations ainsi que pour le calcul "en ligne" d'une variété de systèmes de contrôle.

Lorsqu'elle est utilisée comme calculatrice manuelle, la LOCI-2 peut exécuter des additions, des soustractions, des multiplications, des divisions et des opérations exponentielles, ainsi que des calculs logarithmiques et des extractions de racines. Toutes ces opérations de base peuvent être effectuées en 40 msec.

Pour le fonctionnement programmé dans le mode automatique la LOCI-2 comprend un répertoire souple et puissant de commandes permettant d'effectuer facilement et de manière compacte toutes les procédures itératives en code.

Un assortiment étendu de programmes est prévu (statistiques, mathématiques, construction mécanique, etc), tels que: les fonctions Bessel, les équations polynomiales, trigonométriques et logarithmiques, les analyses de variance, de triangulation, caténaires et de contrainte.

EE 99 774 *pour plus amples renseignements*

MULTIPLICATEURS DE FRÉQUENCE

Microwave Systems Ltd, Caltronics House, Huntingate, Hitchin, Hertfordshire

(*Illustration à la page 755*)

La société Microwave Systems Ltd commercialise maintenant une série de multiplicateurs de fréquence constitués de corps solides et utilisant des varactors.

Les varactors permettent aux multiplicateurs de produire des harmoniques à des niveaux de puissance allant de quelques milliwatts à 5 W dans la gamme de 1 à 2 GHz, et de quelques milliwatts à environ 1 W aux fréquences de la bande C et 300 mW aux fréquences de la bande X. Dans la gamme de 300 à 1000 MHz les niveaux de puissance vont de quelques milliwatts à 10 W. La société Microwave Systems peut fournit, en outre, des dispositifs d'entraînement pilotés par cristal pour convertir n'importe quel multiplicateur en une source de puissance complète constituée de corps solides.

Tous les multiplicateurs ont uns taux élevé de rejet de parasites à 60 dB avec des filtres de sortie; ils sont tous construits à partir de solides blocs d'aluminium ou de forgeages d'aluminium et ils sont propres à l'emploi dans des engins ou des avions.

EE 99 775 *pour plus amples renseignements*

Résumés des Principaux Articles

Un système multiplex d'enregistrement acoustique par R. W. Procunier

Résumé de l'article aux pages 704 à 709

On a mis au point une technique pour la transmission de données de détecteurs acoustiques à un centre d'enregistrement dans l'expérience de la grenade de fusée. Le système comprend sept fréquences de contrôle dans la gamme de 595 à 2.975 Hz. Ces fréquences sont modulées en amplitude avec des variations de pression et deux systèmes enregistreurs, soit une plume à ultraviolets et une bande magnétique. Cette méthode a l'avantage de supprimer les bruits électriques rencontrés sur de longues lignes de transmission et la capacité de reproduire des signaux électroniquement. Utilisée sur le plan pratique, elle a pu étendre avec succès l'altitude maxima de détection de 355 g grenades à 107 km d'altitude.

Détection de l'achèvement d'un cycle de séquence binaire pseudo-aléatoire par J. Kontos et G. Philokyprou

Résumé de l'article aux pages 709 à 710

Il s'agit ici d'une méthode pour déterminer l'achèvement complet d'un cycle de séquence binaire pseudo-aléatoire à l'aide d'informations provenant d'un seul point du générateur de séquences binaires pseudo-aléatoires. Cette méthode s'effectue par le décodage séquentiel d'une section de la séquence binaire pseudo-aléatoire d'une longueur égale au nombre de stades du générateur.

Un bloc d'alimentation transistorisé pour lampe à décharge à rayons ultra-violets par J. Watson

Résumé de l'article aux pages 711 à 713

L'auteur décrit un bloc d'alimentation pour lampe à décharge au deutérium Flood-Hilger. Ce bloc émet un spectre continu du visible à moins de 2000 Å. Le filament de la lampe est excité pendant 90 secondes et après les premières 60 secondes une impulsion de frappe de 300 V est appliquée. L'arc est alors stabilisé à un courant prédéterminé dans la gamme de 0,35 à 0,55, la stabilité de charge étant supérieure à 18.000:1. Le bloc est entièrement muni de dispositifs semi-conducteurs.

La production de formes d'ondes hyperboliques par R. D. McDonald

Résumé de l'article aux pages 714 à 717

Dans la mesure d'événements à basse fréquence tels que le taux des battements du coeur, il est souvent nécessaire de mesurer la fréquence instantanée entre des événements successifs. Si la sortie du dispositif de mesure doit avoir un rapport linéaire avec la fréquence, elle doit être hyperbolique par rapport au temps. La production de formes d'ondes hyperboliques au moyen de formes d'ondes exponentielles est examinée et des équations de dessin sont obtenues.

Un commutateur de réenclenchement à intégrateur rapide par M. H. McFadden et W. J. Niblock

Résumé de l'article aux pages 718 à 720

Au cours des dernières années, les travaux de perfectionnement des calculateurs analogiques se sont portés principalement sur l'accroissement de la vitesse de fonctionnement. L'un des obstacles au progrès de ces travaux a été le problème de trouver un moyen de réenclenchement des intégrateurs dans de très courts laps de temps sans provoquer d'erreurs sérieuses. Bon nombre des circuits de réenclenchement à action rapide qu'on a ainsi mis au point ne fonctionnent pas de manière satisfaisante aux vitesses réduites ou d'un seul coup et certains constituent des montages hybrides de commutateurs électroniques et de relais électromécaniques de manière à combiner les avantages des deux. Le commutateur semi-conducteur décrit dans cet article fonctionne avec précision tant comme dispositif à un seul coup que comme dispositif à vitesse de répétition élevée.

Un bloc d'alimentation à tension variable et à redresseur piloté au silicium par J. L. Everett

Résumé de l'article aux pages 721 à 724

Cet article traite d'un bloc d'alimentation à tension variable dont le transformateur variable classique a été remplacé par un redresseur piloté au silicium. Grâce à cet élément on peut obtenir la commande de tension précise nécessaire lorsqu'il est utilisé en liaison avec un systeme de pompage à laser pour mesurer de très faibles énergies de seuil. Cet élément présente plusieurs avantages par rapport au transformateur variable, le plus important étant l'élimination des degrés de tension causés par les balais du transformateur variable passant au-dessus des bobinages.

La tension de sortie est à variation continue dans la gamme de 0 à 2,3 kV.

Un oscillateur de présicion basé sur un amplificateur opérationnel par E. J. Brach

Résumé de l'article aux pages 724 à 725

L'auteur décrit un oscillateur de précision produisant des fréquences allant de 1 à 10.000 c.p.s. avec une précision de 3 cycles par 1.000. La vase du dessin est une application nouvelle d'un amplificateur opérationnel donnant un étalon de laboratoire peu coûteux.

Un appareil de mesure des courants de pointe et minimum des diodes-tunnel par J. B. Earnshaw et Z. C. Tan

Résumé de l'article aux pages 726 à 727

L'équipement simple décrit dans cet article permet d'effectuer la mesure rapide des courants de pointe et minima des diodes-tunnel. Il est particulièrement indiqué pour déterminer les valeurs relatives de ces courants pour des lots de diodes-tunnel de type semblable.

Dispositifs à effet de Hall régénératif par D. Midgley

Résumé de l'article aux pages 728 à 730

Les avantages d'un disque (disque de Corbino) dans l'électronique constituée de corps solides sont examinés par rapport à une plaque rectangulaire (plaque de Hall) lorsque l'application pratique exige l'entraînement de courant par l'effet Hall. L'auteur suggère l'application de principes régénératifs aux circuits imprimés actifs pour calculatrices numériques. Le refroidissement aux températures proches du zéro absolu peut être ou ne pas être nécessaire; de toute manière, les dispositifs se comparent favorablement en ce qui concerne la linéarité et le fonctionnement bistable symétrique actif à quelques autres cryotrons. Pour un disque de bismuth dans du hélium liquide, des résultats expérimentaux sont donnés en ce qui concerne la modification suivant la boucle d'hystérésis d'un circuit à réaction magnétique déformé.

