INDUSTRIAL ELECTRONICS

JANUARY 1965 5s 0d

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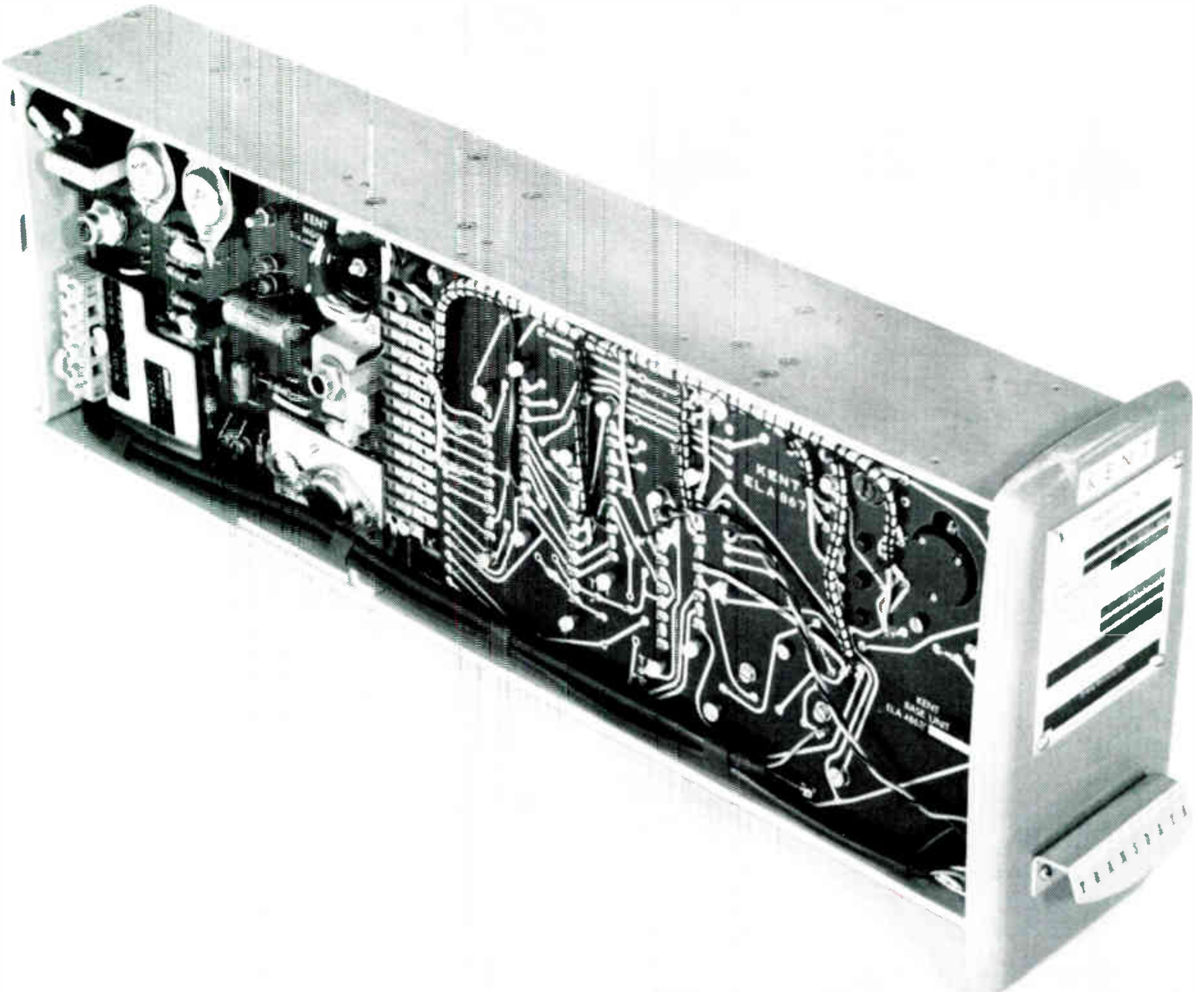

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May we send you further details of the Kent Transdata system?

KENT

For further information circle 200 on Service Card

INDUSTRIAL ELECTRONICS

Automation Instrumentation Control

Volume 3 Number 1 January 1965

continued overleaf

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INDUSTRIAL ELECTRONICS

Automation Instrumentation Control

Contents *continued*

OUR COVER

This month's front cover shows the Niarchos bulk carrier 'World Cavalier', 21,680 tons d.w., discharging grain at London Docks. An electronic solution to problems of ship cargo distribution is discussed in an article which begins on page 2

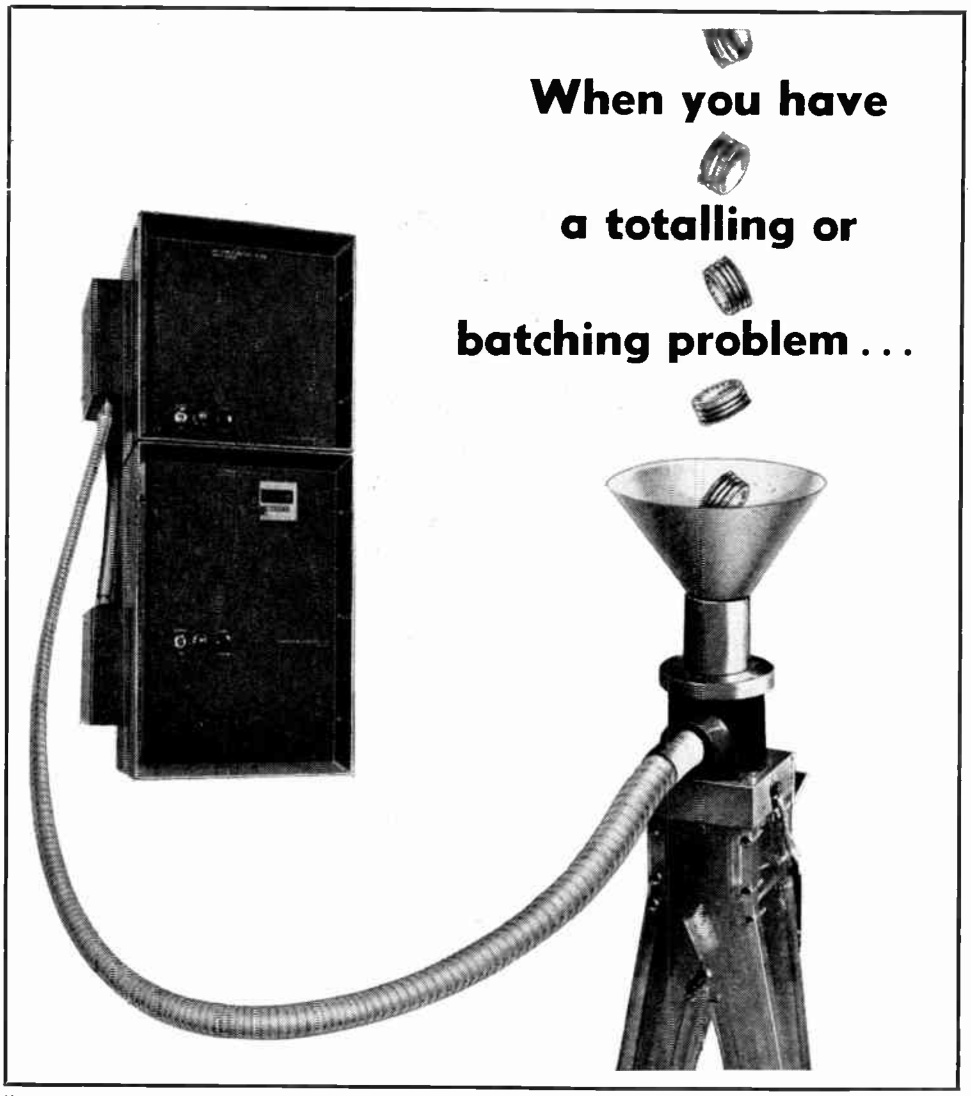
Features

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 included in this journal.

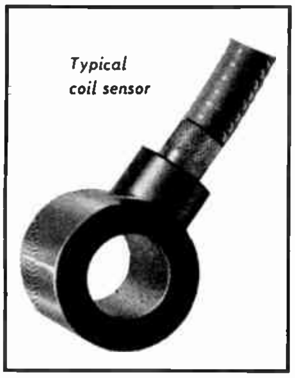
Next Month

A system for the automatic control of high-speed forging will be described in next month's issue. Among the other articles will be one on a land navigation system which enables the position of a vehicle to be continuously plotted.



Vane actuator diverts components into each chute alternately according to batch quantity

LIVINGSTON COUNTS



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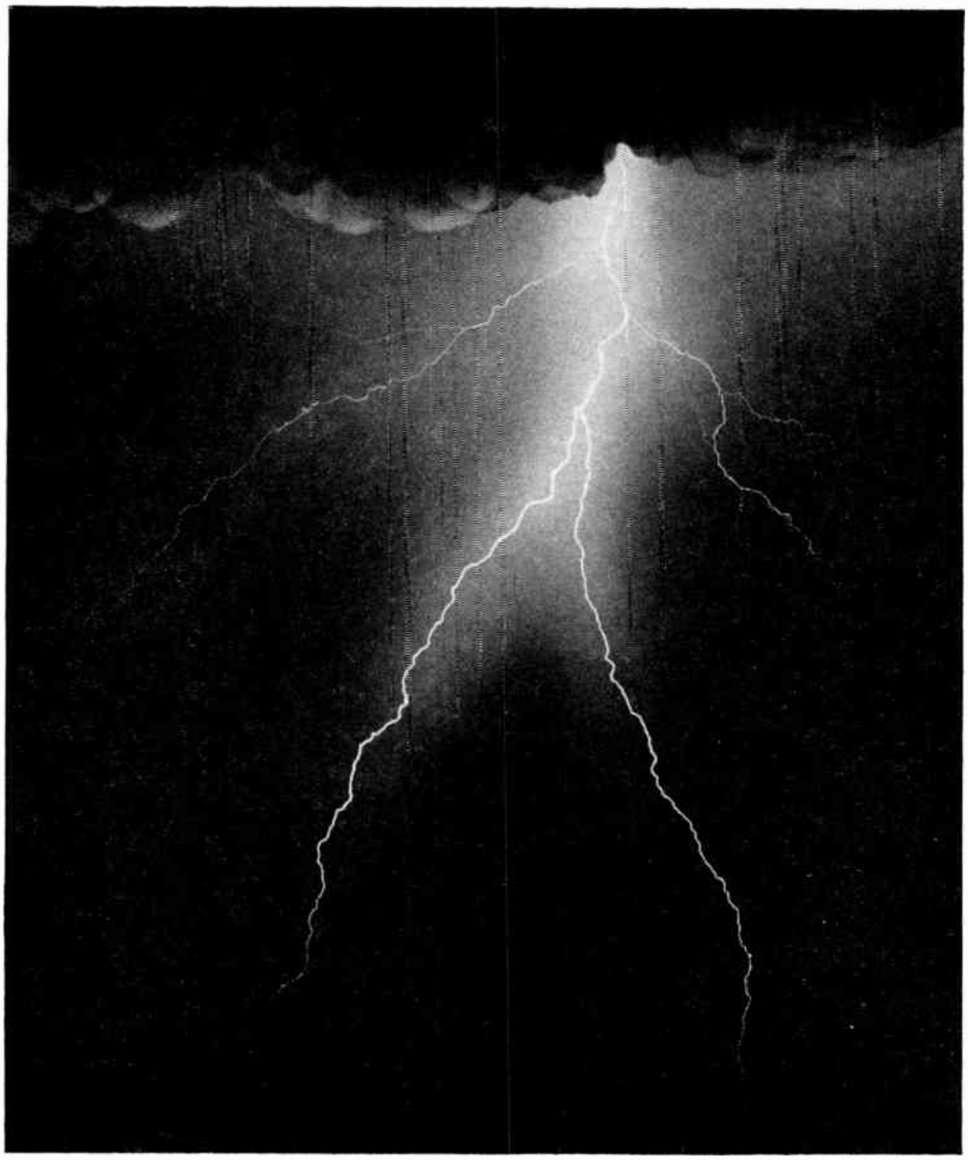

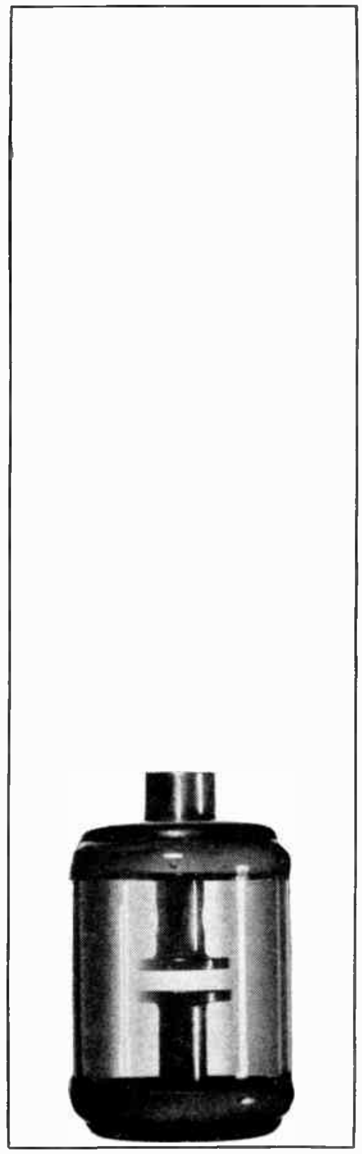

spark gaps

We make the one on the right — less spectacular perhaps but more practical in its application. For example as you read this the chances are that somewhere equipment containing our spark gaps is helping to get another jet pay load safely airborne or maybe a New Zealand cattle farmer is making life a little easier for himself by using electrified fencing energised to the required level with the aid of spark gap tubes.

Your application may not be in these categories — you may be interested only in circuit protection or fuel ignition or just plain high voltage switching — if so we could have a diode or triggered spark gap to suit. Tubes are available with glass/metal or ceramic/metal seals. If you would like more information or care to talk about spark gap applications, write or telephone the Tube Division.

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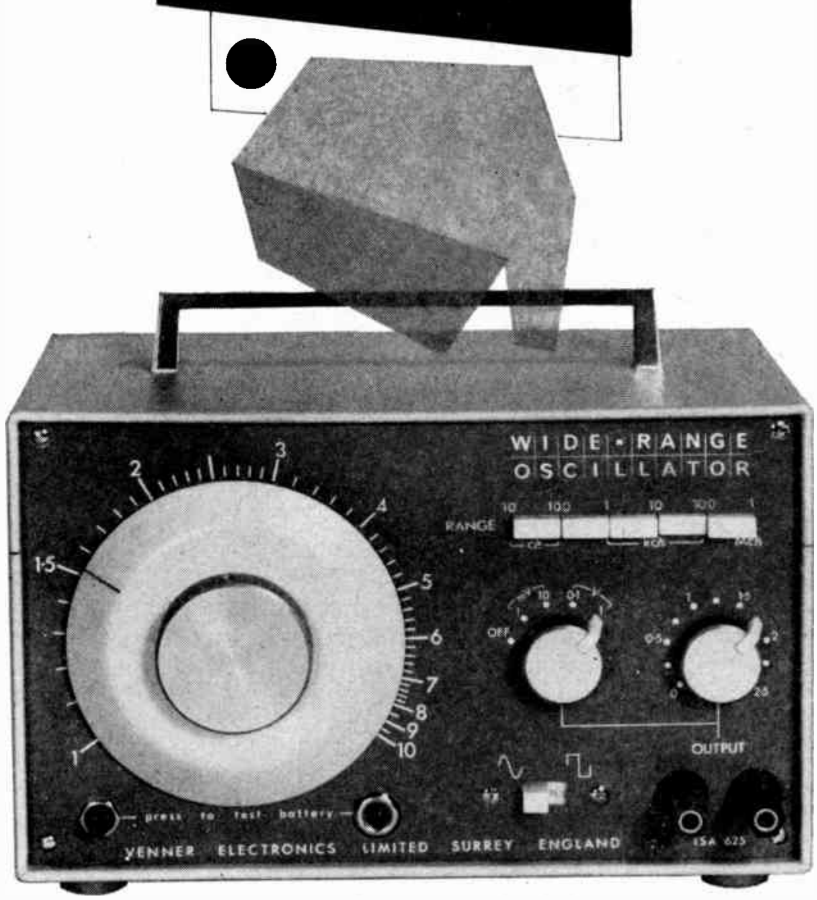

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These components have gained a high reputation for reliability of performance and are widely used in the Radio, Television and Electronic industry at home and overseas.

