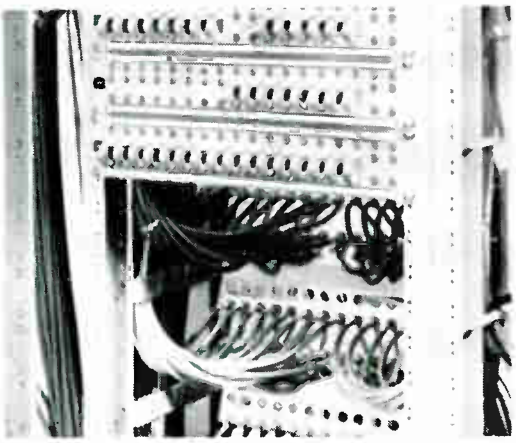
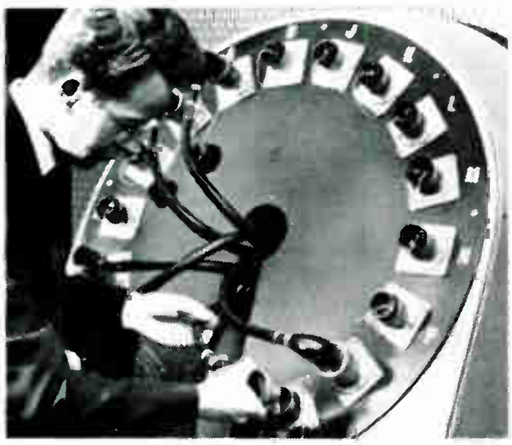
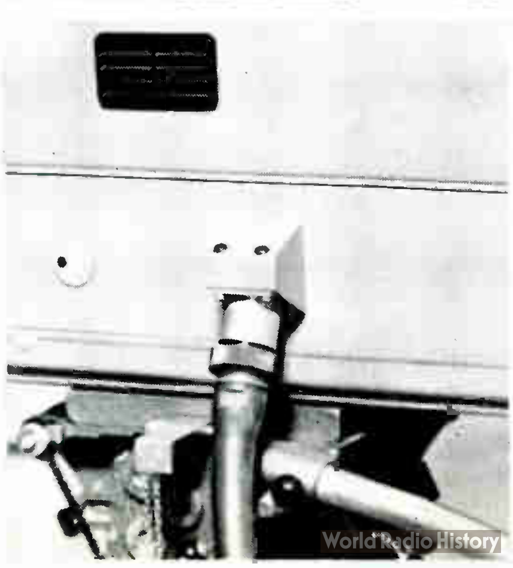
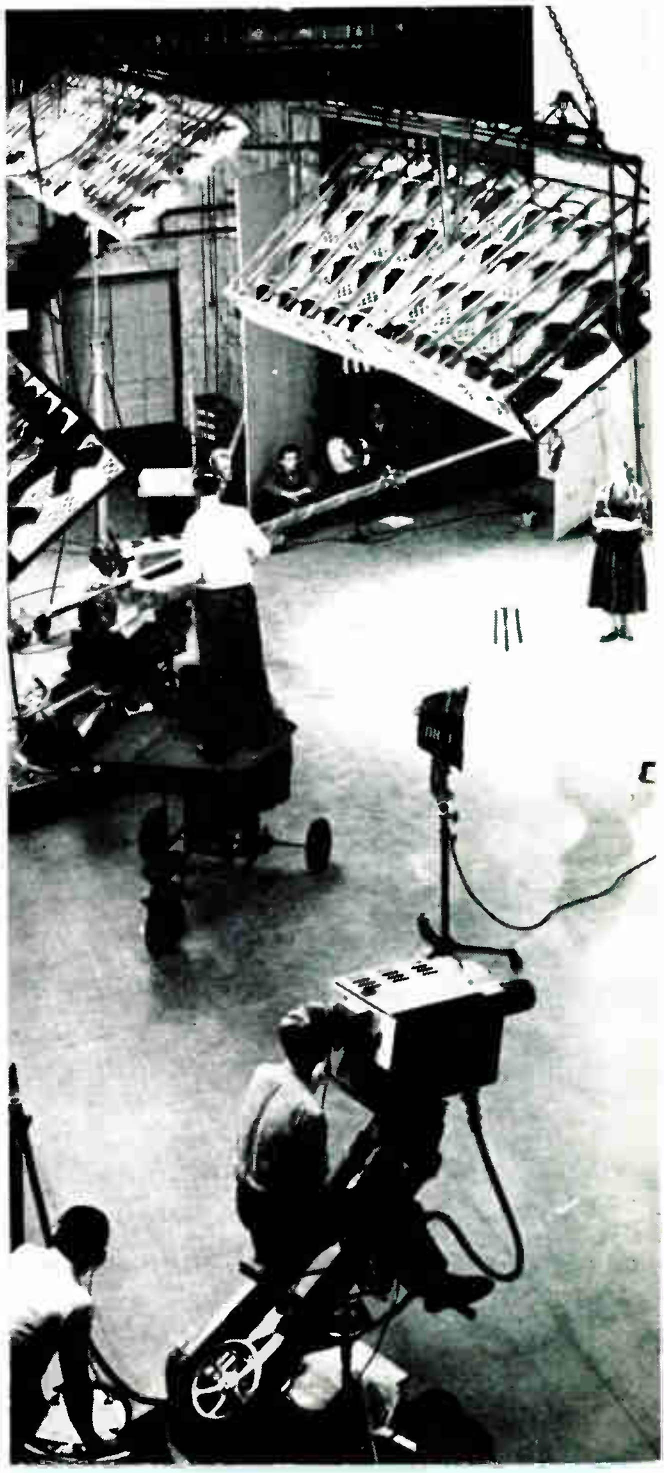
INDUSTRIAL ELECTRONICS

AUGUST 1963 5s 0d









INDUSTRIAL ELECTRONICS

incorporating *ELECTRONIC TECHNOLOGY*

Volume I Number II August 1963

contents

Editor **W. T. COCKING, M.I.E.E.**

Assistant Editor **T. J. BURTON**

Advertisement Manager **G. H. GALLOWAY**

continued overleaf

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ILIFFE ELECTRICAL PUBLICATIONS LTD.
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CANADA and U.S.A. $10.00.

contents continued

FEATURES

OUR COVER

The cover picture shows Dawe Instruments ultra-sonic-cleaning equipment being used by B.O.A.C. for cleaning aircraft parts. It is so used in routine aircraft maintenance. An article elsewhere in this issue describes the apparatus.

Next Month

Load control and indicating equipment will be described in the September issue. Other articles will deal with the welding of plastic-coated steel sheet and with the voltage control of an a.c. generator.

TO SAVE YOUR TIME

We will assist you to obtain further information on any products or processes described or advertised in this issue. Just use the enquiry cards to be found in the front and back of the journal.

CHOOSE G.E.C. FOR

TRANSMITTING VALVES

(The world's finest range, from the makers of the very first)

Here is a selection from our outstanding range of transmitting valves. The majority are of ceramic construction, and feature long life and close tolerance characteristics.
The TT21 is a low cost valve for high frequency communications. The 4X250B, 4CX250B, ACS5 and CAS1 meet the needs of modern television and communications transmitters up to 220 Mc/s.
The 4CX250K, with fully co-axial connections, suits low power television transmitters throughout bands IV and V.

	TT21	4X250B/ 4CX250B	4CX250K	ACS4	ACS5	CAS1
P_{out} (W)	174	225	100	4100	10,000	13,000
frequency (Mc/s)	30	500	1,000	75	110	220
V_a (max) (V)	1,250	2,000	2,000	5,000	7,000	7,000
P_a (max) (W)	37.5	250	250	3,000	6,000	20,000

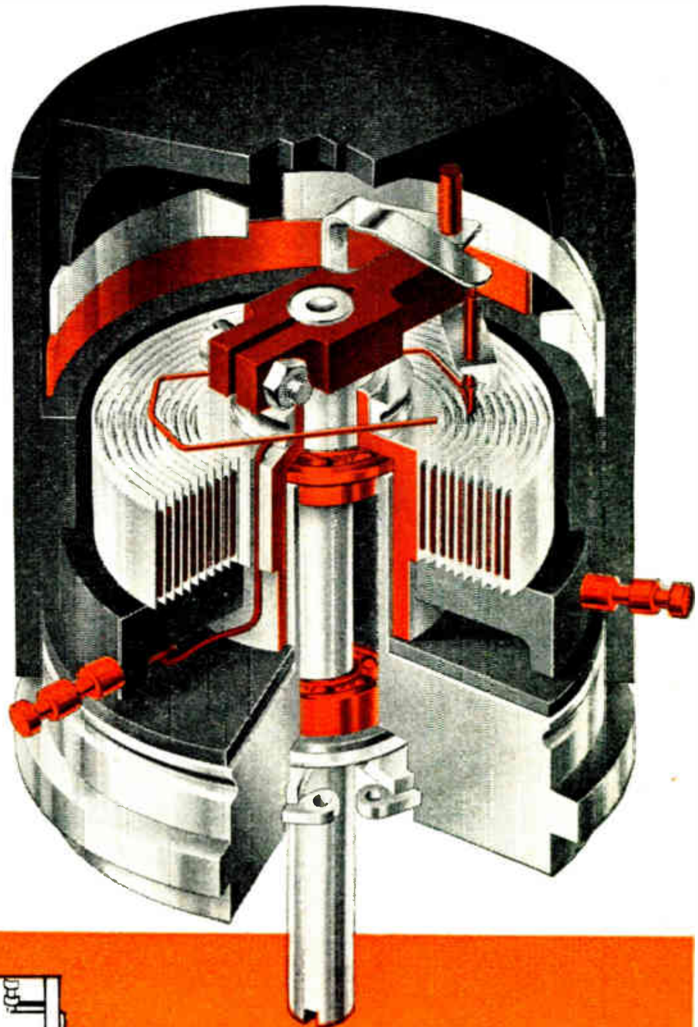
Our technical information centre is ready to help with your application problems. Write for full data sheets on these or other M-OV products, or telephone RIVerside 3431. Telex 23435.

G.E.C.

M-O VALVE CO LTD

BROOK GREEN WORKS · HAMMERSMITH · LONDON W6 · RIVERSIDE 3431

The first major advance in potentiometer design for years ...



After many years of research and development Reliance now announce an entirely new concept in the design of multi-turn wire wound potentiometers. This, combined with new manufacturing techniques provides extremely low inertia, low torque, high law accuracy and multiple tapping facilities for non linear functions. The unit is available in two distinct separate versions:

1. SERIES SYN 11-00 A Synchro Mounting Unit incorporating precious metal winding and precision ball races.
2. SERIES HEL 11-00 A ⅜" diameter Bush Mounting version, plain bearing with standard resistance windings, still retaining high electrical characteristics.

★ RESISTANCE RANGE: 20 ohms—150 K ohms.

★ LINEARITY: ±0.1% or ±0.25% absolute as required.

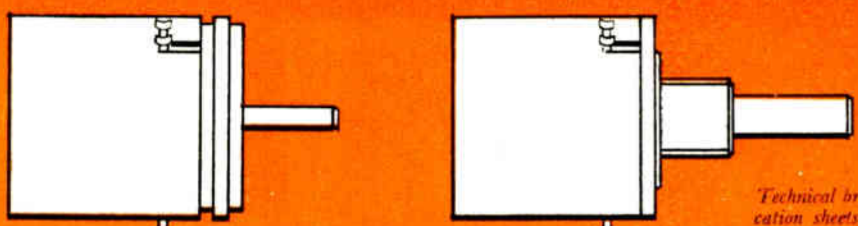
★ TAPPING ACCURACY: ±0.1%.

★ MOMENT OF INERTIA: 0.0004 gm. cm. sec^2.

★ STARTING TORQUE: Synchro Mounting Version 3 gm cm. or better.
Bush Mounting Version 1 oz.in. nominal.
or Sealed Version 2 oz.in. nominal.

★ ROTATION LIFE: > 1,000,000/360° sweeps.

★ NUMBER OF TURNS: Any number up to 10.



Technical brochure and specification sheets are now ready. Write for them to address below or telephone: LARKSWOOD 8404/7

Relcon TAKES THE LEAD IN POTENTIOMETERS

RELIANCE CONTROLS LIMITED, RELCON WORKS, SUTHERLAND ROAD, WALTHAMSTOW, E.17

Telephone No. LARkswood 8404/7 · Telegrams: Reltrol, London, E.17 A MEMBER OF THE BOOKER GROUP OF COMPANIES

World Radio History

Helical cooling technique for Mullard power triodes

INCREASED EFFICIENCY AT LESS COST IN R.F. HEATING AND AUDIO POWER EQUIPMENT

Six industrial power triodes—for use in dielectric pre-heaters and welders, induction heaters, and vibration power amplifiers—are now available with integral helical cooling systems.

The helical cooling system has advantages over the conventional water-jacket system—in particular, a reduction in installation costs and increased cooling efficiency. The volume of cooling water is nearly half that required with the water-jacket system, enabling a substantial reduction to be made in the size of the circulating pump required. In addition, helical-cooled valves can be operated at a higher outlet temperature than those employing a water jacket so that a smaller heat exchanger is required. These factors increase the overall efficiency of the cooling system and allow the cost of the complete installation to be reduced.

CONSTANT-POWER CHARACTERISTICS

Three of these valves have special constant-power characteristics so that with a variation in load resistance of ±50%, the change in power output of the valve is less than ±15%. This constant-power characteristic enables installations to be operated at maximum efficiency despite changes in load, thereby reducing processing times. In induction heating processes in particular, this characteristic stabilises the output power of the valve against the large changes that occur when the load passes through the Curie point.

RUGGED CONSTRUCTION

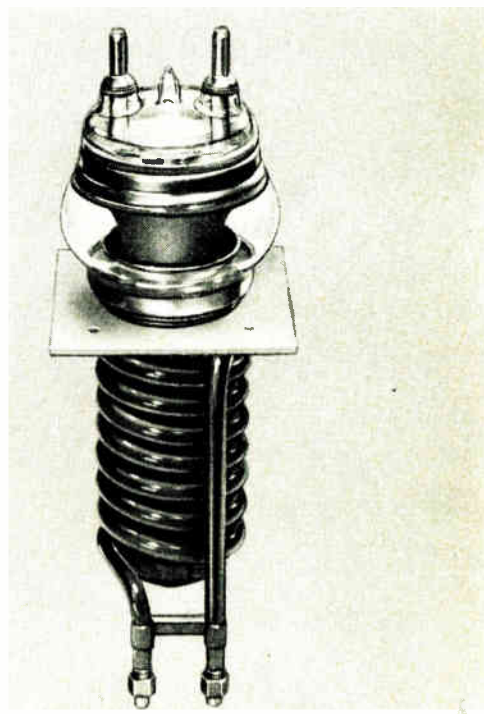
Each of the six industrial power triodes has a heavy-duty thoriated tungsten filament which can provide a reserve of emission even during temporary mains voltage fluctuations of +5 to −10%, ensuring efficient operation of the valve at all times.

Type Number	*Maximum Load Power (kW)* *Oscillator*	*Class AB_2 Amplifier (2 valves)*
TY6–1250H	3·5	8
TY7–6000H	7	20
TY8–6000H	6	16
TY8–15H	14	36
TY12–20H	33	60
TY12–50H	86	200

The grid is constructed from a special material which can withstand the temporary accidental overloads that may occur in dielectric and induction heating processes.

Of particular importance in vibration amplifiers is the adequate reserve of anode dissipation of the valve. This permits the delivery of full rated power into reactive loads, and provides a wide margin of safety when operating at extremely low frequencies.

Brief details of the range are given in the table. For further information, please use the reader reply card of this journal (see reference number opposite).

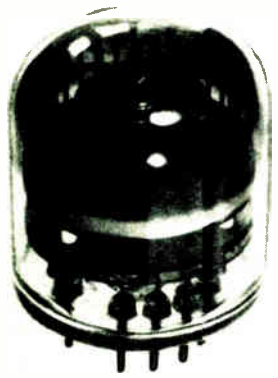


Industrial power triode, type TY8-15H, with integral helical cooling system.

What's new from Mullard

COUNTING SPEEDS OF UP TO 50 kc/s WITH NEW TUBE

Counting speeds of up to 50kc/s are made possible by the introduction of a special gas mixture into a tube of basically the same design as the well-proven type Z504S. The new tube, type Z505S, is the



latest addition to a range of Mullard cold cathode tubes which are being increasingly used in counting, scaling, batching, and welding-control applications. Operating from a supply of 500V, the Z505S has an anode current of 800μA and provides a cathode output potential of 24V.

EXTENDED RANGE OF SILICON P-N-P TRANSISTORS

Three new 0·5A transistors together with BCY30 to BCY34 series form a compatible range of Mullard silicon p-n-p alloy-junction transistors in T0-5 encapsulation.

With good bottoming characteristics and good heat dissipation, these new types—BCY38, BCY39, BCY40—are intended for use in pulse and linear applications.

The general-purpose type BCY38 and high-gain type BCY40 operate at 32V and have similar electrical characteristics to the OC204 and OC206. The BCY39 operates at 64V which is an improvement on the value of $V_{CB(max.)}$ of 60V for the OC205. With a low value of thermal resistance, each transistor will dissipate over 0.5W at a case temperature of 25 C.

Further application for Magnadur Magnets

PRINTED-WIRING MOTOR DEVELOPMENT

Magnadur, a sintered magnet material with a high coercive force and high electrical resistivity, has established itself as the most suitable magnet material for many applications. These applications range from loudspeakers to electric motors, from door catches to echo-sounding equipment. A new use for Magnadur magnets was demonstrated recently in the design of a printed-wiring motor.

The field for this motor was produced by an annular ring of six Magnadur magnets mounted on a mild steel backing plate. The magnetic circuit was completed by a return ring on the opposite side of the rotor.

Printed-wiring motors have the advantage of a high torque/inertia ratio and low mechanical time constant (because of the low moment of inertia of the rotor), and a smooth torque characteristic.

The magnets for this motor represent just one of the many uses for Magnadur.

MORE POWER FROM THYRATRON ZT1011

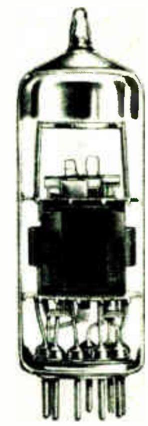
Direct Equivalent of American C3JA

The thyratron ZT1011 will pass an average cathode current of 2·5A at a peak anode voltage (forward or inverse) of 1·25kV. This valve was formerly type XR1-1600A which was recommended as a near equivalent of the American type C3JA, the difference between the two types being the lower cathode current of the Mullard valve. Now, life tests at the C3JA ratings have confirmed that the ZT1011 can be run at these higher ratings and is now a direct equivalent of the American type.
Where a lower cathode current (1·6A) can be accepted, the peak anode voltage of the ZT1011 may be increased to 1·5kV.

NEW DISPLAY TUBE FOR TRANSISTORISED RADAR

A new radar display tube has recently been introduced whose scanning power requirements are such that transistor drive circuits can be used. This tube, type F21-10LD, has a screen diameter of 8½in and a scanning angle of 40°.
The F21-10LD has a useful screen area which meets the Ministry of

Transport requirement of 7½in. diameter for marine radar. The screen has a long-persistence phosphor, making the tube suitable for medium-range general-purpose radar systems.



V.H.F. POWER PENTODE WITH QUICK-HEATING FILAMENT

A low-power pentode has recently been introduced for v.h.f. mobile communications equipment. The valve, type YL1000, is intended for use as the output stage of small mobile transmitters or as a driver stage in larger transmitters. It can also be used as a master oscillator or frequency multiplier.

The quick-heating filament enables the valve to provide 70% of the output within half a second of switching on. This facility allows the valve to be switched off during 'receive' periods, thus economising on heater power and reducing the equipment temperature.

At a frequency of 175Mc/s, the YL1000 has an output power of 3·7W when used as an amplifier and 2·6W when used as a frequency doubler.

Reader Enquiry Service

Further details of the Mullard products described in this advertisement can be obtained through the Reader Enquiry Service of Industrial Electronics using the appropriate code number shown below.

Helical-cooled valves	206
Transistors BCY38, BCY39, BCY40	207
Thyratron ZT1011	208
Counting tube Z505S	209
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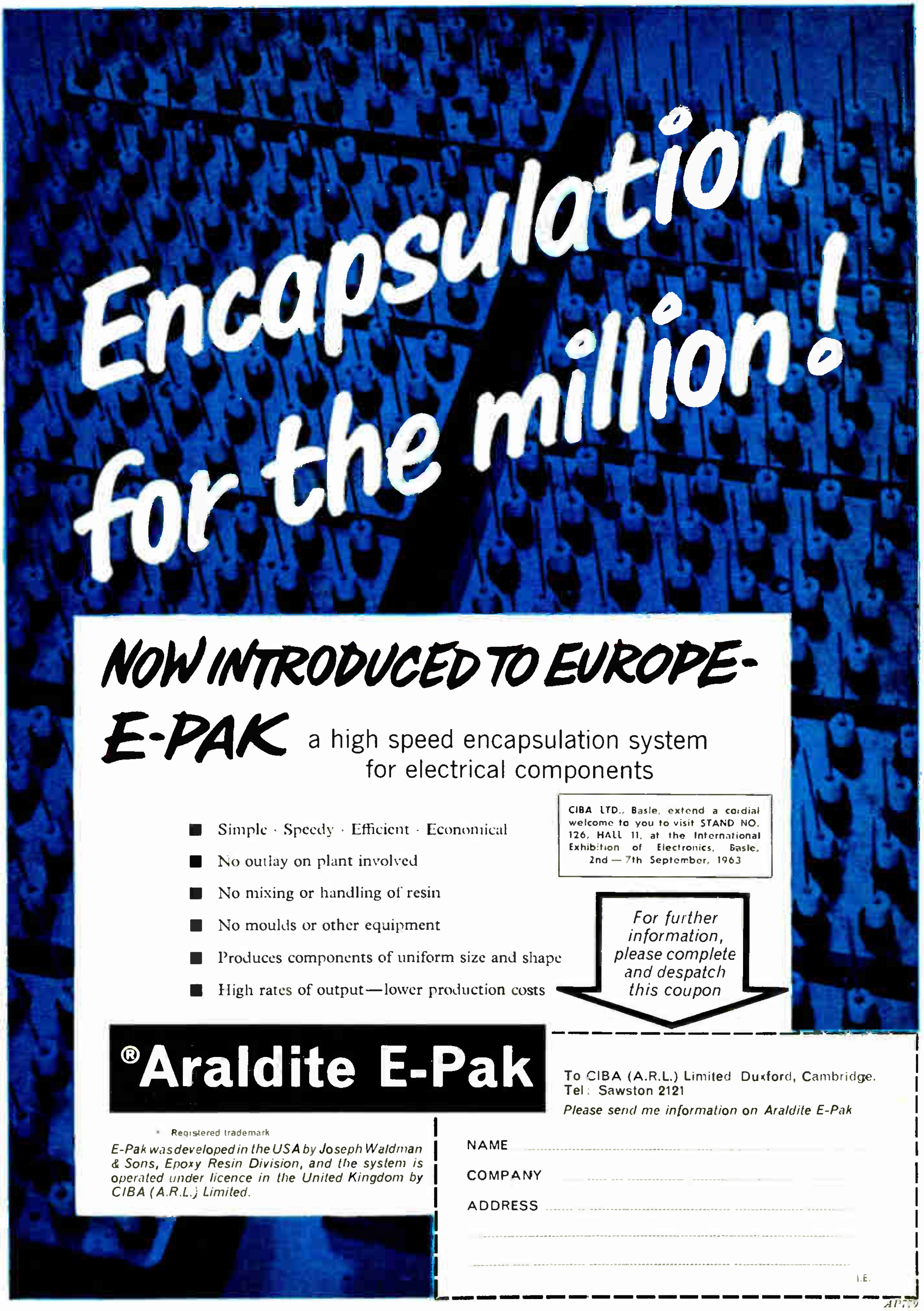
Magnadur	211
Radar tube F21-10LD	212

Mullard **Mullard Limited,** Mullard House, Torrington Place, London, W.C.1. Telephone: LANgham 6633

MI19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Produces components of uniform size and shape
High rates of output—lower production costs
CIBA LTD., Basle, extend a cordial welcome to you to visit STAND NO. 126, HALL 11, at the International Exhibition of Electronics, Basle, 2nd — 7th September, 1963
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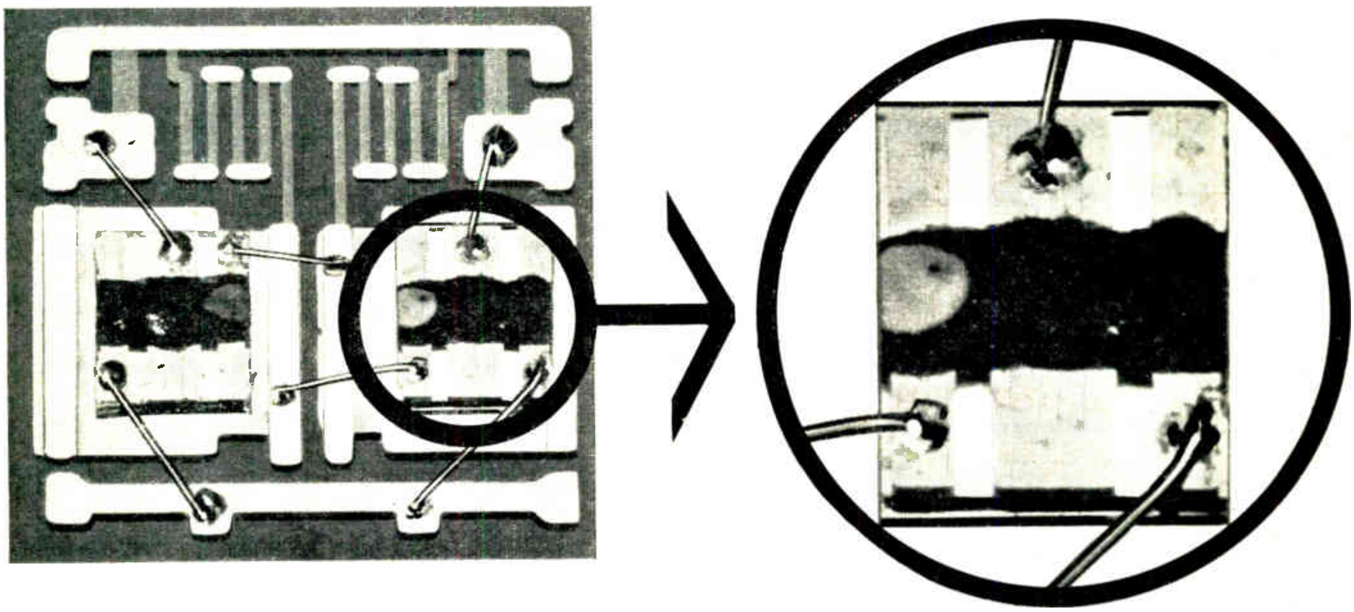
COMPONENTS REVIEW

AUGUST, 1963

MINIFLAKE TRANSISTORS
for thin film circuits



The initial range of STC Miniflake transistors comprises types without leads for direct connexion into thin film circuits, and types with leads for use with subminiature circuitry. In either application, Miniflake transistors do not increase the height of the circuit by more than 0·025 in. (0,635 mm). All Miniflakes are coated with an opaque resin which prevents mechanical damage to the planar surface and eliminates photo-conductivity.

BSY32 and BSY33

These are produced without leads and are for fast switching at mean current levels up to 100 mA. Their characteristics are similar to the conventionally encapsulated BSY26 and BSY27.

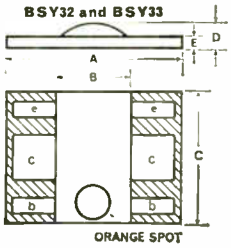
BSY47 and BSY48

Having leads, these Miniflakes are otherwise similar to the BSY32 and BSY33 respectively.

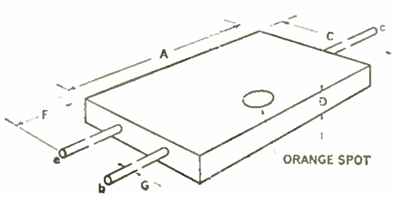
Brief Data

	BSY32 - BSY47	BSY33-BSY48	
f_T ($I_C = 10$ mA, $V_{CE} = 9$ V, f = 100 Mc/s)	200 Mc/s	200 Mc/s	(Min)
I_{CBO} ($I_E = 0$, $V_{CB} = 9$ V)	25 nA	25 nA	(Max)
h_{FE} ($I_C = 50$ mA, $V_{CE} = 2$ V)	15-60	25-120	
V_{CES} ($I_C = 50$ mA, $I_B = 5$ mA)	480 mV	190 mV	(typ)
t_{ON} ($I_C = 10$ mA)	20 ns	19 ns	(typ)
t_{OFF} ($I_C = 10$ mA)	31 ns	35 ns	(typ)

BSY32 and BSY33



BSY47 and BSY48



Dim	in.	mm
A	0·160	4,064
B	0 070	1,778
C	0·120	3,048
D (max)	0·025	0,635
E	0·010	0,254
F	0·5	12,7
G	0·010	0,254

For full details of STC Miniflakes write, 'phone or Telex to STC Transistor Division, Footscray, Sidcup, Kent. Telephone FOOtscray 3333. Telex 21836.

CONTINUED OVER/

SILICON AVALANCHE RECTIFIERS TYPE RAS 310 AF

For the first time—a Silicon Rectifier which is self-protecting against voltage transients.
The avalanche property of this device has a voltage limiting characteristic that permits surges fifty times greater than the conventional silicon rectifier can withstand.
High voltage stack construction is simplified—avalanche rectifiers can be series connected without voltage equalizing resistors and, in many applications, equalizing capacitors are unnecessary.

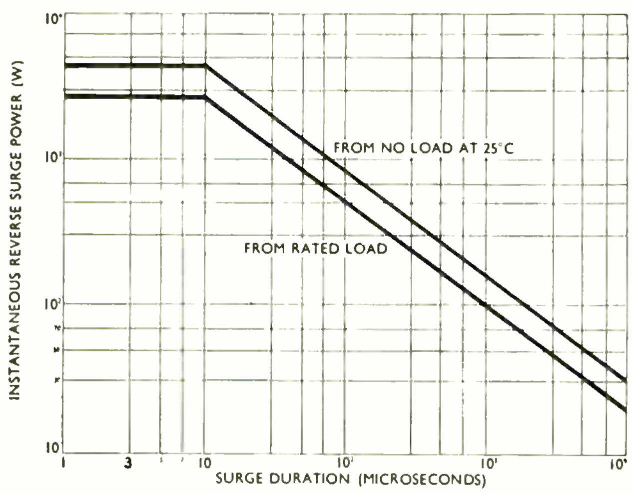
TYPE RAS 310 AF

Rated Forward Current (at 25°C)	*1·25 A*
Rated Crest Working Reverse Voltage	*1000 V*
Minimum Reverse Avalanche Voltage	*1250 V*
Rated Maximum Reverse Surge Power	*4 kW*
Rated Maximum Temperature	*140°C*
Standard Outline	*VASCA SO-16, JEDEC DO 1, IEC 1-101*

NOW AVAILABLE FROM PRODUCTION

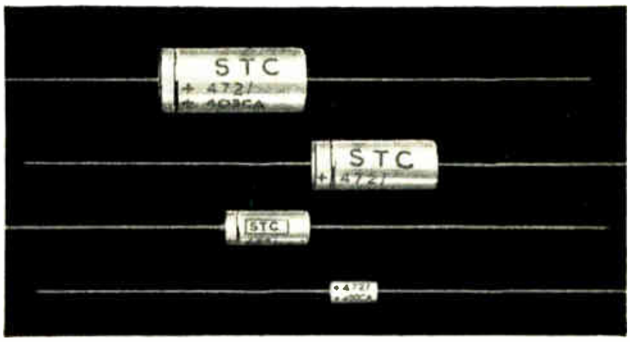
ACTUAL SIZE

SURGE (NON RECURRENT) REVERSE POWER



Write, 'phone or Telex for Data Sheet MF/125 to STC Rectifier Division, Edinburgh Way, Harlow, Essex. Telephone Harlow 26811. Telex 81146.

SRDE APPROVAL FOR STC SOLID TANTALUM CAPACITORS



Departmental Approval Certificate Number NS. 3020, covering STC Solid Tantalum capacitors, has been granted by the Ministry of Aviation. The approval is based on a successful test programme carried out by SRDE to Draft DEF 5134-A-1 and is pending the finalization of this specification.
The STC solid tantalum capacitor series was extended recently by the addition of a 50 volt rating. Rated working voltages at 85°C are now: 50 V, 35 V, 20 V, 15 V, 10 V and 6 V d.c. This range of capacitors is manufactured entirely in the United Kingdom under full Quality Control and all units are aged for 7 days before shipment.
Capacitors to 5% and 10% tolerances are now available, in addition to the standard 20% capacitance tolerance.

* **Designed to DEF 5134-A-1 and MIL-C-26655/2 (Styles CS12 and CS13)**
* **Temperature range: −55°C to +125°C (with voltage derating above +85°C)**
* **Humidity classification: H6 (DEF 5011)**
* **Capacitance range: 0·47 μF to 330 μF**

Performance data available on request

In addition to this range, STC manufacture the following wet-electrolyte tantalum capacitors:

TYPE APPROVED FOIL
HIGH TEMPERATURE FOIL
MINIATURE FOIL
SPECIAL QUALITY FOIL

Write, 'phone or Telex for Data Sheets to STC Capacitor Division, Brixham Road, Paignton, Devon or London Sales Office, Footscray, Kent. Telephone FOOtscray 3333. Telex 21836

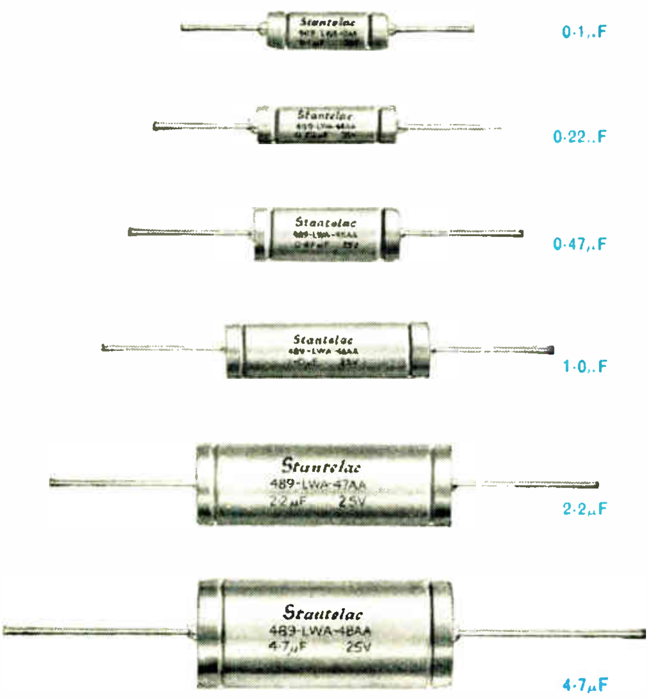
For further information circle 217 on Service Card

STC COMPONENTS REVIEW

MINIATURIZATION
1·5 micron dielectric

A 25 volt STANTELAC capacitor range has now been introduced. This series will be a considerable aid to development engineers who are particularly interested in the miniaturization of low voltage electronic equipment.
The technique employed is an STC development based on the use of an aluminium foil coated with a synthetic resin. The thinness of this integrated dielectric is not limited by the usual considerations of handling and winding etc., and is made to suit the required working voltage. This results in an exceptionally high capacitance-to-volume ratio, particularly at lower voltages.

ACTUAL SIZE



0·1µF
0·22µF
0·47µF
1·0µF
2·2µF
4·7µF

25 volts d.c. wkg. (70°C)

STANTELAC capacitors are ideal for use in place of foil/paper, metallized paper and polyester types to gain an improved space factor and a general improvement in electrical characteristics. The capacitors will have a wide field of application in computers, modern telecommunication equipment and in transistorized equipment generally.
The 50 volt and 100 volt ranges are now well established as high quality components. These ranges have recently been expanded and now include over twice the number of capacitance values previously available.

Write, 'phone or Telex for Data Sheets to STC Capacitor Division, Brixham Road, Paignton, Devon or London Sales Office, Footscray, Kent. Telephone FOOtscray 3333. Telex 21836.

PULSE MODULATOR VALVES
VACUUM TETRODES

The STC range of Vacuum Pulse Amplifier Tetrodes grows steadily as does their reputation for reliable service. The latest valve to be added to the range is type 4B/550E which is a smaller version of the now very popular 4B/603E.

Code		3D21A	4B/550E	4B/603E	4B/602E
V_h	(V)	6.3 or 12.6	26	26	26
I_h	(A)	1.7 or 0 .85	1.2	2	2
V_a	(kV)	3.5	12	15	20
I_a peak	(A)	7	10	15	15
V_{g2}	(kV)	0.8	0.8	1.25	1.25
V_{g1} bias	(V) Typical	−150	−500	−800	−800
V_{g1} pulse	(V) Typical	300	700	1025	1025
Equivalent Codes		CV2659		CV398	CV427

Write, 'phone or Telex for Data Sheets to STC Valve Division, Brixham Road, Paignton, Devon or London Sales Office, Footscray, Kent. Telephone FOOtscray 3333. Telex 21836.

Standard Telephones and Cables Limited

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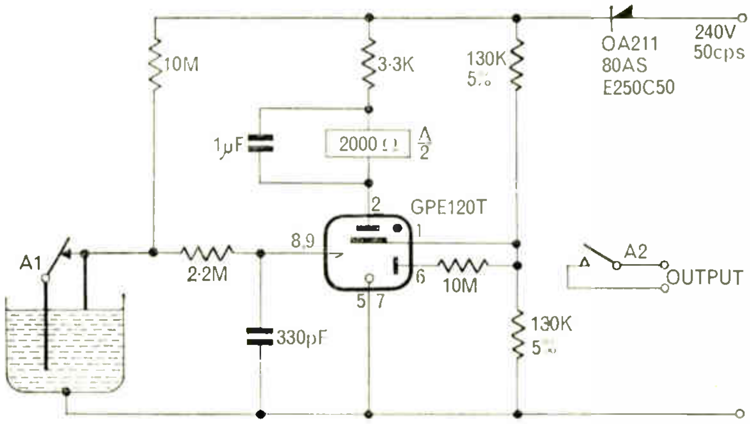
LIQUID LEVEL CONTROL

By and large, the familiar mechanical liquid level controller does a reliable job, but it has its limitations particularly in precise industrial applications. Here the effective answer is inexpensive cold cathode trigger tubes. Reliable to the point of outlasting the useful life of parent equipments, Ericsson trigger tubes meet the most exacting requirements.

Operating from rectified mains they require no special power supplies, they are not affected by severe transient overloads, they give visual indication of current flow and their characteristics remain unchanged by temperature fluctuations.

With suitable electrodes any substance capable of flow even with only a moderate degree of conductivity can be accurately maintained to predetermined levels or measured and delivered in selected quantities.

The circuit illustrates the simplicity of cold cathode trigger tube liquid level control. For more information and data please write to the address below.



Tube Division
Technical Services Dept.,
Beeston, Notts. Tel: 254831.