Un amplificateur diélectrique constitué de corps solides d'un million de mégohms par G. M. Ettinger

Résumé de l'article aux pages 731 à 734

Après avoir sommairement décrit les méthodes de mesure de courant dans les gammes de nanoampères et de picoampères, l'auteur examine un amplificateur diélectrique constitué de corps solides dont la résistance d'entrée à courant continu est d'un million de mégohms. Le fonctionnement de cet amplificateur est basé sur les propriétés de faible fuite de certaines diodes semi-conductrices utilisées dans le mode à varactor. Il fait mention finalement d'un amplificateur à diélectrique réelle de haute tension, basé sur les propriétés ferro-électriques des condensateurs en céramique.

Un électromyographe clinique avec possibilités de rappel améliorées par C. K. Battye, L. D. Kitchen et A. E. Pastellopoulos

Résumé de l'article aux pages 734 à 735

Cet article s'attache à l'etude d'un nouveau électromyographe utilisant des amplificateurs entièrement transistorisés.

Cet appareil permet d'analyser rapidement le contenu d'une mémoire magnétique à une seconde et de mesurer tout aussi vite les potentiels d'action individuelle.

Un synthétiseur de formes d'ondes à fréquence acoustique par A. Horsman

Résumé de l'article aux pages 736 à 737

Cet article décrit un oscillateur qui produit une séquence de 16 impulsions rectangulaires, toutes à variation d'amplitude indépendante mais de largeur égale. La synthèse s'effectue en réglant les amplitudes de manière à ce que la séquence des impulsions se rapproche de la forme d'onde voulue. Le circuit de l'oscillateur effectue la synthèse dans la gamme de fréquence acoustique et l'amplitude et la teneur en harmoniques du circuit sont presque entièrement indépendants de la fréquence fondamentale.

Un filtre actif pour la mesure des spectres de puissance à bruit de basse fréquence par K. F. Knott et J. S. Bowman

Résumé de l'article aux pages 738 à 740

Un filtre actif à Q constant est décrit dans cet article. Ce filtre convient pour la mesure à bande étroite dans la gamme de fréquence de 1 c.p.s. à 10 kHz c.p.s. La gamme de fréquence est couverte en neuf degrés, soit 10^0, $10^{1/2}$, 10^1, $10^{3/2}$, $\ldots$ 10^4 *c.p.s.*

Il est démontré que si Q est choisi pour donner une largeur de bande fractionnelle de 3 dB de 0,15, aucune erreur sérieuse n'est provoquée lorsqu'une méthode de comptage de transit est utilisée pour mesurer les tensions de bruit efficaces.

Étages à réaction locale à structure de déphasage non-minima par V. Mosca et A. Rimondini

Résumé de l'article aux pages 741 à 743

Cet article donne formules complètes non-approximatives de la fonction de transfert de tension, des impédances d'entrée et de sortie d'étages à réaction locale et interne à structure de déphasage non-minima, calculées suivant des circuits équivalents bien connus des paramètres groupés linéaires alables pour des tubes, des transistors et transistors à effet de champ dans les montages àcathode commune, à émetteur commun et à source commune.

Des exemples numériques, illustrant la présence de zéros à droite sont analysés, ainsi que leur influence sur le comportement des systèmes à cadre fermé dans lesquels ils sont inclus.

NEUE AUSRÜSTUNGEN

Übersetzung der Seiten 750 bis 755

Beschreibung neuer Bauelemente, Zubehörteile und Prüfgeräte auf Grund der von Herstellern gemachten Angaben.

Elektronisches Thermometer

Protech Advisory Services Ltd, 21 High Street, Rickmansworth, Hertfordshire

(Abbildung Seite 750)

Das elektronische Thermometer ist ein Präzisionsinstrument in Druckschaltungstechnik und mit neuen Halbleitertypen bestückt.

Durch Betätigung eines Drehschalters wird einer der angeschlossenen Temperaturfühler eingeschaltet; die Temperatur des gewählten Fühlers wird dann auf der Messgerätskala angezeigt. Die angewendeten Fühler sind mit hoher Präzision zu engen Toleranzen gefertigte und austauschbare Elemente. Man kann daher beschädigte Fühler auswechseln und ihre Anzeigen ohne Nacheichung der Messgerätskala miteinander vergleichen. Die Temperaturfühler können bis zu 600 m vom Instrument entfernt positioniert werden, ohne nennenswerte Fehler zu verursachen.

Alle Tele-Thermometer sind so konstruiert, dass sie in bezug auf Messgenauigkeit und Konstanz den strengsten Anforderungen von Industrie und Forschung genügen. Vorhandene Einrichtungen gestatten Testen seitens des Anwenders und Nacheichung mit einem Höchstfehler von 1°C. Für die elektronische Schaltung wurden Patentanmeldungen eingereicht.

Das Instrument kann batterie- oder netzbetrieben werden und ist für bis zu fünf auswechselbare Fühler mit einem Messumfang von −50°C...+150°C ausgelegt. 24 oder mehr Fühler können über ein Schaltgerät angeschlossen werden.

EE 99 751 *für weitere Einzelheiten*

Drahtpotentiometer

Vertrieb: W. Greenwood (London) Ltd, 21 Germain Street, Chesham, Buckinghamshire

(Abbildung Seite 750)

Neue, in der Schweiz hergestellte einstellbare Drehpotentiometer T125S für Direktmontage auf Druckschaltungsplatten wurden von W. Greenwood (London) Ltd angekündigt. Es sind eingängige Potentiometer mit hervorstechenden Feuchtigkeitseigenschaften und 1,5 W Nennbelastbarkeit bei 50°C. Die mittels Schlitzachse regelbaren Elemente haben selbstsperrende elektrische Einstellungen, Edelmetallkontaktke und vergoldete Anschlussstifte.

Das zu konkurrenzfähigem Preis angebotene Potentiometer kommt in Widerstandswerten von 10 Ω bis 50 kΩ mit 12,7 mm Aussendurchmesser × 14,2 mm × 10 mm und wiegt 3,5 g. Es kann eine Höchsttemperatur von +150°C vertragen und wird mit Widerstandstoleranzen von ±10 % geliefert. Engere Toleranzen können auf Wunsch auch eingehalten werden.

EE 99 752 *für weitere Einzelheiten*

Lochstreifenleser

Great Northern Telegraph Works, Kopenhagen, Dänemark Büro London: 5 St. Helens's Place, London, E.C.3

(Abbildung Seite 750)

Der modern gestaltete fotoelektrische Lochstreifenleser 4101 hat eine bei kontinuierlichem Betrieb zwischen 250 und 1000 Zeichen je Sekunde, bei schrittweisem Betrieb zwischen 0 und 1000 Zeichen je Sekunde stufenlos regelbare Lesegeschwindigkeit. Vorwärts- und Rückwärtsvorschub gestattet Lesen in zwei Richtungen mit gleicher Lesegeschwindigkeit, unabhängig von der Betriebsweise.

Start- und Stoppzeiten für den Lochstreifen sind sehr kurz, und die Streifenführung ist sofort auf 5-, 6-, 7- oder 8-Kanalstreifen umstellbar. Ein Servoverstärker gewährleistet konstante Lichtstärke durch Kompensation für das Altern der Lampe sowie für Netzschwankungen. Die erwartete Lebensdauer der Lampe ist besser als 1000 Stunden. Die Fehlerrate des Lesesystems ist niedriger als 1×10^{-9}, und durch Einstecken von zwei Druckschaltungsplatten kann man eine Paritätskontrolle nachrüsten. Das Gerät ist für Betrieb im Bereich −10°C...+50°C bemessen und hat eingebaute Alarmvorrichtungen, die in Betrieb kommen, wenn die Ausrüstung unter fehlerbegünstigenden Bedingungen arbeitet. Der Leser wird wie abgebildet für Einbau in 19″-Gestelle geliefert.

EE 99 753 *für weitere Einzelheiten*

Gleichstromverstärker

Consolidated Electrodynamics Division, Bell & Howell Ltd, 14 Commercial Road, Woking, Surrey

(Abbildung Seite 750)

Der Geschäftsbereich Consolidated Electrodynamics hat einen Gleichstrom-Differentialverstärker mit hoher Verstärkung angekündigt, der eine optimale Kombination von Anwendungsvielseitigkeit und niedrigem Preis bietet.