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S.56-11/1 P.T.F.E. Dielectric. Bush Mounting. Cap: ·5 pf. to 7 pf.

S.50-01/2 P.T.F.E. Dielectric. 20 s.w.g. Wire Mounting or

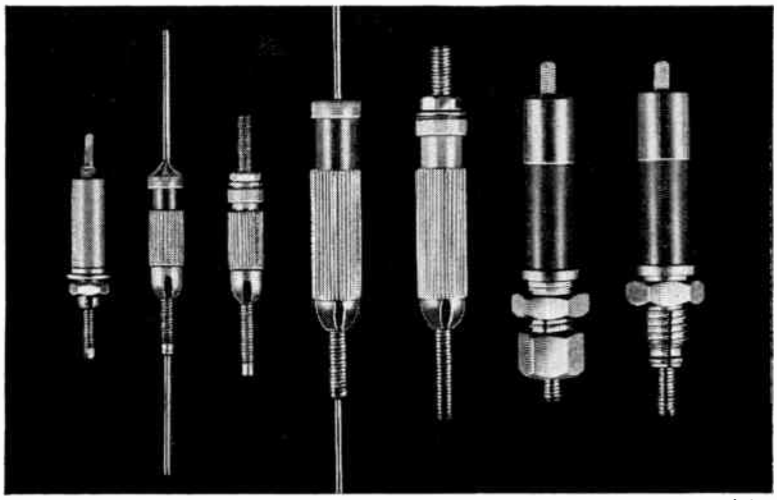
S.50-01/4 Screwed Stem Mounting. Cap: ·7 pf. to 3·3 pf.

S.50-11/3 P.T.F.E. Dielectric. 20 s.w.g. Wire Mounting or

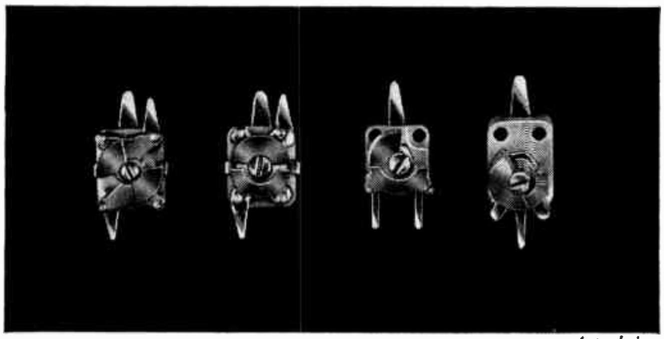
S.50-11/6 Screwed Stem Mounting. Cap: 1 pf. to 12 pf.

S.55-13/1 Mycalon Dielectric. With Locking Nut. Cap: 1 pf. to 10 pf.

S.55-11 Mycalon Dielectric. Without Locking nut.



Actual size



Actual size

AIR DIELECTRIC TRIMMERS

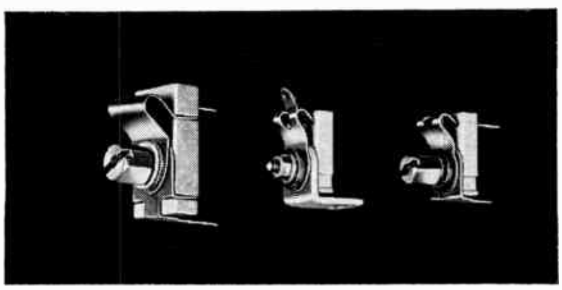
C.39-52 Butterfly type Cap: 7·75 pf. max. each section.

C.39-32 Differential type Cap: 10 pf. max.

C.37-01 Printed Board type Cap: up to 16·5 pf. max.

C.32-01 Cap: 11 pf. max.

COMPRESSION TRIMMERS

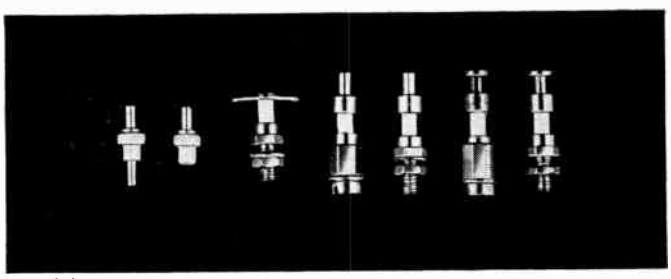


Actual size

S.14-01 Printed Board Mounting Cap: up to 140 pf.

S.15-01 Bracket, or

S.15-11/2 Printed Board Mounting. Cap: 2 - 25 pf.



Actual size

STAND OFF INSULATORS
P.T.F.E. LEADTHROUGHS

P.T.F.E. Leadthroughs: LT. 2-02 LT. 2-02/2.

T.S. 6-01

T.S. 6-01/12 with spill, and internal thread.

T.S. 6-01/6 with spill.

T.S. 6-01/3 Stand Off Alumina Insulator with bollard, and internal thread.

T.S. 6-01/4 Stand Off Alumina Insulator with bollard.

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Measures From 50μV to 500V on 12 Ranges and can be used as an Amplifier

TRANSISTOR
A.C. VOLTMETER
TYPE TM2B

SPECIFICATION

VOLTMETER RANGES
1.5mV, 5mV, 15mV . . . 500V f.s.d.

ACCURACY
±2% of reading ±1% of f.s.d. at 1kc/s.

dB RANGES
−80dB to + 56dB relative to 1mW into 600Ω.

FREQUENCY RESPONSE
±3dB from 6c/s to 250kc/s.
±0.7dB from 10c/s to 100kc/s.
±0.2dB from 20c/s to 50kc/s.
±0.1dB from 30c/s to 30kc/s.

INPUT IMPEDANCE
1.8MΩ and 10pF on 1.5V to 500V.
>0.8MΩ and <60pF on 5mV to 500mV.
>0.5MΩ and <65pF on 1.5mV.

INPUT NOISE LEVEL
<15μV for zero source resistance.
<30μV for 100kΩ source resistance.

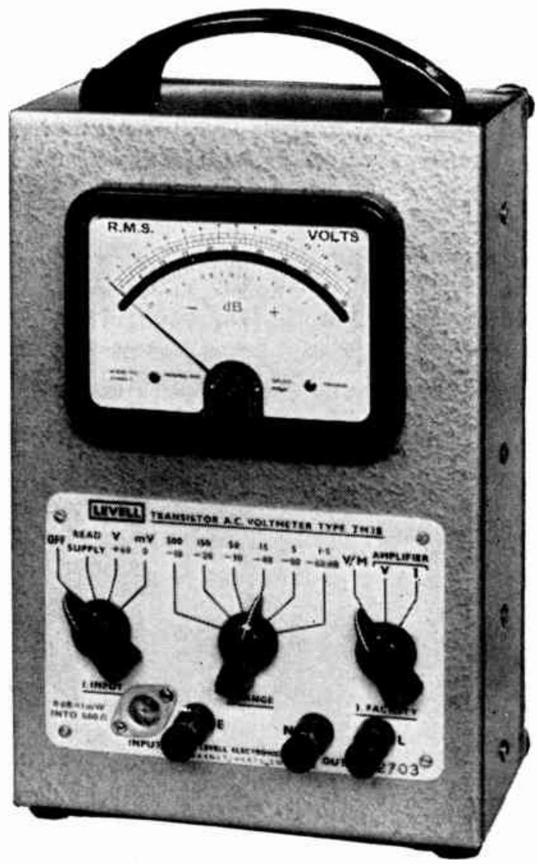
AMPLIFIER RANGES
10dB steps up to 60dB with frequency response and input impedance as above; 80dB gain from 10c/s to 30kc/s with input impedance >50kΩ.
Output 1.5V to 10kΩ.

MICROVOLT INDICATOR RANGE
<150μV f.s.d. <10μV readable from 30c/s to 30kc/s.

MAXIMUM INPUT VOLTAGES
75V A.C. and 350V D.C. on "mV".
750V A.C. peak plus D.C. on "V".

SUPPLY
Self-contained PP9 batteries; typical life 1000 hours or A.C. Mains when power unit is fitted.

SIZE AND WEIGHT
10″ high × 6″ wide × 4″ deep; 6 pounds.



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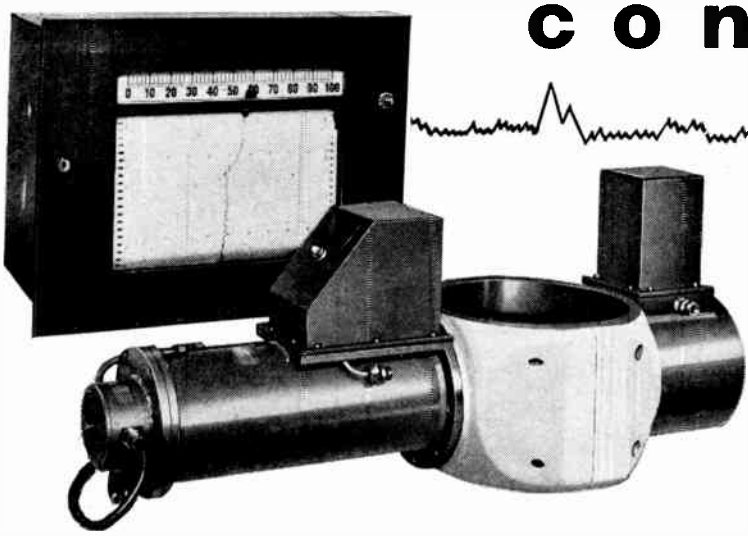
continuous

indication of DENSITY



The Density Gauge Type 336 is designed for accurate continuous indication of density or solids content of liquids, slurries and certain solids in industrial process lines. Considerable economy can be obtained by accurate control of material density during plant start-up and running. Automatic control of dilution, evaporation, bleeding, etc., releases skilled staff from routine testing. The great advantage of this type of gauge is that the small source minimises radiation risks and the instrument automatically standardises itself, eliminating all manual control.

No contact is made with the material to be measured, and readings are preserved on a recorder chart. Installation is extremely simple, the gauge need only be clamped around the pipe through which the material is passing, and once calibrated there is nothing more to do, except switch on. Readings are direct, automatic, and continuous. Gauges are available to fit pipe lines from 2" to 24" in diameter, the optimum size being 10 ins.

Prices range from £800

Write for full technical details

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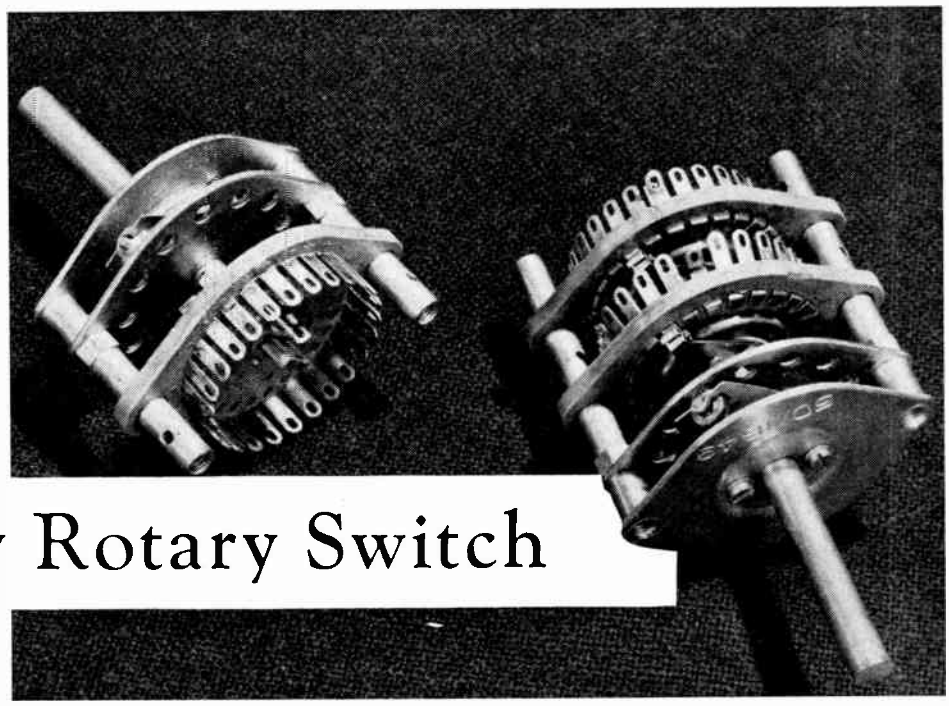