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AUGUST 1963 — *For further information circle appropriate number* (IF)

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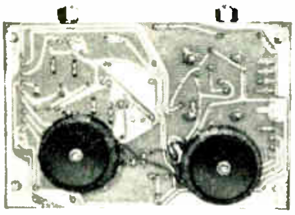

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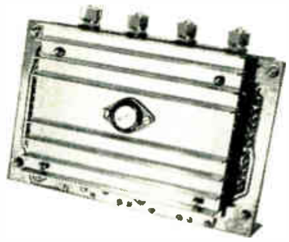

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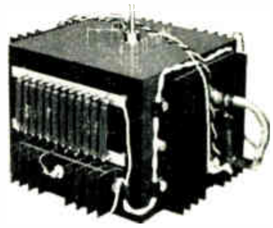

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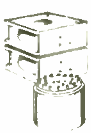

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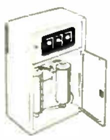

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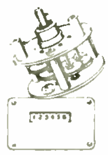

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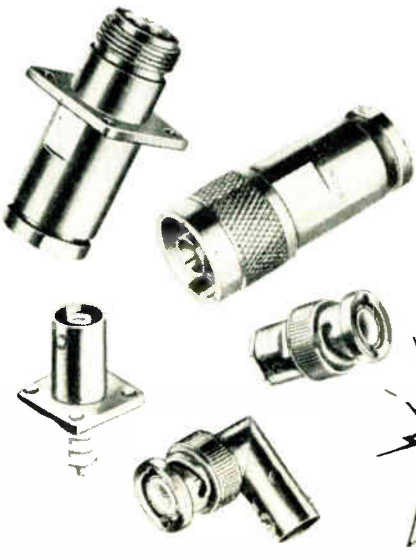

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INDUSTRIAL ELECTRONICS

Comment

From 2nd to 7th September there is an exhibition in Basle known as INEL 63. It is an International Exhibition of Industrial Electronics and elsewhere in this issue we deal with some of the apparatus shown by British Companies.

The advance list of exhibitors provided by the organizers appears to consist of a list of the companies who have booked space in the exhibition rather than of the firms whose products are being shown. Thus *Industrial Electronics* (Stand 10/97) appears in the list as Associated Iliffe Press Ltd.

Some British manufacturers appear under their own names, some have their own names together with those of their Continental agents, and others appear in the list completely disguised by their agents' names. As a crowning touch of confusion, some American products are being exhibited by their British agents.

It is to be hoped that all this will be sorted out in the final list and that in this the prominence will uniformly be to manufacturers' names, for these are the ones which visitors are likely to know best.

Two congresses are being run in conjunction with the exhibition. One is the International Federation of Automatic Control (I.F.A.C.), from 24th August to 4th September; the other is the Inel Congress on 5th and 6th September.

The second and smaller covers the latest developments in electronics and automation as applied to traction as well as the applications of semiconductors in electronic and power engineering. At the time of writing no details have been received about this congress.

The I.F.A.C. Congress is a much bigger one. With two exceptions only, there are four morning and afternoon sessions for seven days. In the total of 51 sessions 160 papers are scheduled to be read! The participants are from very many countries, including the U.S.S.R.

The Congress is divided into three sections by subject. The theory of automatic control has 25 sessions and 80 papers. Applications of automatic control are dealt with in 19 sessions and 57 papers, while components of control devices occupy 7 sessions with 23 papers.

Automatic Translation

A lot of work is going on to produce a machine for translating automatically from one language to another. Most of this has been for translating from Russian into English. Now comes news that I.B.M. are working on one for translating Chinese into English.

Chinese is a particularly difficult language for there are thousands of characters and the linguistic rules are very complex. Special typewriters are used to type the text in Chinese characters and these at the same time punch three rows of holes in paper tape. These holes provide the machine coding for the character. It is said that operators who do not understand Chinese can still be trained to do this at a rate comparable to ordinary English typing.

The actual translation is done by a computer which depends on a rapid-access store containing half-a-million instructions.

At the moment the automatic translation machine seems to be far from commercial application, either as a machine which one can buy or, more likely, as the modus operandi of a translating bureau. There is little doubt that this will come in time, however.

Oral Translation

Useful as the automatic translator would be in turning a written text in one language into another, it would be much more useful to have a machine which would deal with the spoken word; that is, an oral translation machine. Disregarding practicabilities, we should like a small portable device, rather like a hearing aid but perhaps as big as a camera, into which we could speak in English and its loudspeaker would produce the equivalent in French or German or any other desired language. By turning a switch, it would then translate in reverse so that we could hand the microphone to our foreign friend and listen to him in English.

There would certainly be an enormous market for such a device. As yet it is but a dream even with a full-size computer to help. The pocket translator is a complete impossibility in the foreseeable future. It is unlikely that it will forever be impossible, however. When we know how to achieve oral translation with unrestricted equipment, simplification and miniaturization will follow.

The oral translator will not necessarily function on the same lines as the present translation machines. The computer part of it which does the actual translating will probably be much the same, but the input and output devices will be entirely different.

The first attempts will probably be with the aid of a standard translating machine using written texts, to this would be added a recorder and reproducer. The recorder would accept a spoken input and produce from it a typewritten version in the same language. A recorder of this sort would alone be a very useful device. The reproducer would read aloud from a typewritten text. This also would be useful elsewhere, especially for the blind.

In the true oral translator, however, the typewritten texts would not be needed. The heart of a translator, the computer, works on pulses. Arrangements have to be made for the typed material to produce the input pulses and for the output pulses to operate a teleprinter. There seems no reason why the amplified speech current output of a microphone should not be treated to produce the input pulses without the intermediary of a typewritten text.

In the end quite a lot would be different, for if writing disappears so does spelling and the computer programme would be quite different.

It is usual to end any look into the future such as this by saying that it will come but not in our time. Development now proceeds at such a rate, however, that we hesitate to say that it will not be in our time. It may very well be in our time!

Packaging

There was a symposium on electronic circuit packaging in the U.S.A. last year and the proceedings have just appeared. In this connection, packaging does not mean, as one might think, packing apparatus for safe transport. It means what most people would call the mechanical design of apparatus. It is applied to a sub-unit of an equipment, to an assembly of sub-units, and to complete apparatus.

When the electrical side of a design has been finalized and the circuits and component parts are known these parts must be 'packaged' into a whole, perhaps directly or more likely through sub-sub-units into a sub-unit, sub-units into a unit, and units into a whole.

Cordwood

In the same symposium the term 'cordwood assembly' was freely used and so far we have failed to find out precisely what is meant by it. In one case it is used to describe a form of assembly in which tubular resistors and capacitors are stacked parallel to each other to form a solid block and their leads are terminated on two parallel printed-wiring boards. Each individual component lies between the two boards and at right angles to them. However, we are not certain if 'cordwood' is confined to this sort of assembly or whether it has a more extended meaning.

British Exports

The extent of British exports of valves and semiconductors is not always realized. For the first quarter of this year it totalled £2,992,204. Complete cathode-ray tubes accounted for £689,900 of this and semiconductor devices of all kinds amounted to £590,746.

A direct comparison with 1962 is difficult because there has been a revision in the headings of the export list, but B.V.A. and V.A.S.C.A. give the increase over 1962 as 30%, while for transistors it was 50%.

In suitable cases, the use of ultrasonics for cleaning not only enables better cleaning to be obtained but can greatly reduce the time and cost of the operation. This article describes the kind of equipment needed and gives examples of typical applications.

CLEANING BY ULTRASONICS

By W. G. A. McCORMICK*

MENTION of cleaning processes normally conjures up mental pictures of scrubbing, boiling, agitation, soap or detergents and water. In ultrasonic cleaning there is scrubbing, agitation and water or some other solution.

Cleaning by ultrasonics basically depends on two factors, agitation and choice of cleaning solution. The installation normally consists of an ultrasonic generator and an ultrasonic cleaning tank, both of which vary in detail depending on the application for which they are used. A typical type of industrial cleaning unit is the 600/300-watt Dawe Type 1144A Ultrasonic Generator which is used in conjunction with Ultrasonic Cleaning Tanks Type 1163, ranging from 5½ to 14¾ gallons capacity.

The generator, fed from the normal mains electrical supply, produces ultrasonic oscillations which are then applied to the transducer elements attached to the underside of the ultrasonic cleaning tank. The transducers convert the electrical oscillations into mechanical vibrations, thereby producing ultrasonic waves. These mechanical vibrations pass through the cleaning solution contained in the tank, causing rapidly fluctuating pressures to be set up, resulting in the formation and subsequent collapse of minute bubbles or cavities. This process is known as cavitation. On the collapse of the cavities, very high pressures are produced in their immediate vicinity, which result in a scouring action at the surface of the work to be cleaned, detaching fine solid particles while, at the same time, dispersing them in the cleaning solution. This scouring action is extremely effective and penetrates into inaccessible regions, such as crevices, indentations, holes, pores, inside surfaces, etc., where normal brush cleaning would be ineffective.

Ultrasonic cleaning can eliminate hand scrubbing and can be applied to remove insoluble soils that cannot be satisfactorily removed by more conventional methods.

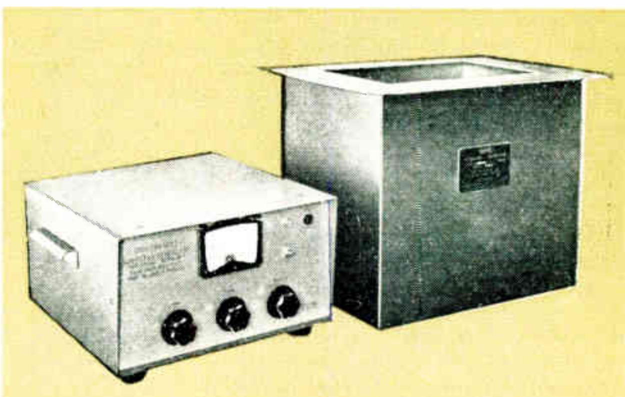
Choice of Frequency and Transducers

Cavitation in the cleaning liquid can be produced at all audible frequencies and at inaudible (ultrasonic) frequencies up to several megacycles per second. The actual watts per square inch required to ensure cavitation in a liquid will vary considerably with different liquids, the amount of gas in the liquid and other factors. For a given set of conditions, the power required to produce cavitation will, however, rise rapidly as the frequency exceeds about 50 kc/s. If the energy level is not high enough to produce cavitation there will, of course, be no appreciable ultrasonic cleaning action.

Factors such as these, and the materials available for transducer manufacture, govern the choice of the most efficient operating frequency. The oldest methods of generating ultrasonic vibrations are probably those using piezoelectric quartz crystals and magnetostrictive metal laminations. Quartz crystals are probably more efficient, since quartz has very low electrical and mechanical losses. However, it requires very high voltages, particularly at the lower ultrasonic frequencies. Being also a very expensive material, it is, therefore, not commercially suitable for ultrasonic cleaning equipment.

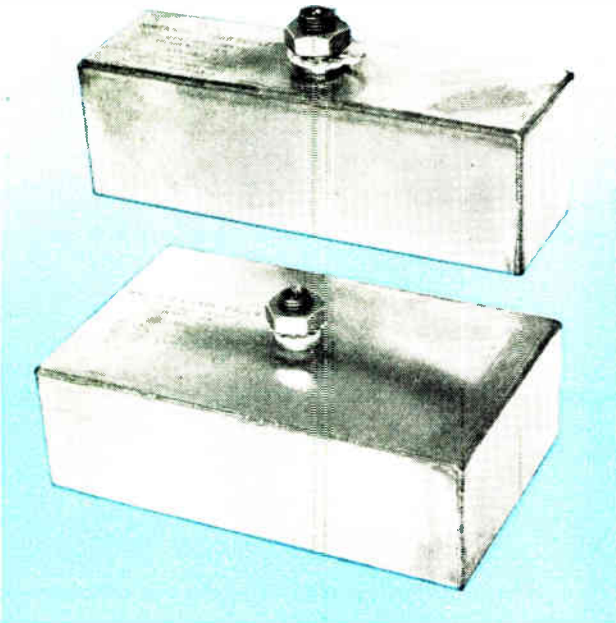
Magnetostrictive vibrators have, however, been used for many years to generate sonic and ultrasonic waves. Such transducers, if properly designed, are robust, will withstand relatively high temperatures and provide very high vibration amplitudes. The limitation of this type, when applied to ultrasonic cleaning, is that the ratio of power input to transducer radiating area is relatively high. Magnetostrictive transducers are more commonly used on applications other than ultrasonic cleaning where high localized amplitudes are required.

The transducers shown, Dawe Type 1164, are manufactured using piezoelectric ceramic materials. With these materials it is possible to operate at 25 kc/s and provide efficient cleaning at low power levels. This type of transducer offers many advantages over other methods, the



Typical medium power Dawe Soniclean ultrasonic generator and ultrasonic cleaning tank with built-in transducers

* Griffin & George Ltd., formerly Dawe Instruments Ltd.



Typical piezoelectric immersible transducers from the Dawe range, encased in welded stainless steel

most important being the much higher conversion efficiency combined with high operating temperatures.

The active element (piezoelectric ceramic) of this type of transducer has the property of expanding in the same direction as an applied voltage of given polarity, and contracting when the polarity of the applied voltage is reversed. This active element will, therefore, vibrate at the same frequency as the applied voltage. The amplitude of this vibration will be at a maximum when the frequency of the applied voltage is the same as the natural (resonant) frequency of the ceramic element.

For a given applied voltage, with the transducer immersed in liquid, the amplitude of vibration at resonance may be ten times as high as the amplitude far from resonance. Since power input per unit area is proportional to the square of the amplitude, it is important to operate transducers at, or near, their resonant frequency to obtain efficient operation. Power output will increase proportionally to the square of the applied voltage; the desired power output could, therefore, be obtained at frequencies off resonance, but electrical losses in the transducer would be excessive.

As will be seen in the illustration, the piezoelectric ceramic is housed in an all-welded stainless steel casing for both electrical and mechanical protection. It is important that the radiating surface of the transducer be immersed in liquid when energizing power is applied from the ultrasonic generator. Experimental tests have shown that for ultrasonic cleaning applications pulsed operation will result in improved performance based on the average power output of the generator, since the peak power on pulses from the generator is several times higher than its average power output rating. This technique also uses the greater power handling capacity of this type of transducer to maximum advantage.

Applications of Ultrasonic Cleaning

The standard range of ultrasonic cleaning equipment, consisting of a wide variety of generators from 80 to 2,000 watts output, coupled with ultrasonic cleaning tanks from 5 pints to $29\frac{1}{2}$ gallons, covers a large field of applications throughout the industry, including cleaning of ball-bearing parts, watch and instrument movements, complex castings, metal tubes, fountain-pen parts, hydraulic components, electrical contacts, printed circuits, valve parts, connectors, motor stators and rotors, switches, etc.

Apart from considerations of higher cleaning efficiency with the use of ultrasonics, economies can play a large part in decisions to install this type of plant. The B.O.A.C. Engineering Branch at London Airport have in fact achieved a considerable saving in skilled labour through use of ultrasonic cleaning and, thereby, increased the volume of overhauled parts through their Component Overhaul Unit.

To maintain the high standard of reliability associated with B.O.A.C., their aircraft are taken out of service at set times for periodic maintenance and overhaul. This involves removal of components, which are then stripped down, cleaned and overhauled. Since many delicate parts are involved, skilled operators must carry out all work of cleaning as well as overhauling. By installing the Dawe unit illustrated in the front cover picture, a saving of about

Cleaning jewellery using the Dawe type 1141A transistorized Soniclean

(Photo by courtesy of Slade & Kempton (Jewellery) Ltd. of Hatton Garden)

The Dawe Soniclean Surgical Instrument Cleaner being used at the Royal Hospital for Sick Children, Edinburgh

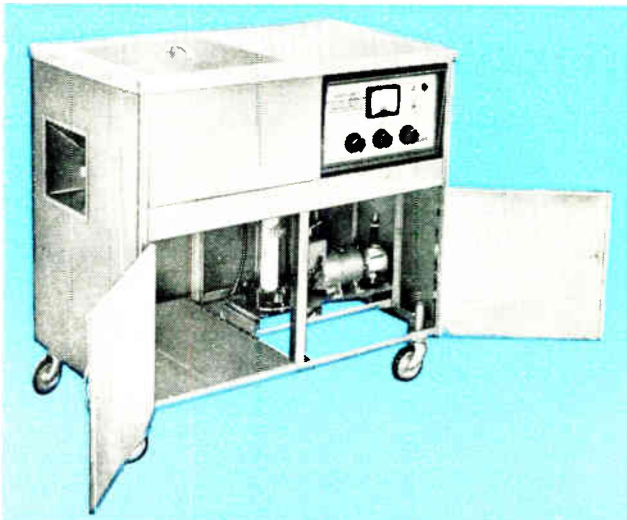
50%, skilled-labour time was achieved on the cleaning operations; also, the cleaning fluids consumption per week was reduced from 20 gallons to about 4 gallons.

A further saving was achieved on reclamation of certain expensive electrical items. Under conditions of manual cleaning certain components such as armatures, etc., could not be thoroughly cleaned without risk of damage. As a result, a considerable number of such units had to be scrapped. On only one of these items the total loss per year amounted to about £3,000. Use of ultrasonic cleaning enabled not only thorough cleaning but with no risk of damage, and a very high percentage of these components are now reclaimed.

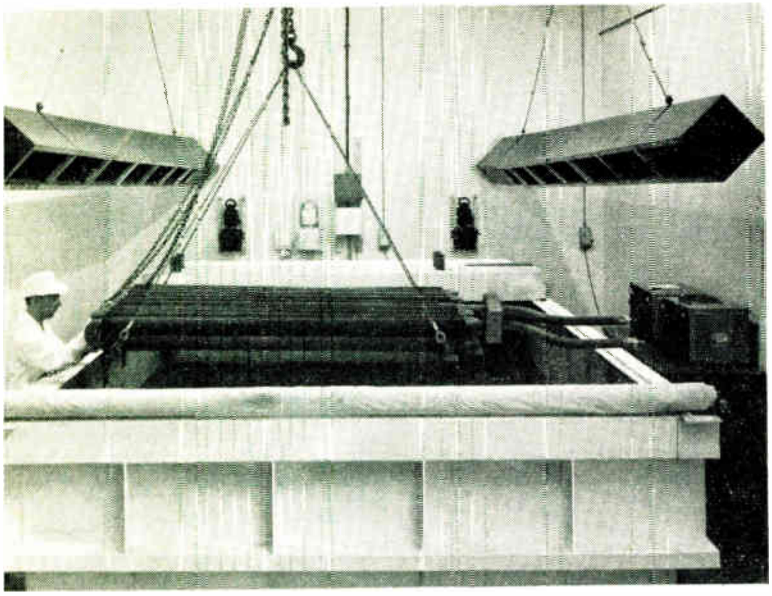
A specialized cleaning unit, the Dawe Type 1141B, has been specially designed as a self-contained unit for rapid cleaning of small or delicate parts. This has found great use in the cleaning of jewellery. It is an inconvenient paradox that the final polishing operation on jewellery of gold and other precious metals, to produce a brilliant and lasting shine, is one of the dirtiest sequences in the whole production story. Polishing is generally carried out by buffing on a high-speed rotary mop which has been impregnated with an abrasive grease containing jewellers' rouge. This material, which in use gets mixed with fine grindings of oxidized metal and worn-off fragments of calico mop, fills all the fine interstices in the jewellery with a black paste which is difficult to remove. Prior to the use of ultrasonic cleaning, removal of this deposit called for tedious scrubbing with brush, soap or detergents and water. This sometimes resulted in scratches requiring further polishing and subsequent cleaning, at best a slow business which frequently caused bottlenecks in production lines. With ultrasonic cleaning the firm of Slade & Kempton (Jewellery) Ltd., of Hatton Garden, found that up to 400 assorted items of jewellery which formerly took one man a full day to clean by hand could be dealt with by Soniclean equipment in about ten minutes.

Nowhere is absolute cleanliness more important than in the operating theatre. It would appear to be relatively easy to keep surgical instruments clean by constant scrubbing and washing, but if closely examined a brown film of hard proteinous matter can often be seen in box joints, serrated jaws and locks. Debris which is not removed by scrubbing is baked on during subsequent sterilization and provides a surface to which further deposits will readily adhere.

After many tests carried out with standard industrial equipment, the first ultrasonic surgical instrument cleaner was designed and built for the Department of Health for Scotland. The equipment is fabricated entirely of stainless steel and has two tanks, each 12 × 16 × 12 in. deep. One tank, for cleaning, has ultrasonic transducers mounted on the underside, giving an unobstructed interior; the other, for rinsing, is provided with a separately controlled spray. The generator driving the transducers is mounted within the



New Dawe mobile ultrasonic cleaning unit incorporating full facilities for filtering cleaning fluids



Heat exchangers weighing 2 tons being lowered into ultrasonic cleaning tank. The two Dawe generators on the right provide all the ultrasonic power

(Photo by courtesy of International Combustions Ltd., Derby)

stainless steel cabinet, thus making a completely self-contained unit.

The tank containing the ultrasonic transducers is filled with water, to which is added a small quantity of an ordinary detergent. The soiled instruments are put into a stainless steel basket, which is placed within the tank; the lid is then closed and the generator switched on. After a few minutes the generator is switched off and the basket of instruments is transferred to the other tank. Here they are thoroughly rinsed with hot water coming from the spray. Since the two tanks are not connected in any way, baskets of instruments can be washed and rinsed simultaneously.

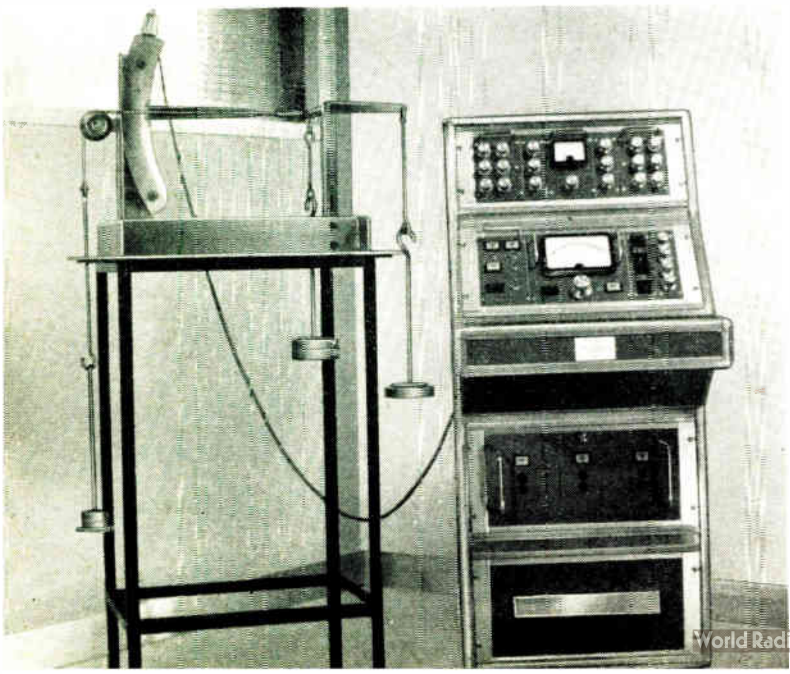
Equipment such as the Type 1170C Surgical Instrument Cleaner can also effect a considerable financial saving. Opinions vary, but it is generally agreed that at least one hour is required to clean 100 instruments by hand. Using the ultrasonic cleaner the same number of instruments can be washed, rinsed and dried in 6–7 minutes. Installed in a central ceaning room, the equipment is capable of handling the instruments from four to five operating theatres without delay.

A further industrial application of ultrasonic cleaning equipment is in the field of metal degreasing. The purpose of this operation is to remove oil and grease from metal surfaces before surface treatment, finishing processes, etc. One of the most powerful grease solvents known is trichloroethylene and this is the basis of the metal degreasing process by I.C.I. Ltd. This company has had many years' experience in metal degreasing, and while most degreasing problems can be solved by the use of an orthodox trichloroethylene liquid or vapour process, the addition of ultrasonic vibrations to trichloroethylene is often necessary where the highest standard of cleanliness is required. To this end, I.C.I. have produced a ULV range of degreasing plants incorporating Soniclean ultrasonic cleaning equipment. All the plants provide boiling liquor, cool liquor and vapour treatment, plus the additional cleaning provided by ultrasonic vibrations.

A recently introduced mobile ultrasonic cleaning unit incorporating Soniclean 600/300-watt generator, a Type 1173 ultrasonic cleaning tank (incorporating heaters) together with built-in filter unit, is the most versatile in the range. It is completely mobile and, being of all stainless steel construction, is suitable for either surgical or industrial applications.

The limit of applications for ultrasonic cleaning have not yet been reached. Volume of bulk size of units to be processed has up to now been no drawback and results obtained on larger components processed show greater cleaning efficiency coupled with labour saving and reduction in costs. A typical example is the cleaning of large heat exchangers used in nuclear power stations. The heat exchanger illustrated weighs about 2 tons and is being lowered into an ultrasonic cleaning tank measuring $17\frac{1}{2}$ ft × 10 ft × $2\frac{1}{2}$ ft deep, holding 1,500 gallons of solvent. Two 4-kW Soniclean generators energize 14 transducers.

VERSATILE DATA ACQUISITION SYSTEM



A data acquisition system recently installed by Norris Brothers at Northampton College of Advanced Technology is employed with their three-component strain gauge wind tunnel balance. The system, which has to combine accuracy, reliability, versatility, and low cost, is designed on a module basis to facilitate modification and expansion for individual requirements.

The equipment accepts output signals from the strain gauge balance via a signal conditioning unit and channel selector; frequency response is from d.c. to 20 c/s, but up to 10 kc/s is available if required. Channels are selected by push-buttons interlocked to eliminate simultaneous operation.

Three-component strain-gauge balance (left) and data acquisition console (right)

For further information circle 47 on Service Card

Modular Construction of Electronic Servo-system Elements

By J. R. MUSHAM*

This article describes a series of standard units which can be connected together in various combinations to meet a great many control system requirements. The standardization so obtained enables control systems to be provided more quickly and cheaply.

In the control systems industry, more often than not, units are manufactured in small numbers. Manufacturers are, therefore, faced with the difficulty of meeting customers' individual and widely-differing requirements with the minimum of special design and development work. To assist in this process, it is useful and time-saving to have at hand certain of the more commonly occurring circuits in the form of modular building bricks. In deciding the types of unit most suited to this form of construction, it is useful to consider a breakdown of common electrical servo systems.

Typical Servo Systems

The main requirements for an electrical servo system are:—

(a) A means of detecting the quantity to be controlled and converting it into an a.c. voltage or current.

(b) A means of converting the a.c. voltage or current into a d.c. equivalent. This conversion is necessary because the great majority of error-detecting means are d.c. operated, and most systems will function adequately by controlling the mean or peak function of the quantity to be controlled.

(c) A means of measuring the quantity to be controlled, comparing it with the required value, and deriving the difference or error.

(d) A pre-amplifier with means for inserting signals from other parts of the system, in particular, integral or differential functions.

(e) A power amplifier to feed the system actuator, e.g., a machine field or motor armature.

(f) A power supply unit to provide the other units with their necessary a.c. or d.c. supply voltages.

Detectors

The means of detecting the quantity to be controlled is usually a current transformer, potential transformer, d.c. transformer, thermo-couple, pressure transducer or magnetic amplifier. These items are largely produced by

* W. H. Sanders (Electronics) Ltd.

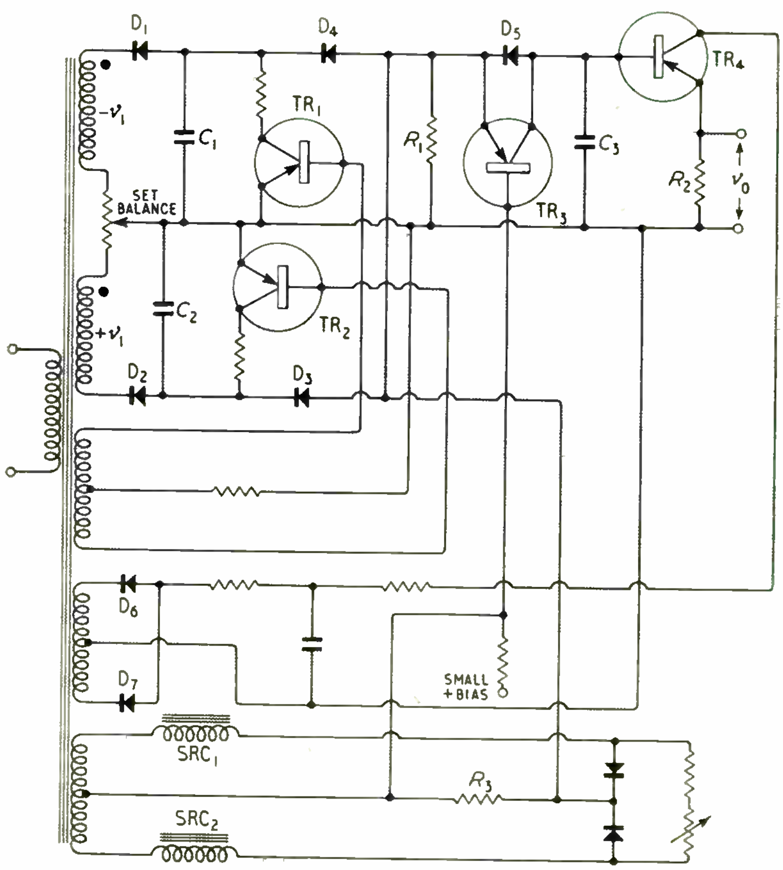


Fig. 1. Basic circuit of a.c./d.c. converter

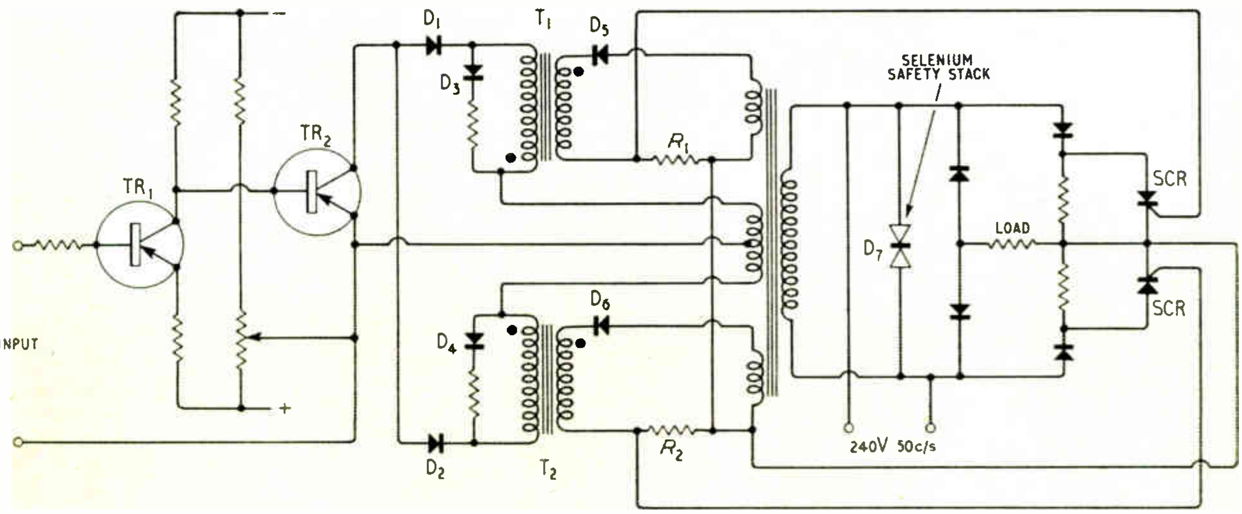


Fig. 5. High-power amplifier. The transistor input stages control the magnetic amplifier which in turn governs the silicon controlled rectifiers

Power Amplifiers

Two types of power amplifier meet most requirements. A low-power amplifier is needed for driving magnetic amplifiers, etc., and this must have an output of reversible polarity, and a high-power amplifier is wanted for driving d.c. motors, machine fields, etc.

Low-Power Amplifier

This is a simple transistor amplifier designed to be driven by the push-pull output of the d.c. amplifier and error-detector unit of Fig. 3. The circuit is shown in Fig. 4 and the base-emitter junctions of TR_1 and TR_2 are forward-biased through D_1 and D_2 to avoid a dead zone in the amplifier characteristic. The output load is represented by R_L and if $Input_1$ goes negative with respect to virtual earth the supply voltage V_1 drives current through the load in the direction of the arrow. If $Input_2$ goes negative and $Input_1$ positive the current reverses and is then driven by V_2.

The input needed for maximum output is ± 5 V at 12 mA, and the inputs must be at $-0{\cdot}1$ to $-0{\cdot}5$ V with respect to earth. The maximum output is $\pm 0{\cdot}5$ A into a 10-ohm load and is linear up to $\pm 0{\cdot}4$ A. Two isolated d.c. supplies are required, each with a mean output of 15 V at 0·75 A from a full-wave rectifier. The unit is rated for operation at temperatures up to 70 °C.

High-Power Amplifier

This unit is based on a voltage-controlled flux-resetting magnetic amplifier and the circuit is shown in Fig. 5. The advantage of this type of circuit is that, being a.c. driven, the time response is genuinely one half-cycle of the input voltage. The magnetic amplifier itself is conventional and is controlled by the two input transistors TR_1 and TR_2. Silicon-controlled rectifiers are used at the output and a considerable number of safeguards for them have been incorporated in the main amplifier circuit. The circuit is made to fail safe, for the output developed across the gate resistors R_1 and R_2 disappears when the input signal is removed. If required, current limiting can be provided by additional windings. Diodes are connected in series with the s.c.r.'s to support the peak inverse voltage during the off half-cycle, in order to prevent avalanche conduction in the reverse direction, and *CR* networks suppress transients which could damage the diodes.

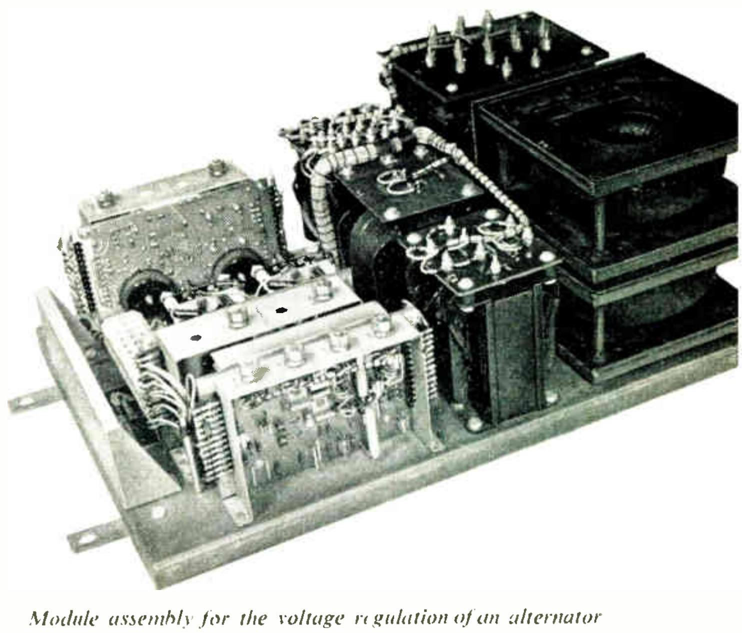
When current limiting is provided it is capable of shutting off the s.c.r.'s within one half-cycle. This is usually fast enough, for most s.c.r.'s will withstand 10–20 times their rated current for this short period.

The upper limit of power output depends on the s.c.r.'s used but can be 80 kW, while the input needed is only 2 mW and the input voltage for full output is 3 V. An s.c.r. gate signal of 8 V at 100 mA is provided, continuing to the end of the firing half-cycle with a firing range of 12–170°. Up to $\pm 40\%$ changes of mains voltage are permissible with negligible change in the firing angle, and the unit is suitable for operation at temperatures up to 70 °C with suitable derating of power output.

Typical Applications

Automatic Voltage Regulator on a Power Alternator

The block diagram of a system designed to regulate the voltage of a power alternator is shown in Fig. 6 and it can be seen that out of the four units employed only one had



Module assembly for the voltage regulation of an alternator

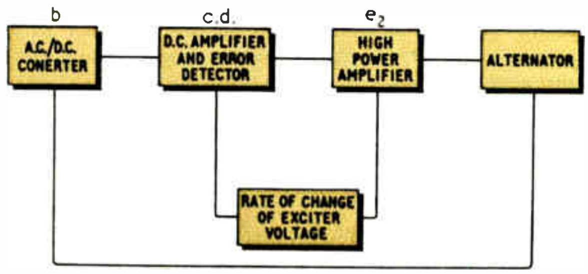


Fig. 6. Block diagrams of control circuit for an alternator

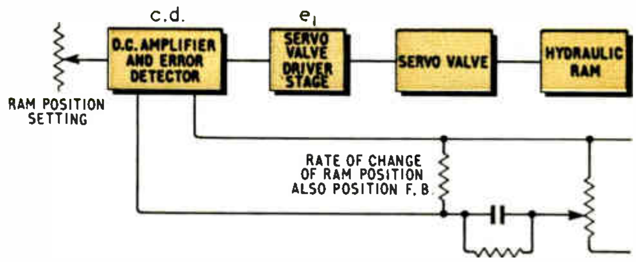


Fig. 7. Servo system for a hydraulic ram

to be designed for the job. This means a considerable saving of time and money and, consequently, many 'one-off' jobs become a practical proposition.

The regulator enables the alternator to provide an output of 1 MVA at a full-load regulation at zero power factor lagging of 0·35%. The recovery time from no load to full load at zero power factor is 1 sec.

Hydraulic Position Servo

The arrangement of this control system is shown in Fig. 7. If a differential drive is required for the servo valve, it can be obtained from the error-detecting and pre-amplifier unit and fed to the servo valve through an additional amplifier which needs only two transistors.

These are only two of the many applications for which the modular system is suitable. As already stated, it is a system which enables most problems to be solved easily and with a minimum of special apparatus. Printed-circuit construction is used for all the units except the high-power amplifier; this takes the form of a potted block with heat sinks attached to the sides.

ELECTRONIC AIDS IN THE NEW THAMES TUNNEL

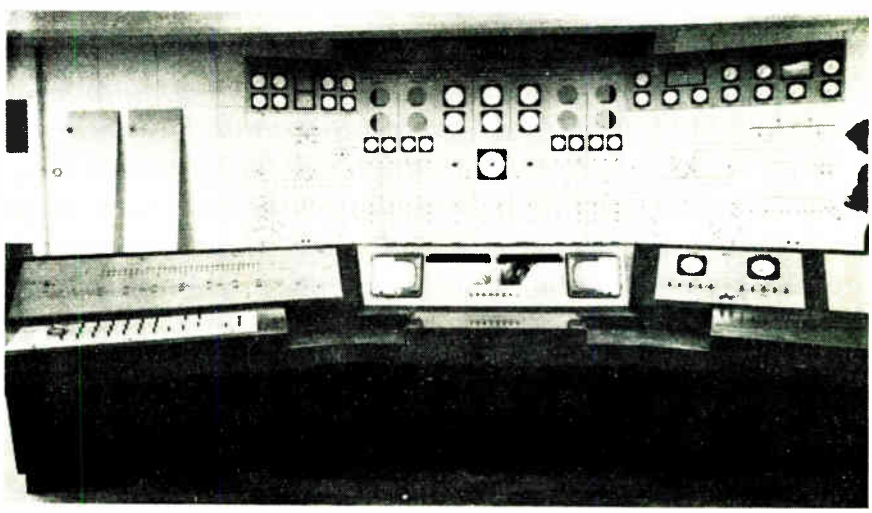
Electronics will be used to facilitate control of the new Dartford-Purfleet tunnel under the Thames. The tunnel, which is just under a mile long, will join the road systems of Kent and Essex.

The console in the control room, situated in the administrative block on the Dartford side of the river, has already been completed. On this console are two closed circuit television monitors, conveying a picture from seven points, five in the tunnel and two just outside. This enables the officer in charge to see what is going on anywhere in the tunnel and its immediate approaches and is particularly valuable in the event of an emergency.

Other information displayed on the console includes automatic counting of traffic; photometric readings of the visibility in the tunnel, worked from remote light meters; atmospheric readings, with separate indication of smoke and carbon monoxide content; performance of the ventilation and pumping machinery; the location of accident or fire when an alarm has been given; and light indicators repeating the emergency traffic signals.