Der Gleichstromverstärker 1-165 ist für das Treiben hochfrequenter Lichtstrahlgalvanometer sowie anderer erdfreier und geerdeter Lasten durch Eingangssignale von Quellen mit mittlerem oder niedrigem Pegel ausgelegt.

Anwendungsmöglichkeiten bestehen überall dort, wo Verstärkung und/oder Impedanzwandlung elektrischer Mittel- oder Kleinsignale gewünscht wird. Diese Situation kann in dynamischen oder statischen Messungen von Beschleunigung, akustischen Vorgängen, Verschiebung, Kraft, Massenstromdichte, physiologischen Phänomenen, Leistung, Spannung oder Strom, Druck, rechteckigen Positionen, umlaufenden Positionen, Dehnung, Temperatur, Drehmoment oder Vibration auftreten.

Merkmale sind u.a. geeichte Feinregelung der Verstärkung von 10...1000, Frequenzgang bis zu 15 kHz innerhalb ±3%, Ausgang bis zu ±10 V, 100 mA, einsteckbarer Schutz und Dämpfung für Galvanometer, regelbare Nullpunktverschiebung ±5 V, Eingangsimpedanz 1 MΩ und ein integraler Netztransformator für jeden Modul. Verschiedene Ausführungen sind lieferbar, u.a. in einem tragbaren Einkanalgehäuse, als Achtkanalgerät für Gestelleinbau oder als Einschub, und im Achtkanal-Tischgehäuse.

EE 99 754 *für weitere Einzelheiten*

Parametrischer Verstärker

Isleworth Electronics, Frederick Street, Waddesdon, Buckinghamshire

(Abbildung Seite 751)

Die parametrische Eingangsstufe des NF-Verstärkers A101 macht ihn sehr rauscharm, vor allem wenn er mit hochohmigen Signalquellen Anwendung findet. Durch seine nicht unter 10 MΩ fallende Eingangsimpedanz ist der Verstärker sehr gut für Einsatz mit keramischen Wandlern und ähnlichen Signalquellen sowie für Anwendung in der Physiologie-Forschung geeignet.

Umschaltbares Sperren hoher Frequenzen gibt dem Anwender die Möglichkeit, das Rauschen niedrig zu halten und die schmalste brauchbare Bandbreite zu wählen. Ausserdem helfen drei schaltbare niederfrequente Siebe in der Unterdrückung der übrigbleibenden Gleichtaktsignale wie z.B. der Netzfrequenz. 100× oder 1 000× Verstärkung kann gewählt werden.

Isolierung der Eingangsstufe vom Rest des Verstärkers ergibt eine Gleichtaktunterdrückung von 120 dB bei 50 Hz. Trotz kleiner Aussenabmessungen von nur 108 mm × 121 mm × 89 mm wird der Verstärker aus internen Quecksilberbatterien mit einer erwarteten Lebensdauer von 40 Stunden gespeist. Ein getrennter Netzanschluss P101 kann bis zu 10 dieser Verstärker speisen. Bis zu drei Verstärker A101 können auf ein 133 mm hohes 19″-Gestellfeld montiert werden.

EE 99 755 *für weitere Einzelheiten*

Elektrischer Miniaturzähler

Veeder-Root Ltd, New Addington, Surrey

(Abbildung Seite 751)

Die von Veeder-Root Ltd angekündigten neuen elektrischen Miniaturzähler wurden in kompakter Bauart und auf Zuverlässigkeit entwickelt. Die neuen Zähler haben niedrigen Stromverbrauch (2,5 W) bei hoher Zählgeschwindigkeit (1000 i/s) und gestatten kontinuierlichen Betrieb mit langer Lebensdauer. Alle Ausführungen sind für Auf- oder Einbau lieferbar, und mit einer Ausnahme haben alle eine Rückstelltaste. Die Ziffern (4 mm hoch × 2 mm breit) werden durch ein Vergrösserungsglas gelesen.

Es gibt fünf Standardmodelle: 4stellig und 5stellig mit Rückstellung, 5stellig mit "Dutzend" Rückstellung, 6stellig mit und ohne Rückstellung. Durch eine neue Schutzschaltung können die 5stelligen Modelle unter Strom ohne Beschädigung des Mechanismus, d.h. also jederzeit, durch Betätigung der Taste zurückgestellt werden.

EE 99 756 *für weitere Einzelheiten*

Miniatur-Gleichstromintegrator

Vertrieb: Universal Control Equipment Ltd, Frome Buildings, London Road, Stroud, Gloucestershire

(Abbildung Seite 751)

Der "Minigrator"-Integrator ZM/54 ist eine neue Miniaturausführung im Fertigungsprogramm für Präzisions-Gleichstromzähler der Fernsteuergeräte OHG in West-Berlin.

Der für das Integrieren elektrischer Werte in Instrumentierung und Verfahrensregelung entwickelte "Minigrator" hat eine Messunsicherheit von unter 0,2 Prozent und ist besonders für die Summierung des Durchflusses von Flüssigkeiten und Materialien geeignet. In der Standardausführung ist das Gerät für Schaltfeldmontage in ein Stahlblechgehäuse von 73 × 37 mm eingebaut. Es kann aber auch ohne Gehäuse für Einbau in bestehende Ausrüstungen wie z.B. Schreiber, Strömungsmesserverstärker, Temperaturmessausrüstungen usw. geliefert werden.

Das Gerät lässt sich bei Einsatz als Spannungsintegrator jedem Bereich zwischen 0...0,3 V und 0...5,0 V anpassen. Strombereiche von 0...5,0 mA und 0...1,0 A sind auch lieferbar, und für jeden Strom- oder Spannungsbereich gibt es beliebige Zählgeschwindigkeiten zwischen 10,0 und 100,0 Ziffern je Stunde. Die Anzeige erfolgt auf einem 6stelligen Zyklometerzähler.

EE 99 757 *für weitere Einzelheiten*

Kohärenzverstärker

Caltronics Ltd, Caltronics House, Huntingate, Hitchin, Hertfordshire

(Abbildung Seite 751)

Caltronics Ltd hat jetzt einen Kohärenzverstärker für Nachweis und Messen von Kleinsignalen herausgebracht. Der Verstärker dürfte vor allem für Ingenieure in der Funkastronomie, Plasmaphysik, Mikrowellenspektroskopie und vielen anderen Gebieten, in denen Kleinsignale entdeckt werden müssen, von Interesse sein.

Der Verstärker hat einen Frequenzbereich von 20 Hz ... 15 kHz und eine Vollausschlagempfindlichkeit von 5 μV_{eff}. Signalnachweis 40 dB unter Empfängerrauschen ist möglich; die Gleichtakt- und Querphase werden unabhängig voneinander geregelt. Die Zeitkonstanten sind zwischen 0,1 und 100 s wählbar. Ein rauscharmer Verstärker mit hoher Verstärkung gibt ausserordentlich gute Stabilität, und ein Synchrondetektor arbeitet fast optimal. Nachweis und Messen von Kleinsignalen ist deshalb auch dann möglich, wenn sie beträchtlich unter dem Systempegel liegen.

Interne oder externe Signale können als Bezugskanal benutzt werden und geben bei Selektion mittels Doppel-T-Filter eine Frequenzüberstreichung von 20 Hz ... 15 kHz.

Ausser der Anzeige auf dem Messgerät gibt es noch einen niederohmigen Ausgang für Direktschreiber.

EE 99 758 *für weitere Einzelheiten*

Zähler-Frequenzmesser

Venner Electronics Ltd, Kingston By-Pass, New Malden, Surrey

(Abbildung Seite 752)

Das Venner-Frequenzmesserprogramm wurde durch das neue Modell TSA 6634 mit 10 Hz...2 MHz Messumfang ergänzt. Ausserdem können Periodensignale von 10 Hz...100 kHz gemessen werden, und es gibt auch Zähldauereinrichtungen. Seitlich sichtbare Kaltkathodenzählrohre geben eine vierstellige Anzeige, deren Anzeigedauer sich auf unendlich oder zwischen 0,5 und 5 s einstellen lässt. Eine mehrpolige Ausgangsbuchse gestattet Betrieb mit einem Tachometer.

Die Zeitbasen für Frequenzmessungen sind 1 ms, 10 ms, 0,1 s, 1 s und 10 s, die Empfindlichkeit ist zwischen 100 mV und 250 V mit Regler einstellbar und die Eingangsimpedanz höher als 200 kΩ.