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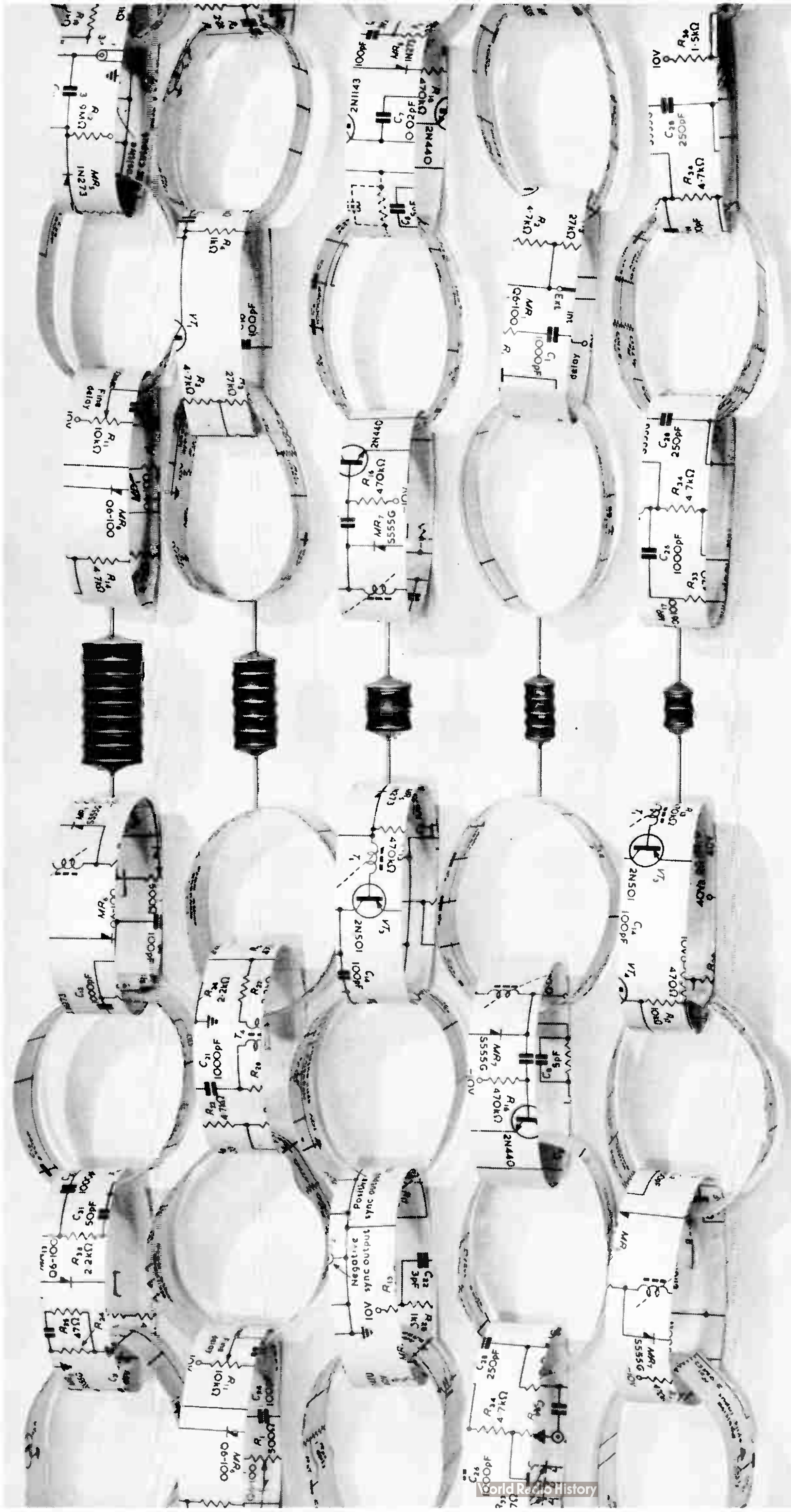
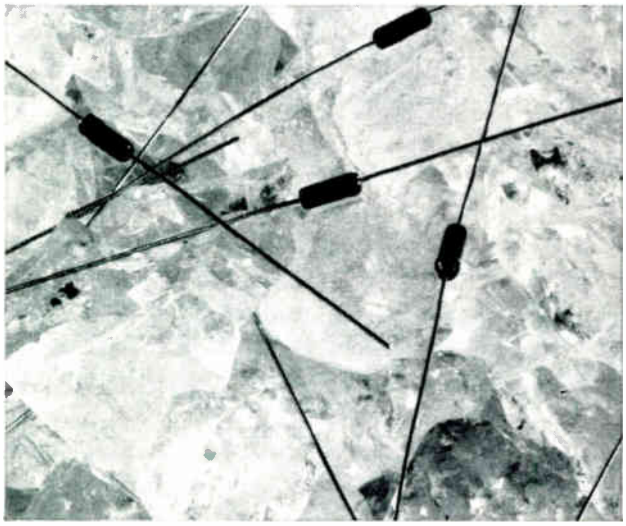


JANUARY, 1965

STC components review



Silicon diodes in all-glass encapsulation

STC silicon epitaxial planar diodes for high-speed switching are now available in an all-glass encapsulation. These will replace completely the earlier, resin moulded version. In addition, the range now includes the popular JEDEC types 1N914 and 1N916, also glass-encapsulated.

Of particular note is the BAY50 charge storage diode which has the following characteristics:—

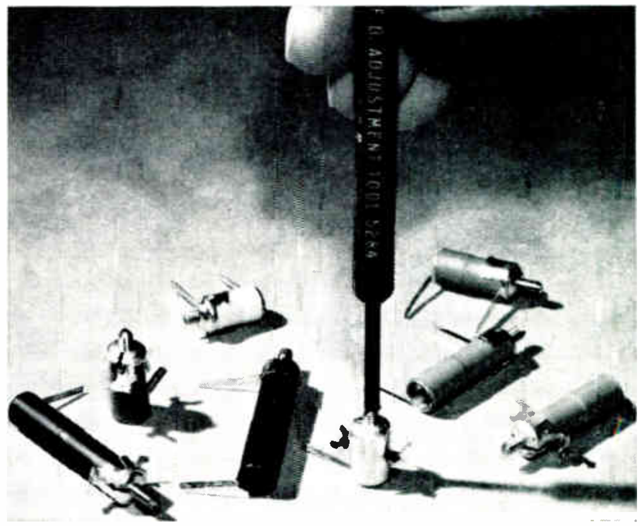
Minority carrier storage at	$I_F = 10mA$	500 pC(min)
Forward voltage at	$I_F = 30mA$	1 V (max)
at	$I_F = 20\mu A$	0·5 V (min)

BRIEF DATA FOR STANDARD RANGE

Type	Maximum Forward Voltage (V)	Reverse Current (nA)	Maximum Reverse Recovery Time (ns)	Maximum Capacitance (pF)	P.I.V.
BAY31	1·0 at 30mA	20 at —15V (typ)	5 at 10mA, 10V	6	15
BAY36(1N4147)	1·0 at 30mA	11 at —30V (typ)	5 at 10mA, 10V	6	30
BAY52	1·0 at 20mA	50 at —10V (max)	15 at 10mA, 6V	8	15
1N914	1·0 at 10mA	25 at —20V (max)	4 at 10mA, 6V	4	75
1N916	1·0 at 10mA	25 at —20V (max)	4 at 10mA, 6V	2	75

The case outline for the range remains in accordance with the VASCA SO-6 and JEDEC DO-7 specifications.

Write, 'phone or Telex for Data Sheets to STC Semiconductor Division (Transistors), Footscray, Sidcup, Kent. Telephone FOOtscray 3333. Telex 21836.



Piston trimmer capacitors

The Stangard, low cost, tubular glass piston trimmer range is now being marketed in the UK by STC Capacitor Division. The trimmers are ideal for use in such equipment as oscilloscopes, bridges, signal generators, frequency standards, calibrators, spectrum analysers, f.m. tuners and many applications previously limited to rotary ceramic discs, tubular ceramics and air variables.

Stangard trimmers are manufactured by JFD Electronics Corporation of New York and stocks are maintained by STC. The trimmers are ruggedly built and have a vinyl encapsulation which protects the glass dielectric against shock. Low cost is achieved through the use of solid electrode bands and automated production lines.

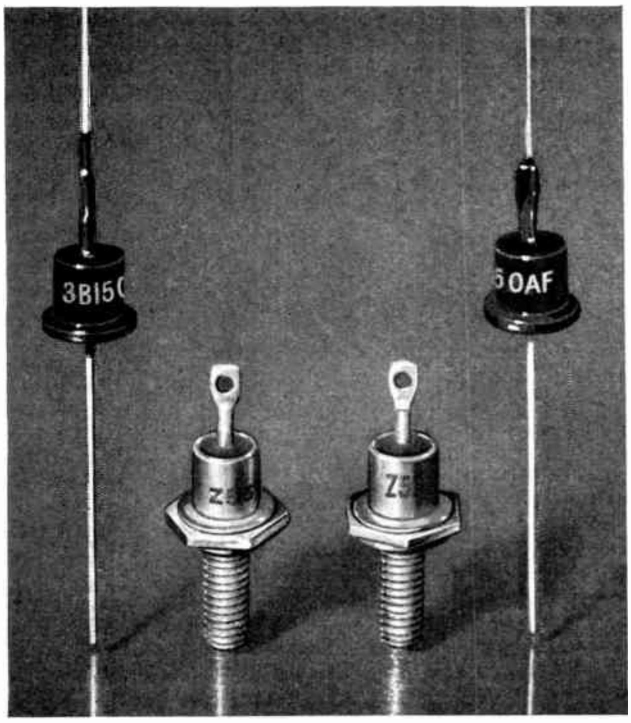
ABRIDGED DATA

Capacitance (pF)		OC Working Voltage (V)	Printed Circuit Model		Chassis Mounting Model		Body dia. Both Models (inches)
Min.	Max.		Code	Body Length (inches)	Code	Body Length (inches)	
0·5	3·0	1000	ST 851	3/32	ST 861	9/16	9/32
0·8	5·0	1000	ST 852	9/16	ST 862	23/32	9/32
1·0	8·0	1000	ST 853	7/8	ST 863	1-1/32	9/32
1·0	12·0	1000	ST 854	1-5/16	ST 864	1-7/16	9/32

Electrical characteristics include: Q better than 1000 at 1 Mc/s, insulation resistance 10^6 MΩ at 500 V d.c. and a dielectric that will withstand in excess of 2000 V. In addition, Stangard capacitors have a smooth adjustment torque and multiturn adjustment for sensitive tuning. These properties are fully retained through a temperature range of −55°C to +125°C.

Other JFD Products available through STC are:
Professional-grade piston trimmers
Ceramic capacitors, Delay lines
L.C. Circuits, Metallized inductors.

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.



Zener diodes

1·5W DISSIPATION

Established ranges of STC Silicon Zener Diodes are wire-ended devices with a maximum rating of 1·5 Watts. Designated Z3 Series, they are available in standard preferred values from 3·3 volts to 100 volts inclusive with voltage tolerances of ±5%, ±10% or ±20%.

ABRIDGED DATA (1·5 W Range)	
Nominal voltage range	3·3-100 V
Maximum power dissipation	1·5 W
Maximum continuous forward current	1·3 A at 25°C ambient
Maximum working junction temperature	175°C
Storage temperature range	−65°C to +175°C
Maximum forward volt drop at 1·3 A	1·2 V
Maximum thermal resistance (junction to air)	100°C/W
Standard outline	VASCA SO-16 JEDEC DO-1 IEC 1-101

10W DISSIPATION

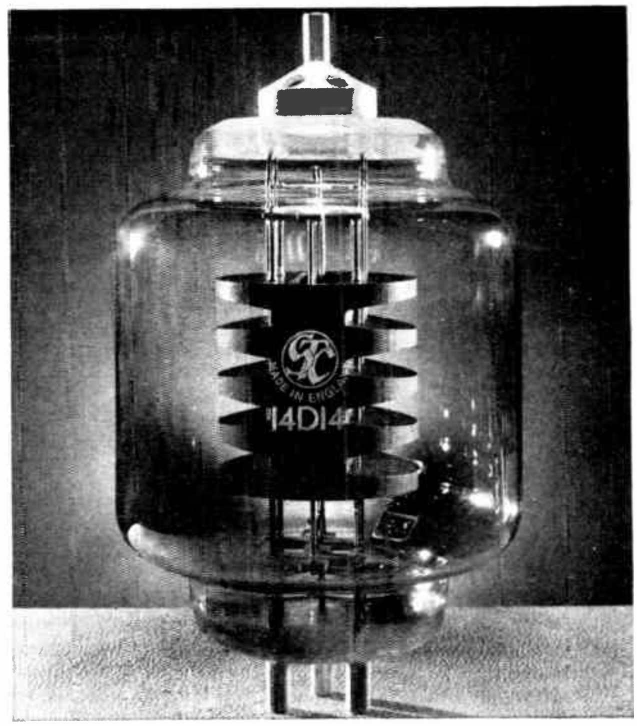
These new additions to the STC range of Zener diodes are available in standard preferred values from 8·2 volts to 100 volts inclusive.

Good Zener characteristics with sharp turn-over, low slope resistance and low leakage current are predominant features.

Their voltage drop is independent of current over a wide current range which makes them suitable for d.c. voltage regulation, clipping, limiting and surge protection within the bounds of their maximum ratings.

ABRIDGED DATA (10 W Range) ELECTRICAL RATINGS AT 50°C STUD TEMPERATURE	
Nominal voltage range	8·2 to 100·0 V
Voltage tolerances	±5%, 10% & 20%
Maximum power dissipation	10W
Maximum working junction temperature	150°C
Storage temperature range	−65 to 150°C
Standard outlines	IEC 1-103 VASCA SO-10 JEDEC DO-4

Write, 'phone or Telex for Data Sheets to STC Semiconductor Division (Rectifiers), Edinburgh Way, Harlow, Essex. Telephone 26811. Telex 81146.



AF Power amplifier valves

STC manufacture power amplifier valves for a range of applications including use as vibration, modulation and public address amplifiers. Typical is the Type 14D14 shown above and which has a safety factor on anode dissipation of 250%. It is intended for use where the load impedance is variable and where the valve may be subjected to high dissipation. The electrical characteristics, other than anode dissipation, are similar to those of type 4212E.

ABRIDGED DATA

Code	μ	Screen Grid (μ)	g_m (mA/V)	P_a max. (W)	AF Output Class AB2 (2 valves p.p.) (W)	RF Output Class C W	RF Output Class C Mc/s	
4242A† (CV25)	12·5	—	4·0	85	220	142	6·0	Triodes
4212E‡ (CV1252)	16	—	8·4	275	1 400	930	1·5	Triodes
14D14	16	—	8·0	750	1 400	930	1·5	Triodes
5B/255M (CV391)	—	9·0	6·0	25	80	40	60	Beam Tetrodes
813 (CV26)	—	8·3	3·75	100	500	275	30	Beam Tetrodes

† Replaces type ES85 ‡ Group 5 version replaces types 1501 & 14D13

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

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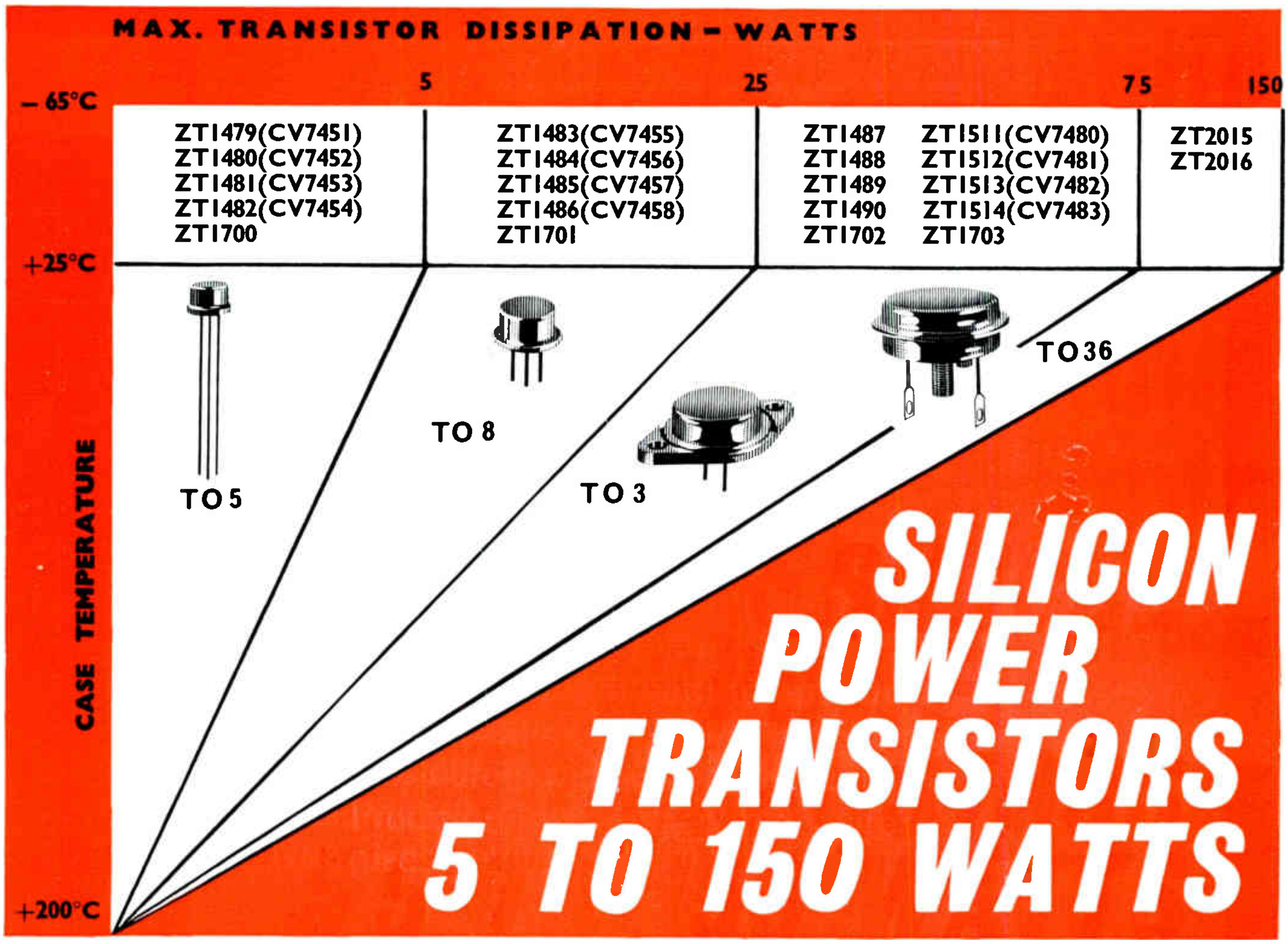