The visibility and atmospheric readings are among the most important routine indications: upon them depend the control of the ventilation and lighting in the tunnel. The remote controls for these and other services are located on a wall behind the console.

Technicians putting the finishing touches to a console



In colour printing successive impressions must be in very close register. This article describes a photoelectric control system which automatically maintains register.

Electronic COLOUR REGISTRATION in Printing

By *J. C. MAWER**

BEFORE outlining some of the methods used to provide automatic registration of colours in colour printing it is, perhaps, pertinent to give a brief outline of the method of printing colour. Colour prints are made up of a number of impressions of single colours which are printed over each other to form the final picture. This is done in a multiple printing press, which is, very diagrammatically, shown in Fig. 1. From this it can be seen that the paper to be printed is fed through several consecutive printing presses, each printing its own colour. In between each press the paper is fed over various drive and tension rollers. All the presses are driven by a common line shaft, or are driven at identical speeds, so that theoretically there is no reason for the impressions by the first press not to line up with the impressions by the subsequent presses.

However, without some form of control the impressions by the consecutive cylinders are not necessarily exactly super-imposed; i.e., they are out of register. This is due to paper stretch, shrinkage, slight discrepancies in the printing rollers themselves, and differences in the amount of pressure each draw roll puts on the paper. While these discrepancies are usually quite small they are, nevertheless, highly visible in the finished print. A trained printer can see differences as small as 1/1,000th of an inch quite easily, while 1/64th of an inch is very visible even to the layman.

It is, therefore, necessary to measure the difference between consecutive prints and in some way to correct this error. In multiple colour printing the usual method of correcting the error is to insert a loop in the paper between each printing press and control this loop by moving a roller at the apex of the loop to increase or decrease the amount of paper in the loop and hence move the register between consecutive presses. In some other registration processes it is possible to use differential gearboxes to insert correction. This is accomplished by connecting the differential gearbox between the two sections where the register is to be controlled, and driving one section from the main motor. The second section is then driven through the differential gearbox at a constant speed, but when it is required to correct register the third shaft of the differential box can be operated, and this will cause the relative positions of the two machines to be adjusted. In electrical terms, the phase angle between the two is varied.

Having described the mechanism of the press and reasons for requiring to control error, we can now turn to the electrical devices used to measure this error. Fig. 2 is a sketch of a piece of material which is being colour printed. It

* Lancashire Dynamo Electronic Products Ltd.

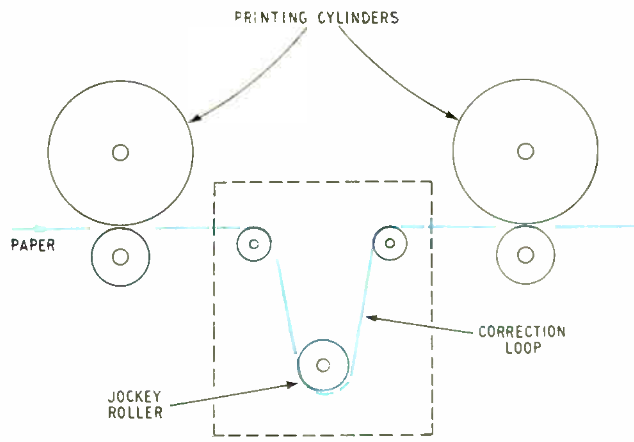


Fig. 1.—Diagrammatic representation of a multiple printing press

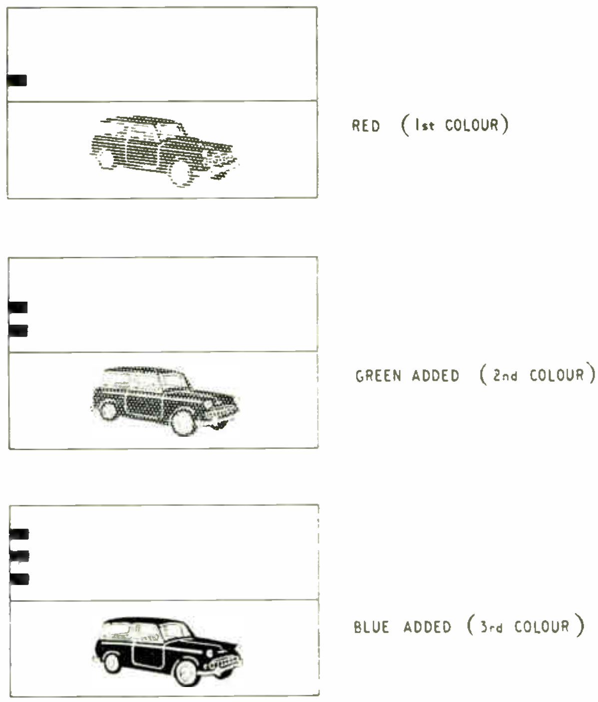
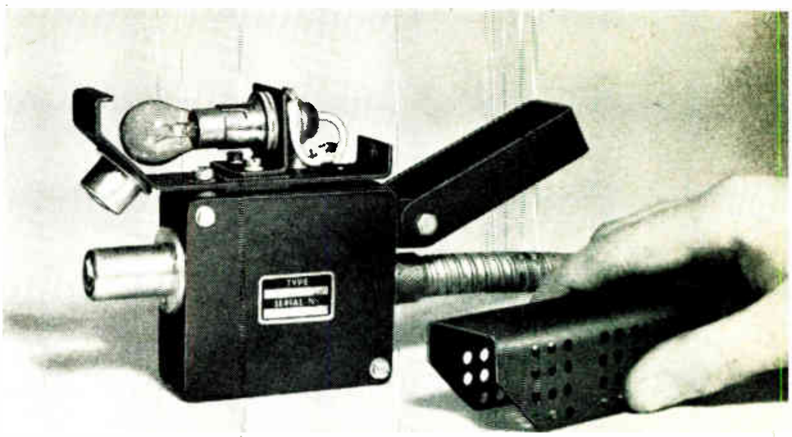


Fig. 2.—Pictures for a three-colour process showing the registration bars

will be noticed that there are bars shown (in different colours) in some inconspicuous place on the page. This is usually in the 'gutter' between the two sides of a page in a newspaper, and in fact these marks can often be seen by removing a page from a newspaper or periodical printed in this way. The marks are always in the form of short bars, the length of the bar being at right angles to the direction of motion of the paper during printing. In some systems the bars are placed side by side, while in others they are spaced along the direction of motion of the printing. In either case the bars are observed photoelectrically and the position compared either with each other or with the position of one or more of the printing cylinders.

The photoelectric scanning units, one of which is shown in a photograph, contain a light source and photocell unit; a lens focuses the light from the light source on to the paper so that the scattered light from the material is then collected by a second lens focused on the photocell. The presence of a printing mark changes the quantity of light reflected and this, in turn, changes the current through



Photoelectric unit with the lamp cover removed

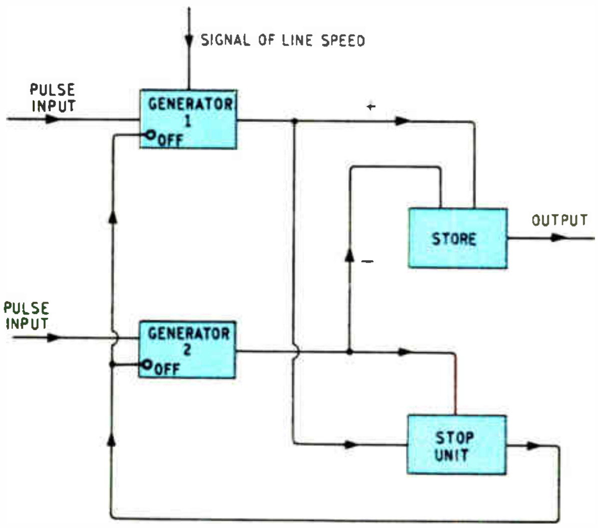


Fig. 3.—Block diagram of the registration control apparatus

the photocell so that a pulse can be generated indicative of the fact that the registered mark has been observed by the head unit. Either digital or analogue techniques may be used to determine the relative position of one pulse to another. The analogue system will be described here. (The digital system was described in the June issue, when the problem of registering printed material into a running press was discussed.)

In block form the circuits used to determine error are shown in Fig. 3. It can be seen that there are two pulse input circuits, and for correct registration these two pulses should occur at the same instant. Each pulse switches on a current generator, one giving a positive signal and the other a negative. The output of each generator is fed into the store, and a circuit is arranged so that when both generators are energized they actuate a reset circuit, which resets the generators and they are both switched off. Thus, if the two pulses occur coincidentally, the generators are switched on and almost instantaneously switched off again and the net signal to the store is approximately zero. If, however, one signal arrives before the other then one generator is on for a longer period and the next signal in the store has a magnitude indicative of the duration between the arrival of the two signals, and a polarity indicating which signal arrived first. If the magnitude of the current signals is controlled by the speed of the printing machine then the magnitude of the signal in the store is directly indicative of the amount of error present. This process is repeated every time register marks are printed on the web, which is usually once per impression or, if the printing machine produces more than one impression per revolution, then once per revolution of the press. Thus a continuous signal is available for indicating error.

Once an error signal has been obtained, the mechanical processes are well enough understood to enable correction to be inserted, and the problem is virtually solved as far as the control engineer is concerned. A wide variety of control techniques may be used, ranging from relays which are switched on when the error signal is present and continue inserting correction until the error signal disappears, to a full three-term control system within the loop, controlling the position of the roller in the paper loop. The most commonly employed system controls the speed of the correcting motor to be equal to the error signal so that zero error equals zero speed but as soon as an error is present correction commences at a speed proportional to the amount of error. Some amount of rate information is usually fed into the system also, so that the rate of approach of the error to zero slows the system down in order to minimize hunting.

ABRACADABRA

EDP; DMC; MAD: Electronic Data Processing; Digital Micro-Circuit; Magnetic Anomaly Detection. These and more than 1,200 other abbreviations are included in the second edition of a glossary prepared by Raytheon and entitled ABRACADABRA (Abbreviations and Related ACronyms Associated with Defence, Astronautics, Business and RAdio-electronics).

With the increasingly complex nomenclature of today, such abbreviations are not merely a convenience but an essential shorthand. This booklet is a handy reference to those in current use, mainly in the U.S.A. To the original list of nearly 400 terms have been added about 900 ABRACADDENDA, many of which reflect recent organizational changes in the U.S. Armed Forces.

For further information circle 48 on Service Card

Experimental Shorthand Transcription Machine

IBM has developed an experimental machine which can automatically transcribe Stenotype, a form of shorthand, into typewritten or printed English. Stenotype is a very fast machine shorthand used widely in the United States for courtrooms and other places where accurate transcription of normal-speed speech is essential. The transcription system automatically converts Stenotype notes into finished copy, punctuated, capitalized, hyphenated and paragraphed.

This experimental system has two possible applications. Firstly, the transcription of Stenotype; although this system can be written at speeds as high as 175 and 200 words a minute, one hour's shorthand may take four hours to transcribe. Machine transcription is virtually instantaneous. Secondly, the use of Stenotype as a rapid means of encoding alphabetic information for machine processing.

The system uses the same basic machine developed by IBM for automatic language translation. The 'dictionary' of Stenotype and English equivalents is contained in the form of black marks on a glass or plastic disc; the disc can contain up to half a million words, any of which can be found in an average of 1/30th of a second. Steootype is basically phonetic but most ambiguities due to homonyms can be easily recognized by the machine by storing the most common contexts. Proper names are spelled out phonetically, but those most usually met with can, of course, be included in the dictionary.

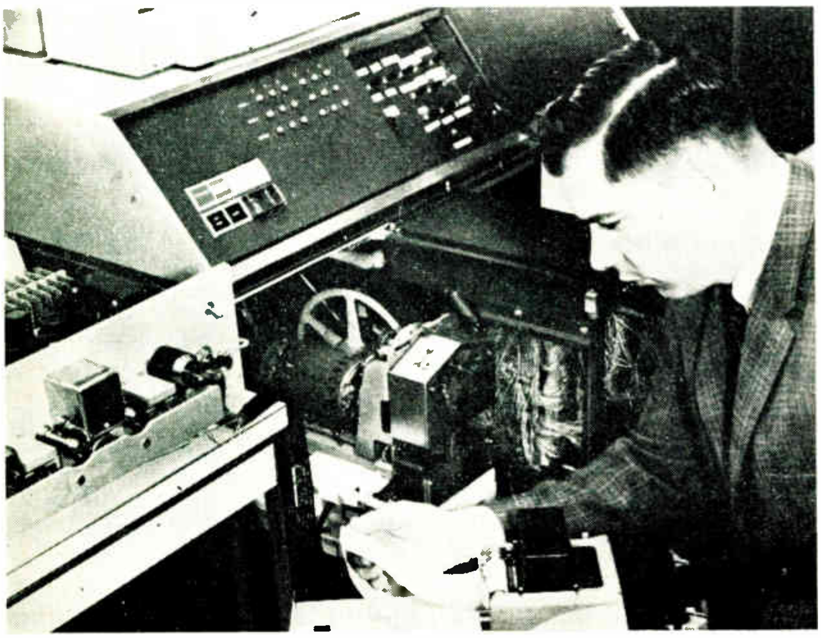
The Transcription System

In its present form, the automatic transcription system makes use of a 'memory' in which photographic techniques are used to obtain storage of an enormous amount of information in a very small space, and with reasonably short access time. Information is stored in the form of tiny black rectangles on an 11-in. diameter disc of glass or plastic. The total number of rectangles is approximately 70 million.

The rectangular spots represent binary information—that is a spot followed by a transparent area represents 0, and a transparent area followed by a spot represents 1. In Stenotype transcription, as in most other systems concerned with words, six binary digits are used to represent one letter. Thus the letter 'e' might be 101001 and 'b' might be 110101, and so forth. In the memory, the '1's' and '0's' are represented by the sequence of black spots and transparent areas.

Various instructions can be coded in a similar way. For Stenotype transcription, every entry in the memory consists of a code representing a possible combination of Stenotype symbols, followed by a code representing the English equivalent and, usually, some additional instructions.

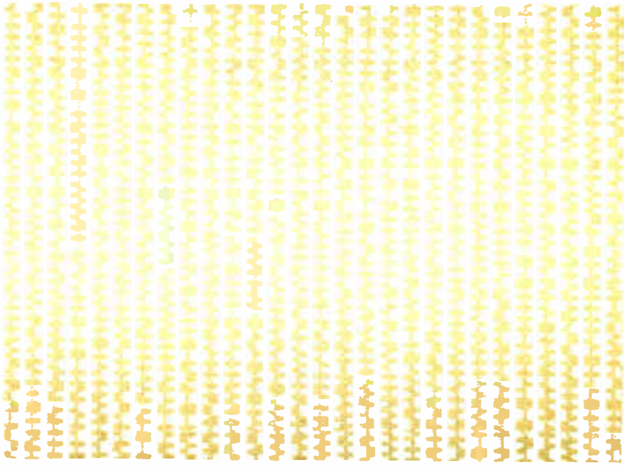
To identify an input word, the memory is searched in descending order of input word length. This arrangement prevents a portion of a long word from being mistakenly identified as a shorter word with which it begins, such as 'otherwise' and 'other'. The arrangement provides a number of important advantages for language translation and for Stenotype transcription. However, Stenotype transcription is complicated by the lack of any form of spacing between the phonetic Stenotype symbols. Thus



This shows a modified Stenotype machine connected to a paper tape punch which produces coded tape according to the keys which are operated. The punched-tape is 'read' by the machine on the left and translated into English by the computer-like equipment in the background the system produces 'overhear' for 'over here', 'inadequate' for 'in adequate', 'accompany' for 'a company' and so forth. The problem can be readily solved by adding an end-of-word key to the Stenotype keyboard, but it has been found that this reduces the operator's speed by about 15 per cent.

This problem has been partially solved by including in the machine memory the most common short phrases in which such ambiguous combinations of words appear. For example, a phrase such as 'a cute girl' might be included since 'a cute' is frequently followed by 'a girl'. The machine would then never mistake 'acute' for 'a cute' in this context. The technique resolves the majority of ambiguities of this type.

An improvement soon to be incorporated in this system will resolve most of the remaining ambiguities. Each word in the memory will contain grammatical information, and the machine will be able to recognize the part of speech of the words on both sides of the ambiguous expression. Thus 'overhear' would usually be followed by an article, pronoun or plural noun. While 'over here' is more likely to be followed by a comma or full stop, and preceded by a verb.



A close-up of the coded tracks of a 'dictionary' disc

The Stenotype System of Shorthand

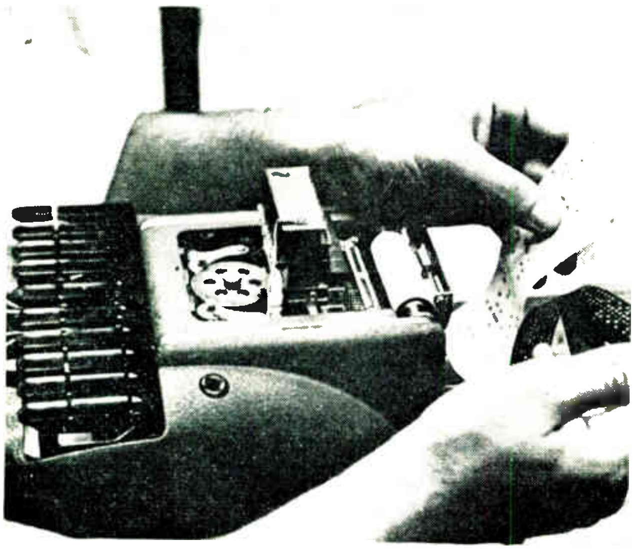
The Stenotype system is a machine form of shorthand in which English words are converted into printed phonetic symbols. The most widely used Stenotype machine is based on a coding method developed almost fifty years ago by W. S. Ireland. The machine contains 23 keys, any combination of which may be struck simultaneously. The fact that the keys can be struck simultaneously, along with a phonetic system of coding that eliminates much redundancy, is the key to the speed of Stenotyping. A minimum of one syllable is printed by each stroke, and a large number of abbreviations of common words and phrases is provided in the coding system.

Similar approaches have since been developed for machine shorthand in a number of other languages besides English.

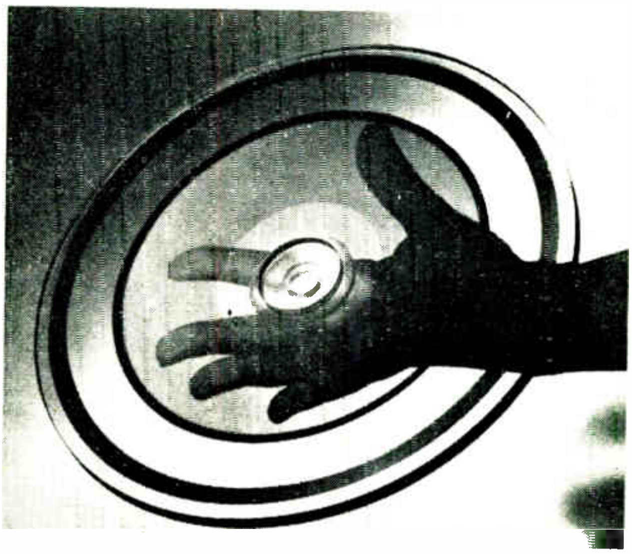
The output of a Stenotype machine is a 3-in. wide paper tape on which the 22 symbols available are printed. (The 23rd key is a kind of shift key which permits the numerals 0–9 to be printed.) Each key prints its character in a separate column on the paper tape. This greatly simplifies an input device which may eventually be incorporated in the automatic transcription system, since no character recognition device will be necessary. With each character printed in a separate column, the mere appearance of a mark in one of the columns determines which character is meant.

In the experimental Stenotype transcription system reported by IBM the Stenotype machine is wired into a paper tape-punching machine, since punched paper tape is the only form of input now used with the automatic translation system.

The fact that any number of Stenotype keys can be struck at the same time permits an enormous number of possible combinations. Technically 2^{23} or roughly 8·4 million combinations are possible. This large number of possible combinations along with the very large storage capacity of the memory, permits the system to do many things in addition to simple transcription of Stenotype code. For example, any kind of standard output sentence, phrase or paragraph can be simulated by a Stenotype code expression.



A close-up of the modified Stenotype machine showing the punched paper tape produced



A coded 'dictionary' disc as used in the Stenotype translation system. These discs may be made of glass or plastic

EQUIPMENT review

1. Oscilloscope Camera

The Southern Instruments 70-mm camera type M.1227 provides a simple means of recording waveforms displayed on a cathode-ray oscilloscope. It is a single shot instrument fitted with a bloomed Dallmeyer f/3·5 lens. Repetitive waveforms are photographed with a brief exposure, and transient waveforms are recorded by exposing the film for one X sweep initiated by the transient.

All working parts are mounted on an aluminium casting and the whole is enclosed with an upper and lower cover. The upper cover is easily removed to give access to the film cassettes for loading and unloading the camera.

For continuous recording, which requires only the Y deflection of the oscilloscope, the camera is coupled to the drive unit type M.1228. This mains-operated attachment provides six continuous feed speeds between 1 and 50 in. per sec.—*Southern Instruments Ltd., Frimley Road, Camberley, Surrey.*

For further information circle 1 on Service Card

2. Miniature Relay

Dewhurst & Partner announce the introduction of an inexpensive and robust miniature unit type relay, known as type EC06, with three normally-open poles rated at 6 A and two normally-closed poles rated at 2 A, all at 550 V a.c.

The double-break solid silver-to-silver contacts have a mechanical life expectancy exceeding 5 million operations, and the relay is rated for severe switching duty. It is suitable for incorporation in compact specialized relay panels required for automation, etc., and the clean lines and small size permit up to 20 relays to be butt mounted in a square foot of panel space. A damp and dust protecting enclosure for single relays is available.

Standard coils cover voltages in the ranges 230-250, 396-425 and 426-455, all at 50 c/s. Non-standard coils are available at a small extra charge.—*Dewhurst & Partner Ltd., Melbourne Works, Hounslow, Middlesex.*

For further information circle 2 on Service Card

3. Solid-State Cryogenic Timer

Tempo Instrument's model 90217 is a 0·05 to 1 sec solid-state electronic timer which is capable of operating over the temperature range of −196 °C to +55 °C. The unit is adjustable by means of an external timing resistor, operates from 20 to 31 V d.c. and incorporates a static output switch capable of delivering up to 500 mA to an external load.

The unit measures 2·5 by 2·5 by 4·05 cm. The components are supported in a low density potting material which enables the device to meet high shock and vibration requirements.

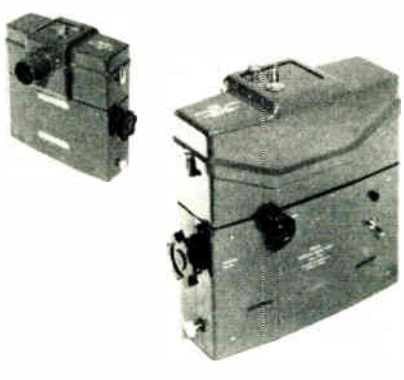
Variations of this device include: time delays up to 100 sec; output current as required up to 2 A; single pulse output; delay on drop-out logic; repetitive square wave output.—*Ad. Auriema Ltd., 414 Chiswick High Road, London, W.4.*

For further information circle 3 on Service Card

4. Transistorized Proximity Switch

Electronic Machine Control have developed a transistorized proximity switch which will sense both metallic and non-metallic objects at a rate of 800/min without physical contact. A metal object with a surface area of 1 by 1 in. can be sensed at a distance of $\frac{1}{2}$ in. and a p.v.c. object 1 by 1 by $\frac{1}{2}$ in. at a distance of $\frac{3}{16}$ in.

Because of its small size the most obvious application for this device is as a limit switch, but it can be used equally well in any control system



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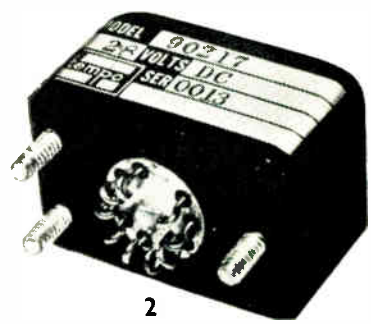

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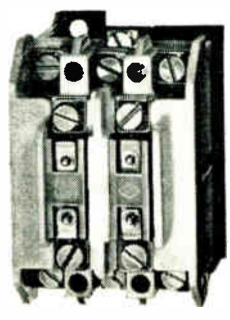

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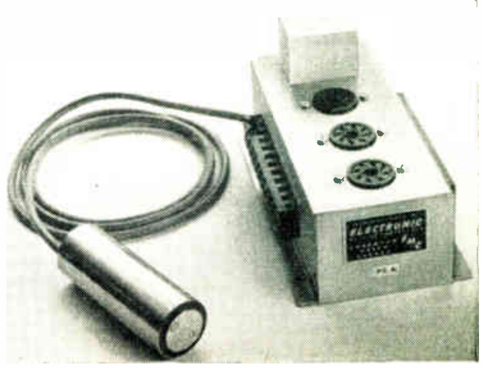

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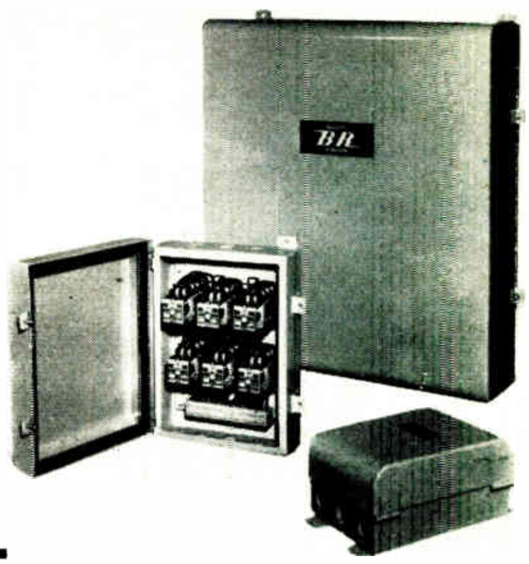

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where sensing and indexing are required, e.g. machine tool control, interlock systems, bottling, etc.

On the left of the photograph is the sensing head (4 in. long by $1\frac{3}{8}$ in. diameter) which houses a crystal-controlled transistor oscillator; on the right is the chassis containing a transistorized amplifier which operates the relay. This power supply relay unit can be supplied for use with either 1 to 4 or 1 to 8 sensing heads.—*Electronic Machine Control Ltd., Mayday Road, Thornton Heath, Surrey.*

For further information circle 4 on Service Card

5. Ultrasonic Sensors

As an addition to their range of Sonac ultrasonic sensing and switching equipment, Westool have announced a series of dry level assemblies to sense the level of solids in industrial bins, hoppers and special containers. The assembly consists of a matched pair of stainless steel sensors. These are unaffected in operation by dust, light and vibration.

The sensors are designed for easy fitting through the bin walls or can be specially mounted if required. The beam path is limited to a range between 18 in. and 10 ft. Dependent on the method of fitting, they can be supplied with an amplifier giving either an instantaneous or a delayed response; the latter is the most commonly used to allow for loose material dropping through the sensor beam.

Various control amplifier enclosures are now being supplied for all Sonac assemblies. These enclosures can be splash-proof, dust-proof or weather-proof depending upon environmental conditions. They can also be fitted with thermostatically-controlled heaters to enable the equipment to work in environmental conditions below the 40 °F limit on the standard amplifiers.—*Westool Ltd., St. Helen's Auckland, Co. Durham.*

For further information circle 5 on Service Card

6. Wall-Mounting Equipment Boxes

B. & R. Relays are supplying a range of wall-mounting boxes in four basic sizes to house complete relay and associated electrical equipment.

Manufactured in pressed steel, the boxes are robust, splash proof and dustproof, and can be fitted with locks if required. The standard finish is grey enamel but other colours can be supplied. The wall mounting base is fitted with external fixing lugs, and with top and bottom knockouts for a variety of conduit sizes. The 9 by 6 in. and 12 by 9 in. (base area) boxes come in 16 s.w.g.; the two larger sizes which are in 12 s.w.g. are 18 by 15 in. and 24 by 21 in. The doors of the boxes are hinged and detachable. In the 9 by 6 in. version, doors with $4\frac{1}{2}$ or 7 in. depth can be supplied. The 12 by 9 in. and 18 by 15 in. come in three depths, $4\frac{1}{2}$, 7 and 10 in., while the largest size 24 by 21 in. is available in 7 or 10 in. lid depths.—*B. & R. Relays Ltd., Temple Fields, Harlow, Essex.*

For further information circle 6 on Service Card

7. Inductive Voltage Divider

The Tinsley inductive voltage divider is a high precision ratio standard which may be used as the ratio arm of an a.c. bridge or as an accurate a.c. voltage divider. It is suitable for operation over a range of frequencies from 50 c/s to 2 kc/s.

The accuracy of the ratio is better than 5 parts in 10 million if the frequency is within 20% of the nominal value. At 1 kc/s the minimum input impedance is 70 kΩ and the maximum output impedance approx. 3 Ω; the effective series inductance is 20 μH. Maximum input voltage is 0·2 times the frequency up to a maximum of 200 V.

The coils of the divider are wound on high permeability toroids; under ideal conditions they have a stability approaching 1 part per 100 million. Coils, switches and terminals are built into a metal box $22\frac{1}{2} \times 8 \times 6$ in. The total weight is $21\frac{1}{2}$ lb.

The advantage of constructing a bridge from close-coupled inductive elements of this type is that the ratio of voltage division depends upon the turns ratio, which is constant, rather than upon the properties of the materials used: thus the precision and stability are greater than those of the corresponding resistance ratio arm.—*H. Tinsley & Co. Ltd., Werndee Hall South Norwood, London, S.E.25.*

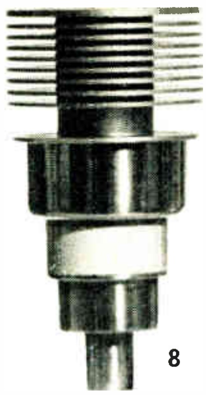
For further information circle 7 on Service Card

8. U.H.F. Planar Triode

A u.h.f. planar triode providing high cathode-current service from low frequency to 3 Gc/s has been announced by the Machlett Laboratories, an affiliate of Raytheon.

The rugged ML-8403 is a high-μ valve employing ceramic-to-metal construction: it is designed as a grid-pulsed, anode-pulsed, or c.w. oscil-

EQUIPMENT review



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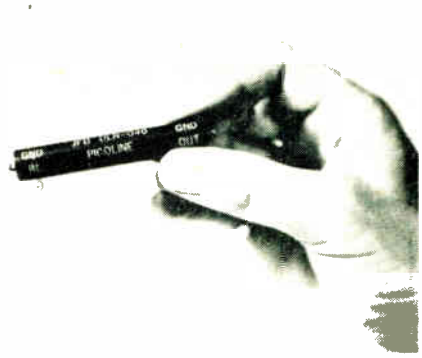

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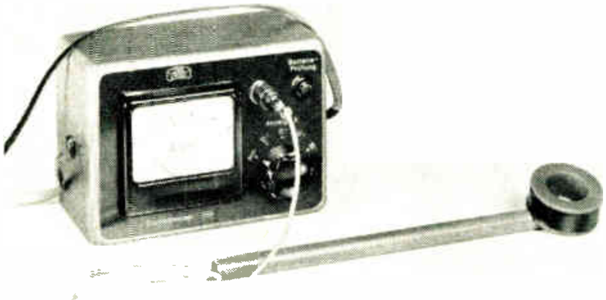

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lator: frequency multiplier or amplifier.

As a c.w. oscillator and amplifier, maximum ratings include a d.c. anode voltage of 2 kV, d.c. grid voltage of −150 V and anode dissipation of 100 W. Maximum ratings as an anode-pulsed oscillator and amplifier include a peak anode pulse supply voltage of 3·5 kV a.c. As a grid-pulsed oscillator and amplifier, maximum ratings include a pulse length of 6 μsec, duty factor of 0·0033, d.c. anode voltage of 2 kV and peak anode current from a d.c. supply of 5 A.—*Raytheon-ELSI, S.p.A., Villagrazia, Palermo, Italy.*

For further information circle 8 on Service Card

9. Subminiature Delay Lines

The Picoline range of subminiature delay lines announced by JFD are intended for use in the v.h.f. and lower u.h.f. ranges, replacing coaxial cable by a general rule of an inch of Picoline to a foot of cable.

Ten standard models are offered in 1 μsec increments from 1 to 10 nsec (tolerance: ±0·2 nsec), but special versions in a variety of case styles can be supplied with ½ nsec steps. Picolines have a linear phase characteristic and, from 3 dB down, bandwidth is in excess of 300 Mc/s.

These shock and vibration-resistant units of metallized glass construction feature a rise time of less than 1 nsec and have a temperature coefficient of delay of approximately 20 p.p.m./°C over a temperature range from −55 °C to +125 °C.—*JFD Electronics Corporation, 6101 16th Avenue, Brooklyn 4, N.Y., U.S.A.*

For further information circle 9 on Service Card

10. Cable Reeling Unit

V. L. Martin have announced the 'Marcaddy' constant-tension cable reeling unit, fitted with the 'Tensator' constant-torque spring. This gives a large number of winding turns, and packs the cable into a very small space, while the recoil tension is evenly maintained throughout extension.

Electrical continuity from the fixed to the moving parts of the unit is obtained by a sturdy slip-ring and brush housing, the whole drum assembly being at earth potential. P.t.f.e. bearings enable the cable drum to react instantly to quick movements of coil or recoil. The outer case, which is only 10½ in. in diameter, is made of a robust plastic moulding, and the complete unit weighs 7 lb plus cable. Models are made for handling 30 ft and 50 ft of 3-core 23/0076 cable at 5 A, and 30 ft of 3-core 70/0076 cable at 15 A.

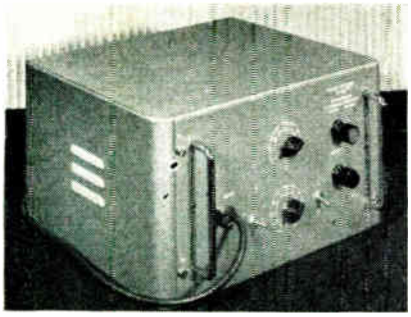
The three types available are: ceiling fixing, machine fixing, and portable, supplied with or without cable. The ceiling fixing model is suitable for portable hand tools, etc. The machine model has a swivel pedestal suitable for fixing on mobile equipment. The portable version is complete with floor skids, socket and handle, making it suitable for any application where an extension lead is required.—*V. L. Martin & Co. Ltd., Witley Works, Witley Gardens, Southall, Middlesex.*

For further information circle 10 on Service Card

11. Stray Field Meter

A magnetic stray field meter, designed for the measurement of alternating magnetic fields of frequencies between 50 and 500 c/s, has recently been announced by the Carl Zeiss Foundation of Western Germany.

This instrument, the SFM.2, is suitable for checking stray alternating fields of more than 5×10^{-3} A/cm which may, for example, cause blurr-



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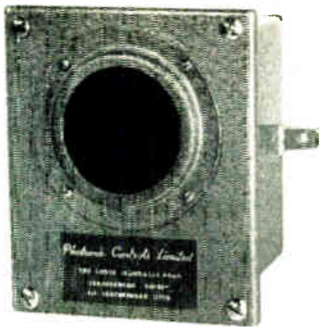

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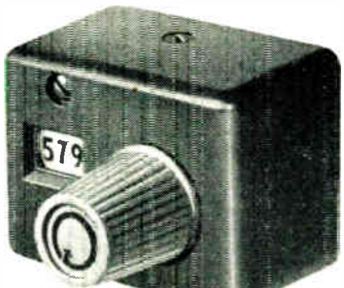

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ing of the image in electron optical devices.

The field to be measured induces in the search coil a voltage which is amplified and rectified in a portable battery-operated multi-step transistor amplifier. The resultant current, which is proportional to the rectified alternating voltage at the input, is indicated on a meter calibrated directly in field intensity units (A/cm). —*Degenhardt & Co. Ltd., Carl Zeiss House, 20/22 Mortimer Street, London, W.1.*

For further information circle 11 on Service Card

12. Phase Shift Unit

An instrument specially designed to provide an output at 240 V 50 c/s with phase angle variable through the full 360° in 1° steps is now available from Robinson and Partners.

Using transformers with their primary windings Scott-connected across a 3-phase supply, the output voltage is completely isolated from the input. Multi-tapped secondary windings are switched to give the output phase required. This system provides a low internal impedance, the output voltage at full load and any power factor being maintained within 7% for any output phase.

Two standard models, having ratings of 100 VA and 500 VA with a single variable phase output are offered, but polyphase units or models with different voltage and power ratings can be made to specification.—*F. C. Robinson & Partners Ltd., Davies House, 181 Arthur Road, London, S.W.19.*

For further information circle 12 on Service Card

13. Inexpensive Lighting Control

Photronic Controls have developed the type LU/4 artificial lighting control suitable for both indoor and outdoor monitoring. The price: 5 gns.

This self-contained unit is housed in a waterproof cast-aluminium case 6 by 5 by 4 in. The plug-in photocell monitors the daylight through a glass window in the lid of the unit and when the pre-set level is reached a relay action is obtained to switch the artificial lighting 'on' or 'off'. A robust relay is employed which is capable of switching 1,500 W; for loads in excess of this figure an additional contactor can be fitted.

A sensitivity control is incorporated in the unit so that the operating point can be set by the installer to suit site conditions, and there is a built-in differential which is automatically set to ensure that the equipment does not 'hunt' as clouds pass over the sun.—*Photronic Controls Ltd., Randalls Road, Leatherhead, Surrey.*

For further information circle 13 on Service Card

14. Transistor Moisture Meters

Two instruments, the model AB60 portable transistor moisture meter (illustrated) and the model AB61 transistor moisture meter are announced by Kappa.

Intended for measurements on materials of reasonably small and uniform particle size, and substances that are easily handled, such as powders, seeds, tea, rag tobacco, grain, etc., the model AB60 is fitted with a removable container for testing samples of up to 300 c.c. maximum.

Measurements on materials of a bulky nature, such as coffee beans, raw sugar, nuts, tobacco leaf, copra, etc., and substances that require the testing of a larger sample to ensure that the measurement is truly representative of the bulk, are afforded by the model AB61. This unit can be supplied with one of three standard container sizes, the largest providing a maximum sample volume of 2,700 c.c.

For materials of reasonably constant composition and texture, the accuracy can be expected to be between 0·05 and 0·4% in the 0 to 20% range, 0·2 and 0·5% in the 20 to 30% range, 0·3 and 0·7% in the 30 to 40% range, and between 0·5 and 1·0% in the above 40% moisture range.

Good discrimination to change in the dielectric constant of the sample, and hence moisture content, is achieved with a sharply tuned heterodyne detection circuit. The reading obtained is indicated on a manually-operated dial that provides a single scale calibration of 900 arbitrary divisions. Both instruments may be operated by internally mounted long-life batteries or by 110 to 125 V or 200 to 250 V, 50 to 60 c/s mains supplies.—*Kappa Electronics Ltd., 159 Hammersmith Road, London, W.6.*

For further information circle 14 on Service Card

15. Digital Indicator

Reliance Controls are offering a simple robust digital-dial position indicator, for use with multi-turn components, e.g. helical potentiometers, variable capacitors, etc.

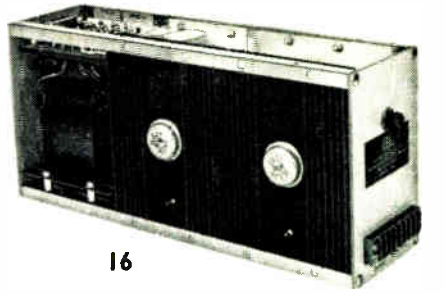
Precise gearing gives good repeatability of readings with no possibility of backlash between knob and component shaft. The collet shaft grip prevents burring by grub screws and thus obviates jamming.