Für Periodenmessungen ist die Zeitbasis 1, 10 oder 100 Perioden des Eingangssignals, 10 μs oder 1 ms. Empfindlichkeit und Eingangsimpedanz wie für Frequenzmessungen.

Das interne Normal ist ein 100-kHz-Kristall, die Fehlergrenze ±1 Signal ±Kristallkonstanz, der Betriebstemperaturbereich −10° C...+60° C. Das Gerät ist für Netzspannungen von 100...125 V~ oder 200...250 V~, 40...60 Hz ausgelegt.

Die Abmessungen des TSA 6634 sind 267 mm breit, 133 mm hoch und 216 mm tief.

EE 99 759 *für weitere Einzelheiten*

Programmwalzenschalter

Sealectro Ltd, Farlington, Portsmouth, Hampshire

(Abbildung Seite 752)

Bisher konnte man bei den von Sealectro Ltd hergestellten ACTAN-Programmwalzenschaltern weder das Programm, noch die Umlaufgeschwindigkeit ändern.

Durch eine Neueinführung kann die ganze Schalteinrichtung nach Auslösen von zwei Hebeln herausgenommen und innerhalb einer Minute durch eine andere Walze mit ganz verschiedenem Programm ersetzt werden. Zur Änderung der Umlaufgeschwindigkeit wird der Schaltmotor nach Lösen von drei Schrauben durch einen mit anderer Treibgeschwindigkeit ersetzt.

Der neue Programmschalter mit auswechselbarer Walze und Zeitsteuerung ist in der Grösse für 60 Positionen lieferbar und auf Kundenwunsch für die Steuerung von 16...57 Kreisen erhältlich. Wie bei allen ACTAN-Programmschaltern, können auch hier die farbkodierten Betätigungsteile einer Walze unabhängig voneinander an Ort und Stelle justiert werden. Die neuen Konstruktionsmerkmale ermöglichen schnelle Programmänderungen und beseitigen die für Änderungen an Ort und Stelle bisher erforderliche Ausfallzeit, da sie jetzt auf einer Reservewalze vorgenommen werden können, die dann gegen die alte einfach ausgewechselt wird.

EE 99 760 *für weitere Einzelheiten*

Millivoltschreiber

KPE Controls Ltd, Vale Road, Tonbridge, Kent

(*Abbildung Seite 752*)

KPE gibt bekannt, dass ein Millivoltschreiber 'KOM-PAC' im Rahmen ihres Programmes für Verfahrensmessung und -steuerung lieferbar ist.

Der Millivoltschreiber 'KOM-PAC' wurde entworfen und seine Fertigung aufgenommen, um der Nachfrage nach einem hochempfindlichen Einkanal-Direktschreiber zu genügen. Er wird in Verbindung mit dem umfangreichen KPE-Sortiment von KPE-Einschubmoduln, die für die Verfahrensinstrumentierung und -steuerung erforderliche zusätzliche Mess-, Alarm- oder Steuerungsfunktionen ausüben, verwendet.

Der Baustein besteht grundsätzlich aus einem gegengekoppelten Transistorverstärker KOM-PAC, der die Millivolteingänge überwacht und einen Standardausgangsstrom für den Betrieb eines Drehspulwerk-Schreibermechanismus abgibt. Der Schreiberverstärker und alle zusätzlichen KOM-PAC-Moduln sind in sich geschlossen.

Die Abbildung zeigt einen KOM-PAC-Einkanalschreiber. Kontinuierlich registrierende Instrumente sind mit bis zu sechs Kanälen lieferbar.

KOM-PAC-Schreiber sind für eine breite Auswahl von Eingängen lieferbar und besonders für Messwertgeber mit niedrigem Ausgangspegel geeignet. Sie lassen sich mit allen Standard-Thermoelementen und Widerstandsthermometern für das Registrieren von Temperaturen einsetzen.

In Verbindung mit KOM-PAC-Moduln stehen eine Anzahl zusätzlicher, in sich geschlossener Einrichtungen zur Verfügung, u.a. Alarm-Steuerkontakte, Proportionalregler für externe oder in sich geschlossene Thyristorstapel, in sich geschlossene Zeitverzögerungsalarme, zusätzliche Ausgänge für Fernanzeigen oder Regler.

EE 99 761 *für weitere Einzelheiten*

Oszillator-Demodulator

S.E. Laboratories (Engineering) Ltd, Astronaut House, Feltham, Middlesex

(*Abbildung Seite 752*)

Die von S.E. Laboratories (Engineering) Ltd herausgebrachten gekapselten Oszillator - Demodulatoren S.E.62/12 geben über einen spezifizierten Messwandler-Druckbereich einen linearen Ausgang von −3 V...+3 V. Kleine Abmessungen gestatten Anwendung in demselben begrenzten Raum wie das Messwandlerelement.

Der Baustein wird von einer externen Konstantstromquelle mit 12 V— gespeist und enthält einen 3-kHz-Oszillator, einen Verstärker und einen Demodulator für Einsatz mit den elektromagnetischen Messwertgebern der S.E. Laboratories für Druck-, Beschleunigungs- und Wegmessungen.

Der durch Kondensation nicht beeinflusste Baustein kann in jeder Höhe eingebaut werden; Anschlüsse erfolgen durch fest verdrahtete Zuleitungen.

Die Abmessungen sind 9 × 2,9 × 2,5 cm.

EE 99 762 *für weitere Einzelheiten*

Drehschrittwähler

Vertrieb: M.L. Industrial Products Ltd. 292 Leigh Road, Trading Estate, Slough, Buckinghamshire

(*Abbildung Seite 752*)

Nach Abschluss eines Agenturvertrages mit L. M. Ericsson in Schweden hat M. L. Industrial Products Ericsson-Drehschrittwähler in England auf Lager genommen.

Der Schalter ist mit sechs Bahnen und 30 Schritten lieferbar, in einer alternativen Ausführung auch mit zwei Schleiferkontaktsätzen, was 12 Bahnen mit 15 Schritten gleichkommt.

Ein hervorstechendes Merkmal dieses Drehwählers ist der komplette Staubschutz für Kontakte und bewegliche Teile, sowie die leichte Austauschbarkeit der Teile.

Falls überhaupt erforderlich, kann es sich trotz der für normale Betriebsbedingungen angegebenen Lebensdauer von 10 Millionen Umdrehungen nur um geringfügige Wartung handeln.

Der Wähler kann mittels Unterbrecherkontakten mit Geschwindigkeiten bis zu 60 Schaltzyklen je Sekunde selbstgetrieben werden, und alle Ausführungen sind mit Rücklaufkontakten ausgerüstet. Sowohl für Bahnen wie auch Schleifer sind vergoldete Kontakte zu haben.

EE 99 763 *für weitere Einzelheiten*

Laufzeitketten

Johnson, Matthey & Co. Ltd, 73-83 Hatton Garden, London, E.C.1

(*Abbildung Seite 753*)

Johnson, Matthey & Co Ltd kündigt die Einführung von "Silver Star"-Laufzeitketten an. Diese LC-Bausteine mit punktförmig verteilter Konstante haben hohe Feuchtigkeitsbeständigkeit, ausgezeichnete Temperaturkonstanz und hervorstechende Zuverlässigkeit im Einsatz.

Jede der "Silver Star"-Laufzeitketten hat eine charakteristische Impedanz von 500 Ω, und das Fertigungsprogramm wurde mit zwei Grundlaufzeitsprüngen von 10 ns und 25 ns entwickelt. Dieses Programm bietet Elektronikingenieuren nicht nur eine Auswahl von neun Grundlaufzeiten von 10 ns bis zu 500 ns, sondern auch eine Auswahl des Verhältnisses Laufzeit zu Anstiegszeit. Andere Laufzeiten oder Verhältnisse Laufzeit zu Anstiegszeit lassen sich ohne Einfluss auf die charakteristische Impedanz von 50 Ω durch Kaskadenschaltung von zwei oder mehr Bausteinen erreichen.