The appropriate commercial type may be released to the relevant CV specification as indicated by the QA number

SPECIAL FEATURES

* HIGH COLLECTOR VOLTAGE
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* HIGH JUNCTION TEMPERATURE
* NARROW GAIN SPREADS
* LOW SATURATION RESISTANCE

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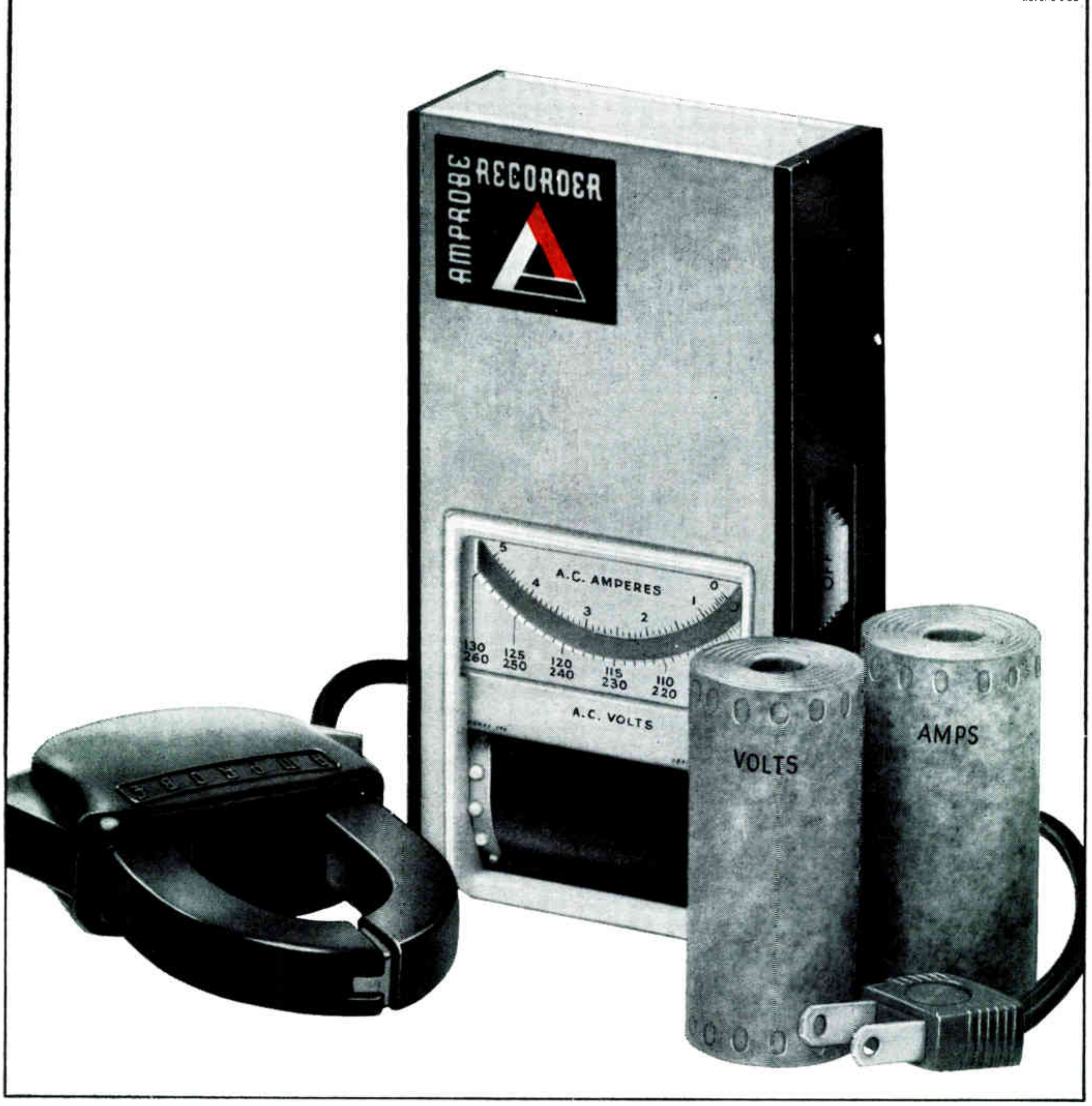
ACTUAL SIZE



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* High impedance input circuit
* Stable against varying supply voltages and ambient temperatures
* Solid-state control switching to 0.1% differential. (No photo-cells)
* Precision long-sweep slide wire gives resolution to 0.1%

Many thousands of these low-cost, potentiometric, servo-operated, fully transistorised instruments have given maintenance-free service for over four years. They are the obvious choice for all temperature applications. Write for leaflets listed below.

THERMOCOUPLE INSTRUMENTS

INSTRUMENT	SCALE LENGTH	CALIBRATION ACCURACY	MAX DISTANCE—MEASURING POINT TO INSTRUMENTS	APPROX. SIZE	WRITE FOR LEAFLETS
Indicator	12½"	± 0.5%	100's yards	6" dia.	BIK PT/2/1
Ind/Controller	12½"	± 0.5%	100's yards	6" dia.	BIK PT/2/1
Recorder/Ind	13"	± 0.5%	100's yards	8¾" x 7½"	BIK PT3/1
Rec/Ind/Cont	13"	± 0.5%	100's yards	8¾" x 7½"	BIK PT3/1
Rec/Ind/Prop.Cont	13"	± 0.5%	100's yards	8¾" x 7½"	BIK PT3/1

RESISTANCE BULB INSTRUMENTS

INSTRUMENT	SCALE LENGTH	CALIBRATION ACCURACY	MAX DISTANCE—MEASURING POINT TO INSTRUMENTS	APPROX SIZE	WRITE FOR LEAFLETS
Controller	9"	± 0.5%	300 feet	4½" dia.	BIK 1
Indicator	12½"	± 0.5%	300 feet	6" dia.	BIK 2/C
Ind/Controller	12½"	± 0.5%	300 feet	6" dia.	BIK 2/C
Recorder/Ind	13"	± 0.5%	300 feet	8¾" x 7½"	BIK 3
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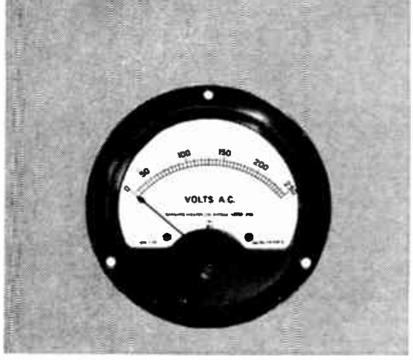

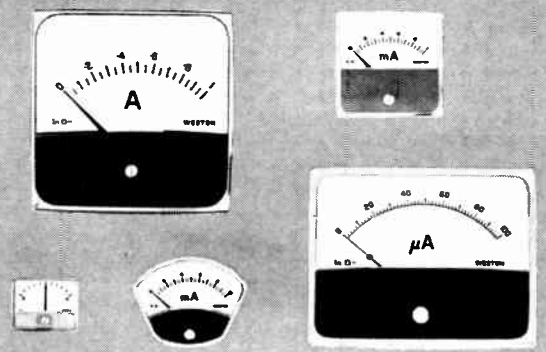

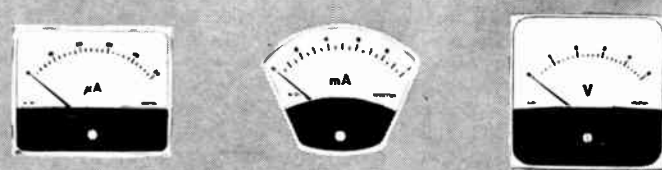

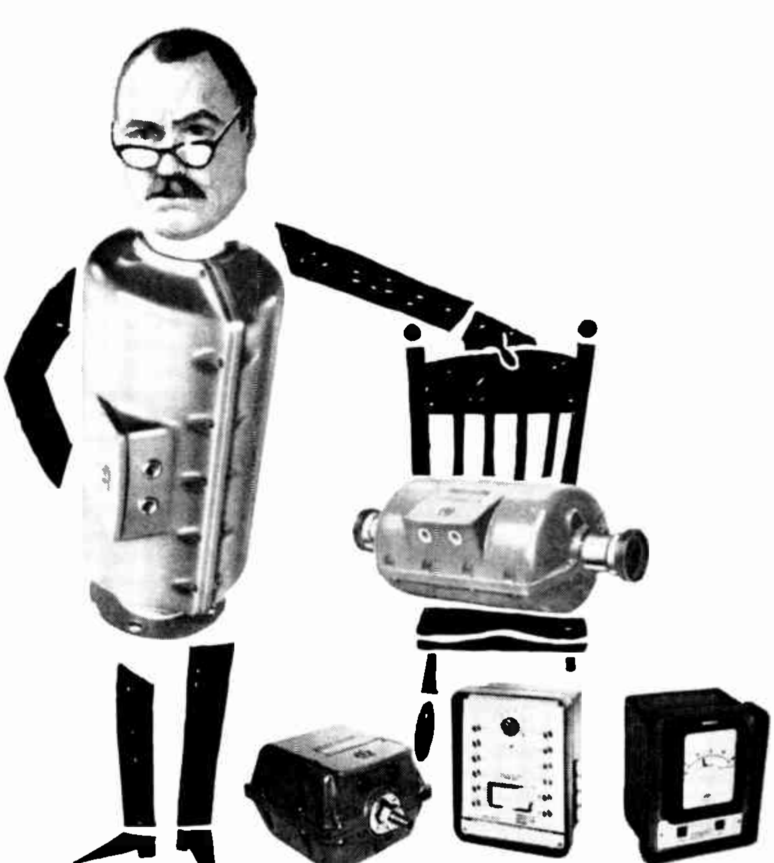

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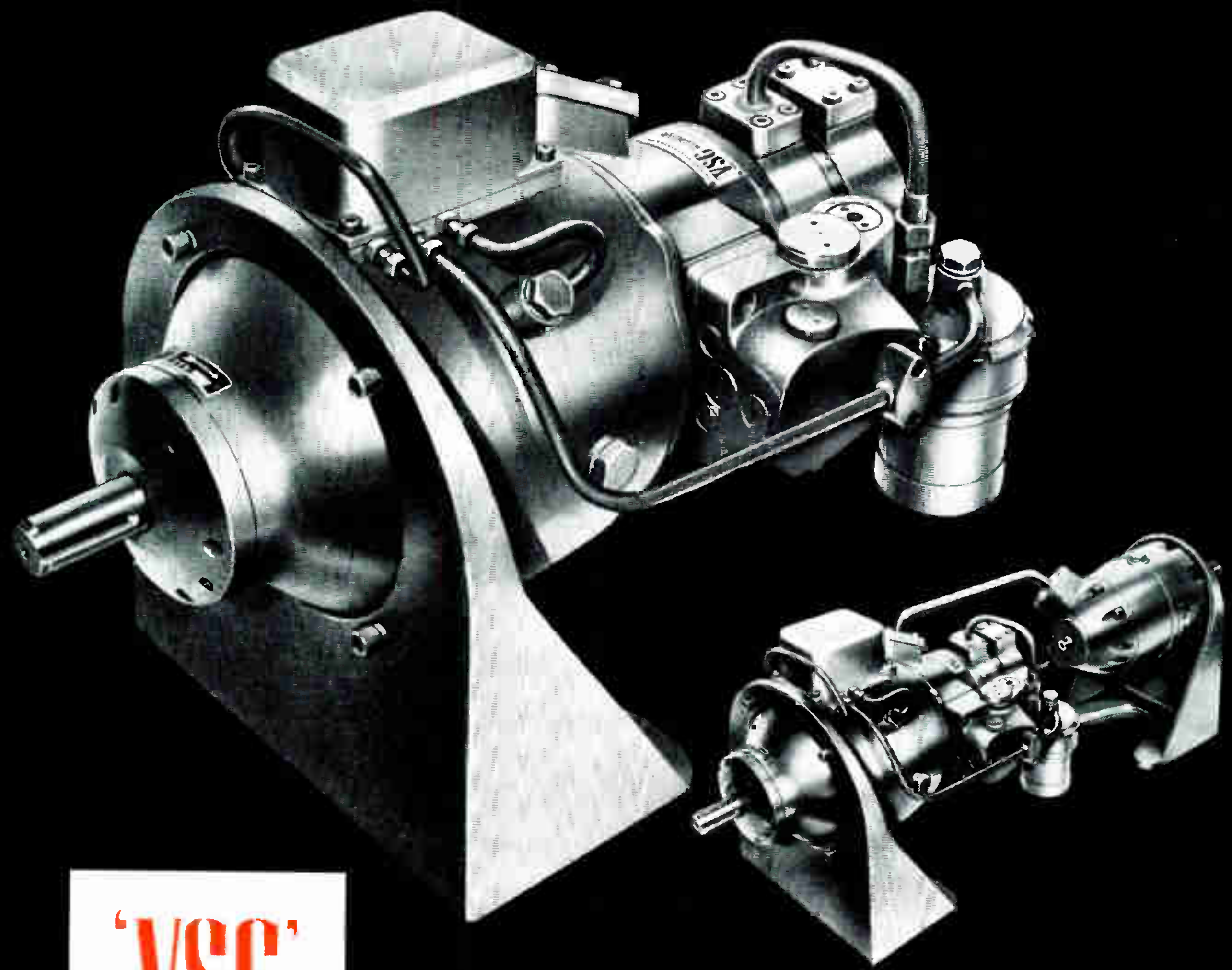
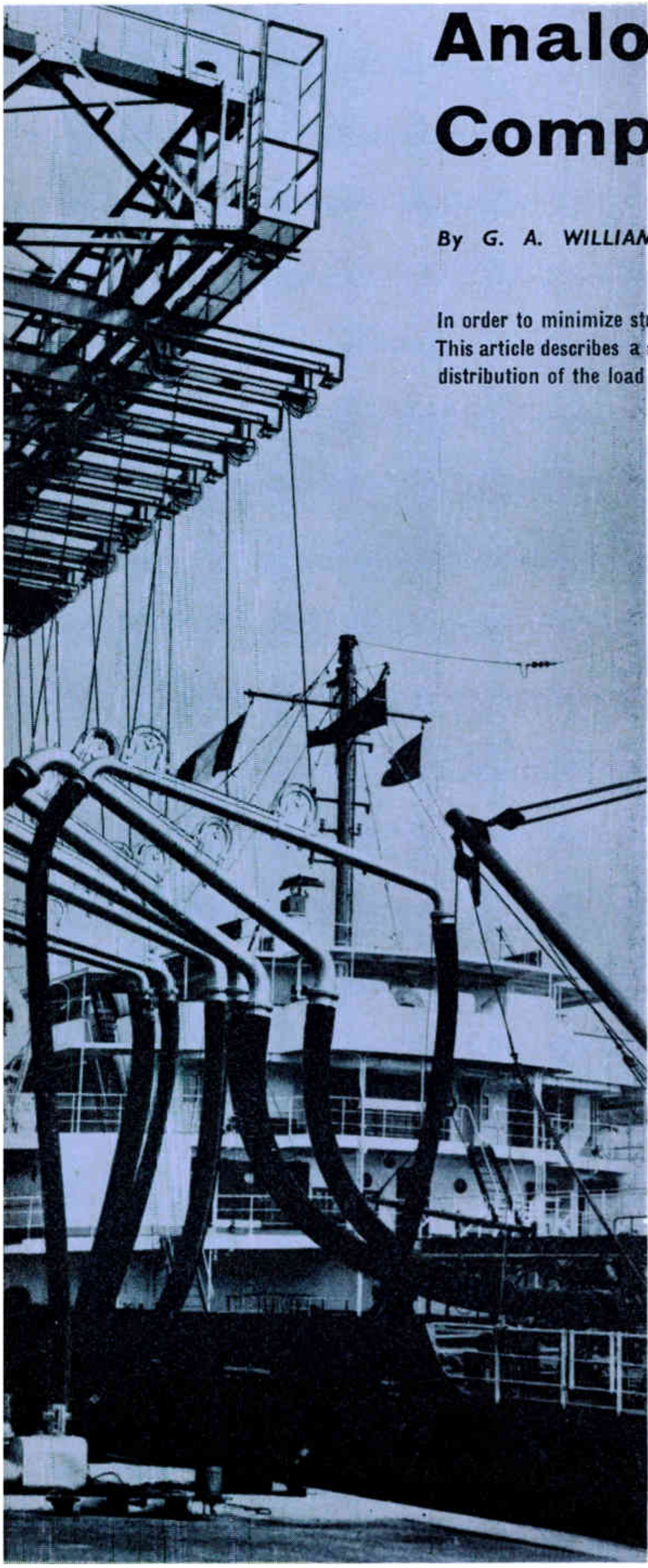