Rotation is continuous with 10 turns

equalling 3,600°. The numerals represent full turns, tenths and hundredths. Dimensions: height, 1·39 in.; width, 1·8 in.; depth, 1·08 in.; overall depth including knob, 1·825 in. The melamine housing and knob are available in black, grey or red.—*Reliance Controls Ltd., Relcon Works, Sutherland Road, Walthamstow, London, E.17.*

For further information circle 15 on Service Card

EQUIPMENT review



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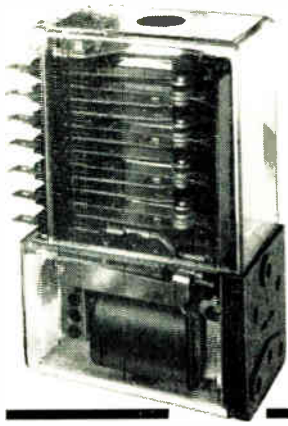

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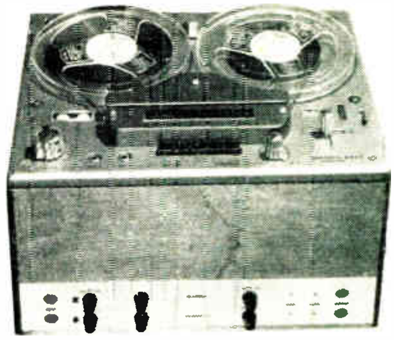

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16. Power Supply Modules

The Electrotech Instruments Division of Coutant Electronics have recently added a new series to their range of modular stabilized power supplies.

Most of the 'E' series offer electronic protection against short-circuit conditions, and have a stability ratio of 5,000 : 1. Output resistance is 2 mΩ, ripple and noise 200 μV peak-to-peak.

By the use of new design techniques in the high gain d.c. control amplifier a very low output impedance has been achieved, typical figures being 100 mΩ at 200 kc/s and 10 mΩ at 25 kc/s. Under constant conditions of mains, load and ambient temperature the random drift is less than 50 parts per million (0·005 per cent of output).

Single or twin isolated outputs are available in the voltage range of 6 to 60 V and currents up to 30 A are standard. The mechanical arrangements allow maximum flexibilty for chassis or front panel mounting. Prices range from £22 for the $\frac{1}{2}$ A unit.—*Electrotech Instruments Division, Coutant Electronics Ltd., 711 Fulham Road, London, S.W.6.*

For further information circle 16 on Service Card

17. Heavy Duty Relays

Magnetic Devices have extended their range of relays by the introduction of a laminated-frame, heavy-duty unit.

The whole contact assembly is mounted on a base plate which is attached to the coil and frame assembly with four screws. Each moving blade consists over most of its length of two blades riveted together in two places. The fact that the two blades are of different lengths and therefore of different fundamental frequencies, tends to damp out resonance of the moving blade. This reduces contact bounce and extends the working life of the blade. Hence any contact assembly can be fitted to any relay without further need of adjustment.

Various contact arrangements are offered, with a maximum of 24 blades. Loads of 20 A at 250 V a.c., 10 A at 500 V a.c. or 5 A at 100 V d.c. may be switched. The coil and frame assembly has an oilite bearing for the armature spindle and a simple spring clip release for easy removal of the coil.—*Magnetic Devices Ltd., Newmarket, Suffolk.*

For further information circle 17 on Service Card

18. Low Cost Tape Instrumentation

The high cost of magnetic tape recording systems of instrumentation standard often precludes their use by many in research, industry and education who could employ instrumentation recording to advantage. The Elliott-Tandberg system is claimed to offer a very high performance at a cost of only £550 complete.

The equipment provides two channels, either or both giving frequency modulation or direct recording as selected by means of a push-button. The f.m. mode permits data in the band from d.c. to 2·4 kc/s to be recorded and reproduced with an overall accuracy of 1%.

Three tape speeds are available: the frequency-modulation system operating at a tape speed of $7\frac{1}{2}$ in./sec and 12-kc/s carrier has a frequency response (±1 dB) of d.c. to 2·4 kc/s: at $3\frac{3}{4}$ in./sec and 6-kc/s carrier the response is d.c. to 1·2 kc/s: at $1\frac{7}{8}$ in./sec and 3-kc/s carrier it is d.c. to 600 c/s. On 'direct record/reproduce' the frequency response at $7\frac{1}{2}$ in./sec tape speed is 40 c/s to 16 kc/s; at $3\frac{3}{4}$ in./sec it is 40 c/s to 10 kc/s; and at $1\frac{7}{8}$ in./sec the frequency response is 55 c/s to 5 kc/s.—*Elliott Brothers (London) Ltd., Chobham Road, Frimley, Nr. Aldershot, Hants.*

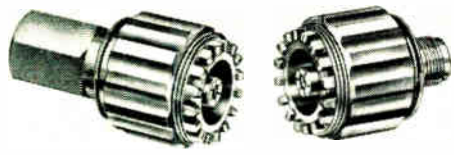
For further information circle 18 on Service Card

19. Coaxial Connector

The major features of a coaxial connector introduced by General Radio are a v.s.w.r. below 1·01 up to 9 Gc/s, good repeatability, and low leakage and insertion loss.

The type 900 uses butting contacts aligned to within 0·001 in. by a centring gear ring and held tightly together by an outer locking nut. Any two connectors, although identical, mate and lock. It is designed for use on rigid, air-dielectric, $\frac{5}{16}$-in., 50-Ω line.

The inner-conductor contact consists of six solid silver-alloy segments, independently sprung. Upon mating, these contacts are forced back and spread, making a wiping contact both with one another and with the inside of the inner conductor. The inner conductor is supported by a press-fit Teflon bead, shaped to compensate for discontinuity capacitances. The outer



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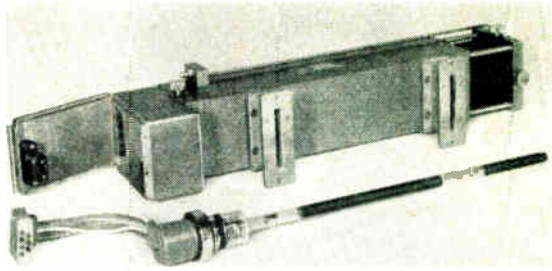

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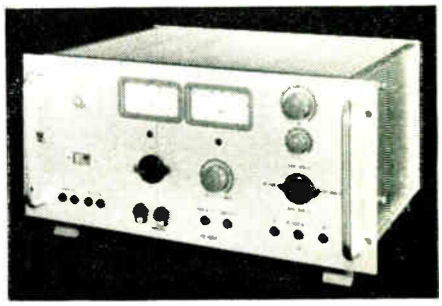

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conductor is of solid coin silver. The butting contact of a pair of outer conductors results in a connection similar to a waveguide joint.—*Claude Lyons Ltd., Valley Works, Hoddesdon, Herts.*

For further information circle 19 on Service Card

20. Travelling Wave Tubes

English Electric has completed development of two travelling-wave tubes for use in 1800 channel microwave link equipment.

These tubes, known as the N1046 (illustrated) and the N1052, cover an overall frequency range of 3·6 to 7·2 Gc/s with a gain of 40 dB at a working output power of 10 W, 20 W saturated. Their noise factor is typically 25 dB. Two associated periodic permanent magnet mounts, N4024 and N4063, have been produced for the N1046 tube, both of which are physically identical except for the size of the waveguide. When this tube is used in mount N4024 (illustrated) the frequency band covered is from 3·6 to 4·2 Gc/s and with mount N4063 the coverage is 4·4 to 5·0 Gc/s.

The N1052 t.w.t., covering the higher frequency range of 5·8 to 7·2 Gc/s, is available with a p.p.m. mount N4062.

Both tubes require relatively low power supplies. This factor, combined with the use of permanent magnet mounts, makes them suitable for use in transistorized equipment. — *The English Electric Valve Co. Ltd., Chelmsford, Essex.*

For further information circle 20 on Service Card

21. All-Diffused Avalanche Rectifier

A 1,200-V all-diffused avalanche rectifier is now available from A.E.I. This 10-A silicon rectifier has rigidly specified maximum and minimum avalanche voltage characteristics, providing protection against voltage surges to itself and associated circuit components.

It is able to operate in the avalanche region indefinitely, without damage, where it will absorb momentary power surges. The rectifier does not require de-rating in the reverse blocking direction, as it is self-protecting against voltage transients. Thus, a 1,200-V p.i.v.-controlled avalanche rectifier is equivalent to a 2,500 to 3,500-V p.i.v. conventional rectifier in many circuits, as safety factors are unnecessary.

The type SLZ 1203A protects other circuit components by its surge clipping characteristics and simplifies series operation of rectifiers in high voltage applications, as no shunting resistors are required.—*Associated Electrical Industries Ltd., Electronic Apparatus Division, New Parks, Leicester.*

For further information circle 21 on Service Card

22. V.H.F. Portable Radio-Telephone

British Communications Corporation have introduced a lightweight portable radio-telephone using transistors throughout and re-chargeable batteries.

Known as the BCC 40/45, it is designed to G.P.O. and international standards and provides speech communication over distances of approximately 1 to 6 miles.

Features of the set include: ease of operation, the provision of 5 or 6 channels within any of the v.h.f. bands with the choice of p.m. or a.m. operation, and a high sensitivity. The sensitivity is 1·6 μV for 20 dB signal-to-noise ratio on p.m. and 10 dB on a.m. The radiated power is 350 mW on a.m. and 400 mW on p.m.

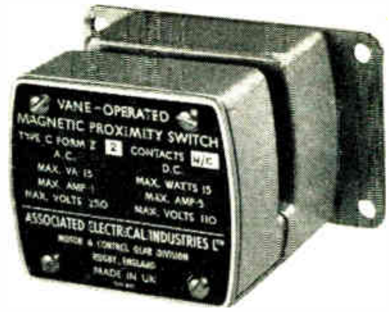
Housed in a robust case, the unit measures 8 × 5 x 2½ in. and weighs only 4½ lb. The battery provides a continuous 12 hours of operation with an average send-receive ratio.—*British Communications Corporation Ltd., Neasden Lane, London, N.W.10.*

For further information circle 22 on Service Card

23. Laboratory Power Supplies

Philips have announced two stabilized d.c. power supply units. Their main range is 0 to 500 V positive, and they have supplementary stabilized low-current outputs of 0 to 85 V negative

EQUIPMENT review



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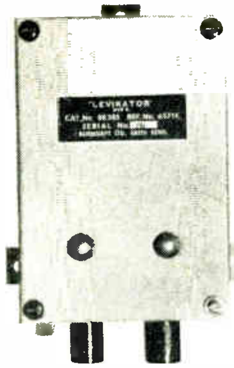

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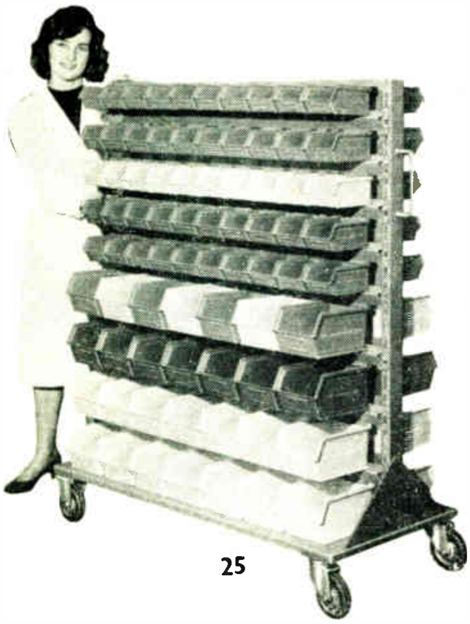

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and 150 V negative, as well as unstabilized 6·3-V a.c. outputs.

The maximum current rating of the 500-V range of one of the units, type PE4830, is 150 mA, and the internal resistance is 0·5 Ω. The maximum 500-V output with the other unit, type PE4831 (illustrated), is 300 mA; internal resistance: 0·25 Ω.

High stability is claimed for both units, their output varying by not more than 1 part in 10,000 for input fluctuations of ±10%. Hum is 1 mV.

The units are fitted with current and voltage meters, and are fully protected against overload. Valves are generously rated to ensure maximum reliability and life. Rack-mounting and cabinet versions are available ex-stock.—*Research and Control Instruments Ltd., Instrument House, 207 King's Cross Road, London, W.C.1.*

For further information circle 23 on Service Card

24. Vane-Operated Proximity Switch

A totally - enclosed, vane - operated magnetic proximity switch, with sealed contacts and no external moving parts, has been introduced by A.E.I. The switch, known as the type C, can be immersed in suds and similar non-corrosive liquids and the contacts are suitable for light electrical ratings, including such applications as static switching, electronics, dry reed and miniature relay control systems.

Operation of the switch depends on shielding the contacts from a magnetic flux produced by a permanent magnet. This shield can be a vane of mild steel, or other magnetic material, fixed to the moving part of the apparatus or machine on which the switch itself is fitted.

The speed of contact response is less than 1 msec from the time the vane reaches the tripping point. Repetitive accuracy of the tripping and reset points is ±0·003 in., given good vane guidance through the slot. Contact life is up to 100 million operations.

Maximum contact ratings are 250 V, 1 A, 15 VA a.c., and 110 V, 0·5 A, 15 W d.c. The contacts are available as either normally open or normally closed and in each case the slot, through which the vane passes, may be either ⅛ in. or ¼ in. wide. The switch can also be supplied with a separately excited biasing coil to give an unusually small operating differential.—*A.E.I. Motor and Control Gear Division, Rugby, Warwicks.*

For further information circle 24 on Service Card

25. Mobile Dispenser

Fix Equipment announce an addition to their range of storage and materials handling equipment. The 'R' type of trolley consists of a mobile platform fitted with horizontal rails for holding plastic containers, and is intended as an answer to the problem of dispensing small parts from store to assembly areas. The trolley and containers allow for up to 200 different parts to be carried at a time. The containers, in four bright colours, give a visual guide to contents or coding of parts. Price: from £24 15s. 0d., containers extra.—*Fix Equipment Ltd., 4 South Lambeth Place, Vauxhall, London, S.W.8.*

For further information circle 25 on Service Card

26. Inexpensive Level Controller

The type BE 305 'Levikator', announced by Burndept, is an electronic floatless level controller. This unit is claimed to offer the cheapest and least complicated automatic level control for any aqueous, acid or alkaline solution and can be used with other liquids, powders and solids provided they are conductive.

The unit consists of a mains-powered control unit, relay and single or dual probes for one or two level control. The circuit employs a thyratron, which is triggered when the substance in the tank touches the probe: a relay is then operated to complete an alarm or supervising circuit.

Designed for continuous duty in industrial applications, the Levikator's chassis is easily removed for servicing and, as the operation of the float is entirely electronic, no mechanical maintenance is required.

The instrument is isolated from the mains by a double-wound transformer with an interposed earthed screen. In the event of mains failure the Levikator fails safe.—*Burndept Electronics, Ltd., High Street, Erith, Kent.*

For further information circle 26 on Service Card

27. Compact Voltage Divider

A new addition to the Wayne Kerr-Gertsch range of ratio transformers is the RatioTran RT 60 which comprises five switched decades for the precise division of a.c. voltages in the frequency band 50 c/s to 10 kc/s. Although of compact dimensions (3½ in. high and adaptable for half-rack mounting), its performance is comparable with that of larger units. It accepts input levels of up to 0·35 × frequency, with an upper limit of 350 V. Resolution is in steps of 0·001%.

This general-purpose instrument is ideal for such applications as checking resolvers and servos, voltmeter calibration, computer testing and transformer turns ratio measurements. Alternatively, it can form part of a specialized test console. In either application, two units can be operated in cascade when additional resolution is required.—*The Wayne Kerr Laboratories Ltd., New Malden, Surrey.*

For further information circle 27 on Service Card

28. Paper Winder for Teleprinter

The introduction of a page winder for the automatic rewinding of teleprinter copy is announced by Creed.

Identified as the 'Model Seventy-five', this accessory overcomes the problem of the untidy accumulation of paper that occurs at teleprinter positions where operations do not call for the removal of individual messages. It will be especially useful, for example, in monitoring applications where a printer is employed to provide a continuous page record of all transmitted and received traffic.

Designed in a style complementary to existing equipment, the winder is a compact, motor-driven unit which automatically adjusts its take-up speed to that of the associated teleprinter and caters for both continuous and intermittent operation. The capacity of the unit is sufficient to take a full standard roll of 100 yd of single-ply message paper and the rewound rolls may be removed quite easily in a few seconds.

The winder is suitable for machine or wall mounting and is intended primarily for use with the Creed model Seventy-five Teleprinter (as shown in the photograph) where the paper supply remains stationary.—*Creed & Company Ltd., Telegraph House, Croydon, Surrey.*

For further information circle 28 on Service Card

29. Miniature Environmental Chambers

Electrothermal Engineering announce the introduction of their range of stabilized thermal chambers.

FC.7902, with a cavity of 5 by 2½ by 1½ in., is intended for use when temperature sensitive components, complete printed-circuit boards, crystal units, etc., require to be stabilized at fixed temperatures up to 85 °C. The chamber operates from 28 V d.c. and is thermometer-controlled by a transistor switching unit.

FC.7921 (illustrated) is a miniature environmental test chamber with a 6-in. cube cavity. It is fitted with two removable shelves, glass doors and cable access for internal connection. A separate controller, in conjunction with a thermistor probe, permits setting up to any temperature in the range 40 to 145 °C within fine limits. The chamber operates from standard a.c. mains supplies and is suitable for bench testing and evaluation purposes when space is limited.

FC.7902 is priced at £28 complete with switch unit and FC.7921 at £57 10s. 0d. with associated temperature controller.—*Electrothermal Engineering Ltd., 270 Neville Road, London, E.7.*

For further information circle 29 on Service Card

30. Crimping Tool

A wide range of removable connector contacts can be fitted by means of the Erma-Buchanan crimping tool. The crimping operation is completely controlled once the appropriate positioner is placed in the tool head. It assures correct alignment between indentors and contact barrel and serves as a positive stop for the indentors, thereby controlling indent depth. A ratchet mechanism is built into the tool, ensuring completion of the crimping operation. No adjustments by the operator are required.

Three contact positioners are supplied with the tool, the two not in use being conveniently stored in the handle. This gives a coverage of all types of contacts with standard crimping barrels and wires up to No. 12 a.w.g. Moreover, each contact will accept a wide variety of wire sizes without need of packing sleeves or specially bored barrels. Additional inexpensive positioners can be provided to suit non-standard contacts for wires down to No. 30 a.w.g.—*Erma Ltd., Mount Pleasant, Alperton, Wembley, Middx.*

For further information circle 30 on Service Card

31. High Resolution Vidicon Tube

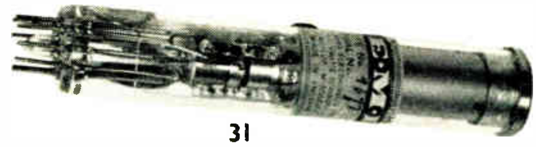
An addition to E.M.I. Electronics' range of one-inch vidicon camera tubes, the type 9677, has a considerably higher resolution than a standard tube when operated at the same final anode voltage and with the same scan and focus coils.

This improved performance may be used to give higher definition pictures (given adequate bandwidth) or to give pictures with a greater signal-to-noise ratio. At 5 Mc/s on a 625-line system the new tube gives over double the depth of modulation of a standard vidicon.

Unlike that of a standard vidicon, the resolution of this tube is not reduced by excess beam current, so the beam control can be preset to the level necessary to discharge any likely overload signal: this operating feature is particularly important in television studios and in cameras employing automatic sensitivity control.

The tube is suitable for operation in

EQUIPMENT review



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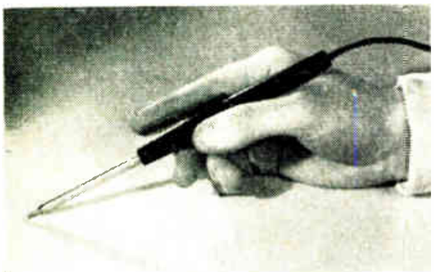

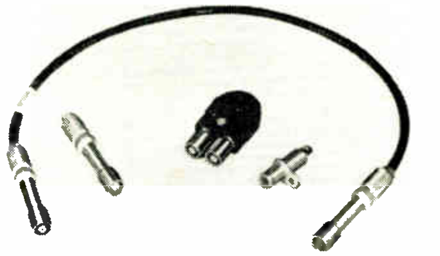

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transistorized cameras as it is fitted with a low wattage heater. A further unusual feature is the absence of picture rotation as the electrical focus is varied. This facilitates the adjustment of three-vidicon colour cameras using this tube.—*E.M.I. Electronics Ltd., Hayes, Middlesex.*

For further information circle 31 on Service Card

32. Miniature Soldering Iron

Only 8 in. long and weighing under 2 oz. the 'Miniscope' soldering iron, marketed by Enthoven Solders, is especially suitable for use whenever fast heat transfer or higher than normal soldering temperatures are required.

This instrument is safe and simple to operate using a pen-holder grip, the index finger being used to depress the switch lever to the 'on' position; this lever is spring-loaded so that the iron is switched off automatically when not in use.

The required power supply is 2·5 to 6 V a.c. or d.c.; a 4-V transformer is an optional extra. The heating time is about 5 sec and the current drain is 20 A.—*Enthoven Solders Ltd., Upper Ordnance Wharf, Rotherhithe Street, London, S.E.16.*

For further information circle 32 on Service Card

33. Video Patch Plugs

Cannon video patch plugs in a wide variety of configurations are available, ranging from dual connectors with coaxial circuits on ⅝-in. centres to patch cable assemblies 4-ft long. Single or dual plugs, single or dual panel jacks, and short or long patch cords are available together with a cable adapter kit.

Designed originally for use with 75 Ω RG-59/U cable, these plugs can be readily adapted for use with 75 Ω RG-11/U cable through the use of the adapter kit.

Cross talk and noise are held to a minimum by the gold plating of metal parts and the individual earthing of circuits. R.f. shielding is provided in both the dual plugs and the dual panel jacks.

Aside from video uses, any equipment which requires rapid changing and/or interconnecting of circuits is an application for these patch plugs.—*Cannon Electric (Great Britain) Ltd., 168-172 Old Street, London, E.C.1.*

For further information circle 33 on Service Card

34. Metallized Ceramic Vane Capacitor

Plessey has introduced a miniature ceramic dielectric variable capacitor. A special feature of the type 83 is that the vanes are metallized directly on to the ceramic; this form of construction is simple, rugged and inexpensive, and has the added advantage of complete freedom from microphony. Being semi-sealed, the unit also resists the ingress of dust and dirt.

This is a single-section unit primarily intended as a replacement for conventional air-spaced or plastic dielectric tuning capacitors in medium and long wave broadcast receivers. Two versions are currently available, 300 pF and 500 pF, both having a diameter of 1·5 in. over the case, which is mounted on a circular 2-in. SRBP panel. Minimum capacitance is less than 20 pF and power factor at 1 Mc/s less than 0·002.

Both the capacitance law (normally linear) and the maximum capacitance can be varied to suit customer applications. If required without stops the case size can be reduced to 1⅛ in. diameter.—*Havant Components Division, The Plessey Company (UK) Ltd., New Lane, Havant, Hants.*

For further information circle 34 on Service Card

35. Lighted Pushbutton Switch

Dubesco announce the release of their Grayhill series 40 lighted pushbutton switch which is available with either a 20 V incandescent lamp or a neon lamp.

This unit, with an independent switch and lamp circuits, has a life expectancy of 500,000 operations at the rated load. The button is pushed to make and the contacts will break 1 A at 115 V a.c. resistive; contact resistance is approximately 3 mΩ and the breakdown voltage between mutually insulated parts is 1 kV a.c.

The switch fits into a hole 25/64 in. in diameter by means of a knurled mounting nut. Button travel is approximately 0·067 in. and the actuating force is 16 oz.

A range of coloured buttons can be supplied and the hot-stamping of letters or numerals on the end of the button is available by special order.—*Dubesco Laboratories Ltd., 5 Violet Hill, London, N.W.8.*

For further information circle 35 on Service Card

36. Radiation Detector

Roberts Electronics, who have been marketing the Ramcor power density meter for the detection and measurement of hazardous r.f. radiation levels, now introduce a similar density meter designed for remote operation. The aerial is mounted in the hazardous field connected by a 25 or 50 ft cable to the 'Densiometer', permitting measurements to be made by the operator in a safe area.

This new instrument is available with five aerials to cover the frequency range from 200 Mc/s to 10 Gc/s, and can measure power density from 0 to 20 mW/cm^2. The unit is very light, portable, battery operated and has an accuracy of $\pm$0·5 dB.—*Roberts Electronics Ltd., 17 Hermitage Road, Hitchin, Herts.*

For further information circle 36 on Service Card

37. Marker Relay

The Electro-Mechanical Division of S.T.C. is now marketing a compact marker relay developed by their associates, Bell Telephone Manufacturing Co., of Antwerp. Size complete with mounting plug is $3\frac{11}{16}$ by $1\frac{1}{8}$ by $1\frac{3}{16}$ in. above the socket (the socket adds $\frac{3}{4}$ in. to length).

The relay provides for sequential switching of 12 circuits with an additional signal contact. Its nylon rotor reduces lubrication requirements and ensures a life of 5 to 10 million complete cycles. Operation speed under self-interruption is 60 steps per sec, the maximum rate using impulse drive being 35 steps per sec. The mounting socket incorporates a supporting and locking security yoke.

This relay has many applications wherever circuits with one common lead have to be switched sequentially, impulses recorded, batches counted, etc. Currents up to 0·5 A 60 V d.c. (non-inductive) can be safely handled by the silver alloy contacts.—*Electro-Mechanical Division, Standard Telephones and Cables Ltd., West Road, Harlow, Essex.*

For further information circle 37 on Service Card

38. Positioning Screwdriver

The 'Tenax' screwdriver, incorporating a positioning device which engages and holds screws firmly in position, is being distributed by Henri Picard & Frere.

In a range of six patterns, the positioners have practical applications in all industries where awkward screw placings are likely to be encountered. The tools are of particular use for removing screws without risk of their falling into some inaccessible part of the equipment or machinery.

The positioners are robust, yet neat in design. A slim, spring-loaded tube fits over the shaft of the screwdriver; when pushed forward, the blade is cleared to allow a screw to be placed in the counter-sunk recess. This, as well as the subsequent release of the screw, is a simple, quick, one-handed operation. The portion of the blade projecting beyond the attachment is sufficient to permit the screwdriver to be used in the normal manner, but the positioner may be detached by unscrewing the tube section.

In addition to models for holding flat and round design slotted head and Philips pattern screws, special positioners working on the same principle for use with nuts and bolts are also available.—*Henri Picard & Frere Ltd., 34/35 Furnival Street, London, E.C.4.*

For further information circle 38 on Service Card

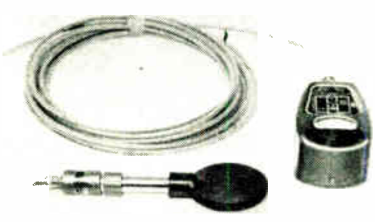
39. Photo-Electric Tape Reader

A low-cost, bi-directional photo-electric perforated tape reader, designed for applications where tape is read at speeds up to 300 characters per second, has been announced by Digitronics.

All solid-state, complete with self-adjusting brakes, the model B2500 utilizes silicon photo-diodes, and offers single speeds at 100 to 300 characters per sec.

Ideal for applications which include machine tool controls, numerical controls and slower speed digital instrumentation, this unit accommodates paper or Mylar tape 0·004 to 0·005 in. thick. It can be adjusted to operate with tapes from 0·0025 to 0·008 in. thick, and tapes with up to 40% transmissivity are acceptable.

The reader is available in either desk or panel mount. The panel mount is



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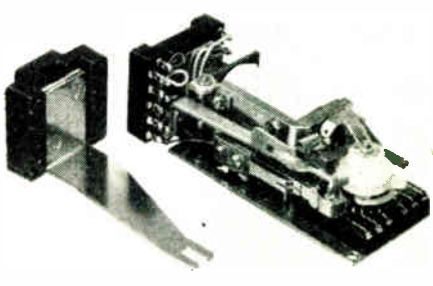

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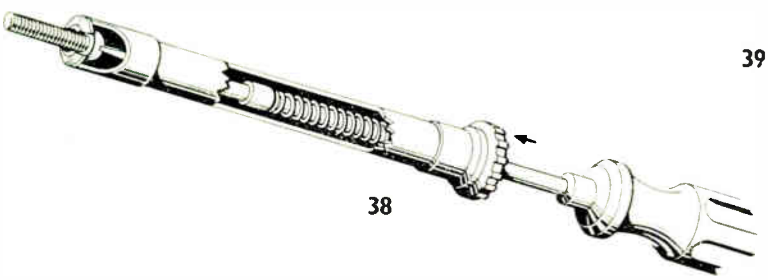

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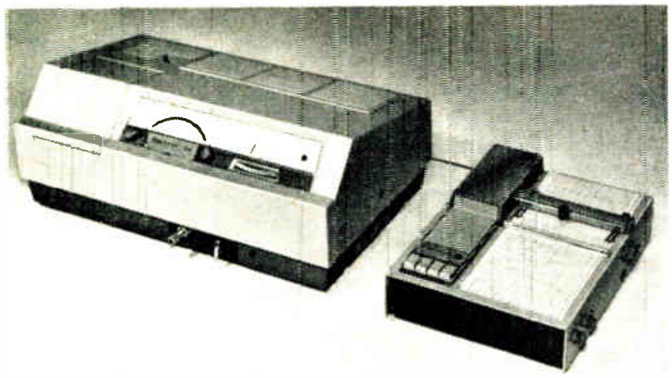

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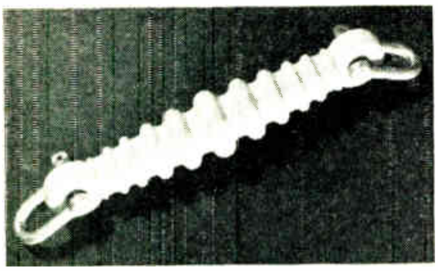

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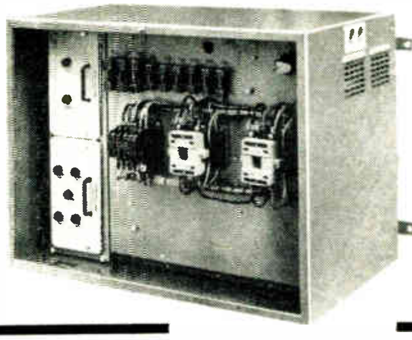

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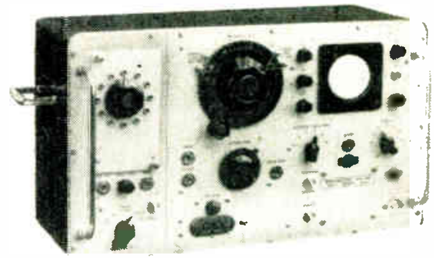

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suitable for a standard 19 in. rack. Dimensions without rack adapter: height, 6 in.; width, 10 in.; depth behind front panel, 11 in.; extension forward of front panel, $2\frac{1}{4}$ in.; panel thickness, $\frac{1}{4}$ in.; rack adapter thickness, $\frac{3}{8}$ in.; height, 7 in.—*Digitronics Corporation, Albertson, N.Y., U.S.A.*

For further information circle 39 on Service Card

40. Spectrophotometer and Recorder

The manufacturers claim that accurate chemical analysis measurements can now be performed in less than half the time with the Beckman DB spectrophotometer and recorder. The use of a double-beam system eliminates most of the adjustments necessary for individual readings with conventional instruments. Fast differential analyses can be made without the time factor involved in manual recording.

The model DB ultraviolet spectrophotometer is a double-beam/single-beam direct - reading instrument, designed for rapid transmittance and absorbance measurements in the 205 to 770 mμ spectral range (using hydrogen and tungsten lamp sources). With its wide wavelength range and ease of operation, the model DB is particularly suitable for qualitative analysis, quantitative analysis and reaction rate study. When used with the recorder, it becomes a low-cost ratio-recording spectrophotometer.

The potentiometric strip - chart recorder is an instrument designed to monitor and record d.c. signals in the 0 to 100 mV range, and has a full-scale range infinitely variable between 10 and 100 mV. With a variety of sensing elements, this 5-in. recorder can plot such variables as frequency, speed, pressure, strain, temperature, flow and pH. The unit stands horizontally on a bench or table adjacent to other instruments, or can be mounted vertically on the wall to conserve space.—*Beckman Instruments Ltd., Glenrothes, Fife, Scotland.*

For further information circle 40 on Service Card

41. Marine Aerial Insulator

A fibreglass aerial insulator introduced to the range of marine equipment marketed by A.E.I. has good hygroscopic properties and a negligible coefficient of expansion.

It will withstand a breaking strain greater than 1,900 lb and, when its surface is wet, has a peak working voltage greater than 25 kV at 500 kc/s.

This insulator conforms to all relevant tracking and arc resistance tests, and is supplied with shackles fitted to the eyelets at each end. Overall dimensions (without shackles) are: length 12 in., diameter $2\frac{1}{4}$ in.—*Marine Communications Department, A.E.I. Telecommunications Division, Woolwich, London, S.E.18.*

For further information circle 41 on Service Card

42. Variable-Speed Motor-Control Unit

Lancashire Dynamo has produced a compact variable-speed motor-control unit, the Transidyne series TWL.II, designed for use with motors ranging from 1 to 3 h.p. The entire control system is housed in a compact wall-mounting cabinet $26\frac{1}{2}$ by $19\frac{7}{8}$ by 18 in. deep (illustrated). The M.G. set is conventionally constructed on a bedplate for separate mounting.

The 'Transidyne' equipment uses a transistorized control system which reduces the electronic circuit to a minimum. A fully closed-loop servo system is employed in which either the motor armature voltage or a tachometer signal is used as a measure of the motor speed. This is compared to the required speed, set by the speed-control potentiometer, and any resulting error is used to adjust the output of the generator and hence the motor speed.

In the case where an armature feedback system is used, a further correction signal is employed, being proportional to the motor load, thus ensuring close control and holding of the desired motor speed irrespective of load variations. In this arrangement the zero to full-load speed holding is within $\pm 1\%$. In the case of the tachometer feedback system, the regulation is $\pm 0{\cdot}3\%$.

A 20 : 1 speed range with constant load characteristics is normally available, but can be increased (with limit on motor output) where required. A full range of control features is provided, including reversal, inching, tacho - feedback, etc. — *Lancashire Dynamo Electronic Products Ltd., Rugeley, Staffs.*

For further information circle 42 on Service Card

43. Wobuloscope

The Metrix Wobuloscope type 232 is intended for setting up r.f. and i.f. stages of television and f.m. receivers up to and including the discriminator. The instrument covers from 5 to 230 Mc/s and from 470 to 860 Mc/s. This makes it suitable for all standards of television and f.m.

A quartz - controlled marker generator is incorporated: the 12-position turret may be fitted with pairs of crystals corresponding to sound and vision frequencies on up to 12 channels, and two separate quartz oscillators working at 1 and 10 Mc/s provide markers every 1 Mc/s up to 50 Mc/s. A built-in oscilloscope fitted with a high gain amplifier displays the response curve of the receiver under test.—*Bemex Instruments Ltd., 54 Victoria Road, Surbiton, Surrey.*

For further information circle 43 on Service Card

44. Small Current Measuring Epuipment

Equipment designed to an N.P.L. specification to measure currents in the range 10^{-10} to 3×10^{-15} A has been announced by Grundy & Partners.

This system works by measuring the time required for the current to charge a standard capacitor to a predetermined voltage. Time and voltage are printed out at the end of each integration and the equipment will recycle up to 10 times.

Housed in two standard 19 in. instrument cases 3 ft high, the equipment comprises an electrometer, a transistorized programming unit, an 8-decade transistor timer fed by a 100-kc/s oscillator (accuracy: 1 part in 10^6), a 5-digit voltmeter (accuracy: $\pm 0{\cdot}02\%$, or 1 bit), and a printer.—*Grundy & Partners Ltd., 3 The Causeway, Teddington, Middlesex.*

For further information circle 44 on Service Card

45. Standard Frequency Divider

A solid - state standard - frequency divider for the delivery of plant frequency standard outputs to calibration benches, production lines and engineering laboratories is now available from Specific Products.

Designated as model SFD, the new unit is capable of providing outputs to as many as 14 remote stations. Due to the modular construction of the system, only the modules needed for each station are required. The system is fail-safe and foolproof and is claimed to have absolute phase lock and station isolation.

The model SFD uses a one-frequency narrow-band cable, d.c. power on a coaxial centre conductor, solid-state circuitry throughout and short-proof current logic. Available in a bench mounting case (model SFD–6) or a rack mount model (model SFD–6R), a typical installation would include the divider, remote station isolation amplifier, decade scalers and wave shapers used in conjunction with a power supply and distribution amplifier.—*Sylvan Ginsbury Ltd., 8 West 40th Street, New York 18, N.Y., U.S.A.*

For further information circle 45 on Service Card

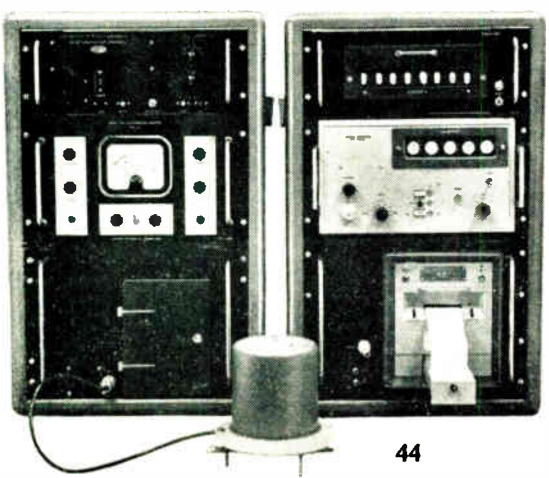
46. 'C' Band Waveguide Duplexer

The Canadian Westinghouse WD2A waveguide duplexer is designed to provide isolation between a 6-kW c.w. transmitter and a parametric amplifier receiver. The unit is tunable from 4·4 to 5·0 Gc/s with a receiver/transmitter spacing of 200 Mc/s.

Tuning is achieved by calibrated micrometers for maximum flat response. Low insertion loss (0·2 to 0·4 dB, dependent on frequency) makes it suitable for operation at high c.w. power. For power in excess of 2 kW, water cooling is required on the transmit filter section: under these conditions units have been tested to 7 kW without failure.

Featuring an advance in c.w. power handling capabilities, these duplexers are now in service with tropospheric scatter equipment. The design gives good rejection (around 20 dB) to transmitter harmonics. The dry weight is 12 lb 14 oz. — *Electronics Division, Canadian Westinghouse Co. Ltd., 286 Sanford Avenue North, Hamilton, Ontario, Canada.*

For further information circle 46 on Service Card



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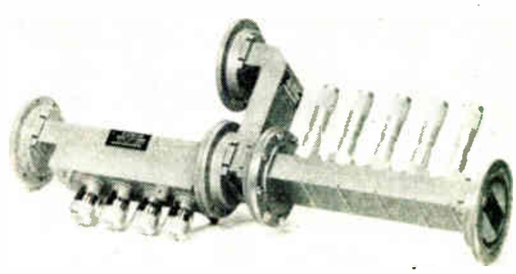

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The author adjusts receiver controls as the E.M.I. type 8 closed-circuit television camera, without using a lens, transmits a picture of a transparency mounted in direct contact with the fibre optic window of the type 9686 tube

Vidicon Camera Tube with a Fibre Optic Window

By A. C. DAWE, B.Sc.(Eng.), A.C.G.I., A.M.I.E.E.*

This article describes the operation of a fibre optic window. The vidicon camera tube is then explained and finally the advantages of a vidicon incorporating a fibre optic window are discussed.