Die Bausteine werden in vier Standardgrössen mit gleichem Querschnitt und unterschiedlicher Länge hergestellt. Jeder Baustein ist in Epoxydharz gekapselt und bildet einen festen, robusten und hermetisch dichten Block. Die verzinnten (galvanisierten) Phosphorbronze-Anschlussdrähte sind genau nach dem Rastergrundmass 2,54 mm für gedruckte Schaltungen ausgelegt. Zur Vereinfachung des Layout und der Verdrahtung sind zwei gemeinsame Anschlüsse vorgesehen.

Die Basis jedes Bausteins hat zwei leicht erhöhte Ansätze, die einen Spalt erzeugen und die Gefahr der Ansammlung von Feuchtigkeit in der Schnittfläche Baustein-Druckplatte beseitigen. Die Ansätze können auf die Platte gekittet werden, um die Festigkeit des Zusammenbaus zu erhöhen.

EE 99 764 *für weitere Einzelheiten*

Messwandlerverstärker

Fenlow Electronics Ltd, Springfield Lane, Weybridge, Surrey

(*Abbildung Seite 753*)

Der Fenlow-Verstärker ZA2 ist für Einsatz mit Dehnungsmessstreifen, Druckgebern und Beschleunigungsmessern in Instrumentierung und Servosystemen bestimmt. Alle für die Arbeitsweise der erwähnten Messwandlertypen erforderlichen Einrichtungen sind in ein gedrängtes Gerät eingebaut, das aus folgenden Komponenten besteht:

Gleichstrom-Differentialverstärker mit niedriger Drift; Feststufen für Verstärkung und Interpolation mittels mehrgängiger Potentiometer mit Skala; Konstantstromversorgung mit Netzanschluss; regelbare Brückendiagonalspannung; Sechsdraht-Nebenschlusseichung; Präzisionsdrahtwiderstände für die Vervollständigung der Brücke; mehrgängiger Brückengleichregler; mehrgängiger Diagonalspannungsregler; wahlweiser Betrieb in halber oder voller Brückenschaltung.

Der abgegebene Strom ist für das Treiben einer Last wie z.B. Moog-Servoventile oder hochfrequente Direktschreiber reichlich bemessen.

Das Gerät ist für Einbau in Standardgestelle mit Anschlüssen auf der Rückseite ausgelegt. Sieben Geräte passen nebeneinander in ein Gestell. Ausser mit Messwandlern kann man den ZA2 auch für Impedanzwandlung und Gleichstromverstärkung einsetzen. Diese Arbeitsweise ist durch einen Frontplattenschalter einstellbar.

Die Eingangsimpedanz des Verstärkers ist über 2 MΩ, die Ausgangsimpedanz unter 1 Ω. Grob- und Feinabstimmung des Verstärkungsfaktors gibt es zwischen 100 und 800. Der Ausgangsstrom ist ±36 mA an 330 Ω, die Ausgangsspannung 40 V_{SS} an 300 Ω. Die Gleichtaktunterdrückung ist 120 dB bei ±5 V, 100 dB bei ±10 V und die Linearität 0,01 Prozent.

EE 99 765 *für weitere Einzelheiten*

Verzinnungslösung

Shipley Chemicals Ltd, Coventry Trading Estate, Sisken Drive, Baginton, Coventry

Shipley Ltd gibt ein neues Tauchverzinnungsverfahren Cuposit LT27 bekannt. Die nach dem Verfahren erstellte Auflage soll selbst nach langer Lagerzeit ungewöhnlich lötbar und korrosionsfest sein.

LT27-Bäder können durch Zusatz von LT27B aufgefrischt werden; das Bad ist äusserst dauerhaft, und Ausbeuten von 80 μm Zinn per 100 cm^2 je Liter wurden dauernd erreicht. 25 μm dicke Auflagen lassen sich in 30 Minuten erzielen.

Verzinnte Kupferteile haben die 96 Stunden lange Salzsprühprobe ohne Durchbruch ausgehalten; verzinnte Teile waren nach 96 Stunden in 95 Prozent relativer Feuchtigkeit bei +32° C ohne Schwierigkeiten lötbar.

EE 99 766 *für weitere Einzelheiten*

Drehfeldgeber-Empfänger

Aviation Division, Smiths Industries Ltd, Kelvin House, Wembley Park Drive, Wembley, Middlesex

(*Abbildung Seite 753*)

Das Programm des Bereiches Luftfahrt der Smiths Industries Ltd für Testausrüstungen wurde durch einen geregelten Drehfeldgeber-Empfänger für das Prüfen elektromechanischer Servosysteme und Bauelemente ergänzt.

Das in einem kompakten Gehäuse mit Abmessungen von 216 mm breit, 150 mm hoch und 241 mm tief untergebrachte Instrument ist mit einem Traggriff ausgestattet, der auch im Einsatz als Stand für das Instrument dienen kann. Eine Skala mit Doppelzeigern zur Darstellung des Wellenwinkels ist zusammen mit allen Schaltern und Bedienelementen vorn am Instrument angeordnet.

Die Zeiger sind mit zwei synchronisierten Drehmeldern gekoppelt und werden durch einen Motortachogenerator getrieben, die alle im Gerät selbst eingebaut sind. Einer der Drehmelder ist ein gesteuerter Transformator, der mit einem Servoverstärker den Eingangswinkel darstellt, während der andere Drehmelder als niederohmiger Drehmomentgeber ausgeführt ist, der jeden auf der Skala gezeigten Winkel übertragen kann. Winkeleinstellung des Gebers kann über eine geeichte Servoschleife in der Geschwindigkeitsregelung erfolgen, die auf Wunsch entweder eine kontinuierliche Rate oder jeden beliebigen Festwinkel geben kann.

In einer weiteren Arbeitsweise kann man die Position des Gebers durch ein externes elektrisches Winkelnormal wie z.B. eine Delta-Brücke steuern, wodurch die Winkelgenauigkeit nur durch die Genauigkeit des Normals und den Bezugspunktfehler des Regelkreises begrenzt wird, was die Fehler im Geber-Drehfeldinstrument und dem Anzeigegetriebe ausschliesst.

Das durchweg in Festkörpertechnik ausgeführte Instrument arbeitet mit Netzanschluss für 115 oder 220 V, 400 Hz; aber in allen Arbeitsweisen kann die Drehfelderregung von einer externen Quelle aus erfolgen, die nicht notwendigerweise mit dem 400-Hz-Hauptnetz in bezug auf Phase oder Frequenz synchron läuft.

Die Genauigkeit ist 10 Bogenminuten, das Auflösungsvermögen der Anzeige 1,5 Minuten, die Schwelle jedoch 0,5 Minuten, so dass die Genauigkeit bei Anwendung mit einer externen Brücke der Brückengenauigkeit ±0,5 Minuten entspricht. Bei der Rateübertragung kann die Schwenkgeschwindigkeit 30 Grad je Sekunde betragen. Eine Selbstprüfeinrichtung ist vorgesehen.

Andere ähnliche Instrumente mit eingebauten Funktionsdrehmeldern sowie Dreidrahtmaschinen und höherer Höchstschwenkgeschwindigkeit, ausserdem Drehmelderanzeigern mit derselben Darstellung der Anzeige und mit eingebauten Regelverstärkern sind auch lieferbar.

EE 99 767 *für weitere Einzelheiten*

Elektronisches Voltmeter

Marconi Instruments Ltd, St. Albans, Hertfordshire

(*Abbildung Seite 754*)

Ein neues elektronisches Voltmeter, das Vielseitigkeit mit hoher Genauigkeit und Konstanz kombiniert, wurde von Marconi Instruments Ltd herausgebracht. Mit dem Instrument TF 2604 können Wechselspannungen von 25 mV bis zu 300 V im Frequenzbereich 20 Hz...1500 MHz, Gleichspannungen von 10 mV bis zu 1000 V und Widerstände von 0,2 Ω bis zu 500 MΩ gemessen werden.

Um das TF 2604 noch nützlicher zu machen, sind folgende zusätzliche Zubehörteile lieferbar: Gleich- und Wechselspannungs-Vorsteckteiler für Hochspannungen bis zu 30 kV— und 2 kV~; eine Aufsteck-T-Steckverbindung für die Wechselstromsonde zum Messen von Spannungen an koaxialen Leitungen; eine genau angepasste, koaxiale 50-Ω-Abschlusslast.