Analogue Loading Computer for Ships

By G. A. WILLIAMS, A.R.I.N.A.* and J. B. CARR, A.M.R.I.N.A., A.M.I.Mar.E., M.C.M.S.*

In order to minimize stresses in a ship it is necessary that its cargo be correctly loaded. This article describes a special- purpose analogue computer which enables the proper distribution of the load to be readily determined.

SHIPS designed for the bulk transportation of cargoes such as crude and refined petroleum, ore, grain, etc., are being built in ever-increasing sizes in an effort to achieve lower ton-mile transportation costs. Tankers built at the end of the last war averaged 14,000 tons deadweight cargo capacity, whereas some modern tankers are capable of loading more than 130,000 tons, an almost ten-fold increase in less than 20 years. The lower transport costs available to the shipper through the use of such giant vessels have, however, produced new problems for the shipowners and their seagoing staff, not the least of which is the danger of the vessel suffering structural damage due to the extreme bending moments and shear stresses set up within the hull by bad distribution of the cargo.

The reasons for the existence of these bending and shearing stresses can best be understood when it is appreciated that, for these purposes, the hull of a ship may be considered as similar to the main beam of a bridge subjected to upward forces at each supporting pier and downward forces due to its own weight and to the weight of vehicles passing over it.

The parallel between the bridge and the ship can perhaps best be shown by Figs. 1 and 2 with their associated bending moment and shear force diagrams.

In the case of a ship, the study of the forces involved is complicated by the continual change in buoyancy due to waves of varying height passing along the hull and, for this reason, all strength calculations are carried out assuming the ship to be floating in still water. Many years of practical experience and the study of wave forms have shown naval architects that stresses introduced by waves never exceed three times the still water stress, so that any particular ship's hull is designed safely to resist three times its normal maximum still-water bending moment and shear force. The term 'normal maximum' is important as it implies that the various loads carried in the ship (i.e., cargo, ballast, water, fuel, etc.) are arranged within the hull to give the lowest possible stress. Incorrect loading can cause stresses in excess of the maximum that the hull has been designed to resist.

This problem of excessive stress is peculiar to the naval architect, as the civil engineer designing a bridge can take the easy way out and simply increase the dimensions of the structural members of his bridge to give a safety factor of, say, five times the likely maximum loading.

In a static construction, such as a bridge, this is economic-

*Sperry Gyroscope Co. Ltd.

ally acceptable but in a ship every extra ton of structural steel weight is a ton less revenue earning cargo that the ship can carry. Although it is not generally realized to be so, ships and aircraft are very similar where the operating economics of the payload/all-up weight ratio are involved. The naval architect must, therefore, ensure that his ship is as light as possible: this he can achieve by providing only sufficient strength to resist normal maximum stress with little or nothing in hand to resist the excessive stress caused by bad distribution of cargo and other weights.

Unfortunately, the recent very rapid growth in the sizes of ships has meant that the designers and operators of modern giant tankers are working well beyond the limits of their previous experience with the result that the risk of over-stressing these very long ships has become a major hazard.

The calculations involved in manually computing the hull bending moment and shear forces are long and complex if the loading is other than the straightforward ship 'full' and 'empty' conditions. For instance, tanker cargoes comprising several different types of oil of varying specific gravity, with part discharge at different ports, is a particularly difficult problem. The Sperry-Sintef loading calculator has been designed as a shipboard instrument to be used by the ship's officers (on whom the prime responsibility for the loading of a ship falls and who are usually untrained in computer techniques). The calculator enables rapid and accurate answers concerning hull stress to be obtained in just such cases.

Basically, the instrument consists of a shallow case with a strong aluminium faceplate supporting all the necessary components. On the lower half of the faceplate is engraved an outline of the ship and within this outline are placed a number of rotatable dials graduated in tons. Each dial represents a compartment in the ship and is so positioned that all the dials bear the same position within the outline as do the compartments or holds they represent in the actual ship.

The layout varies from ship to ship, so that both the design and manufacture of the instruments is on a custom-built, 'one-off' basis, unless the customer operates a number of exactly similar ships.

Above the ship's outline are positioned one or more selector switches together with two sets of two dials and an associated centre-zero meter. The four graduated dials represent respectively, mean draught, shear force, bending moment and trim, and the dials are placed in the correct position for reading off the various values by being rotated until their associated meter gives a 'null' reading.

To operate, the ship's officer sets in on the compartment dials all the various weights he wishes to load into the ship, and then nulls off each read-out dial to obtain the required answers. If any of the answers are unacceptable, then it is an easy matter to relocate some of the cargo to obtain better conditions.

The ship is split into a number of sections along the entire length of the hull, each section being represented by an equivalent electrical network in the calculator. Fig. 3 shows a ship split into ten sections, and Fig. 4 shows the equivalent electrical circuit for the whole ship. Each section contains a hold, double-bottom and wing tanks in the case of a bulk carrier, and centre and wing tanks in the case of a tanker. The fore peak section is comprised of ballast and fuel tanks, while the engine room is divided into one to three sub-sections, depending on its length, these sub-sections containing the after deep tanks and engine room tanks. Finally, the after peak section is made up of ballast tanks, fresh water tanks and provisions.

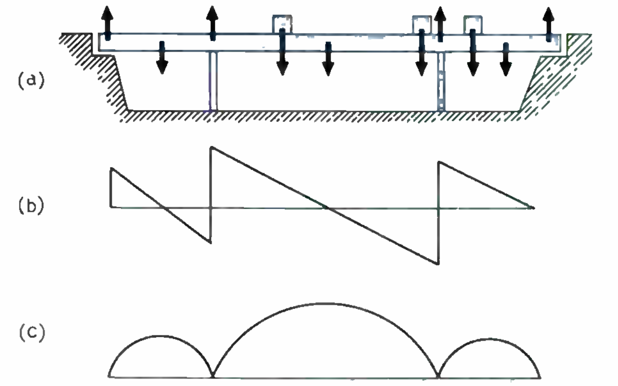


Fig. 1. A bridge structure (a) showing the force distribution with the shear force diagram (b) and bending moment diagram (c)

For each section of the ship, the electrical network shown in Fig. 5 produces an equivalent of the resultant vertical force F in that section. This resultant vertical force is the algebraic sum of the buoyancy of the section and the total weight of the section, the total weight being the weight G of the ship section and the variable loads G_n it contains. The buoyancy of the section is taken as a function of the depth of the section. The relationship is approximated to a straight line from shipyard data, the approximation being given by a factor k_1. If the midship depth is given by D and the trim by T, the resultant force in a section is given by

$$F = G + G_n - k_1 D - k_1 k_x T$$

where k_x is the distance from the centre of gravity of the particular section to the after perpendicular of the ship, which is the reference point from which all bending moments are measured.

The buoyancy and fixed weight of each section are

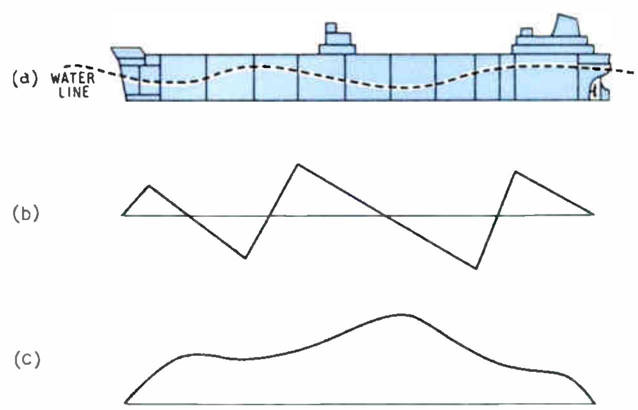


Fig. 2. General form of a ship (a) with the shear force diagram (b) and bending moment diagram (c)

Fig. 3. A ship may be dissected into ten sections each of which is represented by an equivalent electrical network in the calculator

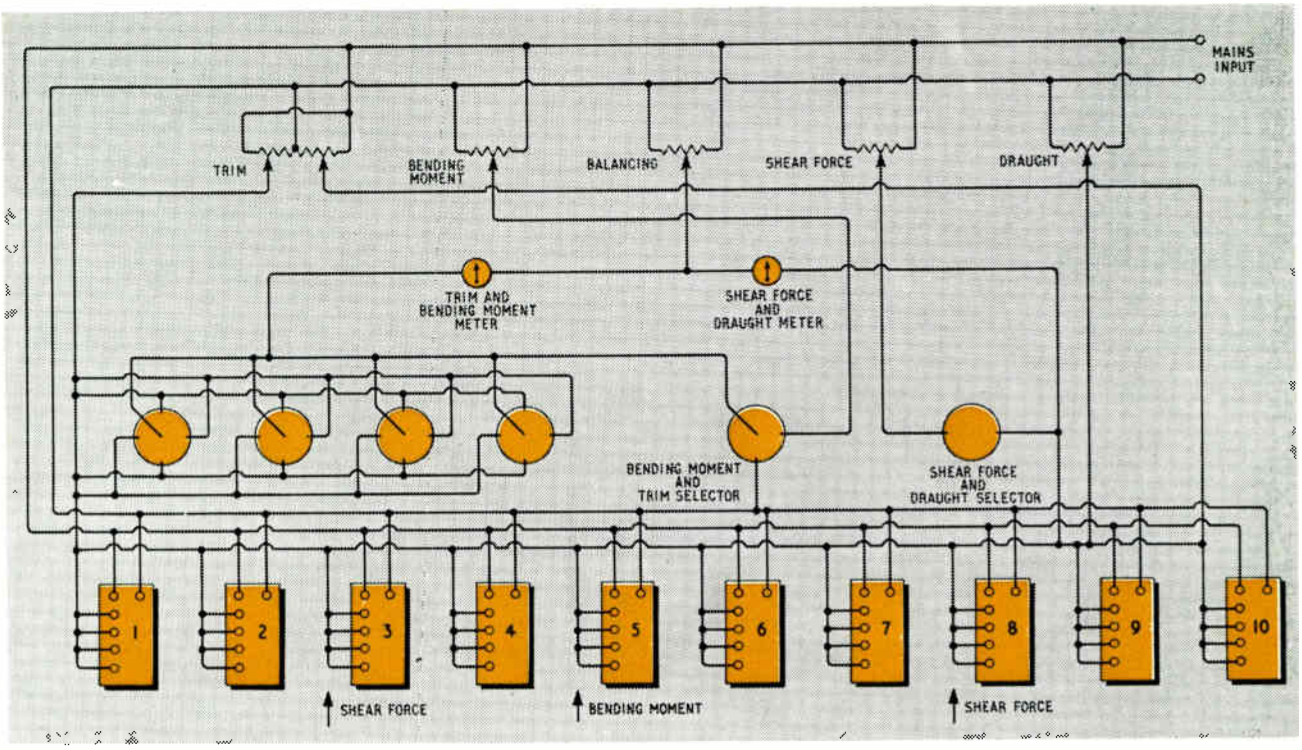


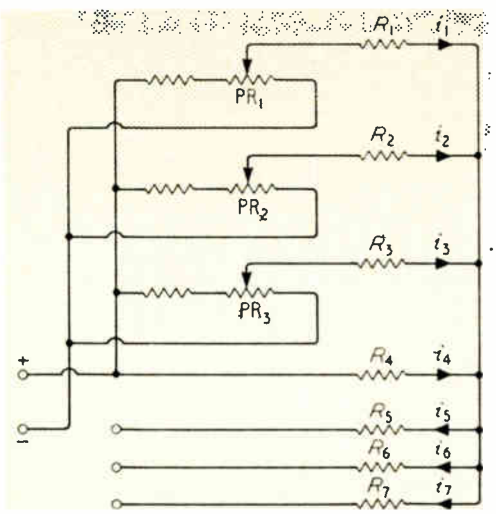
Fig. 4. Block diagram of the calculator

calculated from shipyard data and converted into equivalent resistances which are then built into the relevant circuit. The variable loads placed in each section are then represented by the outputs of the potentiometers. The values of these potentiometers are obtained from the shipyard data by means of set mathematical formulæ. Fig. 5 shows the electrical network contained in each section of the calculator. Thus,

$$i_0 = i_1 + i_2 + i_3 + i_4 + i_5 + i_6$$

The trimming moment and bending moment of each ship section, taken from a pre-determined point, are converted into resistance values and included in the electrical network representing that particular section. Assuming a

Fig. 5. Network for each individual section of the ship



factor s which gives the relationship between current and weight we have,

$$i_0 = sF \qquad i_4 = sG_0$$
$$i_1 = sG_1 \qquad i_5 = -sk_1D$$
$$i_2 = sG_2 \qquad i_6 = -sk_1k_xT$$
$$i_3 = sG_3$$

Therefore the circuit gives a direct analogy to the forces acting in the section being considered. It will be apparent that the resultant currents produced by each section network will represent the algebraic sum of the buoyancy, fixed weight and variable weights of each section. With suitable switching arrangements, as shown in the block schematic drawing of the whole electrical circuit (Fig. 4), the trimming moment, and hence the trim, bending moment, shear forces and draught of each section can be determined. Thus, taking the sum of all the electrical sections, the calculator will give the draught, trim, shear forces and bending moment for any distribution put to it, in terms of current. These currents are then backed off against currents from a fixed source and the varying amount of current required to back off the output from each circuit is read directly off the dials. These are graduated in feet for draught and trim, tons for shear force and tons-feet for bending moment. Once again, the calibration of these dials is obtained from set mathematical formulæ incorporated in the calculator design.