An optical fibre is a fine strand of optical quality glass of high refractive index coated with a glass of lower refractive index. Light rays which enter the fibre at an angle to the axis of less than about 60° are repeatedly reflected from the walls as they travel down the fibre until they are finally emitted from the far end of the fibre at the same angle to the axis as at the input. The transmission efficiency is high and in flexible systems where special combinations of glasses are used this figure could be as high as 80% for a 3-ft length.

Complete optical images can be transmitted, element by element, by a tight bundle of fibres, provided the ends of the fibres are in the same relative position at both ends of the bundle. A bundle in which there is a specific relationship between the fibre ends at both ends of the bundle is called a coherent bundle. It is possible to taper bundles of fibres and a coherent tapered bundle can be used as an image magnifier.

In a fibre optic window, a very large number of short length fibres are fused together parallel to one another and normal to the polished window surfaces.

Fig. 1 shows a section of the fibre optic window used in the new E.M.I. vidicon tube type 9686. It will be seen that the coating glass is very thin and that the fibres are nearly touching each other, so giving a light transmission area of little less than a normal glass window. Each fibre is nearly 6 microns in diameter and about 2 mm in length, so that the transmission efficiency of each fibre is nearly 100%. The window diameter is about 1 in. Fig. 2 shows a microphotograph of a portion of the window surface of the 9686 vidicon.

Fig. 1 also shows the path of a light ray in one of the fibres. It can be seen that the angle of the emergent ray to the fibre axis must be the same as the angle of incidence i. The maximum angle of incidence is computed in the Appendix for a fibre of refractive index 1·72 with a coating of refractive index 1·48. The angle is 61° and so the total acceptance angle of the window is in excess of 120°.

Vidicon Tube

A vidicon is a small, relatively inexpensive television camera tube, which is employed in nearly all industrial television cameras and widely used in television broadcasting. The majority of vidicon tubes are about 6 in. long and 1 in. in diameter, although tubes are available with diameters as small as ½ in, and up to 2 in. Fig. 3 shows a typical 1-in. vidicon tube.

* E.M.I. Electronics Ltd.

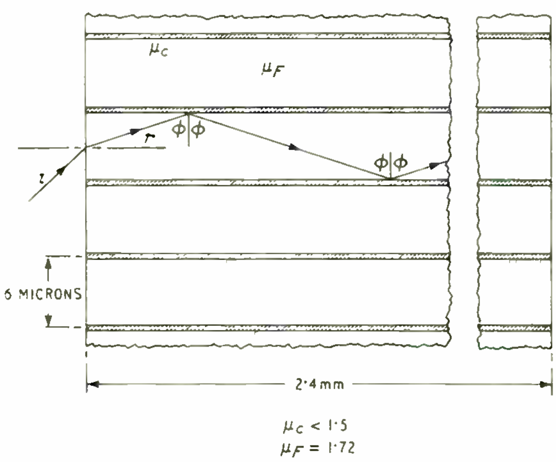


Fig. 1. Section of fibre optic window for E.M.I. vidicon type 9686

On the inside of the window is a transparent conductive coating, called the signal plate, which is connected to the signal electrode ring at the junction of the window and the tubular envelope. Deposited on the signal plate is a layer of photoconductive material constituting the sensitive target. This material has a high resistance in the dark but the resistance falls with increasing illumination.

An electron gun, mounted at the other end of the tube from the window, gives a beam of low velocity electrons. This beam is focused and scanned across the target by external magnetic coils in conjunction with a suitable wall anode electrode and ion-trap mesh. A positive voltage is applied to the signal plate via a signal resistor and, in the dark, the effect of the low velocity scanning beam is to stabilize the surface of the target at gun-cathode potential so that a potential difference is set up across the target. Where light falls on the target a more conductive path is established, current flows across the target and the potential of the illuminated elements rises towards the signal plate potential. When the scanning beam reaches the illuminated elements, it restores them in turn to gun-cathode potential and, because of the capacitive coupling between each element and the signal plate, generates a chain of current pulses in the signal resistor which constitutes the video signal.

The normal target area of a 1-in. vidicon is $\frac{1}{2}$ in. × $\frac{3}{8}$ in., but nevertheless there is little difficulty in resolving 1,200 black and white lines per picture width (i.e., 900 television line resolution).

Fibre Optic Vidicon

The E.M.I. fibre optic window vidicon type 9686 is shown in Fig. 4. It has the dimensions of a standard 1-in. tube and has a fibre optic window in place of the normal glass window. The tube also differs from earlier standard tubes in that the gun has a low wattage heater (6·3 V, 95 mA) to reduce the total power consumption.

The scanned target area is $\frac{1}{2}$ in. × $\frac{3}{8}$ in. and there are, therefore, about 2,100 fibres per picture width. When tested with a test chart and lens focused to give an image on the front face of the window, the limiting resolution is about 1,000 lines per picture width (i.e., 750 television line resolution), which is quite adequate for most purposes.

The great advantage of the type 9686 tube is that it can be very easily and efficiently coupled to any light image emitting tube which is also fitted with a fibre optic window, e.g., image intensifier, X-ray image intensifier or a cathode-ray tube, by simply bringing the two windows into intimate contact and adjusting their positions to get the best resolution. The need for focusing is removed, but the image magnification is unity unless a coherent tapered bundle of fibres is used between the two tubes. The great advantage, however, is that the efficiency of light transfer from one tube to the other is over 80%. This can best be illustrated by considering an f/1·9 lens coupling two tubes with an image magnification of unity.

$$\text{Image brightness} = \frac{BT}{4f^2\ (M+1)^2}\ \text{foot-candles}$$

where B is the brightness of the object in foot-lamberts

T is total transmission of lens, say 80%,

f is lens aperture (1·9)

M is linear magnification (1)

therefore image brightness $= B/72$

Even when using an $f/1$ lens, the object brightness would be reduced by 20 times, whereas there is only about one-third of this reduction with the fibre optic window and no lens.

Another very interesting type of application for the

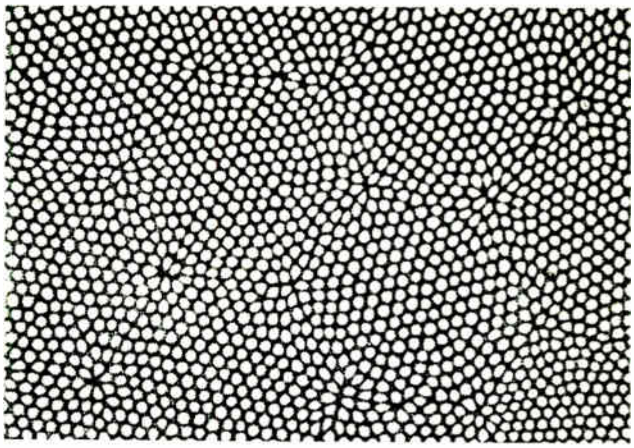


Fig. 2. Microphotograph of the fibre optic window surface

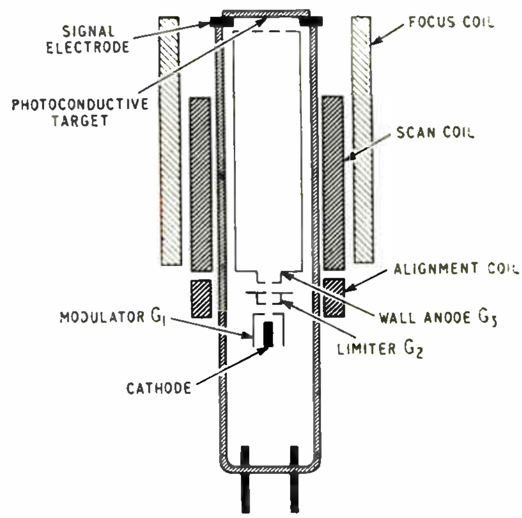
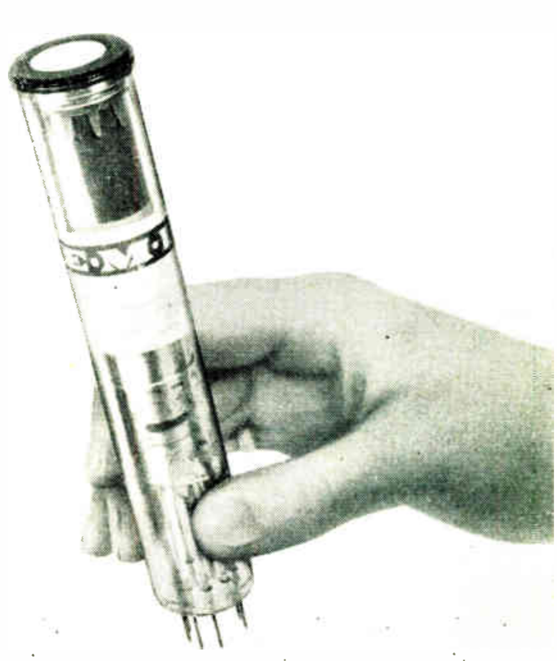


Fig. 3. Diagrammatic arrangement of 1-in. vidicon with scan and focus coils

Fig. 4. Photograph of E.M.I. vidicon type 9686 with fibre optic window



fibre optic vidicon is the production of hard ultra-violet images by means of a suitable phosphor deposited on the outer surface of the fibre optic window, and this has been proposed for satellite astronomy.

An obvious application is coupling the tube to a long flexible coherent bundle of fibres for use as an endoscope.

Finally, the fibre optic window does not prevent the tube from being used with a lens in the normal way, provided the image is focused on the outer surface of the window. An acceptance angle of over 110° is adequate for almost any practical lens system.

The fibre optic window used in this tube has been developed and manufactured by the George Elliott Laboratories, Sunbury-on-Thames, Middlesex, in co-operation with A.W.R.E., Aldermaston.

The author wishes to express his thanks to the George Elliott Laboratories for their valuable assistance and to A.W.R.E., Aldermaston, for the photograph shown in Fig. 2. Thanks are also expressed to the directors of E.M.I. Electronics Ltd. for permission to publish this article.

Appendix

Referring to Fig. 1, if i and r are the angles of incidence and refraction and μ_F and μ_C are the refractive indices of the fibre and its coating,

$$\sin i = \mu_F \sin r = \mu_F \sin (90 - \phi)$$

and for total internal reflection to occur it is necessary to have

$$\phi > \sin^{-1} \mu_C/\mu_F$$

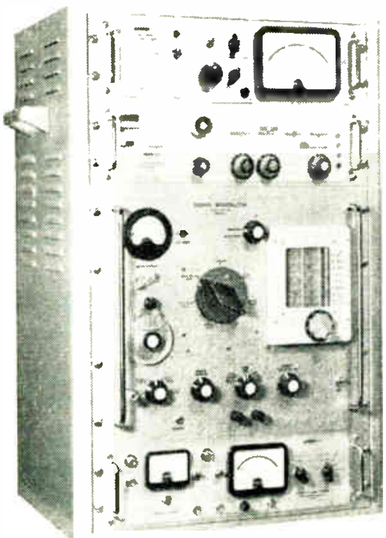
Therefore,

$$\sin i_{max} = \mu_F \sin (90 - \sin^{-1} \mu_C/\mu_F)$$
$$= \sqrt{(\mu_F^2 - \mu_C^2)}$$

With $\mu_F = 1{\cdot}72$ and $\mu_C = 1{\cdot}48$, $\sin i_{max} = 0{\cdot}875$ and $i_{max} = 61°$

MASS SPECTROMETER FOR QUANTITATIVE GAS ANALYSIS IN HIGH VACUUM SYSTEMS

IN many research projects and manufacturing processes carried out in a vacuum it is often necessary to analyse the residual gases in the system in additon to measuring the total pressure. The 'Speedivac' Omegatron mass spectrometer provides a comparatively inexpensive method of identifying the component gases without deterioration of performance due to distortion of the head electrodes after hot degassing. In the Omegatron this problem has been solved by the use of high quality ceramics in an accurately aligned 'stack' structure. The use of a low temperature lanthanum boride coated rhenium filament and platinum-iridium electrodes also contribute to long term stability.



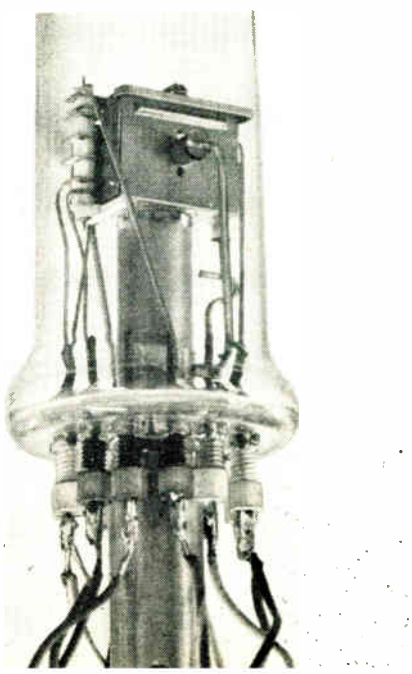
The Omegatron control unit

The mass range of the instrument is 1 to 200 a.m.u. and the sensitivity is about 15/torr for nitrogen. The resolution gives complete separation up to mass 44 and very good separation up to at least mass 60. The pressure range is 10^{-5} to 10^{-11} torr. Baking can be carried out to 450 °C and complete degassing by eddy-current heating to 900 °C. The volume of the glass head is only about 80 c.c., which is of considerable importance when it is used on an ultra-high vacuum system. The envelope can be sealed directly to a Kovar outlet tube for connection to metal vacuum systems. The magnet, of about 5,000 gauss, is mounted on a special table possessing three degrees of freedom so that it can be positioned precisely with respect to the axis of the head.

To operate the Omegatron and to ensure that the best possible performance can be obtained from it, a convenient and comprehensive system of control and indicating equipment has been developed. The control system comprises: a power unit which accurately establishes and maintains the correct head operating parameters, particularly the ionizing current which is controlled to within ±1% over the range 0·5 to 50 μA; a signal generator for the application of the necessary scan frequencies to the r.f. electrodes; a variable time constant d.c. amplifier, with a maximum sensitivity of 10^{-13} A f.s.d., to indicate ion collector current, and a 'Speedivac' model 1 Ionization-Pirani gauge for general measurement of pressure in the range 1 to 10^{-7} torr. A pen recorder, with a second pen for frequency marking, can be supplied although a suitable existing recorder can be used.

For further information circle 49 on Service Card

The 80 c.c. glass head



A basic dynamic storage circuit is described which employs capacitors as the storage elements and p-n-p-n diodes for coupling. From this basic element a versatile and flexible counter and pattern register are developed.

A DYNAMIC DIODE-CAPACITOR STORE

By *J. B. WARMAN, M.I.E.E.** and *H. J. STIRLING**

THE basic dynamic diode-capacitor store stems from a reversal of the normally accepted design philosophy for counters and shift registers. Conventionally, these employ a switching diode or triode as the storage device, the conducting or non-conducting state indicating the yes-no condition. Capacitors are used to couple between stages. However, the dynamic diode-capacitor store under consideration uses capacitors to store the information, the yes-no condition being indicated by their relative charges. The stages are interconnected by p-n-p-n diodes.

Use is made of the two stable states of the p-n-p-n diode characteristic. First, the off or high-impedance state provides the necessary isolation between adjacent stages and secondly the on or low-impedance state provides coupling between adjacent stages when it is desired to transfer information from one storage capacitor to the next.

Reference to Fig. 1 will afford a clearer understanding of the properties of the p-n-p-n diode. In the off state, at voltages appreciably less than the breakdown value, the device has a very high impedance. This corresponds to region I. As the voltage approaches the breakdown value, V_s, the slope vanishes (region II) and the slope of the curve becomes negative (region III). This high negative resistance persists until the diode saturates and a small positive resistance results (region IV). The device is now 'on' and the voltage drop, V_m, is very low.

When biased in the reverse direction the device exhibits a high impedance (region V) until the voltage reaches a critical value, V_{ZB}, whereupon the curve assumes a negative slope (region VI). The curve then assumes an almost zero slope (region VII) with the voltage across the device, V_M, fairly high.

The p-n-p-n devices available will switch on in less than 50 mμs. However, the switching voltage is, to some extent, dependent upon the rise-time of the applied pulse. It has been found that for batches of diodes having a nominal strike voltage of 100 V, the voltage at which the individual diodes strike may be as low as 80 V when the applied switching pulse has a rise-time of 100 V per microsecond. To obviate this, a rise-time of 10 V per microsecond has to be employed. With this order of rise-time all devices strike within 5% of their nominal rated voltage. This facet obviously limits the upper speed of recurrent operation of a p-n-p-n diode.

Basic Storage Element

The basic storage element shown in Fig. 2 comprises essentially a p-n-p-n diode, SD_1, and two capacitors, C_1 and

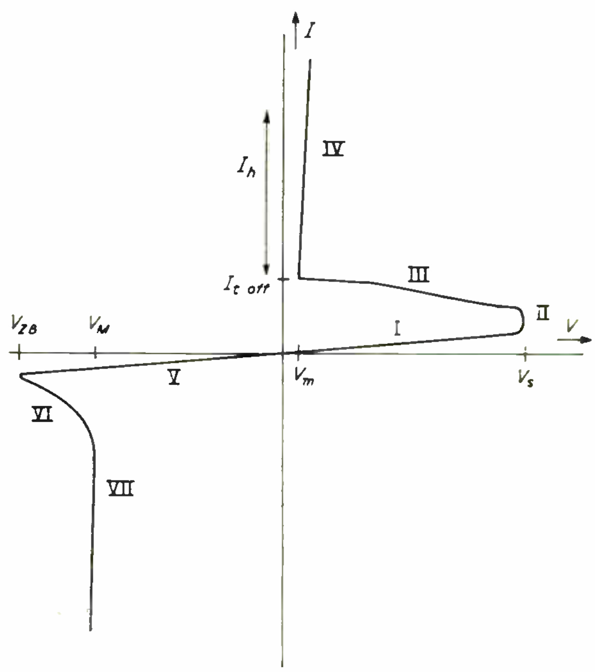


Fig. 1. Characteristic curve of a p-n-p-n diode

C_2. Assuming that both capacitors are initially uncharged and that $C_1 = C_2$, the following sequence of operations takes place.

(i) Switch S_1 is closed, so applying the storage voltage, V_{st}, to capacitor C_1, which charges until the voltage across it is V_{st}. This raises the anode voltage of SD_1 to $+ V_{st}$ volts (which must be less than its strike voltage, V_s).

(ii) Switch S_1 is opened and S_2 closed to apply the transfer pulse, V_t, to the junction of capacitor C_1 and resistor R_1. This causes the voltage at the anode of the diode to rise to $V_t + V_{st}$.

(iii) Provided $V_t + V_{st} > V_s$, the diode switches to its low-impedance state. The resulting current flow through the diode causes capacitor C_1 to lose its charge and C_2 to gain an equal

* Advanced Development Laboratories of Associated Electrical Industries (Woolwich) Ltd.

amount of charge. Because $C_1 = C_2$, the fall in voltage across C_1 equals the rise in voltage across C_2. Thus, if the voltage across C_1 falls from V_{st} to V_{C_1} while that across C_2 rises from zero to V_{C_2}:

$$V_{C_2} = V_{st} - V_{C_1}$$

This assumes that the voltage across the diode remains constant at V_m while the holding current, I_h, decays exponentially until $I_h = I_{t\ off}$. At this point the diode switches off. In practice V_m is not constant but the slope resistance of the on characteristic is small and may be ignored.

Now the anode voltage $= V_t + V_{C_1}$

and the cathode voltage $= V_{C_2}$

therefore $V_m = V_t + V_{C_1} - V_{C_2}$

Thus:

$$V_{C_2} = \tfrac{1}{2}(V_{st} + V_t - V_m) \qquad (1)$$

$$V_{C_1} = \tfrac{1}{2}(V_{st} - V_t + V_m) \qquad (2)$$

(iv) When the transfer pulse ceases the anode voltage of the diode falls to V_{C_1} and the cathode voltage remains at V_{C_2}.

If the amplitude of the transfer pulse is chosen to be:

$$V_t = V_{st} + V_m \qquad (3)$$

then equations (1) and (2) reduce to:

$$V_{C_2} = V_{st}$$

$$V_{C_1} = 0$$

Thus, by using a pulse of controlled amplitude it is possible to transfer the voltage (V_{st}) stored on capacitor C_1 to the capacitor C_2. It is assumed that the duration of the transfer pulse, V_t, is greater than the information transfer time.

The foregoing explanation is valid for any form of switching diode whether of the cold-cathode or semiconductor type. However, the maintain voltage, V_m, for a p-n-p-n diode is usually less than 1 V and is negligible compared with the strike voltage, V_s, which for convenience may be nominally 100 V. Then, in equation (3) V_m can be disregarded and $V_t \approx V_{st}$.

It would appear that V_t can be $\frac{1}{2}V_s$. However, in practice, a voltage approximately 10% higher than this is required to cater for the tolerance on V_s. Thus, for a diode having a strike voltage of 100 V, V_T should be approximately 55 V.

Practical Counter

Any desired number of basic storage elements may be connected in tandem, as shown in Fig. 3. The transfer pulses P_1, P_2, etc., are applied sequentially. A storage charge, V_{st}, is applied to capacitor C_1 by closing the switch S_1. When pulse P_1 is applied to capacitor C_1 via resistor R_1 the charge

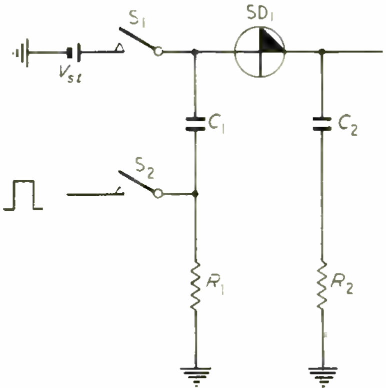


Fig. 2. Basic storage element

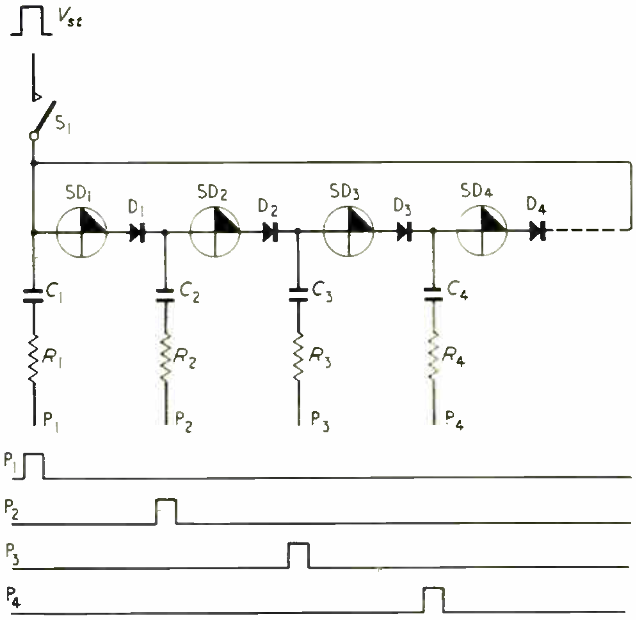


Fig. 3. Practical counter circuit

is transferred to capacitor C_2 as previously described. Similarly when pulse P_2 is applied to capacitor C_2 the charge is passed to C_3 and so on. If the last stage is connected back to the first, a ring counter is produced. Any charge that is introduced into the circuit via S_1 will then circulate for as long as the transfer-pulse trains are applied. The circuit thus provides a dynamic store with periodic access like a delay-line circulating system or a track of a magnetic drum store.

It will be noticed that the counter circuit of Fig. 3 deviates from the circuit of Fig. 2 in as much as the transfer pulses are applied in series with the resistors R_1, R_2, etc., instead of in parallel. These resistors limit the peak current excursions when the p-n-p-n diodes initially switch on. If these resistors were not included, the diodes might be damaged by surges in excess of the maximum rated forward current for the device.

The circuit of Fig. 3 employs as many transfer-pulse generators as there are stages. However, the number of pulse generators can be reduced to two. Resistors R_1, R_3, R_5, etc., are connected together and fed by one pulse generator and R_2, R_4, etc., are connected to the second generator.

The diodes D_1, D_2, etc., are included because the reverse Zener breakdown of the p-n-p-n diodes is often less than their forward breakdown voltage, as shown in Fig. 1. If, for example, the additional diode D_1 was omitted and the value of V_{ZB} for SD_1 is less than the value of V_s for SD_2, the transfer pulse voltage may be clamped by the Zener effect of SD_1 and fail to strike SD_2. The diodes D_1, D_2, etc., are chosen to have a higher reverse breakdown voltage than V_s, thus obviating the danger.

Compensating Actions in the Chain

The ring counter described above may appear to be impracticable due to the assumption that all stages have identical components, thus producing perfect transfer. This would be true but for certain compensating actions which operate.

The description of storage and transfer actions given above, assumed that the maintain voltage, V_m, is identical for all devices used in the chain, and that V_t is the same for each stage. In practice, however, these quantities may vary from stage to stage. Consequently, equation (3) is not satisfied; the previous capacitor is left charged either positively or nega-

(continued on page 581)

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tively and the succeeding capacitor is left charged to a voltage different from that originally on the preceding stage.
Now,

V_m and/or V_{st} high, or V_t low, gives positive potential left on previous capacitor.

V_m and/or V_{st} low, or V_t high, gives negative potential left on previous capacitor.

Also from equation (1):

V_m and/or V_{st} high, or V_t low, gives low potential left on subsequent capacitor.

V_m and/or V_{st} low, or V_t high, gives high potential left on subsequent capacitor.

If, for example, one diode has V_m high, then the voltage left on the subsequent capacitor will be low, but a positive voltage is left on the previous capacitor which supplements the voltage produced next time the stage is operated. Thus a measure of compensation is obtained as a charge is caused to rotate repeatedly round the ring.

Similarly, since the turn-off current of the diode is not zero, the previous capacitor in the chain will be left with a greater or lesser positive charge depending upon the value and variation of $I_{t\ off}$.

If the storage capacitors leak, then the stored voltage gradually falls. This leakage continues all the time the charge is circulating, since it must at any time be on one of the capacitors.

When the voltage stored on a capacitor falls below $V_t - V_m$, a negative potential is left behind when transfer takes place. This is subject to the compensating actions described above. For example, assume that leakage causes the p.d. across capacitor C_2 (Fig. 3) to fall to $V_{st} - dV$. Then, from equations (1) and (2):

Transfer to C_3 gives

$$\frac{V_{st} - dV}{2} + \frac{V_t - V_m}{2}$$

And left on C_2 is:

$$\frac{V_{st} - dV}{2} - \frac{V_t - V_m}{2}$$

Now $V_t - V_m = V_{st}$ [equation (3)]

$\therefore$ Transfer to C_3 gives $V_{st} - \dfrac{dV}{2}$ on capacitor C_3

Transfer to C_3 gives $-\dfrac{dV}{2}$ on capacitor C_2

It will be seen that although the stored potential has decayed by $dV/2$ the potential on the other unmarked capacitor has also decreased by $dV/2$ relative to the adjacent unmarked capacitors. This is, of course, an important condition for the continued cyclic rotation of the charge.

This indicates that as the capacitors continue to leak so the potential of the whole counter chain, on the side of the capacitors remote from the pulse sources, falls. There must be a limit to this negative excursion and it will be apparent that stability is achieved when the leakage of all the negative charges on the unmarked capacitors equals the leakage of the positive charges from the marked capacitors. If N = number of storage elements in a counter chain which is circulating one marking, then:

Approximately positive voltage on marked capacitor

$$= \frac{(N-1)}{N} V_{st}$$

Approximately negative voltage on unmarked capacitors

$$= V_{st}/N$$

The foregoing compensating actions of the counter chain may give rise to a negative potential being acquired by the storage capacitors. This can be obviated, as shown in Fig. 4, by the use of additional diodes D_{11}, D_{12}, etc., to clamp the negative excursions to earth. With these diodes incorporated, the voltages about the circulating loop are more suitable for feeding to other circuitry which may be tied to constant potentials. Alternatively only diode D_{11} need be provided to clamp C_1. This has the effect of restoring the voltage level

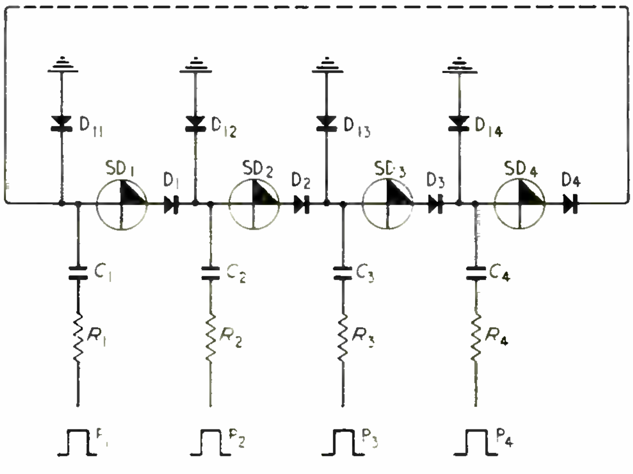

Fig. 4. Clamping negative excursions along the counter chain

to earth once every cycle. The voltage drift on other stages of the chain cannot now be greater than that attributable to one revolution of the counter.

Modes of Operating the Counter

The counter already discussed employs transfer pulses having a positive excursion with respect to earth and stores positive charges which are shifted from left to right along the chain. However, several variations in polarity of both transfer pulse and the stored charge are possible.

Consider the circuit of Fig. 3 and assume that the transfer pulses P_1, P_2, etc., have a negative excursion with respect to earth, all other circuit conditions being unaltered. If capacitor C_1 is charged positively, when pulse P_1 is applied, the anode voltage of p-n-p-n diode SD_1 is reduced substantially to earth (since $V_t = V_{st}$). SD_1 does not switch on and when P_1 ceases the anode voltage rises to V_{st} again. When P_2 is applied, however, the cathode voltage of SD_1 falls towards $-V_t$. This, together with the anode voltage of $+V_{st}$, is in excess of the strike voltage of the diode, which switches on. The resulting current discharges capacitor C_1 and charges C_2 so that, when pulse P_2 ceases, C_2 is left with the positive charge originally stored by C_1. Thus, by using negative transfer pulses, positive charges are shifted from left to right along the chain as in the case previously discussed.

Next consider the counter still employing negative transfer pulses but applied in the reverse order to the previous examples. This is shown in Fig. 5 where the pulse applied to C_4, for example, occurs before that applied to C_3. Assume a negative charge is present on capacitor C_4, all other capacitors being uncharged. The voltage on capacitor C_4, and hence the cathode voltage of SD_3, is at $-V_{st}$ volts. When transfer pulse P_4 is applied to C_4, the cathode voltage of SD_3 is driven more negative towards: $-V_{st} + (-V_t)$. This exceeds the strike voltage of SD_3 and the device switches on. Capacitor

C_3 now charges negatively while C_4 discharges positively. Thus when P_1 ceases, capacitor C_4 is left uncharged while C_3 is charged negatively to $-V_{st}$ volts. Thus, by employing negative transfer pulses, a negative charge stored on a capacitor is shifted from right to left along the chain. This is the reverse of the information transfer direction of the two previous cases.

One final example is obtained by inverting the pulses of Fig. 5 but retaining the same pulse sequence. If a negative charge is stored on capacitor C_4, transfer pulse P_1 will be ineffective because it will merely raise the cathode voltage of SD_3 to earth. However, the application of P_2 raises the anode voltage of SD_3 towards $+V_t$ volts which, together with the cathode voltage $-V_{st}$, strikes diode SD_3, so transferring the negative charge from C_4 to C_3. Thus, the direction of information transfer is again right to left.

It can now be seen that by employing the same basic counter circuit the transfer pulses may be of positive or negative polarity and the stored information can also be positive or negative. However, if the cycling charge is positive, the direction of rotation will be from left to right, whereas if a negative charge is cycling, this will pass from right to left along the chain.

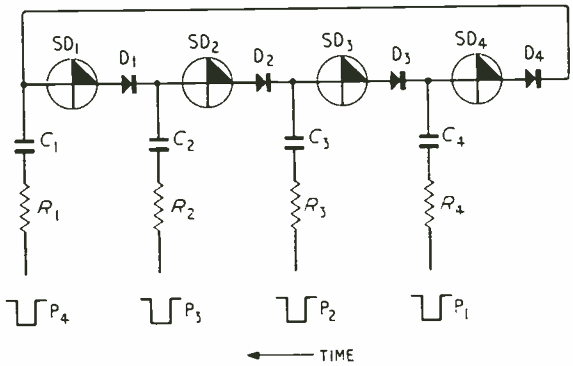

Fig. 5. Counter using negative transfer pulses

Cyclic Pattern Register

It has already been shown that a counter chain storing positive charges transfers the stored information from left to right. If now the direction of rotation of the transfer pulses is made opposite to this (i.e., from right to left), the counter becomes a cyclic pattern register. This is shown in Fig. 6(a).

Ignoring the 'read/write/erase' circuit of Fig. 6(b), consider diode D_1 to be connected back to SD_1 as shown dotted. Assume a positive charge is written into capacitor C_1 just before transfer pulse P_1 occurs. The charge will remain on C_1 while pulses P_1, P_2, P_3 are applied. When P_4 is applied, however, the charge is transferred to C_2 where it remains until the next P_3 pulse occurs. On application of P_3 the charge is transferred to C_3 and so on. Thus any pattern of markings present in the register will be shifted one position down the chain by one complete cycle of pulses. It follows from this that any pattern of markings will be shifted once around the loop by $N-1$ pulse cycles, where N is the number of stages in the register.

It is a simple matter to evolve various forms of pattern register to utilize positive or negative transfer pulses together with positive or negative storage charges.

An additional circuit element may be connected in series with the return loop to provide write, erase and output facilities. This is shown in Fig. 6(b). The same read, write and erase stage may also be employed in the counter circuits previously discussed by inverting polarities, if necessary.

In order to regenerate pulses around the loop, switch S_1 must be closed to provide a positive bias of $+V_T$ volts on the anode of SD_5. If there is a positive charge on capacitor C_4, the following sequence of operations takes place:

(i) Pulse P_1 reverse biases diode D_6 and strikes SD_4.
(ii) The charge on C_4 is now fed via SD_4 and C_5 to raise the anode voltage of SD_5 from $+V_T$ volts to $+2V_T$ volts.
(iii) Diode SD_5 strikes, so charging capacitor C_1 to $+V_T$ volts (since $V_T = V_{st}$). An output pulse of the same amplitude is also derived at the junction of resistor R_8 and capacitor C_7 which is provided to lengthen the pulse.
(iv) At the end of pulse P_1 capacitor C_5 is discharged via diode D_6 and resistor R_6 to earth.

If it is desired to erase a particular marking, switch S_1 is opened at the appropriate instant, so removing the positive bias on the anode of SD_5. The positive voltage from C_4 is then insufficient to trigger SD_5, so the marking is not regenerated into capacitor C_1. To insert a marking, switch S_1 is left closed and S_2 closed prior to pulse P_1. Pulse P_1 is then applied via capacitor C_6 to strike SD_5 and insert a marking into C_1. An output pulse can also be obtained from this stage. The output pulse is capable of driving 1 to 2 mA into the base of a transistor.

The foregoing explanation has assumed, for simplicity, that the control of the write/erase circuit is affected by means of mechanical switches. In practice, it is usual to use electronic gating circuits.

Positive and Negative Charges in a Dynamic Counter

It has been shown that the same counter can be used to store positive or negative charges. It is interesting to consider the conditions pertaining when there are a positive and a negative charge present in the same counter at the same time.

Consider the circuit of Fig. 6(a) and assume that capacitor C_4 is storing a negative charge and C_2 storing a positive charge. Now the positive charge is attempting to transfer from left to right whereas the negative charge is attempting to move from right to left. The following sequence takes place:

(i) Pulses P_4 and P_1 are ineffective.
(ii) Pulse P_2 raises the anode voltage of SD_3 to $+V_t$ volts.
(iii) Diode SD_3 experiences a voltage greater than V_s (since the cathode is already at $-V_{st}$) and strikes.
(iv) The voltage on C_4 rises and that on C_3 falls, so transferring the negative charge from C_4 to C_3.
(v) The anode of SD_2 is already at $+V_{st}$ volts. Therefore, as the voltage on the cathode falls to $-V_{st}$, SD_2 strikes before pulse P_3 is applied to C_2. Thus, the negative charge is not stored on C_3 but passes immediately to C_2.
(vi) If now the capacitor C_1 is storing a positive charge a similar action again takes place, with the negative charge 'jumping' without being transferred by the transfer pulses.

Thus a positive and a negative charge stored in the same counter cannot pass one another without causing a misoperation of the circuit.

It is interesting to note that if cold-cathode gas diodes were employed as the coupling elements instead of p-n-p-n diodes, the positive and negative charges could pass one another in opposite directions. This arises because V_m, in a gas diode, is considerable (say 60–80 volts). Then in equation (3)

$$V_t \neq V_{st} \text{ and}$$
$$2V_{st} < V_s$$

Therefore the stored charges stabilize to a lower value and may be caused to transfer past each other. Similar conditions could be reproduced with semiconductors by introducing a

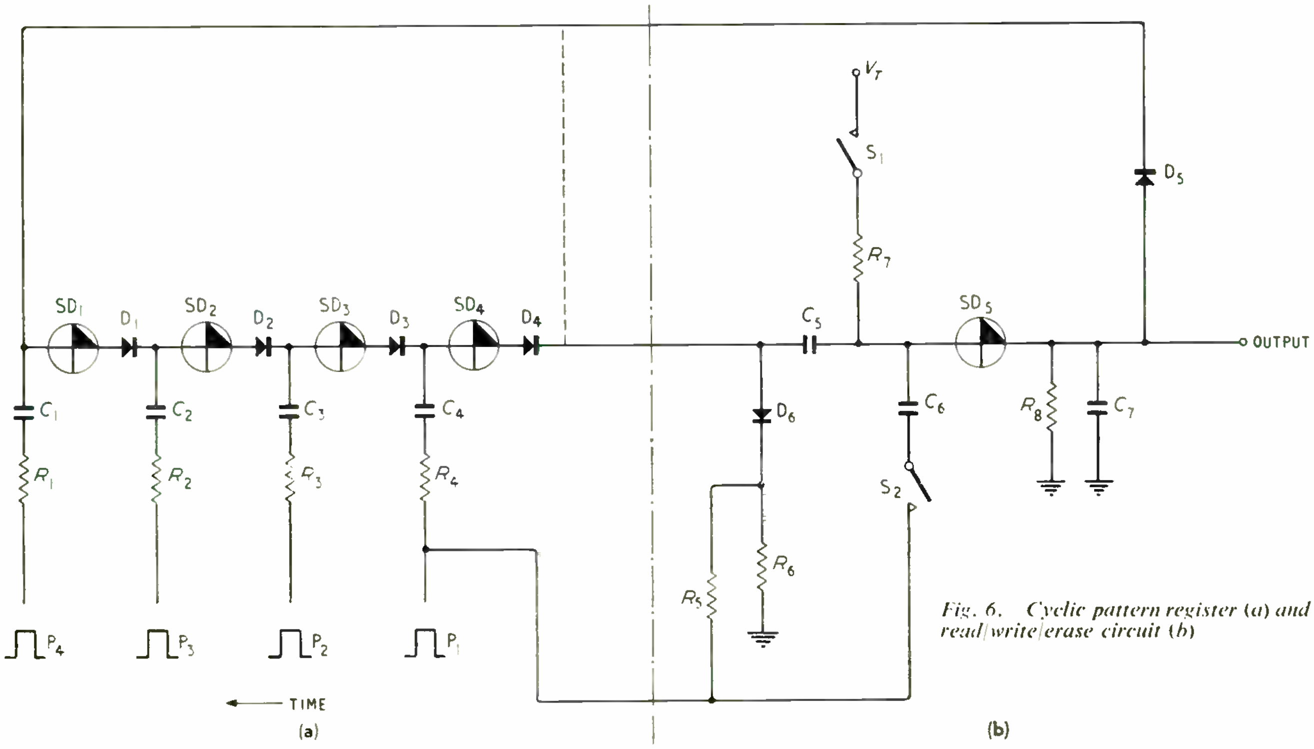

Fig. 6. Cyclic pattern register (a) and read/write/erase circuit (b)

Zener diode in series with each p-n-p-n diode. This would increase the effective maintaining voltage of the diode assembly to be similar to that of a cold-cathode diode.