Die dem Instrument eigene hohe Anzeigekonstanz wird durch Vollstabilisierung der Röhrenheiz- und Anodenspannungen erreicht, und zwar mittels einer Serienröhrenschaltung für die Anodenspannung und einer durch eine Zenerdiode gesteuerten Transistorschaltung für die Heizspannung. Selbst Änderungen der Netzspannung um 10 Prozent werden bei Vollausschlag in allen Bereichen Ausschlagsänderungen von weniger als 4 mV hervorrufen.

Eine bewährte Gegentaktschaltung, in der jede Hälfte aus einem Röhrenverstärker und Kathodenfolger besteht, treibt das Messinstrument. Der Messkopf für Wechselstrommessungen enthält einen fortschrittlichen Scheibendioden-Gleichrichter. Der Frequenzgang bis zu 1500 MHz wird durch die Messkopfkonstruktion mit nur 1,5 pF Kapazität, kurzer Laufzeit und einer Resonanzfrequenz von 3 GHz ermöglicht. Der kleine zylindrische, leichte Messkopf wurde besonders für bequeme Handhabung gestaltet. Ein Aufsteck-Erdstecker für die Erstellung der bei den höheren Frequenzen erforderlichen ultrakurzen Verbindungen wird mitgeliefert.

Das Messen von Gleichspannungen und Widerstand wird durch einen Zweizweckmesskopf mit Fingerspitzenschalter V-Ω erleichtert; Einstellen auf V schaltet einen Trennwiderstand ein, der die zu messende Schaltung gegen den Einfluss der Messkopfleitungskapazität schützt. Für Gleichstrommessungen kann das Messwerk so umgeschaltet werden, dass es entweder bei positiven oder negativen Spannungen Vorwärtsausschlag gibt; für Messungen mit beiderseitigem Ausschlag wird eine Festspannung angelegt, die den Zeiger auf Skalenmitte einstellt.

EE 99 768 *für weitere Einzelheiten*

Thermometer-Messbrücke

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

(*Abbildung Seite 754*)

H. Tinsley & Co Ltd hat neuerdings ein Instrument zum Messen der Widerstandsänderung von Einmal-Thermometerelementen in Ohm nach der Vierpolmethode entwickelt.

Das als Messbrücke 5596 für Einmal-Thermometerelemente bezeichnete Instrument ist für Anwendung mit Tinsley-Vierpol - Einmalthermometerelementen bestimmt.

Der Messumfang ist 75...165 Ω und auf ±0,1 Ω ablesbar. Der Temperaturbereich ist −50° C...+150° C mit 100-Ω-Elementen und Reproduzierbarkeit von ±¼° C. Die Brücke wird durch einen Rechteckwellen-Oszillator mit 2,5 V bei 1000 Hz gespeist, und der Gleichrichter hat ein von einem transistorierten Anzeigeverstärker getriebenes Messinstrument mit beiderseitigem Ausschlag. Die Empfindlichkeit gestattet Nachweis einer Änderung von 0,05 Ω.

Anwendung des Rechteckwellengenerators vermeidet Blindstromfehler, und Zuleitungsfehler werden durch die Vierpolmessmethode zusammen mit hochohmigen Verhältniszweigen reduziert. Die Anwendung von Wechselstromspeisung reduziert thermische Effekte zu einem vernachlässigbar kleinen Einfluss, und die Gesamtgenauigkeit wird üblicherweise durch die Konstanz der Thermometerelemente bestimmt.

EE 99 769 *für weitere Einzelheiten*

Spektralanalysator

Tektronix U.K. Ltd, Beaverton House, Station Approach, Harpenden, Hertfordshire

(Abbildung Seite 754)

Der Präzisions-Breitbandspektralanalysator Typ 491 von Tektronix wurde für schwierige Umgebungsbedingungen, leichte Beweglichkeit und einen Frequenzbereich von 10 MHz...40 GHz entwickelt.

Eine elektrisch identische Ausführung R491 ist für Gestelleinbau lieferbar und ist nur 178 mm hoch.

Die Arbeitsweise des Instrumentes ist einfach. Auflösung und geeichte Zerlegungsregelung sind so gekoppelt, dass bei enger Zerlegung eine enge Auflösungsbandbreite und bei breiter Zerlegung eine breite Auflösungsbandbreite entsteht. Da die Zerlegung geeicht ist, können Frequenzdifferenzen direkt auf dem Bildschirm abgelesen werden. Interne Phasensynchronisierung gibt selbst bei Zerlegung in 1-kHz-Teilungen stabile Anzeigen.

Andere Eigenschaften des Typs 491 sind minimale CW-Empfindlichkeit von -110 bis zu -70 dBm je nach Frequenz, flacher Anzeigegang innerhalb $\pm 1{,}5$ dBm über 100 MHz Zerlegung, Spurverstärkung schnellgeschriebener Segmente der dargestellten Wellenform, langnachleuchtender Phosphor (P7) und galvanisch gekoppelter Schreiberausgang.

Trigger- und Ablenkschaltung wie für Oszillografen gestatten Triggerung mittels interner, externer oder Netzquellen und Ablenkgeschwindigkeiten von 10 μs/Teilung bis zu 0,5 s/Teilung in 1-2-5-Folge. Der Traggriff ist für verschiedene Neigungspositionen einstellbar und dient als robuste Stütze. Der Deckel für die Frontplatte dient gleichzeitig der Aufbewahrung allen Standardzubehörs einschliesslich Zwischenstücken, Kabeln, Hohlleitermischern und Koaxialabschwächern.

Die Aussenabmessungen des Modells im Gehäuse sind 181 mm hoch, 314 mm breit einschliesslich Traggriff, 527 mm tief einschliesslich Deckel und Füssen, mit herausgezogenem Traggriff 572 mm tief.

EE 99 770 *für weitere Einzelheiten*

Funktionsverstärker

Fenlow Electronics Ltd, Springfield Lane, Weybridge, Surrey

(Abbildung Seite 755)

Der Fenlow-A8 ist ein Chopper-Verstärker, der zur Herabsetzung der Eingangsstromdrift auf einen sehr niedrigen Wert mit einem Feldeffekttransistor-Chopper arbeitet. Die Eigenschaften als Integrator sind mit den mit einem mechanischen Zerhacker erreichbaren vergleichbar. Die hohe Verstärkung, Bandbreite und Eingangsimpedanz ergeben sehr genaues Rechnen.

Durch A-Ausgang wird gute Linearität und Beseitigung der Übergangsverzerrung erreicht.

Der Ausgang ist ± 30 V bei 5 mA und die Leerlaufverstärkung bei Gleichstrom 10^8, bei 50 Hz 10^5 und bei 1 kHz 10^4. Die Eingangsimpedanz ist 200 kΩ. Die Spannungsdrift ist niedriger als 1 μV/°C, Breitbandrauschen niedriger als 25 μV_{SS} und von 0 ... 10 Hz niedriger als 2 μV_{SS}.

EE 99 771 *für weitere Einzelheiten*

Thermoelement-Temperaturanzeiger

Spembly Technical Products Ltd, Trinity Trading Estate, Sittingbourne, Kent

(Abbildung Seite 755)

Der abgebildete S.T.P.-Multitemp 6610 CA bietet eine schnelle und einfache Möglichkeit, die Temperatur von Nickelchrom - Nickelaluminium - Thermoelementen über einen breiten Temperaturbereich und praktisch unabhängig vom Schleifenwiderstand zu messen.

Die Temperatur wird über einen kleinen Festkörperverstärker auf einem Messinstrument mit Skala von $-120°$ C ...$+100°$ C angezeigt. Ein in Verbindung mit dem Messinstrument benutzter Messbereichschalter ermöglicht genaue Anzeigen über den Gesamtbereich von $-120°$ C...$+1000°$ C. Eine Schnelleinstellvorrichtung gibt dem Anwender eine sofortige Andeutung der ungefähren Temperatur des Thermoelementes, bevor der entsprechende empfindliche Teilbereich eingestellt wird.

Der Multitemp hat eine eingebaute Vergleichsstellenkompensation sowie Buchsen für Anschluss eines Standardschreibers.