In common with all other instruments now on the market, the standard model Sperry-Sintef measures bending moment amidships only. Thus, with a vessel fully loaded and cargo homogeneously distributed over the cargo carrying section of the hull, the loaded condition is ideal and maximum bending moment occurs approximately amidships. This is shown in Fig. 6, the vessel being a general bulk carrier with a typical number of holds. If heavy ore were carried in all holds, the metacentric height of the cargo would be large in each compartment, due to the cargo being carried low down in the holds, and quick rolling would result in a rough sea. It is fairly common practice to load ore cargo in alternate holds, reducing the metacentric height and hence increasing the rolling period of the vessel. However, this type of loading leads to considerable shear forces acting between full and empty holds at each bulkhead, and the bending moment curve shows considerable variation over the length of the hull with the maximum shifting away from amidships. This is best illustrated in Fig. 7.

It is apparent, therefore, that an instrument which reads bending moment only amidships is useless is cases like this, as the instrument would show a favourable value of bending moment amidships and therefore convey an impression to the operator that he had distributed his cargo adequately. However, the maximum bending moment would not now occur amidships and could, in fact, under these conditions, be nearly two to three times as great as that indicated on the calculator.

The above also applies to both large and very large tankers, ore/oil carriers, etc., in that vessels having mixed cargo and many ports of discharge are very similar to bulk carriers having an alternate compartment type of loading. Thus, as cargo is discharged, the empty tanks would represent a considerable excess of buoyancy and the maximum bending moment would no longer occur amidships.

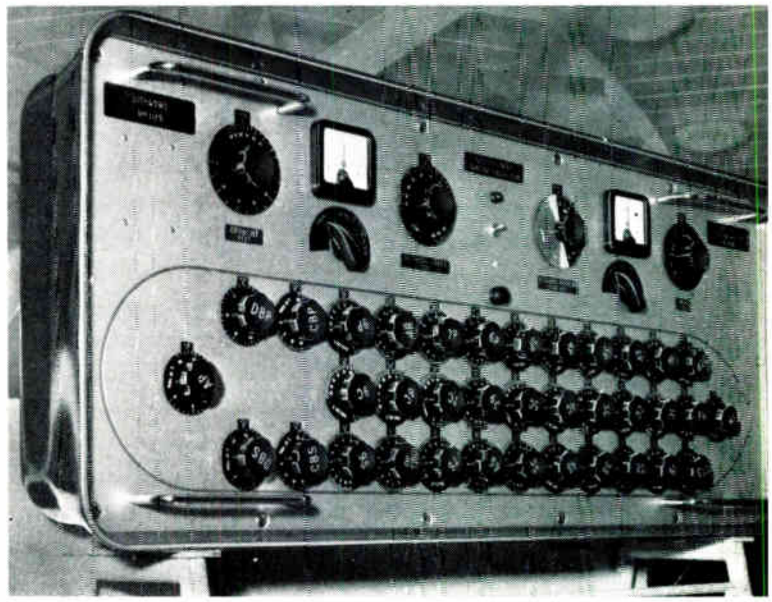
To combat this state of affairs, one of two things can be done. Firstly, a series of calculations can be made covering several set types of fully loaded and ballast conditions, these calculations being made by a naval architect or shipyard. To these the captain of the vessel must strictly adhere, but unfortunately they cannot cover every eventuality nor do they leave the initiative with the captain to sail his ship in the best manner possible for prevailing conditions without the fear of overstressing.

Secondly, an instrument can be made which will indicate bending moments and shear forces at all places where maximum stresses occur. This would give the captain of a vessel unlimited scope to distribute his cargo how he pleased, and enable him to determine the maximum bending moments and shear stresses along the entire cargo-carrying section of the hull, thus obtaining a true picture of the stress pattern for a particular distribution.

The Sperry-Sintef in its standard form lends itself to natural development to fulfil this need, as the basic electrical circuit can be split at any point with suitable switches to enable the shear forces and bending moments to be read off at these points. Sperry have therefore introduced a new type of calculator which embodies this advance.

The loading calculator is an interesting application of a special-purpose fixed-programme analogue computer and, as such, is one of the first applications of computer techniques designed to assist ships' officers in solving day-to-day operating problems.

The authors feel that future developments in shipping are heading towards automation of both propulsion and navigation equipment and that computer techniques will be increasingly used to assist in the many and various facets of ship operation. Apart from assisting in the obvious fields of ship propulsion and navigation, special-purpose computers may well be used to assist the ship's master in the calculations necessary for the correct sequence of general cargo stowage (to reduce loading and discharging times), planned preventative maintenance and other day to day problems. Such problems would include the calculation of crew wages and overtime, the ordering of stores, and customs and immigration clearances, etc.



The Sperry-Sintef loading calculator

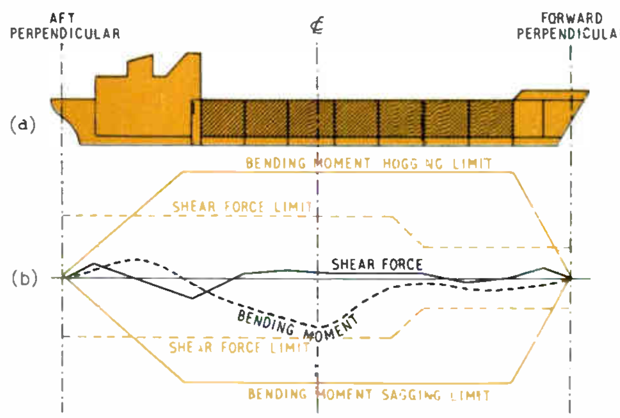
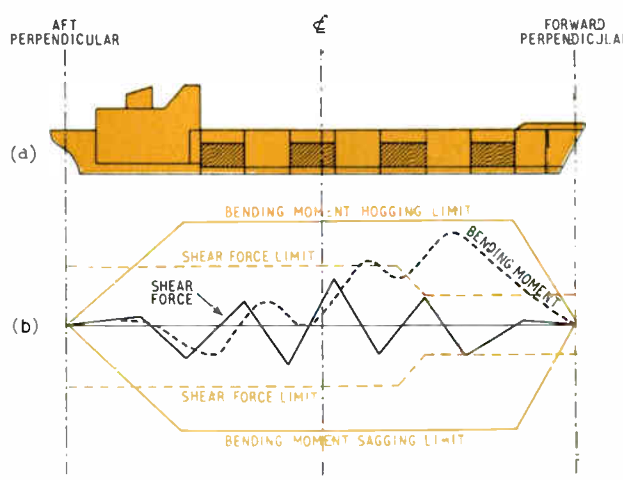


Fig. 6. A well-loaded ship (a) with the force and bending diagrams (b)

Fig. 7. A poorly-loaded ship (a) with the force and bending diagrams (b)



AN ELECTRONIC REMOTE ALARM SYSTEM

Equipment which enables a fault condition in an unattended outstation to be reported automatically to a control centre is described in this article. In a typical installation eight outstations can be connected to a single centre.

*By D. H. MARKS**

THE public utilities such as electricity, gas and water undertakings have, due to economic necessity, many remote unmanned stations housing control and regulating equipment. When an alarm condition arises at one of these stations there is usually a delay before the controlling authority is notified, during which time the fault condition, if serious, may cause the station to fail or create alarm conditions at other stations in the system.

The Pye Telealarm equipment has been designed to detect such an alarm condition, switch itself on and transmit the identity of the station and the fault condition to a master unit at a control centre.

Description of Equipment

In this equipment cold-cathode tubes and their associated components form most of the encoding and decoding logic. These are arranged in the form of plug-in modules, consisting of a printed-circuit board within a rigid metal frame on which most components, except the cold-cathode tubes, are mounted. The tube electrodes are connected to the printed-circuit board by flying leads from the glass bulb which is mounted through the front panel of the module. The printed-circuit board is extended beyond the metal frame, at the rear of the module, to form a printed-edge connector; this locates in a 22-way socket in a module housing. Each module housing will accommodate up to 12 plug-in modules of the type described above.

The basic outstation and master station each have one of these module housings, together with a power unit arranged in a metal cabinet which is suitable for wall or desk mounting.

The alarm display and operator controls at the master station are contained in the annunciator. Cold-cathode tubes are again used to give this display, being viewed end-on through lenses in the front of the board. The display is arranged in groups, mounted on flush-mounting tiles or sub-panels which form the front of the annunciator. Behind each of these tiles is secured a printed-circuit board on which all the components associated with the readout tubes are mounted.

Interconnections between the master-station decoding cabinet and the annunciator board are in the form of a multi-way cable of up to 25 ft in length.

*Pye Telecommunications Ltd.

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System Operation

The basic scheme described below consists of eight outstations each with eight alarm points, a master station and annunciator.

Each outstation is linked with the master station by a common bearer circuit which may be line or radio, for the following purposes:—

1. Sending information (i.e., outstation identity number and state of alarms) which is displayed on the annunciator at the master station.
2. Receiving control signals to prevent outstations from transmitting when the bearer circuit is being used by another outstation or when the master station is not ready to receive a report or to initiate test reports.

Two audio-frequency tones convey information from the outstation to the master station; a pilot tone of 907 c/s and an information tone of 605 c/s. The pilot tone is transmitted in bursts with an equal mark/space ratio to drive the decoding circuits at the master station. The information tone, designated 'A' tone, is interposed between the bursts of pilot tone as required.

The basic equipment provides for the use of 12 bursts of 'A' tone which are allocated as follows:—

1. The first four pulses for station identification using a binary-coding system.
2. The next eight pulses for indicating the state of the alarm contacts at the monitored points. These contacts are scanned in a pre-determined order.

When the outstation has completed its report the master station operator may maintain the displayed information on the annunciator for logging or other purposes. While the display is maintained, the master station will transmit pilot tone in bursts with an equal mark/space ratio, imposing a condition on the circuit similar to the condition when an outstation is reporting. Each outstation receives this pilot tone and applies it to prevent further sending until the display has been cleared.

To ensure that two or more outstations cannot transmit simultaneously each is provided with a delay device with a different time constant for each outstation. When the bearer circuit is free the delay devices at faulted outstations commence timing. The outstation with the shortest delay time starts sending its pilot tone first, blocking the circuit for any other station. These bursts of pilot tone, as those

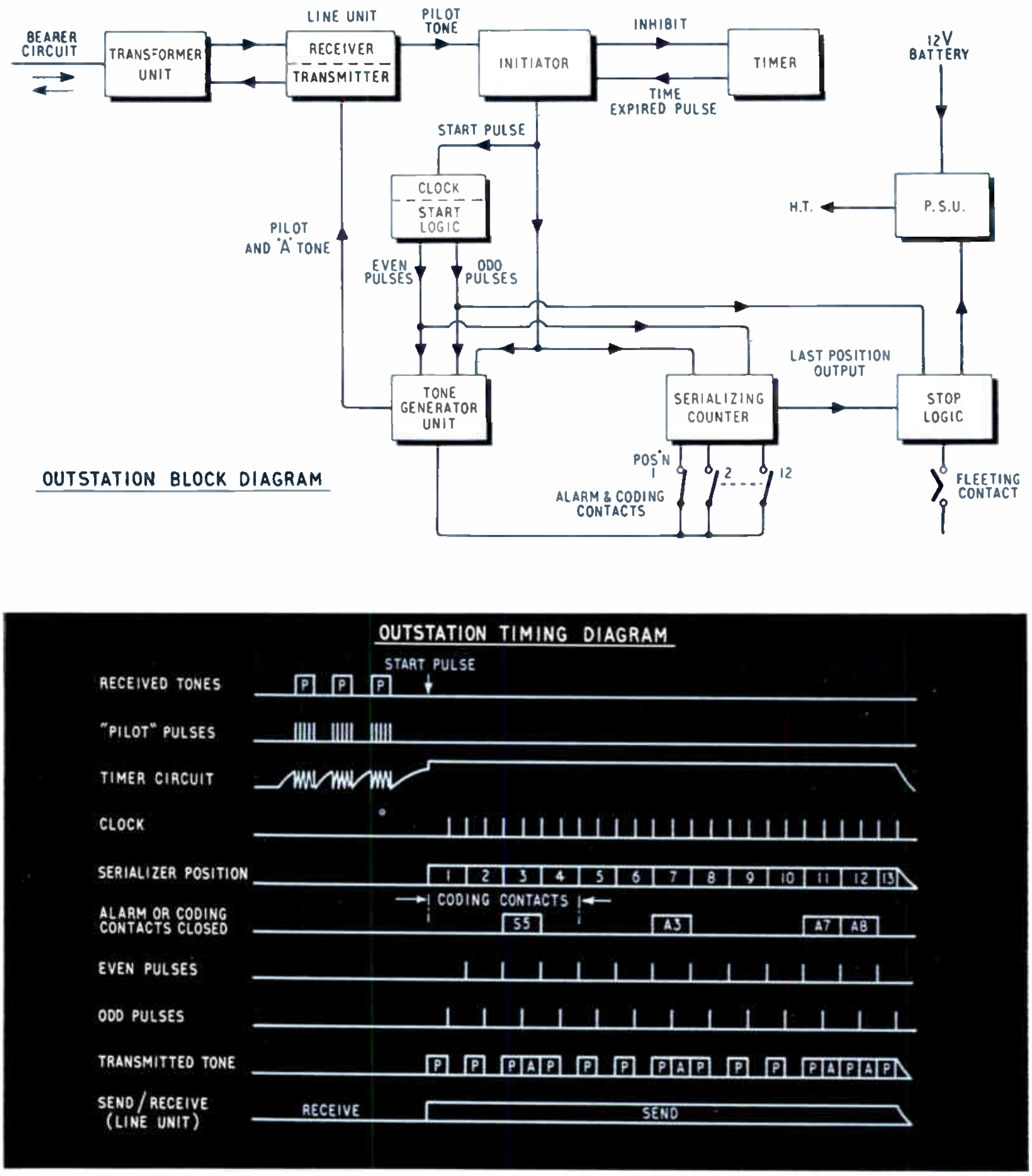


Fig. 1. Block diagram of the apparatus at an outstation and the timing diagram of the various pulses produced in it