Counter Circuit Terminated in a Mismatch

If the counter is terminated at each end in a resistor instead of a capacitor, the circuit behaves rather like a mismatched delay line.

Consider the circuit of Fig. 7 which employs the basic counter circuit of Fig. 2 except that each end is terminated in a resistor. If a positive charge is applied to capacitor C_1 it is transferred from stage to stage down the chain from left to right. When the charge reaches the last capacitor, pulse P_3 strikes SD_4 and C_3 discharges to earth through R_{m1}. When pulse P_3 ceases, the voltage on both sides of C_3 must fall by V_t volts so leaving the anode of SD_3 at $-V_t$ volts which equals $-V_{st}$. Thus, C_3 is now charged negatively and this charge progresses, by pulse stepping, back down the chain from right to left. When it reaches capacitor C_1, pulse P_4 strikes SD_4 and the capacitor discharges through resistor R_{m2}. When P_5 ceases, C_1 is left with a positive charge which travels back along the chain from left to right.

It must be noted that only one marking can be present in the chain at any time since positive and negative charges cannot pass one another. If, however, cold-cathode diodes are used, patterns of markings can be made to pass in either direction as indicated earlier. This reflective store may be used as a pattern register.

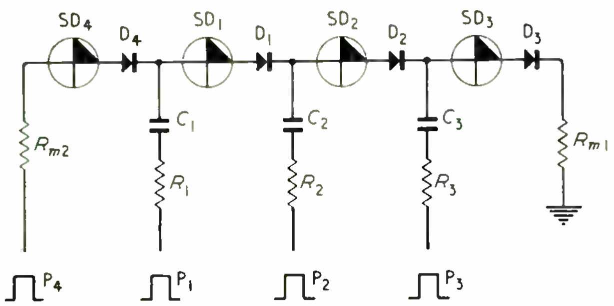

Fig. 7. Counter terminated in a mismatch

Conclusions

In shift-register systems employing capacitors and semiconductors it is usual to attribute the storage function to the semiconductor device and the transfer function to the capacitor. It might be thought that a reversal of this would result in systems where the storage time is limited by capacitor leakage. The circuits described show that this need not be so, it being possible to employ the active switching elements so as to give regeneration of the charge. Power is consumed primarily to overcome capacitor leakage and so may be very small, especially at low cyclic speeds.

It is improbable that this type of circuit offers sufficient advantages to justify its replacing more conventional cyclic storage circuits in use at this time. However, the circuit is very simple in construction because the switching diodes of a chain are connected in series, with capacitors tapped along the length. Such circuits should be very suitable for automatic assembly or composite manufacture. If this issue arises it is important to realize that this converse of the normally accepted technique can give rise to useful circuits.

Acknowledgment

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Celestion	13/355	Egli, Fischer & Co. A.G.
Colvern	13/355	Egli, Fischer & Co. A.G.
Continental Connectors	13/396	Metronic Verkaufs A.G.
Cybernetic Developments	11/254	—
Datum Metal Products	11/201	—
Dowty Rotol	13/321	Adr. M. Eschler Urania-Accessoires
E.M.I. Electronics	13/376	Filmo S.A.
Evershed & Vignoles	11/225	H. Huber & Co. A.G.
	11/131	Omni Ray A.G.
	11/136	
Ferranti	13/390	—
Fielden Electronics	11/225	H. Huber & Co. A.G.
Gardeners Transformers	13/429	Dam
Goodmans Industries	13/386	Roschi
Hallam, Sleigh & Cheston	13/334	—
Harrison	11/135	Infranor
Hatfield Instruments	13/341	Ema A.G.
De Havilland Aircraft	13/332	Endress
Henry & Thomas	13/429	Dam
Hewlett-Packard	13/335	Hewlett-Packard S.A.
A. H. Hunt Capacitors	13/396	—

Firm	Stand No.	Agent
Imperial Metal Industries	11/165	Dr. Ing. Koenig A.G.
Industrial Electronics	10/97	—
Johnson, Matthey	13/371	Dewald A.G.
Levell Electronics	13/371	Dewald A.G.
Linton & Hirst	11/165	Dr. Ing. Koenig A.G.
Lintronic	13/342	—
Claude Lyons Ltd.	13/378	Seyffer & Co. A.G.
	13/381	
Mallory Batteries	13/432	K. Hirt Elektronik
Marconi Instruments	13/378	Seyffer & Co. A.G.
	13/381	
McMurdo	13/355	Egli, Fischer & Co. A.G.
M.E.C.	13/355	Egli, Fischer & Co. A G.
Muirhead	RH/461	—
Nagard	13/444	J. Baerlocher
Polar	13/355	Egli, Fischer & Co. A.G.
Pye Ling	13/386	Raschi
Pye Telecommunications	13/371	Dewald A.G.
Pye T.V.T.	13/371	Dewald A.G.
Racal Instruments	13/378	Seyffer & Co. A.G.
	13/381	
Rank Cintel	13/324	Silectra
Reliance Controls	13/396	Metronic Verkaufs A.G.
W. H. Sanders Electronics	13/444	J. Baerlocher A.G.
Satchwell Controls	11/158	Trüb, Täuber & Co. A.G.
Servomex Controls	11/131	Omni Ray A.G.
Short Bros. & Harland	17/568	—
Standard Telephones & Cables	11/165	Dr. Ing. Koenig A.G.
Steatite & Porcelain Products	11/165	Dr. Ing. Koenig A.G.
Telequipment	13/371	Dewald A.G.
Thorn Electrical Industries	11/231	—
Venner	13/405	Venner A.G.
Vero Electronics	11/145	Traco
Westinghouse	13/366	—

THE first INEL exhibition opens at Basle, Switzerland, on 2nd September to show to the world all that is new in electronics and closes its door on 7th September. Truly international, this exhibition includes about 400 firms from 16 different countries. Besides various groups of components and measuring devices, the latest applications of electronic valves and semiconductors in light-current engineering and electronic application in power engineering, automatic control and computing will be displayed.

To the industrial user, electronics generally means a piece of equipment that will do a job of work more quickly, accurately or more efficiently than conventional devices or methods. This down-to-earth approach is reflected in many of the exhibits of the British companies or their agents. Complete equipments designed for specific purposes are to be displayed on most stands.

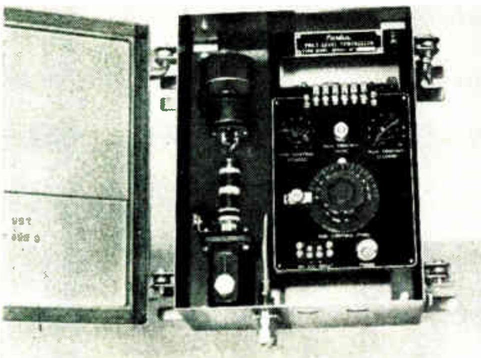
The Servomex Controls portable oxygen analyser type D.C.L. 101 **(50)** serves to illustrate this trend. Here is an oxygen analyser which is able to compete with standard chemical absorption methods for accuracy, but which is also quick, clean, and above all, simple to use.

This instrument is battery powered and, therefore, completly portable. It makes use of a paramagnetic susceptibility measuring cell. In the instrument a silica dumb-bell is suspended in a non-uniform magnetic field and experiences a torque which is proportional to the oxygen content of the surrounding gas. This torque is balanced against a restoring torque due to current flow in a coil wound on the dumb-bell. The balance condition is achieved by adjusting a calibrated 10-turn potentiometer to 'zero' the position of a light beam reflected from the dumb-bell. The zero position is initially determined by passing pure nitrogen (or other oxygen-free gas) into the measuring cell. The range covered is 0 to 100% oxygen content at 0·1% accuracy.

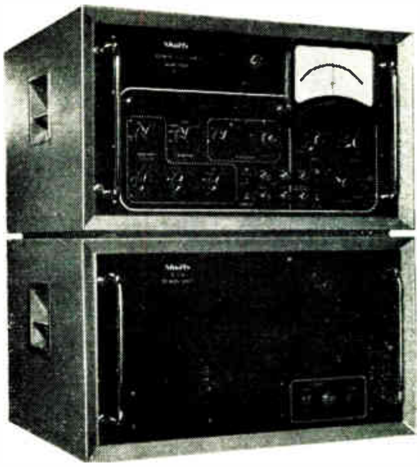
Another complete device, wire diameter gauge type WG-1 **(51)**, is to be demonstrated by International General Electric Company of New York Ltd. This gauge is designed for use in industries concerned with the continuous measurement of the diameter of wires, rods or filaments. The whole gauge is built as a compact unit measuring about 9-in. high × 7·5-in. wide by 14·5-in. long. There is a housing built up at each end of the gauge base with a gap between for the unimpeded passage of the wire to be measured. In one housing there is a lamp and lens assembly which projects a beam of parallel light across the gap to the other housing. A mask in the gap divides the light into an upper measuring beam, which is adjustable, and a lower fixed reference beam. After the light enters the second housing, the upper beam falls on a measuring photocell and the lower beam falls on a similar reference photocell. The two photocells are connected so that their output voltages oppose each other.

In the 'operate' position the wire passes through the measuring beam. If the diameter deviates from that required, the light falling on the measuring photocell varies and the output meter directly indicates the variation of diameter in mils. This is the basic unit and other units can be added to provide alarm and automatic control facilities.

Control of another kind—levels of liquids—is provided by the Fielden Electronics new electro-pneumatic level controller or transmitter type PNL3 **(52)**. It is a simple self-balancing capacitance measuring device with pneumatically-operated feedback. It produces an output air pressure of 3 to 15 p.s.i. exactly proportional to the change of liquid level. A knob control provides adjustment to give a transmission signal covering the full variation of level in the container or conversely to give a proportional control signal over a small variation of level in the container. Being a capacitance-type level controller only a



The Fielden Electronics level controller type PNL3



Shorts control system analyser

This batch counter type CB11 is one of the many devices to be shown by Thorn Electrical Industries (94)

Shown here is the Venner frequency counter type TSA3334 vertical probe in the container is required ; a range of these is available to meet any specific requirement.

Automatic temperature control is an accepted technique in industry and is now even more acceptable by using transistor circuitry to improve reliability and reduce the size of the electronic control unit. Hatfield Instruments temperature controller type LE460 **(53)** typifies the developments in this field. This is a robust industrial type instrument for providing close control of any oven temperature up to 1,000 °C.

In this a bridge network is energized with an a.f. signal and the output is amplified and fed to a phase-sensitive detector which operates a relay via a further transistor amplifier. One arm of the bridge is made temperature sensitive and is placed in the oven to be controlled. This is completely self-contained, in a cabinet measuring 9·75 × 8·5 × 3·75 in., with the exception of the sensing element and the contactor to switch the heating elements. With this, control of temperature is maintained to less than 0·1 °C of that required.

Control systems for temperature, humidity, etc., are to be the main items shown by Satchwell Controls. Typical of these is the 'Duotronic' temperature and humidity controller **(54)** for the control of heating, ventilating and air-conditioning plants.

This uses an electronic circuit to amplify signals produced by temperature or humidity change and to apply proportional plus integral correcting action.

In operation, elements in the humidity and temperature detectors form part of a Wheatstone bridge. A change in the element resistance, due to temperature or humidity, produces an out-of-balance signal which is amplified to provide a correcting control signal. Thus there is no permanent deviation from the pre-set control point.

In most modern closed-loop control systems servo components are used in many ingenious ways but when it comes to displaying these at exhibitions ingenuity seems to take a holiday. Fortunately this is not true in the case of the proposed Evershed & Vignoles display. An interesting servo-controlled demonstration is to illustrate the use of their servo components. A pointer on a dial is driven by an a.c. servomotor-generator which is controlled by an electronic amplifier. The motor-generator is mounted on a special servo gearbox having a spring-loaded split gear to eliminate backlash between the magslip and pointer. When operating as a position control system, the pointer position is determined by a knob on the control panel. With a switch on the panel in the 'scanning' position the servo becomes a velocity-controlled system and the pointer rotates at a pre-set constant speed. In this system the output from the tacho-generator is compared with a fixed reference voltage and the difference fed into the amplifier to control the motor.

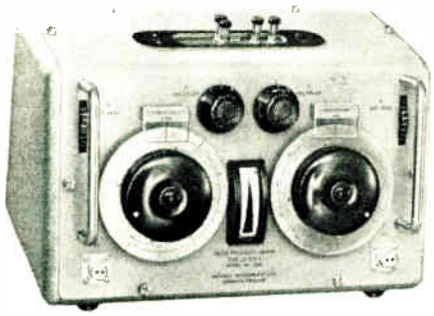
For measuring the performance of automatic control systems Short Brothers & Harland are showing their control system analyser **(56)**.

This analyser employs the method of steady-state frequency response. The test system is excited by sinusoidal oscillations of known amplitude and frequency. At each selected frequency the system steady-state response is analysed in terms of gain and phase difference.

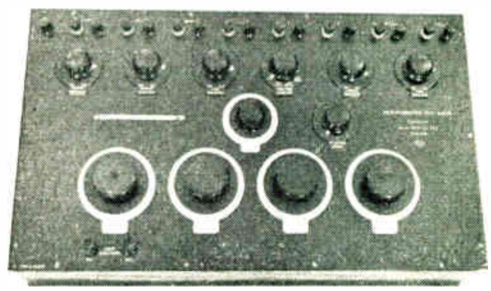
The instrument is made up of two sections—an oscillator to drive the test system, and a phase-sensitive voltmeter which determines the amplitudes of the in-phase and quadrature components of the system output waveform.

Instrumentation

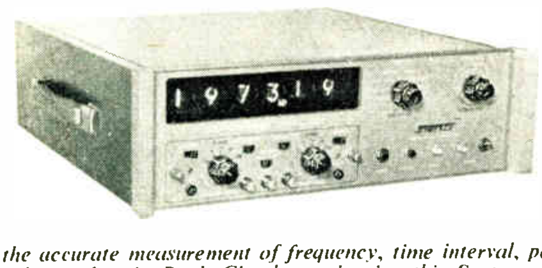
At an exhibition of this nature the coverage must be broad since it caters for the industrial user and potential user of electronic equipment and devices. It is therefore



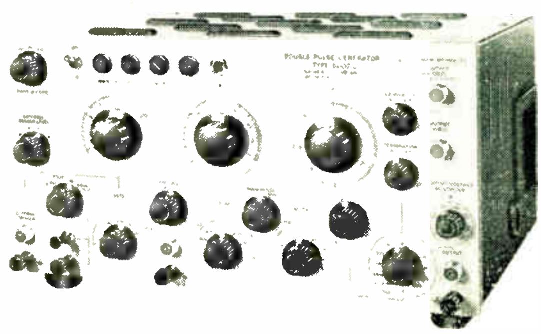
The Hatfield r.f. bridge type LE300



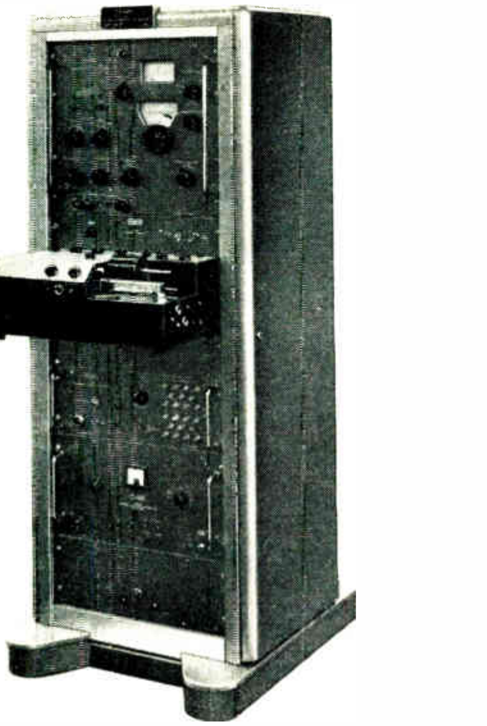
Shown by Cambridge Instruments this latest version of their Microstep potentiometer has been developed for very high precision voltage measurement. It has a discrimination of 1 part in 2 × 10⁶ and gives readings in steps of 0·1 μV up to 2 V on a single range **(57)**



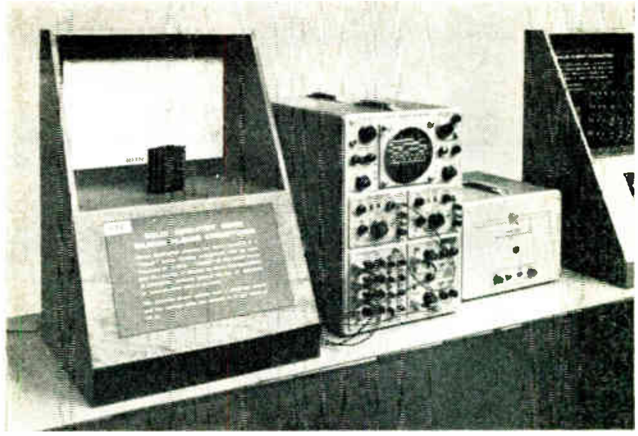
For the accurate measurement of frequency, time interval, period, phase lag and ratio Rank Cintel are showing this Systron model 1032 counter-timer. Ranges covered include frequency, 0 c/s to 2·5 Mc/s; period 1 μsec to 10 sec; time interval 1 μsec to 10 sec; ratio A : B = 10⁶ max (input A = 0 to 2·5 Mc/s, input B = 0 to 1 Mc/s) **(55)**



This illustrates the Advance Nagard double-pulse generator type PG5002C



One of the working demonstrations on the Muirhead stand will be noise and vibration waveform analysis using this type K-101-A analyser



The Components Group of Standard Telephones and Cables are including static and working displays of their range of semiconductors. A highlight of the display will be a working demonstration of their latest integrated semiconductor elements **(62)**. Illustrated here is the set-up which will be used to demonstrate S.T.C. solid circuits in the form of 10 Mc/s logic units

This shows one of the two digital voltmeters which are to be featured by Digital Measurements. Both models provide 5-digit, in-line readout plus polarity indication, binary coded output signals and 6 modes of operation; the total conversion time is 20 msec. Model DM2020 **(63)**, illustrated here, has an accuracy of 0·01%, a sensitivity of 10 μV, a range from 0·19999 to 1999·9 V and a maximum input impedance of >10,000 MΩ

to be expected that electronic instrumentation will form a large proportion of the show, as indeed it appears to. Many of the instruments to be shown can operate as test devices and functional devices on a production line and often it is difficult to classify them precisely.

For instance the Venner Electronics frequency counter TSA3334 **(58)** could be used in a laboratory for general functions or in a production plant by service engineers concerned with frequency measurement or shaft speed determination. This instrument is claimed to be the smallest in-line readout frequency meter available anywhere in the world. The display is on four brightly illuminated in-line indicators and the frequency range extends to 1·1 Mc/s.

Racal Instruments are also very concerned with electronic counters and are to display a range of these for various applications. Typical of their range is the SA.532 batch counter **(59)**. This is a transistorized batch/pre-set counter designed specially for industrial applications which include batching articles, pre-set counting and length measurement. It operates at batching speeds of up to 25,000 per second and batches of up to 9,999 or 99,999 with a pre-batch warning facility.

Typical of the general purpose counter-timers is the Levell Electronics type TMS1B **(60)**. This is a trasistorized digital counting instrument for the measurement of signal frequencies and time periods. The ranges covered are 1 c/s to 3 Mc/s and 3 μsec to 27·77 hr. The counter has five decades operating on a 1-2-4-8 code.

Advance Components and their Nagard Division are displaying and demonstrating most of their current ranges of instruments including the Nagard double-pulse generator type PG5002C **(61)**.

This provides single or double square pulses which may be selected as either negative or positive in potential with respect to earth. With a single-pulse output a continuously adjustable repetition frequency range of 0·1 c/s to 1 Mc/s is obtained which is effectively extended to 2 Mc/s using a double-pulse output. The triggering facilities of the 5002C are comprehensive.

For triggering an oscilloscope timebase a pre-pulse is provided, either positive or negative, having a pulse width of 0·2 μsec and a minimum amplitude of 20 V. The delay between the pre-pulse and a single main pulse may be adjusted between 0·2 μsec and 2 sec. With double-pulse operation the same delay exists between the pre-pulse and the second main pulse.

For the first time in Switzerland, Muirhead will show its full range of instruments including oscillators, analysers and bridges. The K-101-A automatic recording wave analyser **(64)**, which analyses complex waveforms of noise and vibration in the frequency range 10 c/s to 19 kc/s, will be demonstrated.

Thorn Electrical Industries are to be well represented by the products of their many divisions. Included in their range of transistorized television test equipment are two units for studio engineers. The first is a line-up generator based on the B.B.C. units type GE4 508. This is known as PLUGE **(65)** and it generates a video test signal for setting up studio picture monitors. The second unit is type WH11 **(66)** dot and graticule generator and is designed as a multi-standard test unit for accurately assessing the linearity of television scan systems.

here but, for reasons of personal preference, are called instead the 'adjacent-balancing arm' and the 'opposite-balancing arm' types respectively.

Preliminary Considerations

Convergence to Balance

The four-terminal electrical bridge configuration is shown in Fig. 1. It is known[1] that no matter to which pair of opposite terminals the supply oscillator (of zero output impedance) is connected, and to which remaining pair the detector (of infinite input impedance), the relation between the input voltage to, and the output voltage from, the bridge is given by

$$V_{out}/V_{in} = (Z_1Z_3 - Z_2Z_4)/[(Z_1 + Z_2)(Z_3 + Z_4)] \quad (1)$$

The only manner in which zero output voltage can occur for finite input voltage and finite components is that which causes the numerator of equation (1) to become zero. This numerator therefore plays rather an important part and is denoted δ henceforth, i.e.,

$$\delta = Z_1Z_3 - Z_2Z_4 \quad (2)$$

The manner in which the bridge converges to balance is thus the manner in which this quantity δ approaches zero. Equation (2) for δ is henceforth called the 'characteristic equation' of the bridge.

Stipulations on the Ideal Bridge

The requirements to be met by what may be termed the 'ideal' bridge were, as far as the author is aware, first proposed by Ferguson, although not enunciated in precisely the form they are to be used here.

In the general case each of Z_1, Z_2, Z_3 and Z_4 will be complex so that the characteristic equation will have a real and a j-component, i.e.,

$$\delta = \alpha + j\beta \quad (3)$$

where each of α and β are functions of the constituents of each of the bridge arms.

As the characteristic equation occurs in symmetrical form, any of the impedance arms may be chosen as the unknown being measured; let it be Z_1 in this analysis where

$$Z_1 = R_1 + jX_1 \quad (4)$$

and X_1 may be either positive or negative.

The first condition on the ideal bridge is that each of the quantities α and β appearing in equation (3) shall be a function of *only one* of R_1 or X_1. Thus α may be a function of either, *but not both*, of R_1 or X_1; β must then in turn contain the remaining component only of the unknown. The object of this condition is primarily to allow of the simple expression of the unknowns R_1 and X_1 in terms of the remaining arms of the bridge, and to avoid the necessity of solving simultaneous equations.

The second requirement to be met by the ideal bridge concerns the manner in which δ is brought to zero. From equation (3) it is seen that for δ to be made zero each of α and β must individually be brought to zero, and in this regard this second condition requires that each of α and β be capable of being made zero independently. The latter is then a stipulation that there has to appear in the expression for α any one constituent of the bridge impedance arms (other than, of course, the unknowns themselves) which does not simultaneously appear in the term β, and conversely there should simultaneously feature in β any one constituent which does not also appear in the expression for α.

The implications of the above two requirements are then the following. First, using a Utopian detector of infinite sensitivity and also continuously variable balancing arms it should be possible to balance the bridge in only two operations, one in which α is brought to zero quite independently of any considerations of β, and the second in which β itself is made zero. In practice, of course, more than two such operations must be expected, first, because of the detector's finite sensitivity and secondly because of the difficulty of obtaining completely continuously-variable arms. Nevertheless the bridge converges to balance in extremely rapid fashion.

The second implication is that each of these bridge balancing arms determines only one component of the impedance being measured. As variable impedance arms are obtainable to an accuracy normally lower than that associated with a fixed element, this means that, other conditions being equal, the measurement of each component of the unknown is achieved more accurately if in the equation for its determination there features only one variable arm and not two.

The argument may be proposed at this stage that there are many bridge configurations which will permit of a balanced state but which do not comply with the requirements on the ideal bridge mentioned above, and as such why should these arrangements be excluded from further consideration. The answer here is possibly to see how far one may proceed while holding out for the most stringent specifications, and then to re-consider the issue depending on what emerges. If only a few possibilities are forthcoming then the conditions above must be relaxed; if on the other hand there are found to be many which do fulfill the stipulations the question can be side-stepped.

Further Considerations of the Characteristic Equation

The contents of the last section may become clearer upon considering a specific case. The unknown has already been specified by equation (4); in addition let each of the remaining bridge arms be of the general form $R + jX$, where the sign of the letter X will be taken as positive for the moment. Equation (2) becomes

$$\delta = (R_1 + jX_1)(R_3 + jX_3) - (R_2 + jX_2)(R_4 + jX_4)$$

i.e., $\delta = R_1R_3 - X_1X_3 - R_2R_4 + X_2X_4$
$$+ j[X_1R_3 + R_1X_3 - X_2R_4 - R_2X_4] \quad (5)$$

Consider equation (5) in the light of the stipulations of the previous section. With regard to the first of these conditions it is seen that the real portion of δ, that is α, contains a term involving the unknown R_1 as well as one involving X_1. With regard to the second requirement it is seen that there is no constituent of any of the bridge arms which appears only in α and not in β, and vice versa.

The important conclusion is therefore reached at this stage that the four-terminal electrical bridge in which an *impedance* features in each of the arms *does not satisfy the requirements of the ideal bridge*; modifications are thus necessary. There are two different methods by which these modifications can be achieved. The first, termed the 'adjacent balancing arm' method for reasons to be seen later, is considered next and the second, denoted the 'opposite balancing arm', is investigated later.

The Adjacent Balancing-Arm Method

Restrictions on the Impedance Z_3

Equation (5) is seen to be constructed in such a form that α contains terms involving products of *like* components of opposite arms while β those of products of *unlike* components of the same opposite arms. This is fortunate in that if *one* of R_3 or X_3 is made zero, only one component of the unknown impedance appears in α and only the other in β. Thus one method of satisfying the first condition is for the arm *opposite to the unknown to be made either purely resistive or purely reactive*. Each of these two possibilities is to be

Classification of

FOUR-TERMINAL BRIDGE NETWORKS

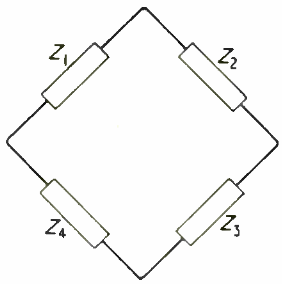


Fig. 1. The general four-terminal electrical bridge network

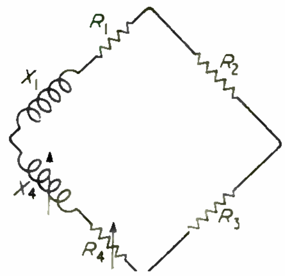


Fig. 2. X_2 zero

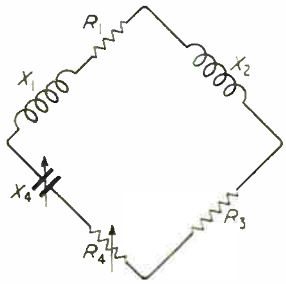


Fig. 3. R_2 zero

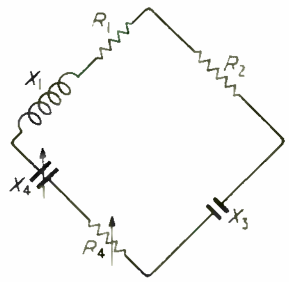


Fig. 4. X_2 zero

considered in turn, and in each case the methods of fulfilling the second requirement on the ideal bridge must be investigated.

X_3 made Zero

The characteristic equation then becomes

$$\delta = R_1R_3 - R_2R_4 + X_2X_4 + j(X_1R_3 - X_2R_4 - R_2X_4) \qquad (6)$$

To meet the second requirement it is seen that either R_2 or X_2 on the one hand, or R_4 or X_4 on the other, must be made zero. There are no other possibilities. In other words, any *one* of the arms *adjacent* to that containing the unknown must be restricted to be purely resistive or purely reactive. It makes no difference which of the two adjacent arms is so chosen, as each of them merely serves to connect the unknown impedance to its opposite arm of the bridge. Z_2 will thus be arbitrarily chosen here to be the adjacent arm not permitted to be a complex impedance. Again two cases arise which must be considered separately, first that in which X_2 is zero and secondly that where R_2 is zero.

X_2 made Zero

Equation (6) becomes

$$\delta = R_1R_3 - R_2R_4 + j(X_1R_3 - R_2X_4) \qquad (7)$$

Here R_4 is seen to appear only in the real portion of δ and X_4 only in the j-component; as such the second condition is fulfilled and these two elements become the balancing variables of the bridge. Equating like components of equation (7) yields at balance, when δ is zero,

$$R_1 = R_2R_4/R_3 \qquad (8)$$

and

$$X_1 = R_2X_4/R_3 \qquad (8a)$$

Equation (8a) immediately shows that, as the ratio R_2/R_3 is positive, the reactance X_4 must be of the same type as that being measured, that is X_1.

It is to be noted that in view of the derivation of this type of bridge *both the balancing variables feature in the same bridge arm.* It is of course also to be pointed out that there exists no other possible combination of balancing elements, as R_4 was the only constituent to appear in the α of equation (7) and not in the β, and conversely for X_4. The resulting bridge configuration for X_1 taken as positive is shown in Fig. 2.

R_2 made Zero

Equation (6) now becomes

$$\delta = R_1R_3 + X_2X_4 + j(X_1R_3 - X_2R_4) \qquad (9)$$

Again X_4 and R_4 are seen to be the only permissible balancing arms. Equating like components of equation (9) yields at balance

$$R_1 = - X_2X_4/R_3 \qquad (10)$$

and

$$X_1 = X_2R_4/R_3 \qquad (10a)$$

Equation (10a) shows that as R_4/R_3 is positive X_2 is to be a reactance of the same type as the unknown X_1. Equation (10), as R_1R_3 is positive, indicates that X_2 and X_4 are of opposite type: hence X_1 and X_4 are reactances of opposite type.

The resulting bridge configuration for X_1 positive is shown in Fig. 3. The above two sections have resulted for the case where X_3 was zero. The instance of R_3 zero must now be considered.

R_3 made Zero

The characteristic equation (5) becomes

$$\delta = -X_1X_3 - R_2R_4 + X_2X_4 + j(R_1X_3 - X_2R_4 - R_2X_4) \qquad (11)$$

The last two terms in the α and in the β of this equation are seen to be respectively the same as those appearing in equation (6), and therefore the remedy which was suitable to make the latter equation obey the second condition likewise applies in this case. Thus X_2 is first to be made zero and then R_2.

X_2 made Zero

Equation (11) becomes

$$\delta = -X_1X_3 - R_2R_4 + j(R_1X_3 - R_2X_4) \qquad (12)$$

R_4 and X_4 are again the only permissible balancing arms, resulting in the equation at balance being

$$X_1 = -R_2R_4/X_3 \qquad (12a)$$

and

$$R_1 = R_2X_4/X_3 \qquad (12b)$$

whence from equation (12b) X_4 and X_3 are reactances of the same type, and from equation (12a) X_1 and X_3 are reactances of the opposite type; and hence X_1 and X_4 are reactances of the opposite type.

The resulting bridge configuration for the case of X_1 positive is shown in Fig. 4.

R_2 made Zero

Equation (11) becomes

$$\delta = -X_1X_3 + X_2X_4 + j(R_1X_3 - X_2R_4) \qquad (13)$$

Classification of

FOUR-TERMINAL BRIDGE NETWORKS

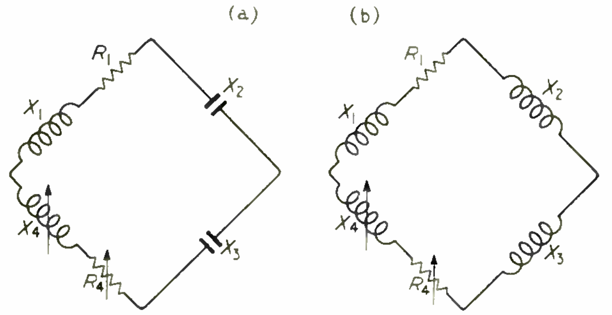


Fig. 5a. R_2 zero, X_3 negative *Fig. 5b. R_2 zero, X_3 positive*

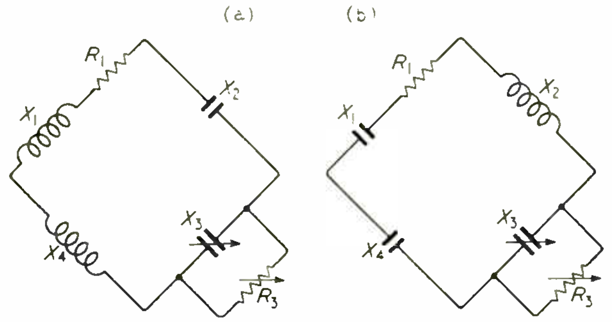


Fig. 6a and 6b. R_2 and R_4 simultaneously zero

Again X_4 and R_4 are the only permissible balancing arms resulting in the equations at balance

$$X_1 = X_2X_4/X_3 \tag{13a}$$

and

$$R_1 = X_2R_4/X_3 \tag{13b}$$

whence from equation (13b) X_2 and X_3 are reactances of the same type, and hence from equation (13a) X_1 and X_4 are reactances of the same type. It should be noted, however, that in this instance there is no condition relating any of X_2 or X_3 to any of X_1 or X_4. Thus two different bridge configurations emerge from this case, and are shown in Fig. 5(a and b) for the case of X_1 positive.

Resumè

This section has enabled the characteristic equation to satisfy the first condition imposed on the ideal bridge by the method of restricting the impedance arm opposite to that containing the unknown impedance being measured to be either purely resistive or reactive. It has been shown that for the second requirement to be met this has resulted in one arm adjacent to the unknown similarly being restricted from being a complex impedance and has then caused the only two permissible balancing variables to be found in the remaining arm adjacent to the unknown impedance. Hence the designation of this type of bridge as the 'adjacent-balancing arm' category.

In many cases, however, it is found inconvenient to have the two variable elements in *series*, as is the situation with the configurations derived in this section. As the input frequency applied to the bridge is increased in value, it is found that the operator's body-capacitance to earth plays an increasingly important role in the successful operation of the bridge. One method of eliminating this latter effect is for each of the balancing arms to have a direct connection to earth: this is then seen to be impossible when the two variable arms are in series and in the same arm of the bridge, as they are here.

This consideration places importance on that category of bridge in which the balancing variables are capable of being in *parallel*; the possibility of such a class of bridge is then to be investigated. This is the subject of the following section.

The Opposite-Balancing Arm Method

Choice of Balancing Variables

The previous section automatically commenced on the assumption that each of the bridge arms consisted of elements in series. Under these circumstances the determination of the eventual bridge balancing variables was a derived, as opposed to a specified, topic. In this instance, however, for the reasons advanced at the end of the previous section, the balancing variables are to be *specified initially* as definitely having to be in parallel. It then remains to see which arm, if any, of the bridge is then the most convenient for this parallel combination.

This is possibly achieved most conveniently by considering the expression of the unknown impedance Z_1 in terms of the remaining general impedances under balance conditions. Thus, from equation (2) with δ zero,

$$Z_1 = Z_2Z_4/Z_3 \tag{14}$$

from which it is immediately apparent that it is most convenient from the viewpoint of mathematical manipulation if the parallel balancing variables are to be found in the arm 3. Denoting the latter by R_3 and jX_3 respectively the characteristic equation (2) becomes under these circumstances

$$(1/Z_3)\delta = R_1 + jX_1 - (R_2 + jX_2)(R_4 + jX_4)(1/R_3 + 1/jX_3) \tag{15}$$

i.e.,

$$(1/Z_3)\delta = R_1 - (R_2R_4 - X_2X_4)/R_3 - (X_2R_4 + R_2X_1)/X_3$$
$$+ j[X_1 + (R_2R_4 - X_2X_4)/X_3 - (X_2R_4 + R_2X_1)/R_3] \tag{16}$$

Under balance conditions δ is to be zero, but Z_3 will be finite; the right-hand side of equation (16) may therefore be considered in the same manner as previously despite the presence of the multiplier involving Z_3 on the left-hand side of this equation. This follows since it is the alteration of the right-hand side of this equation which is to result in δ being zero at balance.

The different structure of equation (16) as compared with that of the corresponding equation (5) for the 'adjacent-balancing arm' type of bridge is immediately apparent. First, it is seen that without the use of any further impositions the unknown R_1 appears in only the α portion of the equation and the unknown X_1 in only the β. Secondly, the second term in the α expression is seen to differ from the second in the β component in denominator only; this property applies also to the third term in each component. This latter feature yields the clue to the method of handling this characteristic equation.

By hypothesis R_3 and X_3 are to be the balancing arms, and thus only one of these should feature in the α of equation (16) and only the other in the β. To remove X_3 from the α which, according to the reasoning above, simultaneously eliminates R_3 from the β, the term $X_2R_4 + R_2X_1$ in equation (16) must be made zero. There is obviously more than one method of achieving this, but the two which have the most far-reaching effects on the remaining portion of the equation are those which either (a) make R_2 and R_4 zero simultaneously or (b) make X_2 and X_4 zero simultaneously.

Conversely to remove R_3 from the α, and simultaneously X_3 from the β, the term $R_2R_4 - X_2X_4$ must be made zero. There again exist numerous methods of achieving this, but none more powerful than those which either (i) make R_4

and X_2 zero simultaneously, or (ii) make R_2 and X_4 zero simultaneously.

Stating these conditions in an alternative fashion, it is seen that the remaining opposite arms of the bridge, that is those not containing the unknown impedance or the balancing variables, are to be restricted to be either purely resistive or purely reactive. The four combinations mentioned above are now considered separately.

R_2 and R_4 Simultaneously Zero

Equation (16) becomes under these circumstances

$$(1/Z_3)\delta = R_1 + X_2X_4/R_3 - j(X_1 - X_2X_4/X_3) \qquad (17)$$

The balancing arms have been specified by hypothesis and therefore there is no derivation required. At balance, when δ is zero, there follows

$$R_1 = -X_2X_4/R_3 \qquad (17a)$$

and

$$X_1 = X_2X_4/X_3 \qquad (17b)$$

whence from equation 17(a) X_2 and X_4 must be reactances of opposite type, and hence from equation (17b) X_1 and X_3 must be reactances of opposite type.

It is to be noted that there exists no relation between any of X_2 and X_4 and any of X_1 and X_3. Hence two bridge configurations result from this case depending upon the types allotted to X_2 and X_4 in turn. For the case of X_1 positive the resulting configurations are shown in Fig. 6(a) and (b).

X_2 and X_4 Simultaneously Zero

Equation (16) becomes

$$(1/Z_3)\delta = R_1 - R_2R_4/R_3 - j(X_1 + R_2R_4/X_3) \qquad (18)$$

with the resulting equations at balance, when δ is zero,

$$R_1 = R_2R_4/R_3 \qquad (18a)$$

and

$$X_1 = -R_2R_4/X_3 \qquad (18b)$$

From equation (18b) the reactances X_1 and X_3 are seen to be of opposite type. The resulting bridge configuration for the case of X_1 positive is shown in Fig. 7.