Dem Aussehen nach ist der S.P.T.-"Unitemp" 6650 GP für Anwendung mit Thermoelementen aus Nickelchrom-Nickelaluminium, Eisen-Konstantan und Kupfer-Konstantan dem Multitemp ähnlich. Die Temperaturskala des Messinstrumentes kann auch für Millivoltanzeige eingestellt werden, was das Messen von Thermoelementen aus anderen Kombinationen ermöglicht. Der Unitemp gibt genaue Temperaturanzeigen von $-30°$ C...$+1000°$ C und hat Ausgangsbuchsen für Anschluss eines Standardschreibers.

Eine Klemmseite auf der Rückseite des Gerätes ermöglicht Anschluss von bis zu zwölf Thermoelementen, die jeweils durch Bedienung eines 12stufigen Schalters an das Messgerät gelegt werden. (Verbindungen 1...5 sind zweifach vorhanden und haben Standard-Spembley-Buchsen.)

Beide Geräte werden aus Langlebensdauer-Quecksilberzellen gespeist und sind tragbar.

EE 99 772 *für weitere Einzelheiten*

Fernsehkamera

G.E.C. (Electronics) Ltd, East Lane, Wembley, Middlesex

Eine netzbetriebene transistorierte Studio-Fernsehkamera hoher Qualität, die sich hauptsächlich für Schulfernsehprojekte eignet, wurde vom Bereich Nachrichtenverkehr der G.E.C. Electronics entwickelt.

Ein besonderes Konstruktionsmerkmal der mit VCT2/S bezeichneten Kamera ist ein transistorierter, elektronischer 18-cm-Sucher, der sich leicht abbauen und getrennt als Bildmonitor einsetzen lässt. Kamera und Sucher haben getrennte Stromversorgungen.

Die Kamera ist mit einer Zeilennorm von 625/50 oder 525/60 lieferbar und kann 10 MHz Bandbreite übertragen. Diese Bandbreite soll breiter sein als die der Konkurrenz und eine bessere Bildschärfe geben.

Die mit einem Vidikon bestückte Kamera hat einen Revolverkopf für vier Objektive in C- oder Rundfunkfassungen. Ein Bedienknopf an der Seite der Kamera ermöglicht Einstellen des optischen Fokus, oder andererseits kann man eine Fernsteuerung nachrüsten.

Die Kamera hat einen eingebauten Synchronisierungsimpulsgeber, und alle elektrischen und elektronischen Hauptschaltungen sind auf leicht auswechselbaren Druckschaltungsmoduln untergebracht, was den Service erleichtert. Der Videovorverstärker ist direkt über der Fokussierspule des Vidikons eingebaut, um die Länge des Signalkabels zu kürzen.

Hoher Signalabstand—36 dB Spitze-zu-Spitze bei 0,2 μA Signalstrom—wird im Vorverstärker erreicht.

Die Regler für Fotokathodenspannung, Strahlstrom, elektrischen Fokus und Schwarzpegel sind üblicherweise voreingestellt, können aber mit einem Kontrollgerät verbunden werden, das Fernsteuerung gestattet.

Die elektronischen Schaltungen des Suchers sind auch zur Erleichterung des Service in Druckschaltungstechnik ausgeführt.

EE 99 773 *für weitere Einzelheiten*

Tischrechner

Cybernetics Instrumentation Ltd, 174 Glanville Road, London, N.W.2

(Abbildung Seite 755)

Der LOCI-2 ist ein geschlossener Elektronenrechner, der aus einem Rechenwerk, Speicherregistern, manueller Programmiertastatur, automatischem Lochkarten-Programmiergerät und grosser, 10stelliger Anzeige des Ergebnisses besteht.

Der Rechner kann für drei bestimmte Aufgaben eingesetzt werden: als erweiterte Rechenmaschine, für manuell oder automatisch programmierte Berechnungen und Lösung von Gleichungen, sowie für prozessgekoppelte Berechnungen in verschiedenen Regelsystemen.

Manuell betätigt kann der LOCI-2 Additionen, Subtraktionen, Multiplikationen, Divisionen und Exponentionen ausführen sowie Logarithmieren und Radizieren. Alle diese Grundoperationen können innerhalb 40 ms ausgeführt werden.

Für programmierten Betrieb in der automatischen Arbeitsweise hat der LOCI-2 eine leistungs- und anpassungsfähige Befehlsauswahl, mit der sich schrittweise Verfahren leicht und vollständig programmieren lassen.

Eine umfassende Programmbibliothek (statistisch, mathematisch, technisch usw.) ist vorhanden und enthält z.B. Programme für Besselfunktionen, polynomische, trigonometrische und logarithmische Gleichungen, Varianz, Triangulation, Kettenlinien und Beanspruchungsanalyse.

EE 99 774 *für weitere Einzelheiten*

Frequenzvervielfacher

Microwave Systems Ltd, Caltronics House, Huntingate, Hitchin, Hertfordshire

(Abbildung Seite 755)

Microwave Systems Ltd vertreibt neuerdings Festkörper-Frequenzvervielfacher mit Kapazitätsdioden.

Die Kapazitätsdioden gestatten Erzeugung von Harmonischen in den Vervielfachern mit Leistungspegeln von Milliwatts bis zu 5 W im Bereich 1,0...2,0 GHz, von Milliwatts bis zu 1 W bei C-Band-Frequenzen und 300 mW bei X-Band-Frequenzen. Im Bereich 300...1000 MHz liegen die Leistungspegel zwischen Milliwatts und 10 W. Microwave Systems kann auch transistorierte kristallgesteuerte Treiber liefern, die jeden Vervielfacher in eine komplette Festkörper-Leistungsquelle verwandeln.

Alle Vervielfacher dieses Types haben eine hohe Störfrequenzunterdrückung von 60 dB mit Ausgangsfiltern, sind in Vollaluminium-Blockkonstruktion oder als Aluminium-Gussstücke ausgeführt und für Anwendung in Flugzeugen und Raketen geeignet.

EE 99 775 *für weitere Einzelheiten*

Zusammenfassung der wichtigsten Beiträge

Ein Multiplexsystem für eine akustische Registrierung von R. W. Procunier

Zusammenfassung des Beitrages auf Seite 704-709

Eine für die Übertragung von Daten von akustischen Messwandlern in einem Raketengranatenversuch zu einem Registrierungszentrum eingeführte Technik wird beschrieben. Das System umfasst sieben Trägerfrequenzen im Bereich 595 . . . 2975 Hz, die mit Druckabweichungen amplitudenmoduliert werden, und zwei Registriersysteme: (1) ein UV-Schreiber und (2) ein Magnetbandgerät. Es wird gezeigt, dass das in langen Übertragungsleitungen auftretende elektrische Rauschen dadurch beseitigt wird und dass das System die Fähigkeit besitzt, Signale elektronisch wiederzugeben. Bei Einsatz in Aussenversuchen wurde dadurch die maximale Höhe für den Nachweis von 355g wiegenden Granaten auf 107 km erhöht.

Erkennen der Zyklusbeendigung einer Pseudo-Zufallsbinärfolge von J. Kontos und G. Philokyprou

Zusammenfassung des Beitrages auf Seite 709-710

Ein vorgeschlagenes Verfahren zum Erkennen der Zyklusbeendigung einer Pseudo-Zufallsbinärfolge (P.R.B.S.) beruht auf der nur einem Punkt des Generators der Pseudo-Zufallsbinärfolge entnommenen Information. Das wird durch Folgedecodieren eines Abschnitts der Pseudo-Zufallsbinärfolge, dessen Länge der Anzahl der Generatorstufen entspricht, erreicht.

Eine transistorierte Stromversorgung für eine ultraviolette Entladungslampe von J. Watson

Zusammenfassung des Beitrages auf Seite 711-713

Die beschriebene Stromversorgung kann eine Flood-Hilger-Deuteriumentladungslampe, die ein vom sichtbaren Licht bis zu unter 2000 Å kontinuierliches Spektrum ausstrahlt, speisen. Dem Heizfaden der Lampe wird für 90 Sekunden Energie zugelegt, und nach Ablauf der ersten 60 Sekunden wird ein Zündimpuls von 300 V zugeführt. Der Leuchtbogen wird dann bei einem vorbestimmten Stromwert im Bereich 0,35 . . . 0,55 A stabilisiert; die Konstanz der Belastung ist besser als 18 000:1. Es finden durchweg Halbleiter Verwendung.