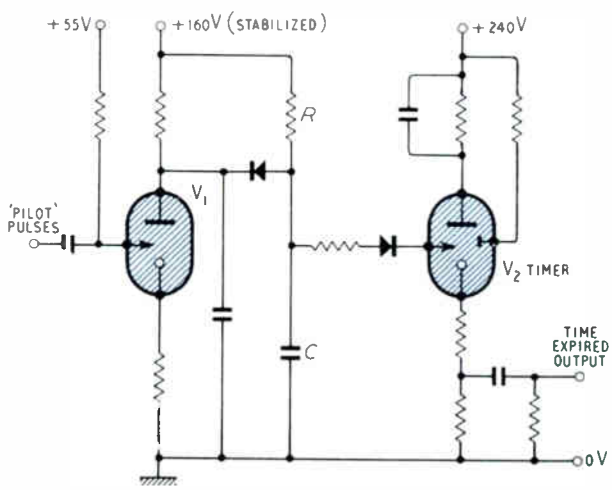
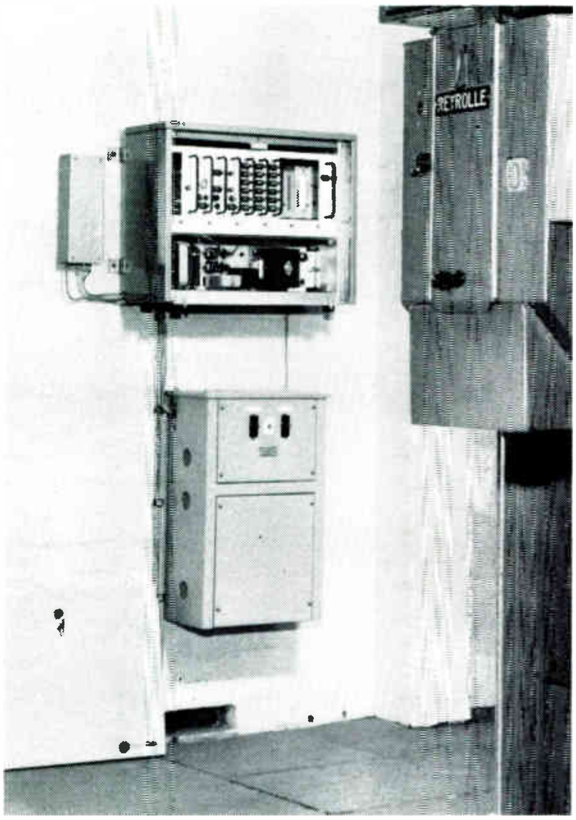
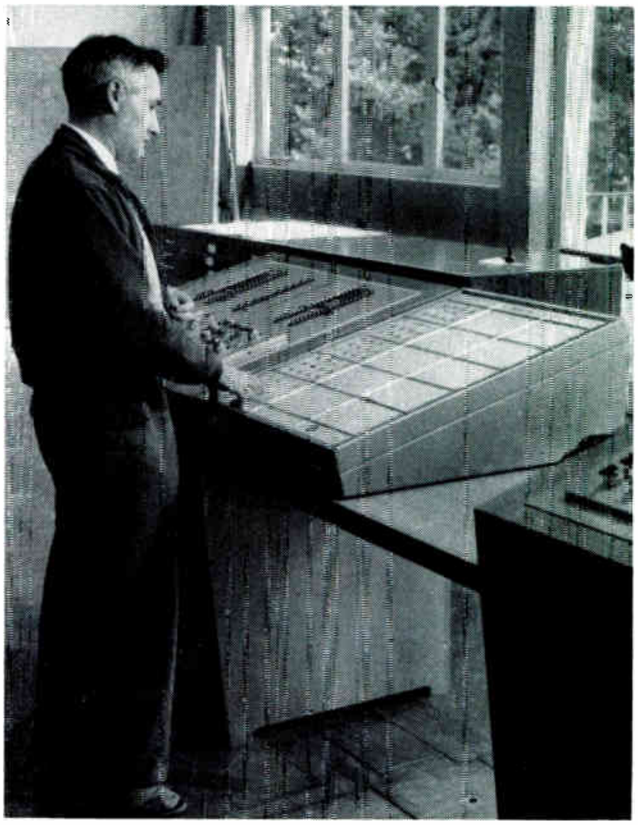


Fig. 2. Circuit of the timer





(*Left*) *The Telealarm outstation.* (*Right*) *The Telealarm annunciator at the master station* (*Courtesy Eastern Electricity Board*)

in the 'station decoder' unit which is again applied to the 'station-identity indicator'.

The third and fourth 'pilot' pulses move the 'decode counter' to the fourth position and inhibit the 'zero' pulse generator.

An 'A' pulse that will add four to the station identity will be between these two 'pilot' pulses if it is required. This third 'A' pulse completes the station identity decoding in the basic scheme, therefore, the fourth 'information' interval after the fourth burst of 'pilot' tone will not be used.

With the fifth 'pilot' pulse the master station starts to decode the information concerning the eight alarms at the reporting outstation. This pulse triggers the fifth tube in the counter in readiness for the next 'information' pulse, if any.

All the 'A' pulses produced during the decoding sequence, including the ones produced during the station-identity decoding, are applied to all the 'alarm indicator' tubes; but will not be able to trigger any of the tubes until the 'decoder counter' tube associated with a particular indicator tube is conducting.

If the first alarm contact at the outstation is closed an 'A' pulse will appear in the fifth information space, which because the fifth 'decode counter' tube is conducting will trigger the first 'alarm display' tube.

The sixth 'pilot' pulse received moves the 'decode counter' to position six, biasing the second 'alarm display' tube for the following 'A' pulse, if received.

The master station continues to decode in this manner until the twelfth information bit has passed. After this there should be only one more burst of 'pilot' tone from the outstation, the last before it switches off. The resultant 'pilot' pulse moves the 'decode counter' to a 'rest' tube.

As no more 'pilot' pulses are forthcoming to hold it off, the 'zero' pulse generator will start to oscillate. The first 'zero' pulse generated is gated with the output of the 'rest' tube to trigger the 'pilot' tone gating unit. Consecutive 'zero' pulses then switch the 'pilot' tone on and off until the 'accept' control on the annunciator board is operated. While 'pilot' tone is being generated, the master station is switched from the receiving to the transmitting state and the 'pilot' tone is passed to the bearer circuit to hold off any outstation that may be waiting to report.

The master station has now got a complete display on the annunciator and the audible alarm is sounded to alert the operator. As soon as he is satisfied with the display he operates the 'accept' control. This switch removes the h.t. supply from the display and the 'pilot' tone gating unit hence returning the master station to the listening condition.

If the received code has been mutilated so that the

ELECTRONICS
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correct number of 'pilot' pulses have not been produced, the counter will not be in the 'rest' position when the first 'zero' pulse arrives, hence the station will not act on this pulse in the manner described above, but will trigger the 'code reject' display tube on the annunciator. The current flowing through this tube is used to de-energize momentarily a reed relay whose contact opens and the display is cancelled. The 'code reject' tube remains in a conducting condition until the operator accepts it or a further report is received.

Additional Features

Other facilities have been incorporated in the equipment to cover a range of operational requirements, the most important of these being a 'test' and a 'report three times' facility.

The 'test' facility comprises an operator's control at the master station, which, when operated, causes 'pilot' tone to be transmitted for a period of about 1 second. This prolonged burst of tone is detected by all outstations, causing them to switch on. When the test tone ceases the outstations will report in the normal manner, as described previously.

At the master station, a 'test' indicator tube conducts on the 'scan state' indicator tile, just above the test control, when the switch is operated. This tube remains conducting until the last outstation has reported and been decoded correctly, giving the operator a visual indication that the test has been completed.

The 'report three times' facility is incorporated in the outstations. This facility will make a station scan through and report up to three times if necessary before switching off. After the first report the station pauses and listens for 'pilot' tone from the master station, indicating the master station has decoded the report correctly. If this tone is present then the station will switch off. With no 'hold-off' from the master station the outstation will repeat the transmitter sequence, again pausing to detect 'hold-off' tone at the end. With silence on the bearer circuit the station will report for the third and last time, this time switching off in the normal manner.

The equipment is designed so that under standby conditions the bearer circuit is not loaded. This feature enables an existing private telephone circuit to be employed on a shared basis without any degradation of telephone speech level. In addition, bearer circuit proving equipment can be added.

As well as its uses in the public utilities already mentioned the Pye Telealarm equipment is suitable for such diverse applications as flood warning, reservoir and hopper levels, machine minding and any other applications where automatic remote alarms or state indications are required.

With an annual stock turnover approaching one million rose bushes and trees, Wheatcroft Brothers of Ruddingon have found it progressively more difficult to keep a check on the stock position. It was therefore decided to install some form of mechanical, electromechanical or electronic stock control system.

The problem to be solved was to provide, at a glance, the stock-for-sale position on 300 fast-moving varieties of stock.

The solution to the problem has proved to be a 300-channel data analyser designed and produced by English Numbering Machines of Enfield. Basically comprising 300 electromechanical counters, the analyser is a combined desk and console housing the complete system.

The 300 counters are mounted in panels in front of the operator with an identifying tab under each counter. As well as writing the name of the appropriate rose variety on each tab, Wheatcrofts have coloured each tab to correspond with the colour of the bloom. Associated with each counter is a corresponding push-button switch which prepares the counter to receive an addition to, or subtraction from, the total displayed. The number which is to be added to, or subtracted from, a counter total is set up by the operator on a push-button switch panel—a number up to 199 can be selected. Having selected the counter or counters and the number to be added, or subtracted, the operator pushes the " add " or " subtract " button and the remaining operation is automatic. An electronic pulse generator and a ring counter together provide the appropriate number of pulses for the counters. If necessary, the number can be simultaneously applied to up to 50 counters. Automatic button release operates at the end of each entry. Manual button release is also provided in the event of the operator selecting the wrong button.

In practice, Wheatcrofts count the stock before selling begins and set the total for each variety into the appropriate counter. Then as individual orders are received they are subtracted from the stock totals. In this way, the operator processing the orders can be certain that sufficient stock is available to complete them. Additionally, data is easily available for stock and trend analyses. The cost of the complete system was about £3,000.

With the analyser, the daily orders are dealt with in about half the time taken when using the previous paperwork system.

For further information circle 50 on Service Card

Shown here is the operator at Wheatcrofts processing a daily batch of orders on the analyser

In steelmaking a controlled supply of oxygen is required. This article describes a system using pneumatic controllers which is used in the Aldwarke plant of the Park Gate Iron and Steel Co.

OXYGEN SUPPLY AND CONTROL SYSTEM FOR A STEELWORKS

By A. R. CRESWICK, A.M.I.E.E.* and P. D. BLACKMORE*

OXYGEN plays an important part in all modern steelmaking processes and in successful systems its supply must be completely reliable for 24 hours a day, 365 days a year. The system must be as simple as possible, requiring little maintenance, and be provided at minimum cost. Such a system may be considered as a distribution of pressure drops and a careful study must be made of customers' load patterns before the primary line pressure and storage capacity can be decided. Capital cost must be studied as well as operating cost, the whole object being to obtain the minimum cost per unit of oxygen at the customers' load device.

In the particular application to be described, which is for the Kaldo process, there are two identical sets of oxygen injection equipment for two 75-ton Kaldo basic steelmaking furnaces. These are installed at the new Aldwarke Steelmaking Plant of the Park Gate Iron and Steel Co. The steelmaking vessel used in this process is cylindrical, having a truncated cone shape at the top through which all materials are added, and in which the water-cooled oxygen lance, and the raw-materials addition lance, are inserted.

During the steelmaking process this vessel is rotated at a maximum speed of 40 r.p.m. and inclined at an angle to improve the area of contact between the metal and the slag. The complete process, which is outside the scope of this article, is fast, has a high scrap utilization, is economic and extremely flexible and is only possible because large weights of gaseous oxygen can be made available at economic prices. The oxygen injection equipment (i.e., the lance) is shown in one of the photographs and it forms a removable unit together with the fume hood. During the oxygen injection period it is possible to move the lance in an oscillatory fashion.

*British Oxygen Co. Ltd.

◀ *A Kaldo furnace in action*

Supply Process Oxygen

The oxygen supply for the steelworks is taken from an extensive pipeline distribution system which is fed by two large oxygen-producing plants, one of 200 tons per day capacity located at Aldwarke and the other of 100 tons per day capacity at Brinsworth, some six miles away. The distribution system feeds various other major consumers as well as the steel plant. Continuity of supply is ensured by the two plants, and, in an emergency, there is always a supply of liquid oxygen which can be vaporized to feed the system. The oxygen supply to the steelworks distribution centre is at a constant pressure of 600 p.s.i.g. at ambient temperature, is dry and at a purity of 99·5 per cent.

The unit of oxygen measurement used is the standard cubic foot (s.c.f.) which is one cubic foot of dry gas at a pressure of 14·696 p.s.i.a. at a temperature of 15·56 °C. This is in fact a weight unit and one standard cubic foot as defined above weighs 0·8 lb.

As the oxygen demand of a furnace is not constant but varies from a high rate of up to 6,000 cubic feet per minute (c.f.m.) for different periods of time to zero for other periods it is not economical to supply these wide flow fluctuations directly from the oxygen plant. This is because the time constants of the plant are large and variations in plant output are only possible over periods in excess of, say, one hour. Thus, any sudden reduction in demand from the process would necessitate the surplus oxygen having to be vented to atmosphere at the plant. Because of the large time constants the oxygen plant can be looked upon as a constant-pressure constant-flow generator.

To meet the fluctuations in demand a storage system is inserted between the supply point and the process, the flow from the plant being at a constant pressure of 600 p.s.i.g., and at a constant flow which is set to meet the variable process flow demands. These demands are required at a constant pressure of 170 p.s.i.g. Ideally, therefore, a mass balance should be achieved between input and demanded output. However, should the average output fall below the input, then oxygen is vented to atmosphere, while if the reverse should occur there is a loss of secondary distribution pressure.

A simplified schematic of the storage system and the type of pressure and flow rates required for the steel plant are shown in Fig. 1(a), while (b) and (c) show the variations of storage pressure and flow for a typical furnace demand. Apart from the supplies to the Kaldo furnaces many other constant pressure variable flow supplies are also taken from the distribution centre, some for general purpose use, others for steel production equipment.

The Distribution System

The complete oxygen distribution and control arrangement is shown in Fig. 2 in simple schematic form. Protection of the steel process lines, which have priority of supply, is by means of back pressure valves V_2 and V_4. Other customers, connected at points such as A and B, take their supplies at 180 p.s.i.g. with the line CD operating at a variable pressure and acting as a storage system. The circuit through the distribution centre to point X is basically the steelworks storage system described already, while beyond X is the Park Gate metering and control equipment.