R_4 and X_2 Simultaneously Zero

Equation (16) becomes

$$(1/Z_3)\delta = R_1 - R_2X_4/X_3 - j(X_1 - R_2X_4/R_3) \qquad (19)$$

leading to the two equations at balance

$$R_1 = R_2X_4/X_3 \qquad (19a)$$

and

$$X_1 = R_2X_4/R_3 \qquad (19b)$$

Here X_4 and X_3 are seen to be reactances of the same type, and likewise X_1 and X_4; that is X_3 and X_1 are similarly like reactances.

All previous bridge configurations thus far have been illustrated for the case of the unknown X_1 being positive; in this instance, however, it is of greater importance to indicate the result for X_1 negative, and this is shown in Fig. 8.

R_2 and X_4 Simultaneously Zero

Equation (16) becomes

$$(1/Z_3)\delta = R_1 - X_2R_4/X_3 + j(X_1 - X_2R_4/R_3) \qquad (20)$$

whence at balance

$$R_1 = X_2R_4/X_3 \qquad (20a)$$

and

$$X_1 = R_4X_2/R_3 \qquad (20b)$$

From equation (20a) X_2 and X_3 are seen to be reactances of the same type, and from (20b) X_1 and X_2 are also reactances of the same type. Hence X_1 and X_3 are like reactances. The resulting configuration, again for the case of X_1 negative, is shown in Fig. 9. The close relation between Figs. 8 and 9 is to be noted.

Resumé

The main point of interest at this stage is the difference in approach between the methods adopted in this section and those used in the previous one of causing the bridge characteristic equation to satisfy the requirements initially stipulated.

Dealing first with the last section, it was seen that representing each arm of the bridge by a *series* impedance caused the characteristic equation, in this case equation (5), to fulfil *neither the first nor the second* of the conditions on the ideal bridge. Attempting initially to have the first condition satisfied attention was paid to the arm 3, whence it was shown that restricting this arm from a series impedance to either a pure reactance or a pure resistance produced the required effect. With this first requirement satisfied, attention was then paid to methods of fulfilling the second. At the end of this procedure there eventually emerged the bridge-balancing variables, which were the two series constituents of an arm adjacent to that containing the unknown.

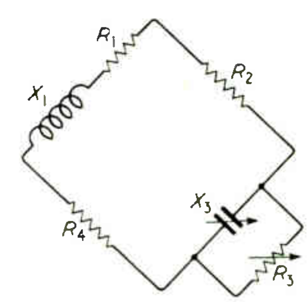
Considering now this section, it was seen that upon the *initial specification* that the balancing variables had to be in parallel, arm 3 emerged as the most convenient, for mathematical reasons, to house the latter.

Thus the first similarity between the two approaches arises in that arm 3 was in each case the first to receive attention.

However in this section, the placing of the two parallel variables in arm 3 caused the characteristic equation, equation (16), *automatically to satisfy the first of the ideal conditions* and thus the investigation had at that stage to consider merely means of fulfilling the second. As in the last section, this was again achieved by restricting certain arms to be pure resistances or reactances.

In view of the remarks of this section, it is seen that one

Fig. 7. X_4 and X_2 simultaneously zero



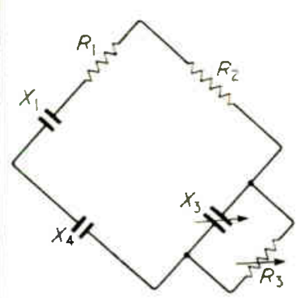
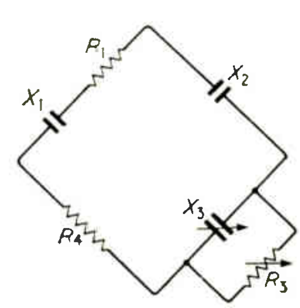


Fig. 8. R_4 and X_2 simultaneously zero

Fig. 9. R_2 and X_4 simultaneously zero



Classification of
FOUR-TERMINAL BRIDGE NETWORKS

method of simple recognition whether a given four-terminal bridge configuration satisfies the requirements of the 'ideal' arrangement is to pay attention to the arm *opposite to that containing the unknown*. If this arm is neither a pure resistance or reactance, or each of these in parallel, the mode of operation of the bridge is not what has been termed in this article the 'ideal'.

Conclusions

The whole of the derivation of the generalized classification of the four-terminal electrical bridge, both as presented here and as proposed by Ferguson, has hinged on the two initial stipulations to be met by what was termed the 'ideal' bridge. These latter warrant elaboration, especially since in an instance of this type there might be grounds for the accusation that the initial requirements to be met by the bridge were so chosen as to be capable of resulting in a generalized theory, or alternatively that the former were laid down only after the latter had been completed!

It must be stated at the outset that the ideal electrical bridge has obviously to meet far more than the two requirements mentioned in detail. At the same time, however, the author would express the personal opinion that whatever these additional conditions may be, the first two in order of importance are those which have been used as the basis of the generalized classification presented here and by Ferguson. The additional considerations involved with regard to the satisfactory operation of an electrical bridge[1,2] pertain to the positiveness with which the balanced condition is obtained, in other words the sensitivity of the configuration, secondly to the degree of stability and reproducibility of this balanced state, and thirdly to the role played by second- and higher-order terms.

In this latter regard the author would stress at this stage that the effect of component residuals and such second-order quantities has been completely overlooked in this article.

Ferguson's aim in presenting his classification of four-terminal bridge methods was to provide some basis of correlation of what had evidently appeared up to 1933 to be merely a compartmentalized collection of separate bridge configurations. This present article has in turn, by using the convergence-to-balance expression as opposed to the balance equations themselves, attempted to simplify Ferguson's approach to, and arguments in, such a correlation. In this regard it merely remains to point out that Fig. 4 is Owen's method for the determination of an inductive impedance, that Fig. 7 is Maxwell's method for the same measurement and that Figs. 8 and 9 are Schering's bridge for capacitance and dissipation factor determination. The remaining bridge configurations are theoretical possibilities and as such can be used in those circumstances where any additional practical considerations as may arise can be satisfactorily fulfilled.

Frequency Dependence of the Balance Equations

The two prime conditions which the 'ideal' bridge was to meet are given early in this article. It is seen that nothing is said there regarding the frequency dependence or independence of the balance equations of the resulting configurations which obeyed these two conditions.

In the author's opinion, the advent of the electronic counter has removed virtually all the disadvantages previously assigned to those bridge networks whose balance equations contained a frequency term; according to the arguments of this article the latter are then to be correctly classed as 'ideal' provided prime conditions of this article are fulfilled.

It is to be noted, however, that all the balance equations of the 'ideal' four-terminal configurations derived here are frequency *independent*. Such a coincidence is rather remarkable, and it is therefore to be investigated whether such frequency independence is an initial property of all four-terminal bridges or whether it is actually a consequence of the two conditions imposed on the 'ideal'.

This question proves more difficult to answer than might appear at first sight. It is easy to see how the application of the two conditions, for example to equation (5), has confirmed the frequency independence of the resulting balance equations; the author has not yet been able, however, to ascertain whether this property would still have existed in the absence of these conditions, or alternatively if there are any other which would have resulted in the same frequency independence of the balance equations.

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RADIO FOR MARSHALLING YARDS

Efforts being made by British Railways to reduce running costs and overheads by speeding the turn-round of rolling stock will be helped at Tyne, Tees and Healey marshalling yards in the north-east by the installation of a u.h.f. radio communication system for the control of locomotives when shunting.

The equipment, which has been developed by the Electronic Apparatus Division of Associated Electrical Industries Ltd., in collaboration with A.E.I.-G.R.S. will enable speech communication to be made between a locomotive and the control centre. Instructions can thus be given without delay so that valuable time is saved in turning round rolling stock. At present the system is installed on some nineteen locomotives.

Known as the A.E.I. type 700, this u.h.f. communication system has been designed to G.P.O. specification W.6303. It operates in the 450 - 470 Mc/s band and is continuously rated.

The system permits one-way return speech from locomotive to the control centre. Orders to the locomotive and various cab signalling tones are transmitted from the control centre through an inductive loop system designed by A.E.I.- G.R.S. Ltd.

Each locomotive has a transmitter on its own individual frequency, where sufficient frequencies can be made available by the Post Office, working to its own receiver channel via a wide-band aerial amplifier at the control centre. The equipment is fixed in a cradle with anti-vibration mountings to withstand the heavy jolting on shunting locomotives.

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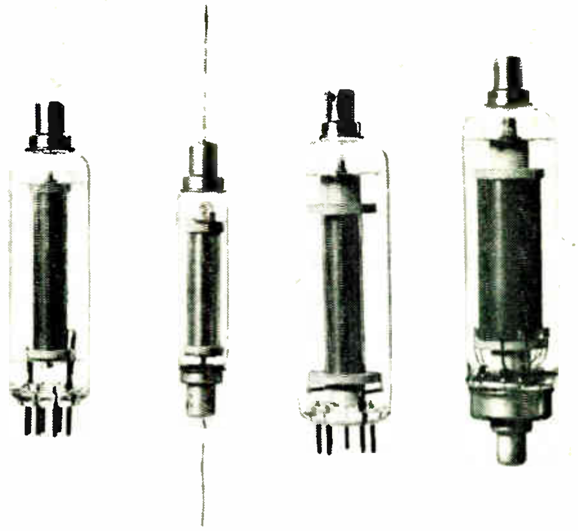
Corona voltage stabilizers, from left-to-right, types SC1, SC3, SC2 and SC5



This article presents various methods of stabilizing low-current high-voltage power supplies of the kind often needed for electronic instruments. They are based mainly on the corona stabilizer tube.

Stabilized High-Voltage Supplies

By J. P. HOLLAND, A.M.Brit.I.R.E.*

THERE is a growing need for stable high-voltage supplies in modern electronic equipment. One reason for this is the application in industrial instruments of techniques which were formerly used only in the laboratory. Manual voltage control may be quite satisfactory for the skilled experimental user, especially when the emphasis is on simplicity and cheapness. It will not, of course, serve in industrial measuring instruments, which have to be used by comparatively unskilled people, or by those whose skills lie in other directions. Such instruments must, as far as possible, work by themselves.

Examples of devices needing stabilized e.h.t. supplies are Geiger-Müller tubes, gas chromatographs, photomultipliers and high-voltage insulation testers. Experts in particular fields of instrumentation will know of many others. The current required is usually quite small, of the order of 1 mA or less. Some form of shunt stabilizer is particularly useful in such cases.

General

By way of illustration, four typical circuits of this kind will be given. They were the subjects of a working display unit on high-voltage stabilization shown on the stand of The M-O Valve Co. Ltd., at the Institute of Physics and Physical Society Exhibition, January 1963. All were designed to stabilize against mains supply-voltage variations of ±7% and output currents from zero to full load. Close tolerance resistors are generally necessary in this class of circuitry. These designs allow for changes of up to ±10% from the nominal values, which, it will soon be apparent, restricts the range of output current obtainable from a particular circuit. The design figures and measured performance of each circuit will be given, so that the relative merits of the different methods may be compared.

The four example circuits each operate from an e.h.t. supply with a no-load voltage of nominally 4 kV, and give outputs in the range 2 to 3 kV. In principle, however, the methods, or extensions of them, may be applied to any voltage.

It is generally advisable, as the electronic devices concerned have a finite life, to incorporate a voltmeter in the circuit. This has been done in the four examples. The meter in each case reads 3 kV f.s.d., and consists of a 50-μA movement with a series resistor multiplier. Account is taken of the meter current.

Another point which applies to each of the four circuits is that the value shown for the input resistor R_1 includes the internal impedance of the power supply. This total, like the other resistances, must be within 10% of the value shown for the circuit to function as designed.

Simple Corona Stabilizer Circuit

The corona stabilizer, as its name implies, utilizes the corona mode of discharge in a gas. The electrode system comprises a thin wire anode, surrounded by a metal cylinder which forms the cathode, and operates in a hydrogen atmosphere. The cathode is not activated, and the operating voltage depends on the geometry of the system and the gas pressure. Ionization occurs in a luminous region which forms a sheath around the anode wire—the place where the field is most intense.[1, 2]

The corona stabilizer is used in much the same way as the glow discharge tube, but at considerably higher voltage and lower current. For example, the SC series marketed by The M-O Valve Co. Ltd., covers the range from 350 V to 6,800 V, at tube currents of up to 1 mA.

The striking voltage of a corona stabilizer is generally less than 10% above the operating voltage. Because a large

* The M-O Valve Co. Ltd.

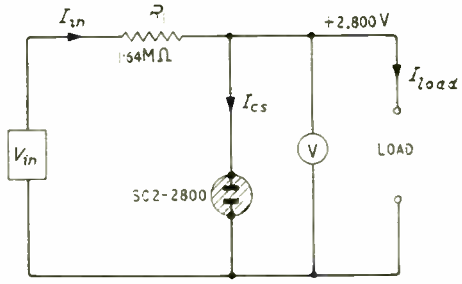


Fig. 1. Simple corona stabilizer circuit

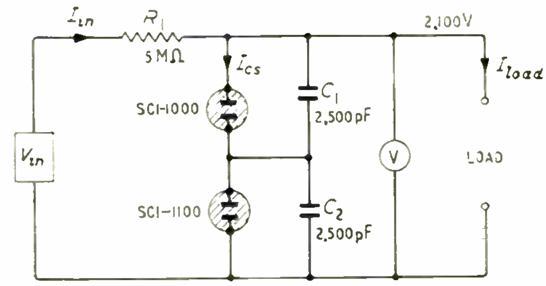


Fig. 2. Corona stabilizers in series

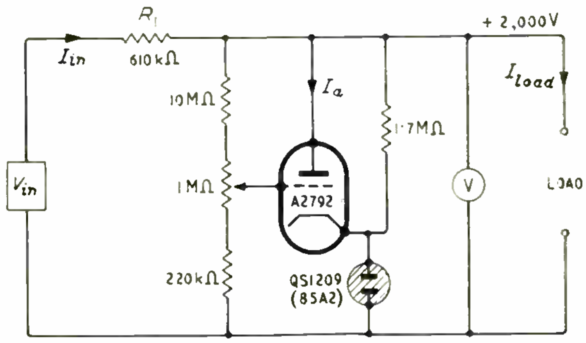


Fig. 3. Triode shunt stabilizer

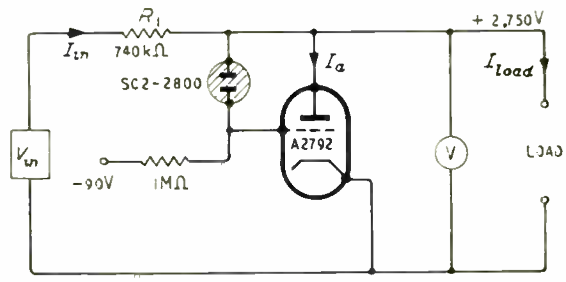


Fig. 4. Corona stabilizer as reference for shunt triode

input resistor (R_1) is needed to give a reasonable degree of stabilization, in practice the available voltage is always ample for striking.

The first and simplest of the example circuits is illustrated in Fig. 1. Table 1 shows the design data for 7% high and 7% low mains, at no-load (NL) and full-load (FL) output current. The voltage and current symbols correspond to those in the figure.

The design procedure consists of Ohm's law calculations, which need not be described. It is important that the corona stabilizer current I_{cs} should not be allowed to go outside the permitted range for the SC2 series, namely 0·025–1 mA (continuous), even when R_1 varies by $\pm 10\%$, and allowing for the $\pm 2{\cdot}5\%$ tolerance on the stabilizer voltage. Voltage variations due to tube impedance may be ignored, as they prove to be in the 'right' direction. In effect, one assumes for calculation purposes that the tube has zero impedance.

The minimum and maximum operating currents for a corona stabilizer exist because below this range the discharge may become intermittent, while at higher currents the discharge tends to change to the glow mode, resulting in a negative impedance which causes relaxation oscillations.

The measured variation in output voltage for $\pm 7\%$ mains changes and the full range of output current is 70 V overall, a typical performance for this simple circuit.

Corona Stabilizers in Series

The SC series of corona stabilizers extends from 350 to 6,800 V. When a higher voltage is required, two or more tubes may be connected in series. This may also be done in order to obtain a supply with intermediate tappings, or to derive an odd voltage using standard tubes.

An example of series connection is shown in Fig. 2, and Table 2 gives the design conditions.

This circuit combines an SC1-1000 and an SC1-1100 to give an output voltage of 2,100 V. As these tubes have a lower operating current than the SC2 series, the available output current is lower than in the first example.

Table 1: Design Conditions for Circuit of Fig. 1

V_{in} (V)	I_{in} (mA) (NL and FL)	(I_{cs} mA) (FL)	I_{cs} (mA) (NL)	I_{load} (mA)
4280	0·90	0·50	0·85	0·35
3720	0·56	0·16	0·51	0·35

Table 2: Design Conditions for Circuit of Fig. 2.

V_{in} (V)	I_{in} (mA) (NL and FL)	I_{cs} (mA) (FL)	I_{cs} (mA) (NL)	I_{load} (mA)
4280	0·436	0·201	0·401	0·20
3720	0·324	0·089	0·289	0·20

Table 3: Design Conditions for Circuit of Fig. 3 (2,000 V Output)

V_{in} (V)	I_{in} (mA) (NL and FL)	I_a (mA) (FL)	I_a (mA) (NL)	I_{load} (mA)
4280	3·74	1·40	2·40	1·00
3720	2·81	0·47	1·47	1·00

Table 4: Design Conditions for Circuit of Fig. 4

V_{in} (V)	I_{in} (mA) (NL and FL)	I_a (mA) (FL)	I_a (mA) (NL)	I_{load} (mA)
4280	2·00	1·05	1·85	0·80
3720	1·24	0·29	1·09	0·80

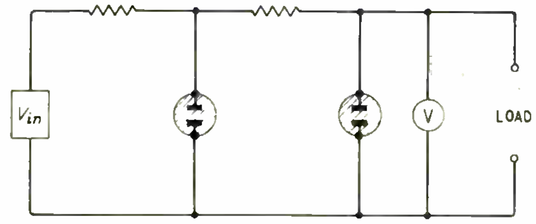


Fig. 5. Corona stabilizers in cascade

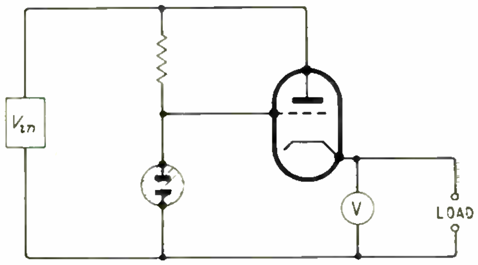


Fig. 6. Corona stabilizer with cathode follower

The overall voltage change for full mains and load current variation is 20 V. The restricted current and the consequent larger value of R_1, compared to the first circuit, are reasons for the better performance.

An important practical point concerning the use of tubes in series is the necessity for the capacitors C_1 and C_2 (Fig. 2). Their value is not critical, but if they are omitted the circuit is prone to relaxation oscillation. This appears to be due to small changes in the voltage drop of one tube affecting the other in such a way as to increase its current momentarily to a larger value. It is an empirical fact that two valves which individually do not exhibit relaxation oscillation, nevertheless can oscillate at random frequency when connected in series.

Triode Shunt Stabilizer

The corona stabilizer circuit gives a fixed output voltage. Of course, to supply a low-current device such as a Geiger-Müller tube or an ionization chamber, the output may be varied with a resistive potential divider. However, for a variable low impedance e.h.t. supply, one requires some form of hard valve circuit, such as that shown in Fig. 3, which uses a shunt stabilizer triode, the A2792. Table 3 gives the design data for operation at 2,000 V output.

The circuit of Fig. 3 may be used at output settings other than 2,000 V, but the available output current depends on the voltage. For instance, it is approximately 3 mA at 1,000 V and zero at 2,500 V. The circuit is designed so that the anode current of the A2792 does not fall to zero, and the anode dissipation rating of 6 W is not exceeded, in any conditions. This includes not only mains variation of $\pm 7\%$ and the full range of output current, but changes in the resistors of $\pm 10\%$ from nominal values.

The overall change in the 2,000 V output is 50 V, for full mains and load current variation.

Corona Stabilizer as Reference for a Shunt Triode

Although the previous circuit is useful and versatile, its stabilization performance is not ideal, owing to the attenuating action of the grid potential divider. The feedback may be increased by replacing the upper limb of the divider with a corona stabilizer. This leads to the circuit of Fig. 4, in which the feedback is almost 100%. Here, the corona stabilizer, connected between anode and grid of the A2792, carries a nearly constant current of about 90 μA, and acts as a voltage reference. The output voltage will be slightly less than the corona tube drop, the difference being the negative bias for the triode. Table 4 shows the design figures.

The voltage variation in this circuit is too small to measure by means of the output voltmeter. In fact, the output impedance may be shown to be $1/g_m$, or about 500 Ω, which is very low, by usual standards, for a 2,800-V supply.

Other Circuits

There are many other possible high-voltage stabilizer circuits. For example, two corona tubes may be used in cascade, the second one being of lower voltage than the first (Fig. 5). The stabilization against supply variations is then very much better than in the simple circuit of Fig. 1. On the other hand, the output impedance is no better than with a single tube.

One useful circuit (Fig. 6) employs a corona stabilizer as a reference for a series valve or cathode follower. This can give a larger output current than the shunt valve circuit of Fig. 4, but needs an insulated heater supply.

Conventional series-stabilizer methods may be used at high voltage also. Again there is the need for an insulated heater supply, and the circuit is more complex, but these points are offset by the very low output impedance.

Sometimes a high-voltage high-μ triode is required for e.h.t. stabilizer operation and no valve specifically made for the purpose proves to be available. In such cases a pulse modulator pentode or tetrode, such as the A2426/CV4082, with the screen-grid connected to cathode, may be found suitable. As this application would involve characteristics which are not controlled by the valve manufacturer, a rather wide variation in those characteristics should be expected, but this is often acceptable.

Conclusion

There must inevitably be many gaps in this brief survey of a large subject. Nevertheless, it is hoped that the techniques presented will prove helpful by indicating possible lines of approach to individual problems in the field of high-voltage stabilization.

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By ALAN SMITH

CAPACITANCE CONTROLS IN FLUID HANDLING

The use of capacitance probes in the control of fluid level is described in this article. Attention is drawn to special cases, such as drainage control, where the use of two probes can obviate damage in unusual conditions.

Capacitance devices are widely applicable where pump or valve operation is required at certain pre-determined high and low levels within a container. In this respect they are comparable with several other types of electronic detecting equipment, conductivity, photo-electric and ultrasonic. A special advantage, however, is that it is comparatively straightforward to arrange for control action affecting the level of liquid or solid material in a container to be related to the contents level in another where this second level is subject to variation.

This is because capacitance devices inherently provide for continuous measurement over a chosen range, whereas the other types of equipment determine the presence of contents only at fixed points. With a capacitance probe mounted vertically in a container, the level of contents is detectable at any time: the probe may, in fact, be likened to a dip-stick. With a conductivity device, the level is detected at the tips of the electrodes, and with photo-electric and ultrasonic apparatus at the level at which the light or ultrasonic beam is arranged.

Continuous measurement is, of course, obtainable with ultrasonics by an 'echo' arrangement, but the comparison here is with the mode whereby a beam is interrupted by container contents.

Control arrangements whereby the contents level of one container may desirably be related by means of capacitance devices to the level in another are found in industry generally and, notably, in land-drainage pumping and lock-gate control. The essential component in a capacitance control is the probe, comprising a mild-steel rod with a sheath of insulating material. The rod forms a live electrode and whatever surrounds the probe the earth electrode. Capacitance between the two electrodes is measured by a radio-frequency bridge circuit in the relay box.

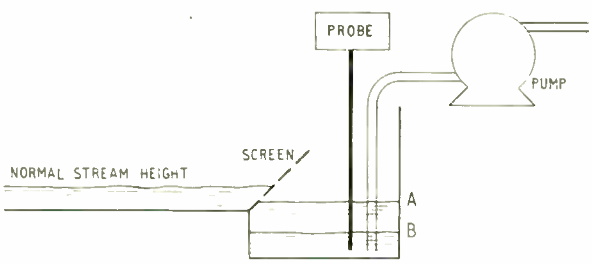


Fig. 1.—Simple control of water level in a drainage sump. The pump is switched on when the level rises to A and off when it falls to B

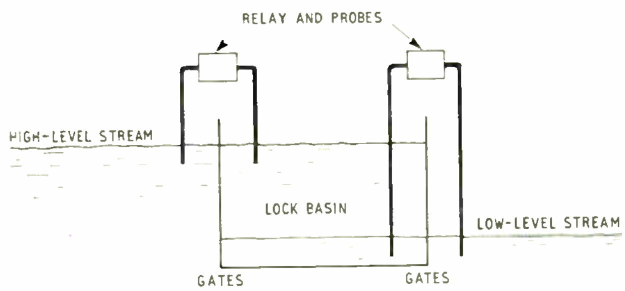


Fig. 3.—A pair of probes can be used to detect when the water levels on each side of a pair of lock gates are equal and so prevent any attempt to open the gates before equal levels have been reached

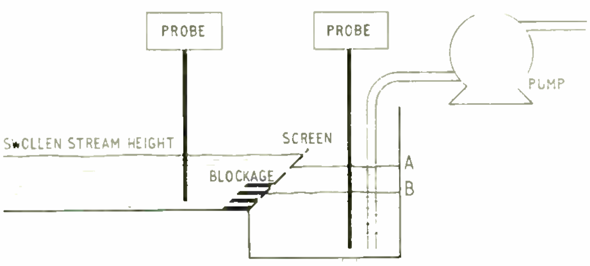
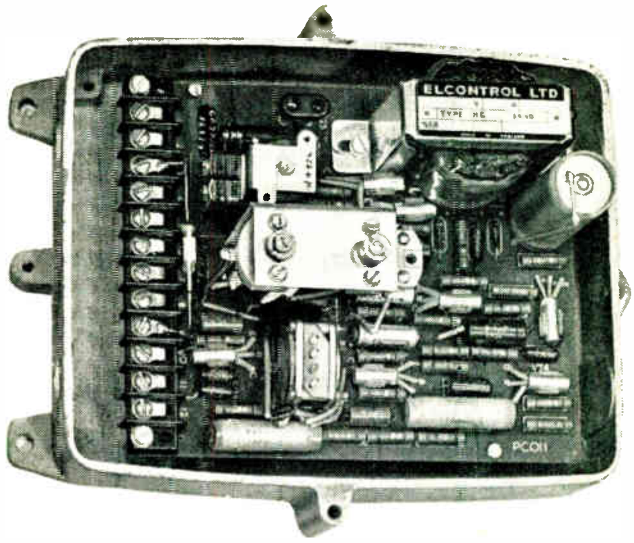


Fig. 2.—Under flood conditions the screen may become partially blocked and may be damaged if the sump levels are controlled as in Fig. 1. By using a second probe the control levels can be raised to prevent such damage

With the probe placed vertically in a container, control action can be obtained according to the length of probe immersed in the contents. Thus an inlet valve can be opened to replenish the container when the contents level drops to the bottom of the probe, and similarly it can be closed as the level reaches the top. There will be a difference in capacitance between the conditions of slight and almost complete immersion of the probe, and it is a simple

Capacitance probe



Elcontrol DLC electronic level control with cover removed

matter of setting the control so that valve opening and closing occurs at the desired levels.

A simple arrangement of this kind is acceptable when no other conditions need be taken into account. In the case of land-drainage pumping, however, there is a variable factor to be reckoned with. Fig. 1 depicts a culvert leading to a sump from which water is pumped. There is a screen to prevent trash such as leaves and twigs from falling into the sump. With a capacitance probe—or indeed any other control device—the pump will be brought into operation when the height of water in the sump rises to level A, and be cut out when the level drops to B, say 24 in. lower.

So long as the height of water in the culvert remains the same, within reasonable limits, this control arrangement will function without trouble. But with the coming of a storm, much more trash is borne by the water than usual and the lower part of the screen becomes blocked. The result is that the water rises in the culvert and pours into the sump mainly through the upper part of the screen. With the same kind of control as provided for normal conditions, water is pumped out of the sump and the entire sump side of the screen is deprived of hydraulic support. Because of this, and the build-up of pressure against a large area of the screen on the culvert side, breakages are liable to occur, leading not only to costly repairs but also a failure of the drainage system at a time when it is most needed.

With capacitance equipment, this difficulty can be overcome by having a probe in the stream on the culvert side of the screen in addition to that in the sump (Fig. 2). This detects the stream level and, when a rise occurs, the operation of the probe in the sump is suitably compensated. The high and low levels thus become relative not to invariable points in the sump but to stream height. When conditions are normal, the high and low pumping levels may be similar to those of a single-electrode arrangement, but should stream height increase due to screen blockage, the sump is evacuated not to the same depth but to the selected differential below stream height. In effect this means that the screen is not deprived of hydraulic support and breakage is obviated.

For lock-gate control, the application is similar except that the equipment is required not to control level differentials but indicate equal water levels on each side of the gates (Fig. 3). Opening lock gates when there is too much difference between water level places undue stresses on motor gear or mechanical linkages. By the most common existing methods, checking levels may be done visually—that is by a man simply looking at the water on each side of the gates—or by comparing readings on individual indicators. Either involves liability to human error, particularly in bad weather.

A simple capacitance-relay installation can exclude the factor of human error. The relay may be connected to two vertical electrodes arranged one on each side of a pair of gates, and an indication is given when the water levels are the same. Furthermore there is automatic compensation for tidal influences. If desired, the relay can be directly connected to the gate motor to start it automatically at the correct moment.

MULTI-WAY CABLE TESTING

Illustrated here is one stage of telephone cable testing at the Prescot factory of British Insulated Callender's Cables Ltd. The sequence of checks includes those for continuity, resistance, insulation resistance, mutual capacitance and capacitance unbalance. In order to speed up this test programme and to record the results, fully transistorized equipment with electric typewriters have been installed.

INDUSTRIAL NEWS

Personal and Company News

Evershed and Vignoles Ltd. have announced the following board changes: Ivor Bowen, G.M.G., M.Sc., F.R.Ae.S., has joined the board and will act as part-time consultant to the company; D. D. Walker, M.A., M.I.E.E., while continuing to be an active director, has relinquished his position as joint managing director. Allan R. Pike, B.Sc.(Eng.), M.I.E.E., has been appointed commercial director.

The new headquarters of the **General Electric Co. Ltd.** is 1 Stanhope Gate, London, W.1. (Telephone: Hyde Park 8484).

R. A. McMahon has retired after 29 years' service with the Electrical Research Association.

Plessey Overseas Ltd. is to become a principal operating company of the Plessey Group, with the prime function co-ordinating under one management the overseas manufacturing resources of Automatic Telephone, Ericsson and Garrard.

Lord Hill of Luton has been appointed by the Postmaster General to be chairman of the **Independent Television Authority** from 1st July, in succession to the present acting chairman, Sir John Carmichael.

E.M.I. Electronics Ltd. have transferred certain sales activities to different divisions. The newly-formed Automation Division has taken over the systems work of the Industrial and Instrument Divisions, and sales of packaged goods are grouped together under the Instrument Division, which will continue to handle sales of closed-circuit television equipment.

British Aircraft Corporation Ltd. have announced two new appointments: E. L. Beverley, D.F.C., as civil aircraft contracts manager, and F. W. Higginson, D.F.C., D.F.M., as sales and service manager of the Guided Weapons Division.

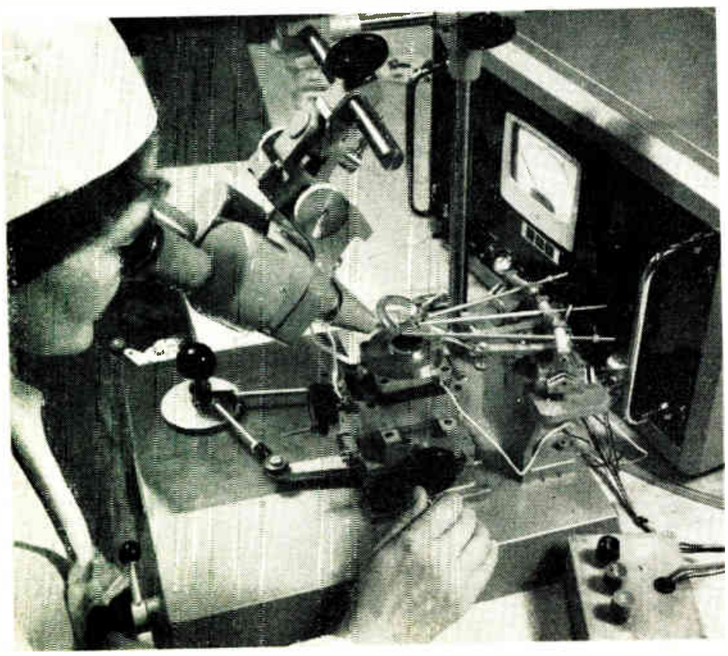
The Rank Organization is combining the professional cinema, furnishings and closed-circuit television equipment marketing operations of the Rank Kalee Division with those of Rank Audio Visual with permanent headquarters at Woodger Road, London, W.12.

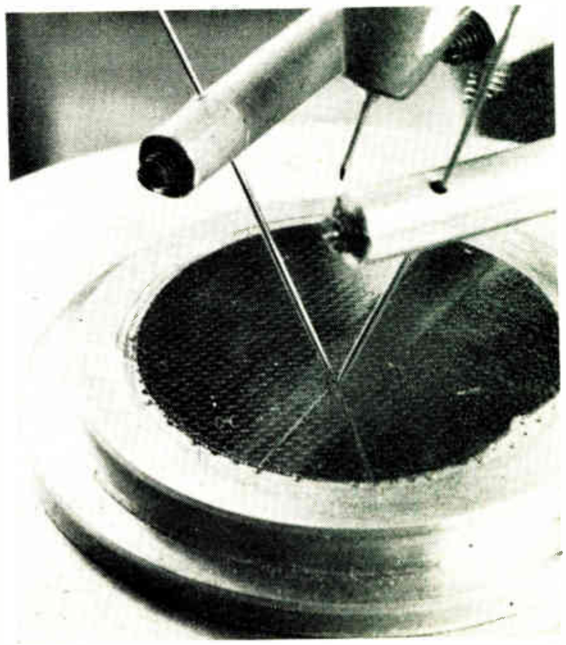
J. S. Skinner has retired as chairman of **Remington Rand Ltd.** The new managing director is M. G. Lovatt.

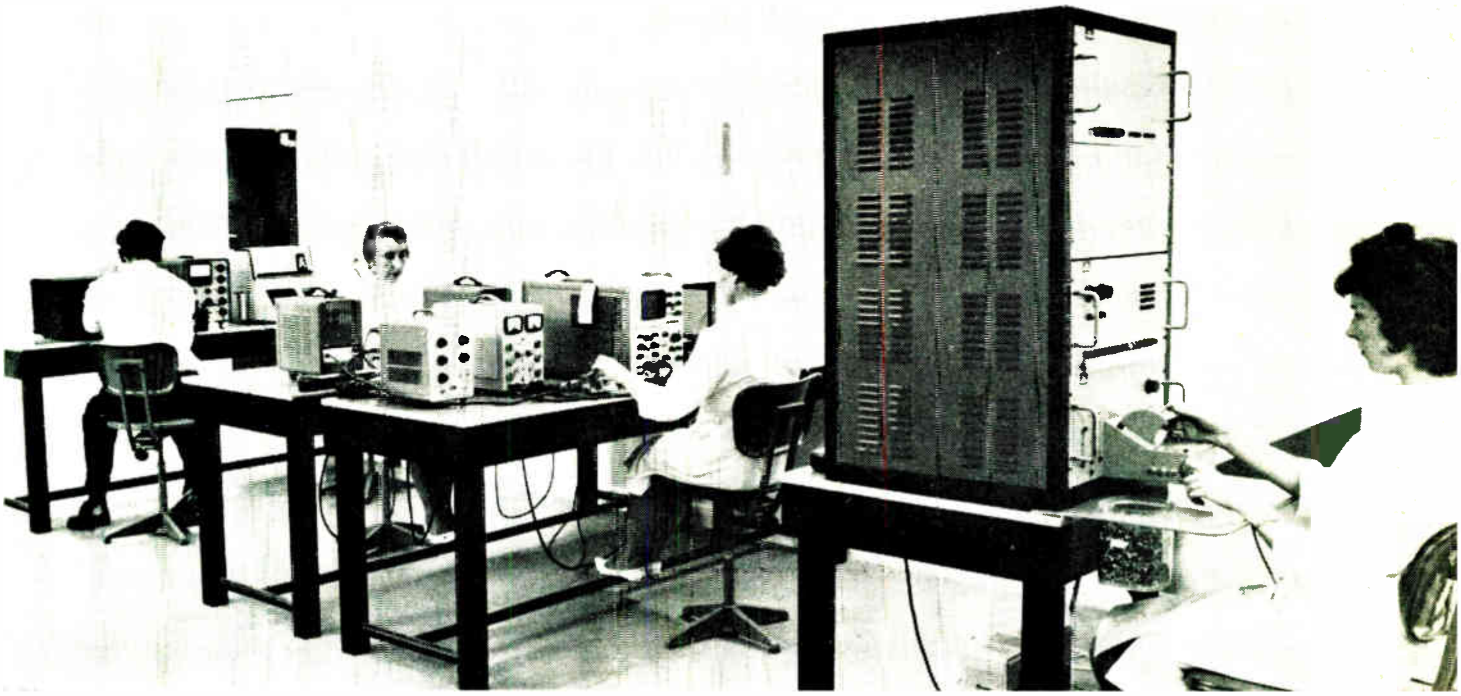
Morganite Resistors Ltd. have announced the appointment of J. H. Wood as general sales manager of the Electronics Division, D. A. Forrest as general sales manager of the Electrical Division, and A. J. Flower as sales office manager.

D. A. Pitman has resigned from the board of **Electronic Instruments Ltd.** in order to form a company specializing in the sales and service of medical instruments.

Apparatus used at the Caswell Research Laboratory of the Plessey Co. Ltd. for testing microminiature solid circuits. The silicon slice contains 100 solid circuits and the close-up shows point probes contacting base and emitter of a transistor







Silicon planar transistors manufactured by SGS-Fairchild at Ruislip are tested for 16 primary parameters automatically. The test set has 16 lamps. If the transistor passes the tests all 16 lamps go out; if it fails any, one or more lamps remain alight

The Transistor Division of **Standard Telephones and Cables Ltd.** has been amalgamated with the Rectifier Division to form a single Semiconductor Division. The manager of the new division is J. M. Wilson, formerly manager of the Rectifier Division.

An agreement has been signed between **Painton & Co. Ltd.** and the Waltham Precision Instrument Co. Inc. (Camblock Division) for the exclusive manufacturing and marketing rights for a range of terminal blocks to be known as Painton Camblocks.

H. Fanning has been appointed sales engineer for the Technical Division of **Chilton Electric Products Ltd.** and will represent the company in Scotland. He will also represent Chilton Solenoid (U.K.) Ltd. as sales engineer for the same area.

Group Captain D. P. Hanafin, C.B.E., D.F.C., A.F.C., has taken up a civilian appointment with the instrumentation company of **S. Davall & Sons Ltd.**

R. G. B. Benson has been appointed chief engineer at **Expert Industrial Controls Ltd.**

Allan Appleby has been appointed chief electronic engineer of **S.E. Laboratories (Engineering) Ltd.**

The **B.B.C.** has announced the retirement of F. G. Chadder, O.B.E., senior superintendent engineer.

D. A. Clark has been appointed administrative assistant to D. J. Taysom, chairman and managing director of the **Brush Crystal Co. Ltd.**

E. F. Duncan, A.M.I.E.E., has been appointed divisional director and general manager of the Accessories Division of **British Insulated Callender's Cables Ltd.**

Hugh Veysey has been appointed general manager of the Publicity Department of **A.E.I. Ltd.** in succession to Sir Arthur Elton who is resigning to rejoin the board of Film Centre Ltd.