Die Erzeugung hyperbolischer Wellenformen von R. D. McDonald

Zusammenfassung des Beitrages auf Seite 714-717

Beim Messen niederfrequenter Vorgänge wie beispielsweise dem Herzschlag ist es oft notwendig, die momentane Frequenz zwischen aufeinander folgenden Vorgängen zu messen. Wenn der Ausgang der Messeinrichtung in bezug auf die Frequenz linear sein soll, so muss er in bezug auf Zeit hyperbolisch sein. Die Erzeugung hyperbolischer Wellenformen mittels exponentieller Wellenformen wird besprochen und eine Entwurfgleichung abgeleitet.

Ein schneller Integrator-Rückstellschalter von M. H. McFadden und W. J. Niblock

Zusammenfassung des Beitrages auf Seite 718-720

In den letzten Jahren richtete sich die Entwicklungsarbeit an Analogrechnern auf die Erhöhung der Arbeitsgeschwindigkeit aus. Eins der Hindernisse war die Entwicklung einer Einrichtung zur Rückstellung des Integrators in einer sehr kurzen Zeitspanne und ohne Einführung ernsthafter Fehler. Viele der entwickelten schnellen Rückstellschaltungen arbeiten bei niedrigen Geschwindigkeiten oder in der Einmal-Arbeitsweise nicht zufriedenstellend. Einige Hybridanordnungen elektronischer Schalter und elektromechanischer Relais verbinden die Vorteile von beiden. Der in diesem Beitrag beschriebene Halbleiterschalter arbeitet zufriedenstellend sowohl als Einmaleinrichtung wie auch bei hohen Folgefrequenzen.

Regelung der Spannung einer Stromversorgung mittels steuerbarer Siliziumgleichrichter von J. L. Everett

Zusammenfassung des Beitrages auf Seite 721-724

In einer beschriebenen Stromversorgung wird die Spannung statt mit dem herkömmlichen Regeltransformator mit einem steuerbaren Siliziumgleichrichter geregelt. Mit diesem Gerät kann man die genaue Spannungsregelung erreichen, die notwendig ist, wenn es in Verbindung mit einem Laserpumpsystem zum Messen sehr niedriger Schwellenenergien angewendet wird. Das Gerät hat verschiedene Vorteile gegenüber dem Regeltransformator; einer der bedeutendsten ist die Beseitigung der Spannungssprünge, die durch das Laufen der Bürsten über die Wicklungen des Regeltransformators hervorgerufen werden.

Die Ausgangsspannung ist zwischen 0 und 2,3 kV stufenlos regelbar.

Ein auf einem Funktionsverstärker beruhender Präzisionsoszillator von E. J. Brach

Zusammenfassung des Beitrages auf Seite 724-725

Ein Präzisionsoszillator für die Erzeugung von Frequenzen zwischen 1 und 10 000 Hz mit einer Fehlergrenze von 3×10^{-3} Perioden wird beschrieben. Der Entwurf beruht auf einer neuartigen Anwendung eines Funktionsverstärkers, die ein preiswertes Labor-Normal ergibt.

Ein Messgerät für den Spitzen- und Talstrom von Tunneldioden von J. B. Earnshaw und Z. C. Tan

Zusammenfassung des Beitrages auf Seite 726-727

Die beschriebene einfache Ausrüstung gestattet genaues und schnelles Messen von Spitzen- und Talströmen von Tunneldioden. Sie ist besonders für die Bestimmung des relativen Wertes dieser Ströme für Partien gleicher Tunneldiodentypen geeignet.

Rückgekoppelte Hall-Effekt-Elemente von D. Midgley

Zusammenfassung des Beitrages auf Seite 728-730

Die Vorteile einer Scheibe (Corbino-Scheibe) in der Festkörperelektronik werden im Vergleich mit einer rechteckigen Tafel (Hall-Platte) für den Fall besprochen, in dem praktische Anwendung Erzeugung von Strömen mittels Hall-Effekt erfordert. Vorschläge für die Anwendung des Rückkopplungsprinzips auf Druckschaltungen mit aktiven Elementen für Digitalrechner werden gemacht. Kühlung auf den absoluten Nullpunkt oder seine Nähe könnte oder brauchte nicht notwendig zu sein; in jedem Fall fällt ein Vergleich dieser Elemente mit einigen anderen Cryotrons in bezug auf Linearität und aktiven symmetrischen bistabilen Betrieb günstig aus. Versuchsergebnisse für eine Wismutscheibe in flüssigem Helium werden in Form einer Modifikation der Hystereseschleife einer magnetischen Rückkopplungsschaltung gegeben.

Ein parametrischer Teraohm-Verstärker in Festkörpertechnik von G. M. Ettinger

Zusammenfassung des Beitrages auf Seite 731-734

Nach einer kurzen Übersicht über die Methoden zum Messen von Strömen im Nano- und Pikoamperebereich wird ein parametrischer Festkörper-Verstärker beschrieben, der einen Gleichstrom-Eingangswiderstand von einem Teraohm hat. Die Arbeitsweise dieses Verstärkers beruht auf den niedrigen Reststromeigenschaften gewisser Halbleiter, wenn sie als Kapazitätsdioden angewendet werden. Abschliessend wird ein wahrer parametrischer Verstärker für hohe Spannungen erwähnt, der auf den ferroelektrischen Eigenschaften keramischer Kondensatoren beruht.

Ein klinischer Elektromyograf mit verbesserter Rückrufeinrichtung von C. K. Battye, L. D. Kitchen und A. E. Pastellopoulos

Zusammenfassung des Beitrages auf Seite 734-735

Der Beitrag beschreibt einen neuen Elektromyografen mit volltransistorierten Verstärkern, die es gestatten, den Inhalt eines 1-Sekunden-Magnetspeichers schnell abzutasten und einzelne Tägigkeitsspannungen schnell zu messen.

Ein Tonfrequenzgenerator mit Wellenformsynthese von A. Horsman

Zusammenfassung des Beitrages auf Seite 736-737

Ein beschriebener Oszillator erzeugt eine Folge von sechzehn Rechteckimpulsen gleicher Dauer, aber mit für jeden Impuls unabhängig regelbarer Amplitude. Für die Synthese werden die Amplituden so eingeregelt, dass die Impulsfolge näherungsweise der gewünschten Wellenform entspricht. Mit der beschriebenen Schaltung kann das über den Tonfrequenzbereich erzielt werden, und der Ausgang ist in bezug auf Amplitude und Klirrfaktor von der Grundfrequenz unabhängig.

Ein aktives Filter zum Messen niederfrequenter Rauschleistungsspektren von K. F. Knott und J. S. Bowman

Zusammenfassung des Beitrages auf Seite 738-740

Ein aktives Filter mit konstantem Q wird beschrieben, das für Schmalband-Rauschmessungen im Frequenzbereich 1 Hz . . . 10 kHz geeignet ist. Der Frequenzbereich wird in neun Stufen überstrichen, und zwar 10^0, $10^{1/2}$, 10^1, $10^{3/2}$ . . . 10^4 Hz.

Es wird gezeigt, dass, wenn bei Anwendung der Laufzeitzählmethode zum Messen des Effektivwertes der Rauschspannung und Wahl eines Q, das für die 3-dB-Bandbreite 0,15 der Gesamtbandbreite ergibt, keine ernsthaften Fehler eingeführt werden.

Örtliche Rückkopplungsstufen aus Netzwerken ohne Mindestphasenverschiebung von V. Mosca und A. Rimondini

Zusammenfassung des Beitrages auf Seite 741-743

Komplette nicht angenäherte Formeln werden für die Spannungsübertragungsfunktion, Eingangs- und Ausgangsimpedanz örtlicher und interner Rückkopplungsstufen aus Netzwerken ohne Mindestphasenverschiebung gegeben, die an bekannten Ersatzschaltungen des linear punktförmig verteilten Parametertypes, die für Röhren, Transistoren und FET in der Konfiguration mit gemeinsamer Kathode, gemeinsamem Emitter und gemeinsamer Quelle gültig sind, berechnet werden.

Zahlenbeispiele, die die Gegenwart rechtseitiger Nullpunkte illustrieren, werden zusammen mit ihrem Einfluss auf das Verhalten der Systeme mit geschlossener Schleife, zu der sie gehören, untersucht.