The Industrial Electronics Division of the **International General Electric Co. of New York Ltd.** has moved to Boulton Road, Reading, Berks. (Telephone: Reading 82468).

Southern Instruments Ltd. announce the appointment of John R. Bell as sales manager of their Instrumentation Division.

Graham Clifford, secretary of the Brit.I.R.E., has returned from a tour of India where he discussed the constitution of an Indian Division.

Obituaries

David C. Dance, sales engineer for Miniature Electronic Components Ltd., died on 23rd May following a motoring accident. Company representation for the south of England is now carried out by John R. Wood.

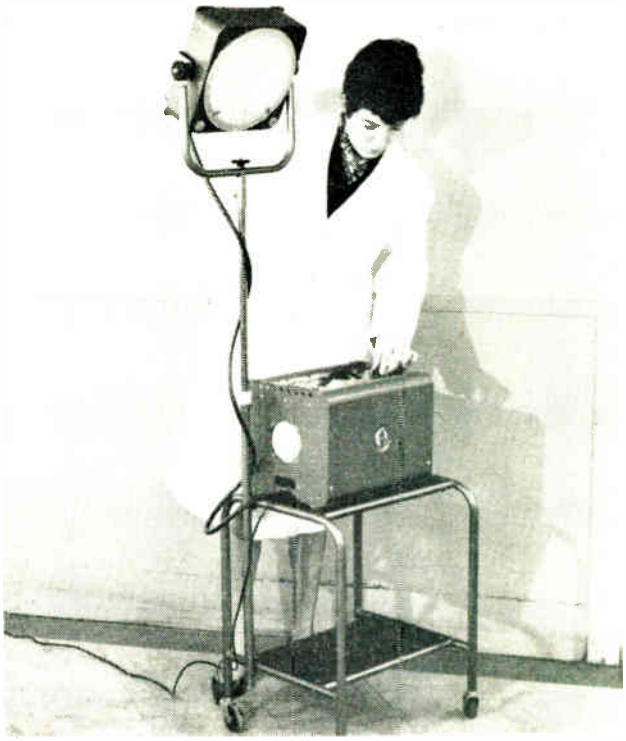
George Partington, chief engineer of Marconi's Broadcasting Division, died on 13th June. A prolific inventor and designer, he was perhaps best known for his work on the development of television cameras.

E. F. Stephenson, chief engineer of The Rotameter Manufacturing Co. Ltd. (Elliott Automation Group), has died after a short illness.

The death occurred on 9th June of Leonard Satchwell founder of The Rheostatic Co. Ltd. His name is well known for the invention, in 1927, of the magnetically controlled micro-gap switch.

Television Advisory Committee

Changes in the membership of the Television Advisory Committee have been made following the appointment of Prof. Sir Willis Jackson, D.Sc., M.I.E.E., as chairman. The three members from the radio industry are C. O. Stanley, C.B.E., Dudley Saward, O.B.E., and F. N. Sutherland, C.B.E. Representing general interests are Lord Aberconway, R. A. L. Cohen, O.B.E., and Roger Falk, O.B.E., all from industry and commerce. Also on the committee are three senior officials from the Treasury, the M.o.A. and the G.P.O., and the directors general of the B.B.C. and I.T.A. The terms of reference of the committee are: 'to advise the P.M.G. on the development of television and sound broadcasting at frequencies above 30 Mc/s, and related matters'.



The picture shows a trolley with a built-in lamp standard for the E.M.I. Electronics Ltd. stroboscope type 6. This has a xenon discharge tube and a range of 300–60,000 flashes a minute

For further information circle 79 on Service Card

European Marketing Organization

Euro-Center Marketing Systems Ltd. have announced the establishment of the first 'Euro-Center' in Brussels. The object of these centres, which are to be opened in the main commercial and industrial towns in Europe, is to facilitate the entry of British firms into European trade. A comprehensive marketing service is offered for under £500 p.a. The address of the head office is 1 Westminster Palace Gardens, Artillery Row, London, S.W.1.

Symposia, Conferences and Exhibitions

A Symposium on Instrumentation is to be held this year at Brunel College, Woodlands Avenue, Acton, W.3, on 17th, 18th and 19th September.

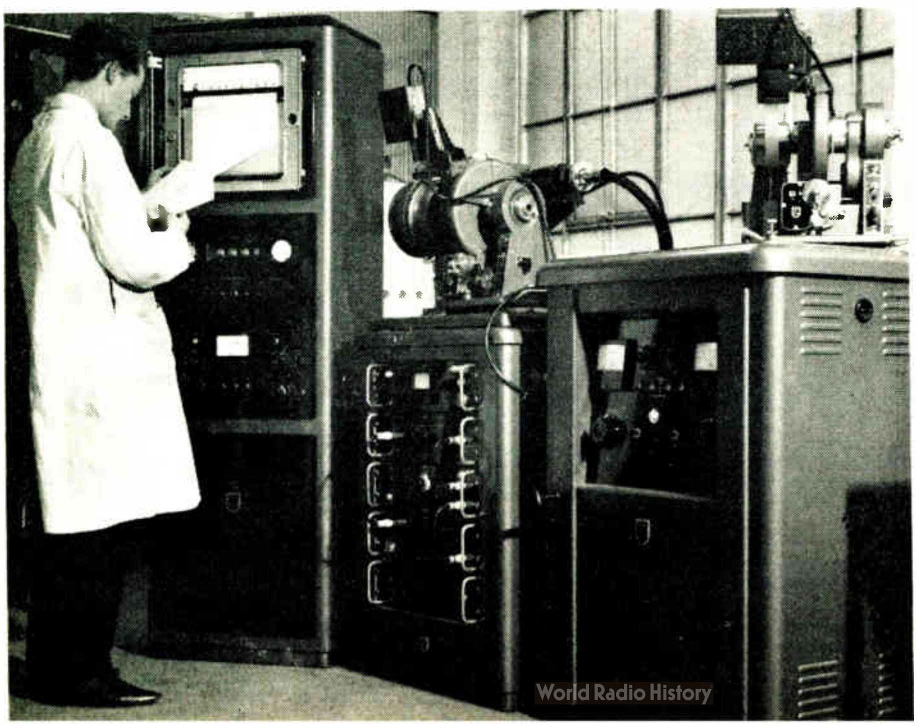
The Systems Engineering Section of the Society of Instrument Technology is holding an all-day symposium on 'The Use of Redundancy in System Design' at the Northampton College of Advanced Technology on Friday, 14th February 1964.

The Professional Group for Line and Radio Communication Systems of the Electronics Division of the I.E.E. is arranging an International Conference on Transmission Aspects of Communication Networks to take place from Monday to Friday, 24th to 28th February 1964.

The 1964 Electrical Engineers Exhibition is to be held at Earls Court, from 18th to 25th March, with a late night to 9 p.m. on Tuesday, 19th March.

Army Link with Electronics Industry

A scheme to assist suitably qualified technicians in their transition from the Army into industry, agreed recently between the War Office and the Electronic Engineering Association, came into effect on 1st July. The pilot scheme is confined initially to the Royal Corps of Signals, but it is hoped to extend it in the near future to include R.E.M.E. This idea will, no doubt, be of interest to other sections of industry and the armed forces.



X-ray spectrometer in a new laboratory of Research Control Instruments Ltd. The laboratory will carry out a certain amount of work on a contractual basis and it also is available to demonstrate X-ray instruments and advise on their use

For further information circle 80 on Service Card

NEW BOOKS

Models of Transistors and Diodes

By JOHN G. LINVILL. Pp. 190 + x. McGraw-Hill Publishing Co. Ltd., 95 Farringdon Street, London, E.C.4. Price 62s.

A model of a semiconducting device is something different from an equivalent circuit. It is, in fact, a kind of circuit which represents the device but the elements of it are intended to represent physical processes. The elements of the model are not confined to the usual resistances, capacitances, inductances and voltage and current generators from which the normal equivalent circuit is built up.

The elements of a model are storances, combinances, diffusances, mobilances, driftances to represent the storage, re-combination, diffusion, mobility and drift of charge carriers in the semiconductor. They have this difference from the elements of equivalent circuits, they are just paper symbols of defined meaning for the properties of the semiconductor whereas equivalent circuit elements are not only this but also represent real elements in their own right. The equivalent circuit is a paper representation of the real thing, it is true, but all its elements exist as individual components and it is possible to assemble the physical elements of an equivalent circuit into a piece of apparatus which will function in the same way as the real thing.

If a perfect equivalent circuit existed it would be possible to assemble its elements into a closed box and if the real device were put into another it would be impossible to distinguish between them by making measurements at the accessible terminals. This is not true of the models of this book. A resistor having the property of resistance exists as a physical thing; a driftor having the property of driftance does not so exist.

The explanations given in this book of how semiconducting devices work are exceptionally clear but it is very doubtful if they are helped by the model elements. They are all strange to the newcomer and added to the difficulty of understanding a semiconductor he has that of trying to remember what all the strange new symbols mean. It may well be, of course, that when they have become as familiar as the ordinary circuit symbols they will be as helpful.

The book ends with the transmutation of some of these models into familiar equivalent circuits.

Microwave Engineering

By A. F. HARVEY, D.Phil., B.Sc.(Eng.), M.I.E.E. Pp. 1,313 + xlii. Academic Press Inc. (London) Ltd., Berkeley Square House, Berkeley Square, London, W.1. Price £12 10s.

The twenty-six chapters of this enormous book take one from wave propagation in circuits to techniques of radio and radar astronomy. There is very little connected with microwaves that is not the least mentioned.

The book is primarily a reference book and one for those who already possess a fair knowledge of the subject. It is tersely written and the size of the book comes about because of the enormous amount of material included and not because of any prolixity on the part of the author. There are copious bibliographies and the reader is thereby referred to other publications for more detailed information.

The treatment is by no means entirely theoretical and a great deal of useful practical material is also included.

Radio-Interference Suppression on Marine Installations

Pp. 42. B.S. 1597 : 1963. British Standards Institution, 2 Park Street, London, W.1. Price 10s.

In this new edition of the standard, the scope has been extended to cover frequencies within the range 15 kc/s to 300 Mc/s, and stipulates limits within this range for the intensity of the interference-producing voltages developed at the terminals of the ship's aerials.

The requirements and test conditions for suppression components, particularly capacitors, used on board ship have been revised and extended to bring them into line with current practice.

General guidance on the steps to be taken to reduce radio-interference, covering such aspects as the radio receiving installations, electrical machinery and appliances, the wiring installations, aerial systems and ship's rigging, has been revised and extended and is now set out in appendices.

Supplement to the Elsevier Dictionaries of Electronics, Nucleonics and Telecommunication

Compiled by W. E. CLASON. Pp. 633. Elsevier Publishing Co., P.O. Box 211, Amsterdam. Price £5.

The basic dictionary comprises terms in alphabetical order with their definitions. These are in English on the left-hand pages. One the right-hand pages are the French, Spanish, Italian, Dutch and German equivalents of the terms. The terms are all numbered sequentially.

The second half of the book comprises a list in alphabetical order of the language concerned of the terms with the corresponding number of the term in the English half. An English user has need only of the first half, where he finds his term alphabetically, and is at once presented with the definition and foreign equivalents. A foreign user must first turn up his word in the appropriate section of the second half to find the serial number and then refer to the first half by this number, where he finds the English and other foreign language equivalents. The definition is provided only in English.

For example, a Spanish user turns first to section E (Español) in the second half. There he looks up 'aislador de entrada', say, and finds the number 1341. Turning to this number in the first half, he reads 'lead-in insulator' and has an English definition and the other foreign language equivalents.

Sell's Automation, Electronics, Nuclear Engineering Buyer's Guide

Pp. 314 + v. Business Dictionaries Ltd., 133-137 Fetter Lane, Fleet Street, London, E.C.4. Price 21s.

This buyer's guide comprises an alphabetical list of manufacturers' names and addresses as well as classified sections and indexes for general engineering and instrumentation. The indexes give no page or other references and appear to be merely a list of the alphabetical headings of the classified sections.

Ultrasonic Technology

By RICHARD G. GOLDMAN. Pp. 304 + x. Chapman & Hall Ltd., 37 Essex Street, London, W.C.2. Price 88s.

This book is of American origin and, apart from the introduction, its five main chapters cover the nature of sound, ultrasonic transducers, power applications, testing and examination, and the measurement of time and distance. The longest chapter is that on transducers followed closely by the one dealing with testing.

Most kinds of transducer are clearly explained, and even fluid jet methods of generating ultrasonics are included. The treatment is mainly explanatory, but a little algebra is used.

The book forms a good introduction to the subject. It is obviously intended for readers with a good background knowledge of electronics.

British Standards Yearbook 1963

Pp. 711. British Standards Institution, 2 Park Street, London, W.1. Price 15s.

The bulk of this yearbook is devoted to a list of British Standards and Codes of Practice with a description of the contents of each. I.S.O., I.E.C. and C.E.E. publications are also included. There is a detailed subject index.

Communications in Space

By ORRIN E. DUNLAP, Jr. Pp. 175 + xi. Harper & Row Ltd., 35 Great Russell Street, London, W.C.1. Price 35s.

Der Transistor

By H. SALOW, H. BENEKING, H. KRÖMER and W. V. MÜNCH. Pp. 426 + viii. Springer-Verlag, Heidelberger Platz 3, 1 Berlin 31. Price DM82.

Les Hyperfréquences

By ROGER RIGAL. Pp. 331. Editions Eyrolles, 61 Boulevard Saint-Germain, Paris 5e. Price F60.50.

Manufacturers' Literature

Belling & Lee Technical Catalogue. To provide for the filing of future information, Belling & Lee have adopted a loose-leaf style for their new technical catalogue. It is now available to senior designers and engineers, on application from their head of department.

Initially the catalogue includes 88 pages covering, by thumb-indexed sections, plugs and sockets, terminals, circuit protection devices, shielded enclosures and suppressors, and a numerical index.

Belling & Lee Ltd., Great Cambridge Road, Enfield, Middlesex.

For further information circle 81 on Service Card

What is a Capacitor . . . why Tantalum? An interesting 8-page leaflet in the form of a simple introduction to solid tantalum capacitors. Supporting this are a number of data sheets on tantalum capacitors.

Union Carbide Ltd., 8 Grafton Street, London, W.1.

For further information circle 82 on Service Card

Jastac Fixing Techniques. A 4-page leaflet giving details of a method for the insertion and fixing, by punch-through tags, of a range of components such as solder tags, terminal pins, insulating bushes, etc. With this method component tags can be punched into metal plates or laminates without the necessity for pre-punching or drilling holes.

J. & S. Engineers Ltd., 1A London Road, Crayford, Kent.

For further information circle 83 on Service Card

Automatic Plating Plant. This 32-page booklet describes various systems, types of plant and ancillary equipment used in automatic electroplating today.

The International Nickel Company (Mond) Ltd., 20 Albert Embankment, London, S.E.1.

For further information circle 84 on Service Card

Mullard Valves and Tubes for Industry Communications and Radar: Abridged Data on Current Types. This 40-page brochure highlights the principal performance characteristics of Mullard devices and tabulates them in order of their performance.

Mullard Ltd., Government and Industrial Valve Division, Mullard House, Torrington Place, London, W.C.1.

For further information circle 85 on Service Card

Brush Engineered Chart Paper. Describing the range of Brush chart paper for all types of direct writing recorders, this 4-page brochure also includes small samples of charts for ink, electric, pressure-thermal and forced-fluid recorders. Available in the U.K. through

Aveley Electric Ltd., South Ockenden, Essex.

For further information circle 86 on Service Card

Westinghouse Application Report: Trinistor Three-Phase A.C. Regulators. In this application report AR9 several circuit arrangements using Trinistor silicon controlled rectifiers for the control of 3-phase power are discussed, for loads containing resistance and resistance and inductance. A comparative assessment is made of the circuit characteristics.

Westinghouse Brake and Signal Co. Ltd., 82 York Way, London, N.1.

For further information circle 87 on Service Card

SGS-Fairchild Transistor Application Reports APP-49 & APP-58. The 8-page report APP-49 is entitled, and deals with, 'The Design of High Speed All Transistor Logic Circuits'. In 7 pages APP-58 covers 'Class-C High Frequency Amplifier'.

S.G.S.-Fairchild Ltd., 23 Stonefield Way, Victoria Road, Ruislip.

For further information circle 88 on Service Card

Dubilier 'Terecap' Plastics Film Capacitors. This 4-page leaflet lists the relevant details of one of the latest Dubilier capacitors using polyethylene terephthalate dielectric. The normal units range from 1·0 to 0·0001 μF at various working potentials from 125 to 400 V d.c.

Dubilier Condenser Co. (1925) Ltd., Ducon Works, Victoria Road, Acton, London, W.3.

For further information circle 89 on Service Card

Elliott-Automation in Aviation. A 20-page brochure in which brief details are given of the equipment and systems produced by Elliotts for aviation. Also included is a useful list of the addresses and telephone numbers and functions of the E-A companies and divisions in aviation.

Elliott-Automation Ltd., 34 Portland Place, London, W.1.

For further information circle 90 on Service Card

The Haynes Plastics Extrusion Monitor. A monitor which automatically measures and records wall thickness and concentricity of plastics tubes during extrusion is described in this 4-page leaflet. The instrument is electronic and needs no access to the inside of the tube. Distributed in the U.K. by *Research and Control Ltd., 207 King's Cross Road, London, W.C.1.*

For further information circle 91 on Service Card

Reel-Type BTM Magnetic Tape Units. Designed to operate over a standard range of transfer rates between 20,000 and 100,000 characters sec, these tape units are available in several configurations. Features include: pneumatic capstan, bin buffer storage of tape and use of motorized reels. Produced by Bell Telephone Manufacturing Company. An 8-page brochure describing the units is available in the U.K. from

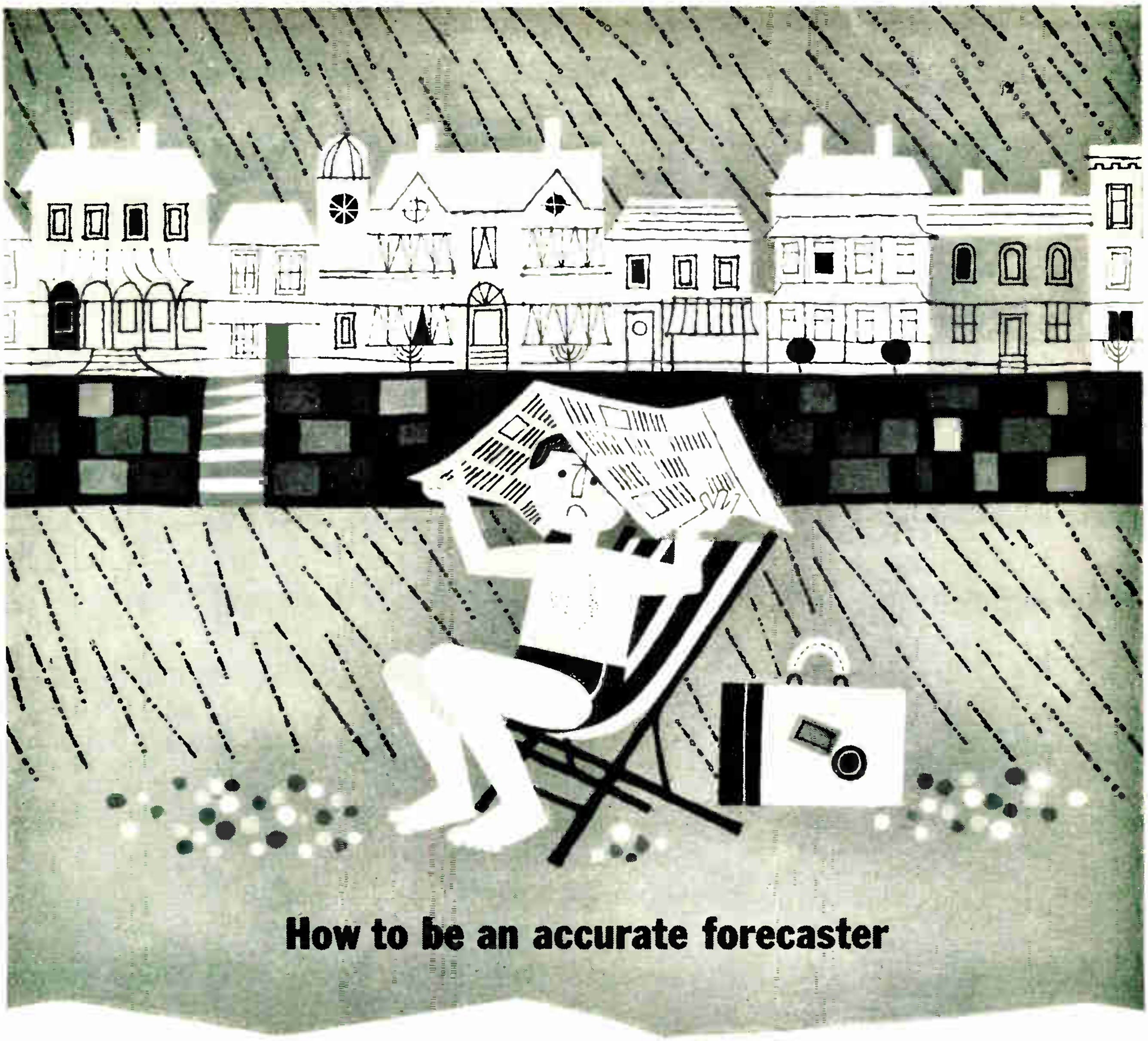
Standard Telephones and Cables Ltd., Integrated Electronic Systems Division, Burleigh House, 101-145 Great Cambridge Road, Enfield, Middlesex.

For further information circle 92 on Service Card

Fairchild Semiconductor Condensed Catalog. Listed in this 12-page booklet are details of SGS Fairchild transistors, diodes, micrologic products and test equipment. Distributed in the U.K. by

S.A.S.C.O. Ltd., Adastral House, Nutfield, Redhill, Surrey.

For further information circle 93 on Service Card



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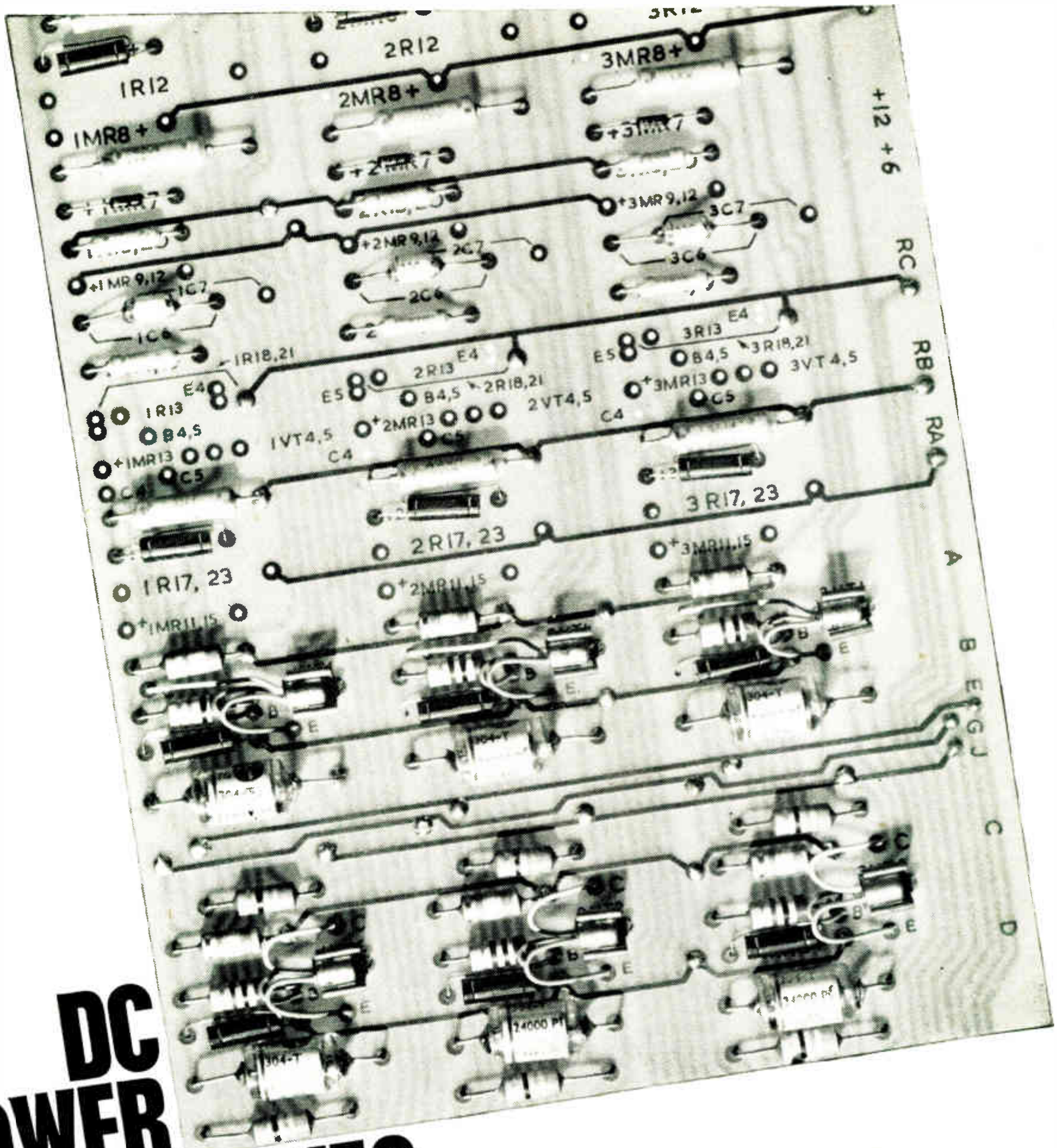

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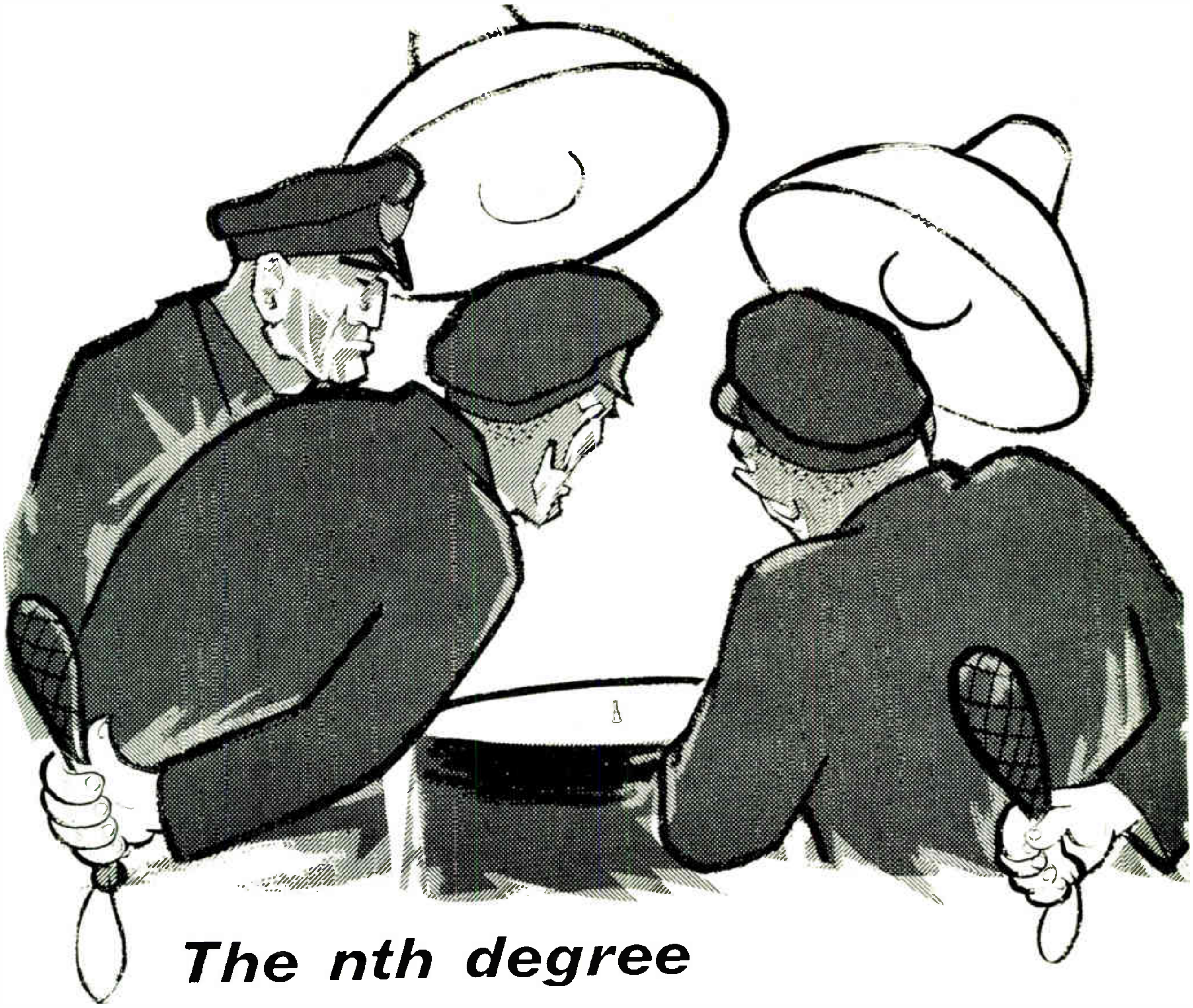

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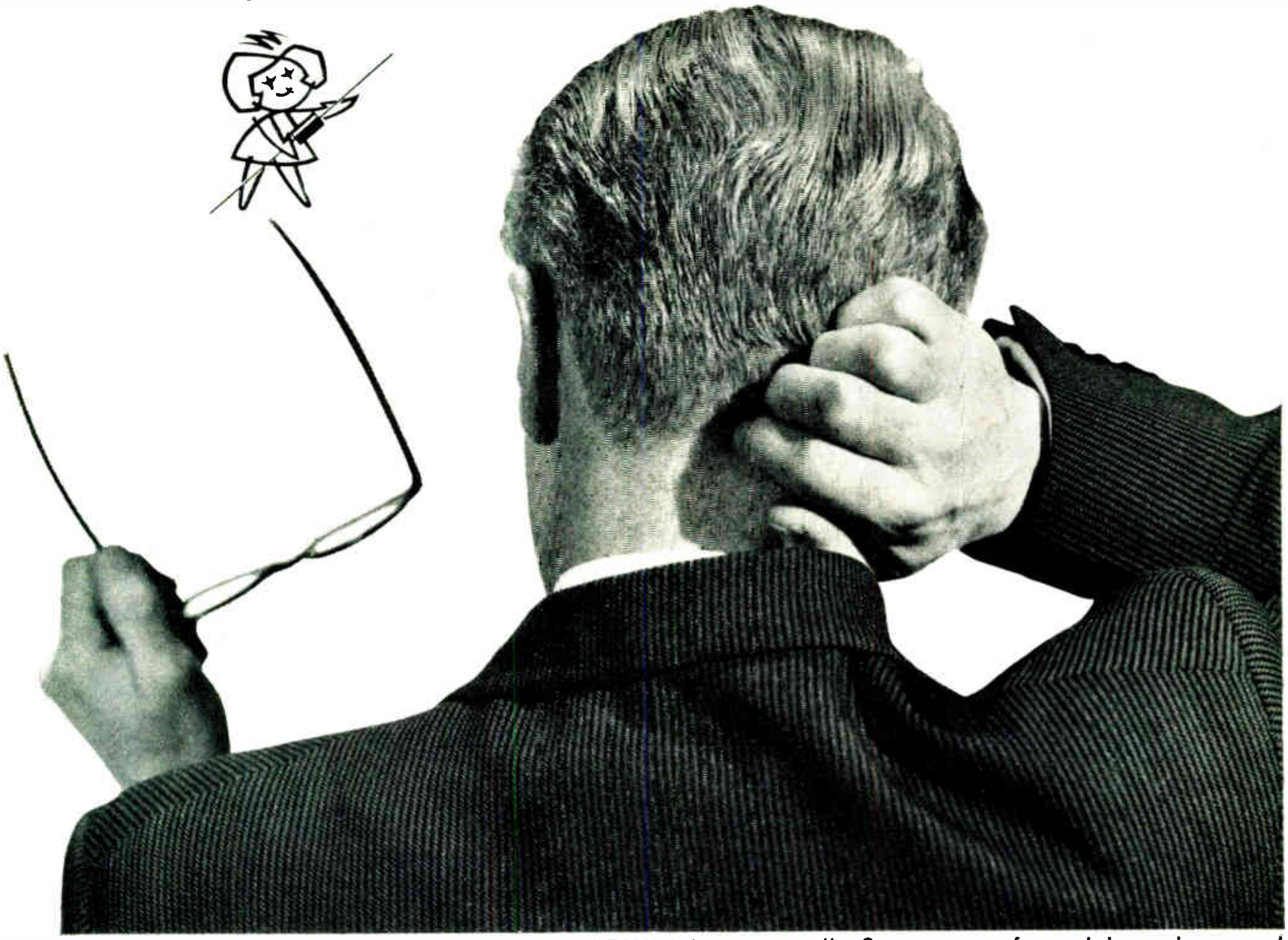

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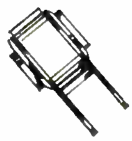

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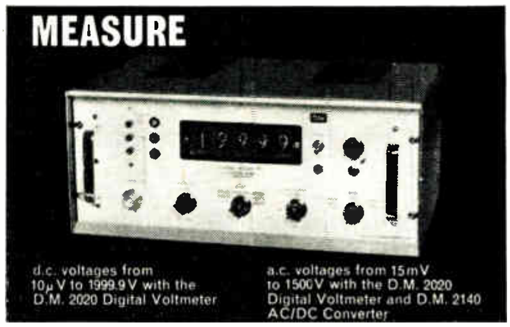

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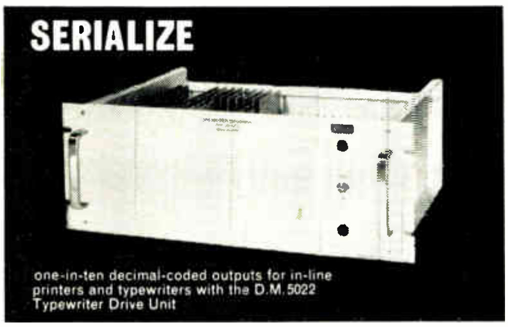

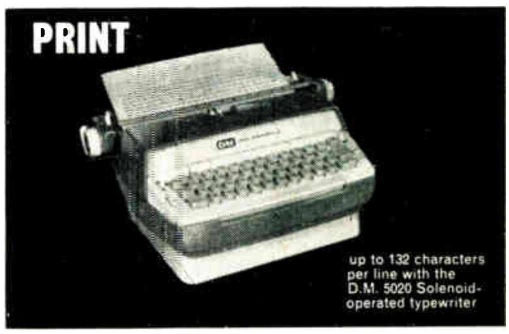

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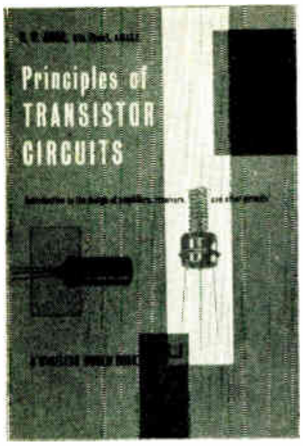

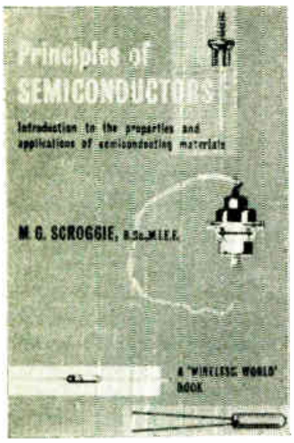

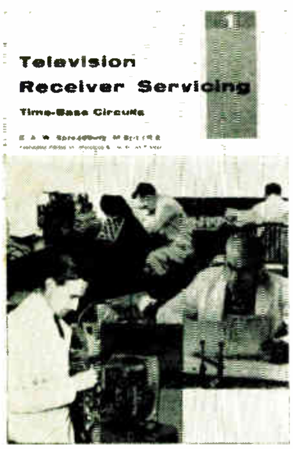

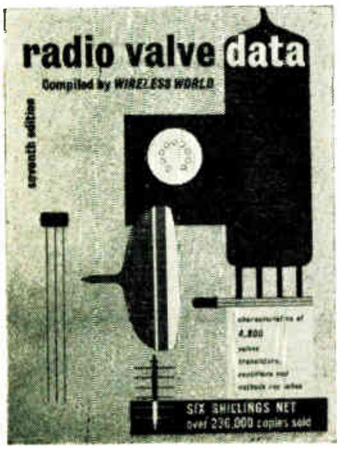

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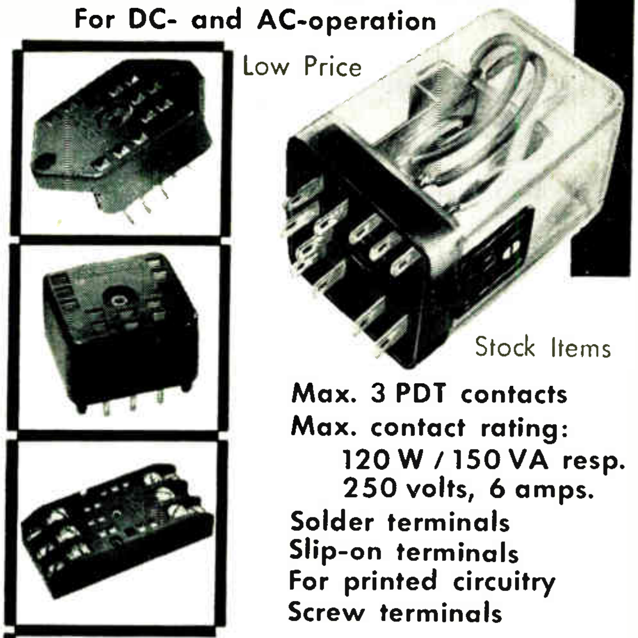

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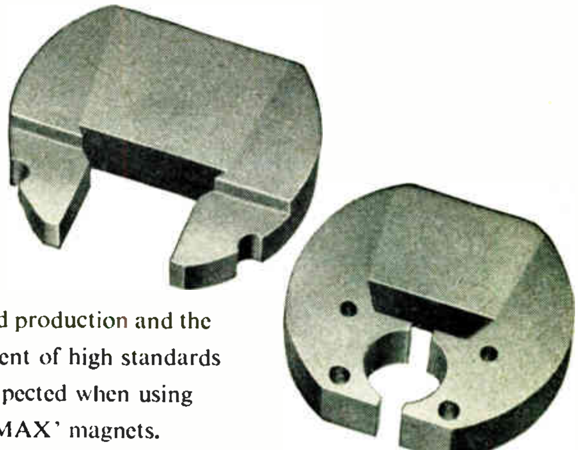

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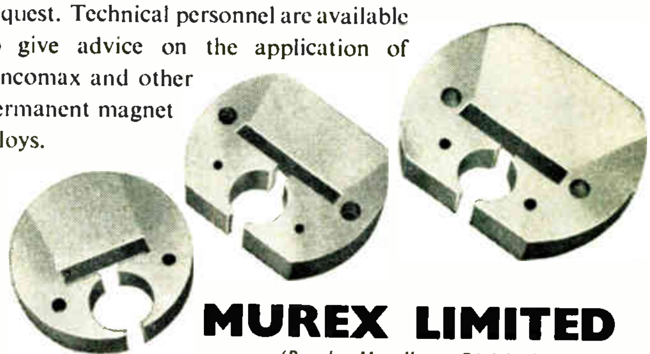

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