At Park Gate there is an oxygen distribution centre which controls the overall oxygen requirements. From here the steelworks controller is able to see the overall

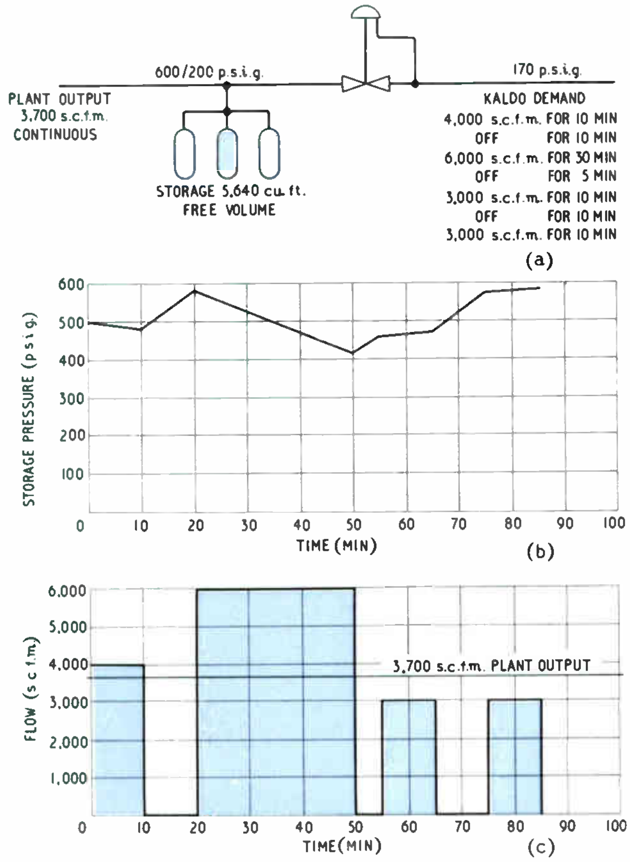

Fig. 1. A simplified diagram of a supply line which includes storage is shown at (a) with a typical flow variation chart at (b). The variation of storage pressure is indicated at (c)

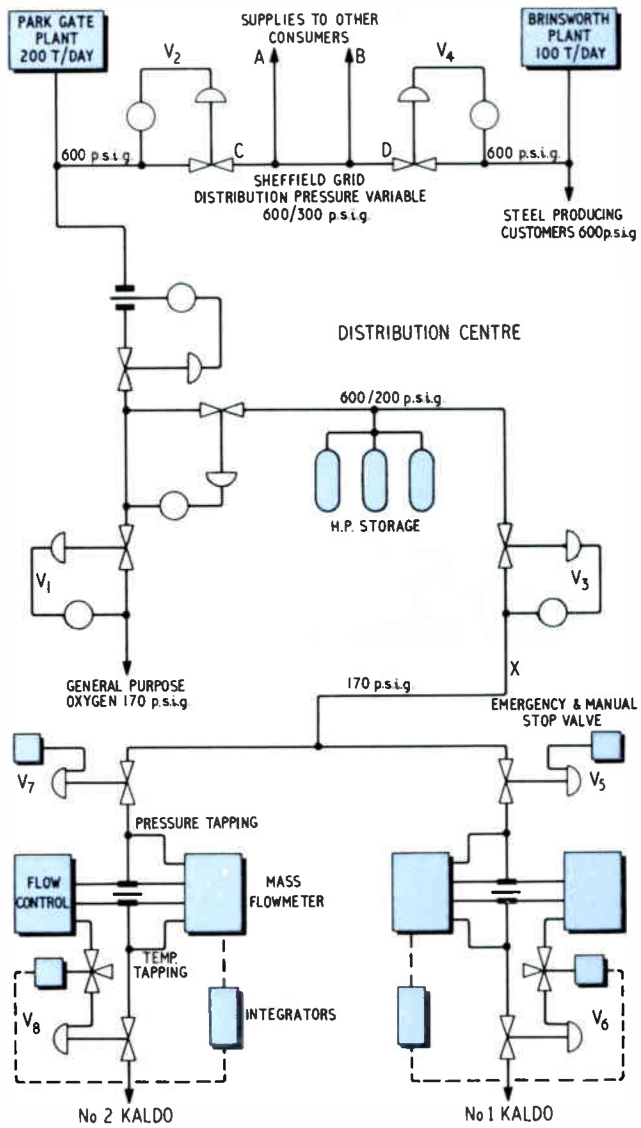

Fig. 2. (Right) Simplified diagram of the distribution system

picture of oxygen usage, consulting with the steelmakers and oxygen producing works in a constant effort to match the input and output demands for oxygen. He can also, if necessary, arrange with the oxygen producing works to increase the input. The major design considerations here are simplicity and reliability of components, together with low power consumption, fast action of valve operating motors and tight shut off in the case of the control valves. During the actual testing and proving periods for the Park Gate installation the two flow control valves operated as many as 200 times in 24 hours, without any signs of wear.

The load consuming devices of the steelworks are the oxygen lances of the furnaces which are simply water-cooled tubes. The pressure at the open end of a lance, which is also the pressure at the top of the furnace, is reasonably constant and near atmospheric. As the pressure at the top of the lance is always in excess of twice the atmospheric pressure the flow in the lance is always critical and so the rate of mass flow to the furnace is directly proportional to the pressure on the lance head. As the pressure at point X is sensibly constant and V_5 is only a manual or emergency control the object of the control equipment is to adjust valve V_6 so that it may absorb the difference between the pressure at point X and that actually required at the lance head to give the required mass flow.

The control problem presented by this situation is not particularly difficult. There is very little transfer lag in the process because the length of pipe between the measuring and the correcting elements is short. In such a system there is only the compressibility of the gas to consider and this may be neglected if the pressure and temperature correction ranges are small. To eliminate any instrument lags, measuring and transmission connecting systems are kept to a minimum by the on-line mounting of equipment. The schematic diagram of the apparatus for metering and providing mass flow control of the plant oxygen is shown in Fig. 3. What the steelmaker wants to know from this equipment is the pounds of oxygen consumed. In providing this information, it must be borne in mind that at the control point on the pipeline pressure variations may be expected in the range 160–200 p.s.i.g. and temperature variations in the range of 32–120 °F. These

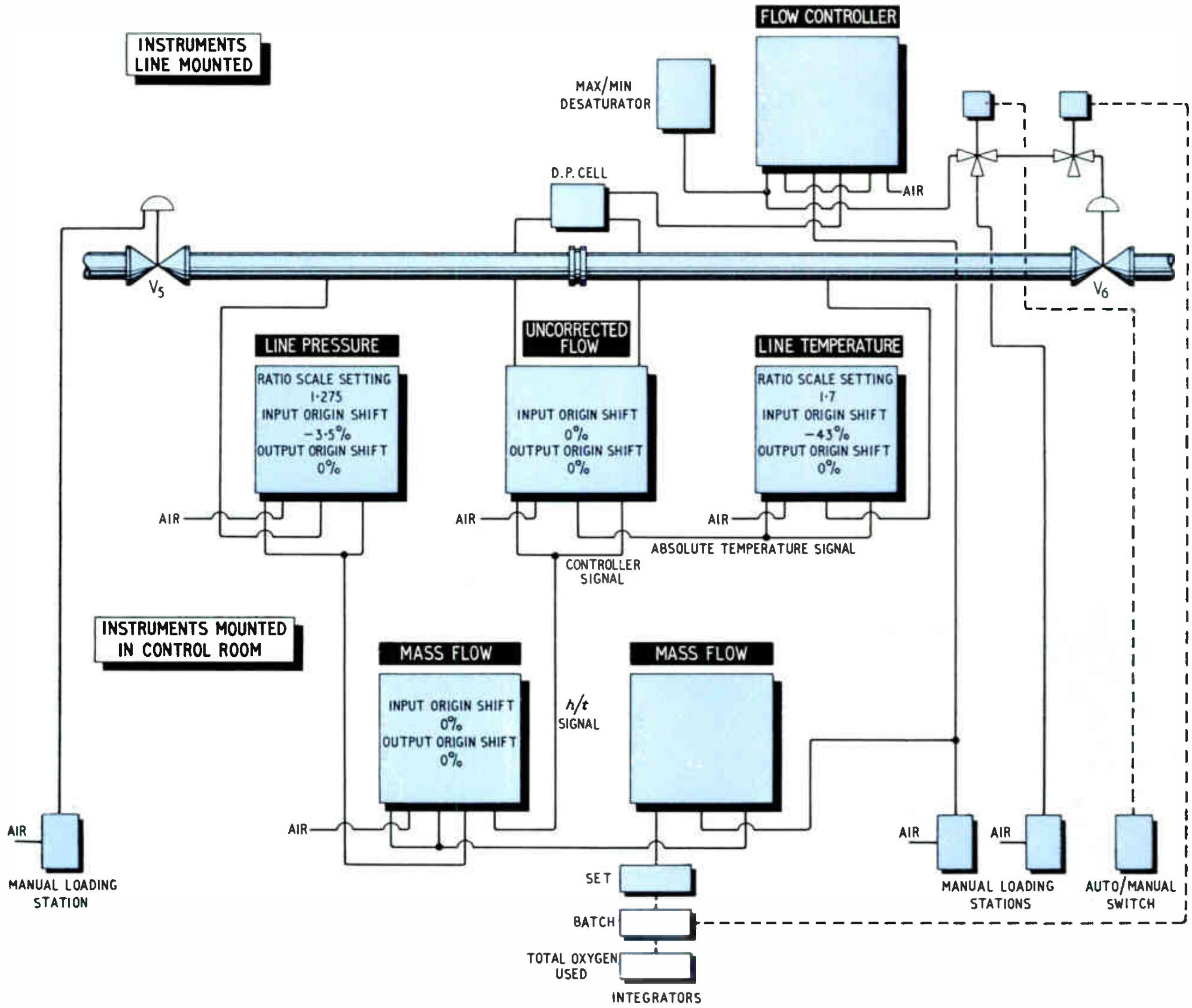

Fig. 3. Schematic diagram of the measurement and mass flow control system

variations are caused by the length of the line, the wide variations in flow and the extreme ambient conditions through which the oxygen passes. In order to compensate for density changes and obtain mass flow it is thus necessary to correct for these changes and obtain absolute pressure and absolute temperature conditions.

The equipment used for this purpose forms a pneumatic-mechanical computer designed to solve the equation,

$$Q = K\sqrt{\frac{PH}{T}}$$

and is designed to operate with an accuracy of $\pm 2\frac{1}{2}\%$ in the mass flow range of seven to one.

In this equation

Q = mass flow rate.

H = differential head produced by the orifice plate.

P = absolute pressure.

T = absolute temperature.

K = constant defined by the units used.

Although there are many ways of performing this computation the choice of method is always influenced by the ranges over which compensation is required. This particular method was used because the scheme was possible using standard instruments without any special calibration. The first step in dealing with this problem is to check that the operating conditions are within the bounds of possibility for a standard flow meter having a maximum turn down range of 100 : 1 in head and 10 : 1 in flow.

Range of max. flow	= 1,000–7,500 s.c.f.m.
Temperature variation	= 500–560 degrees Rankine.
Pressure variation	= 175–215 p.s.i.a.

On inserting these figures in the formula $h = tPm^2$ it is

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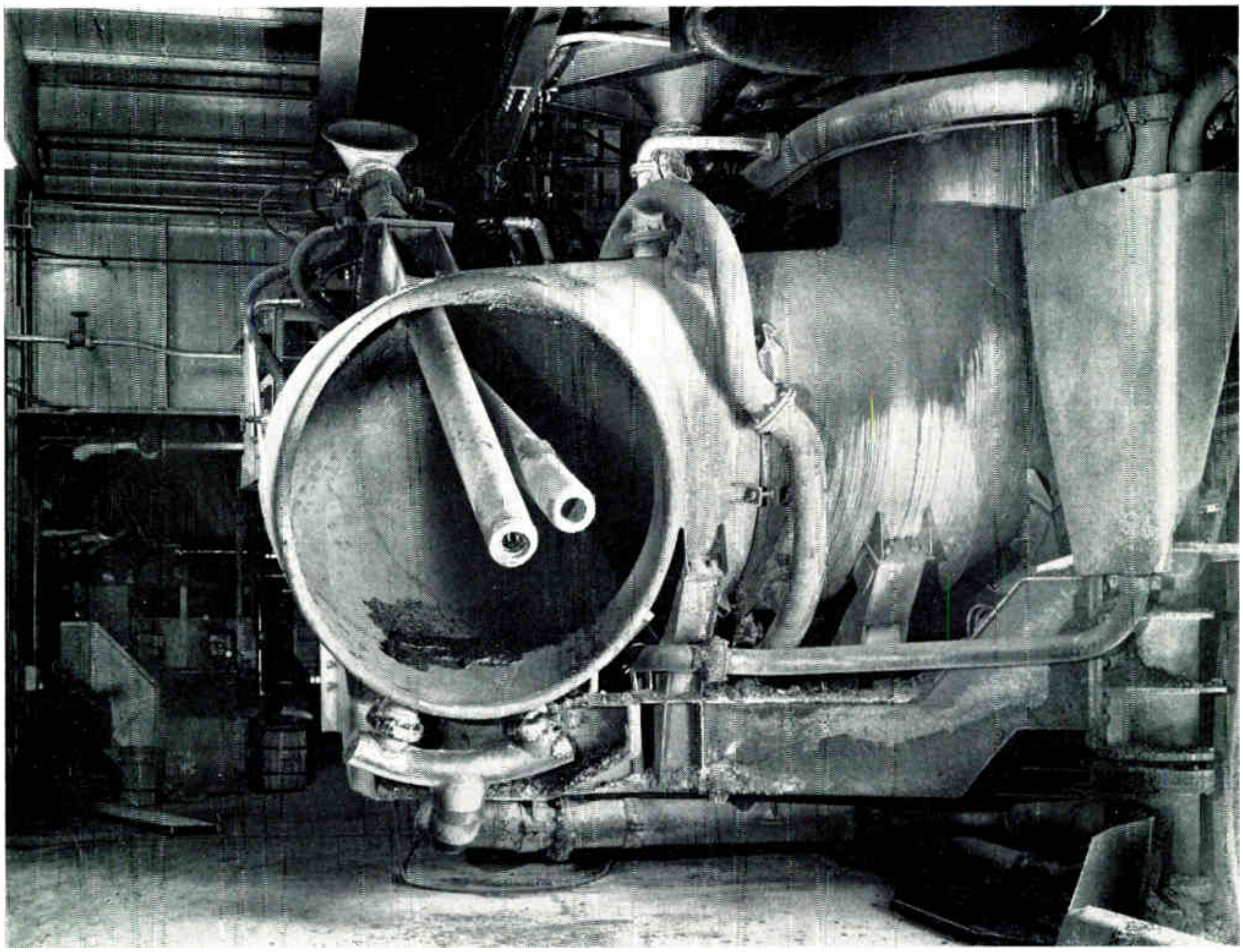


Lance used for injecting oxygen in steelmaking

necessary for h to be less than 100 for the scheme to be possible
where

h = working head.

t = ratio of maximum to minimum absolute temperature.

P = ratio of maximum to minimum absolute pressure.

m = ratio of maximum to minimum mass flow.

On inserting these figures in the formula $h = tPm^2$ we find that h comes out at 77·5 and this is well below the figure of 100 which is necessary for the scheme to be possible. It is, of course, also desirable that the maximum working head should be as near as possible to the maximum scale reading of the instrument.

Mass Flow Computation

The uncorrected flow is derived from an orifice plate which is calculated in accordance with B.S. 1042. This feeds a mercury-type flow meter which includes a two-

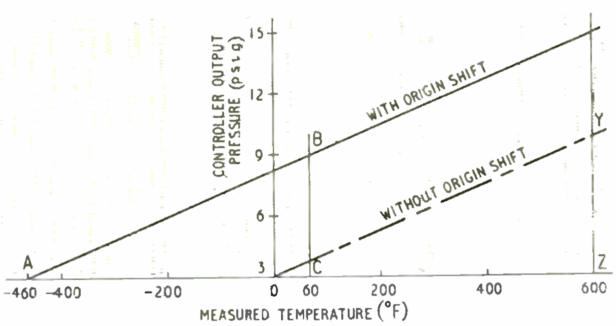


Fig. 4. Temperature correction in the measurement of mass flow is obtained by a shift of origin

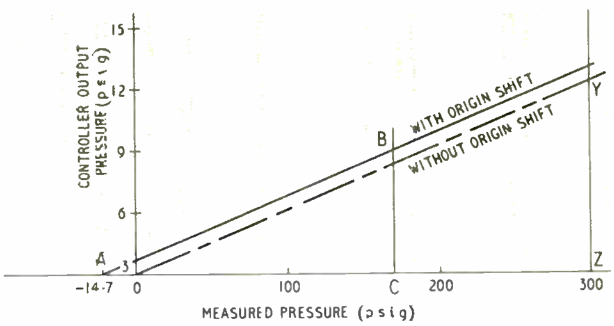
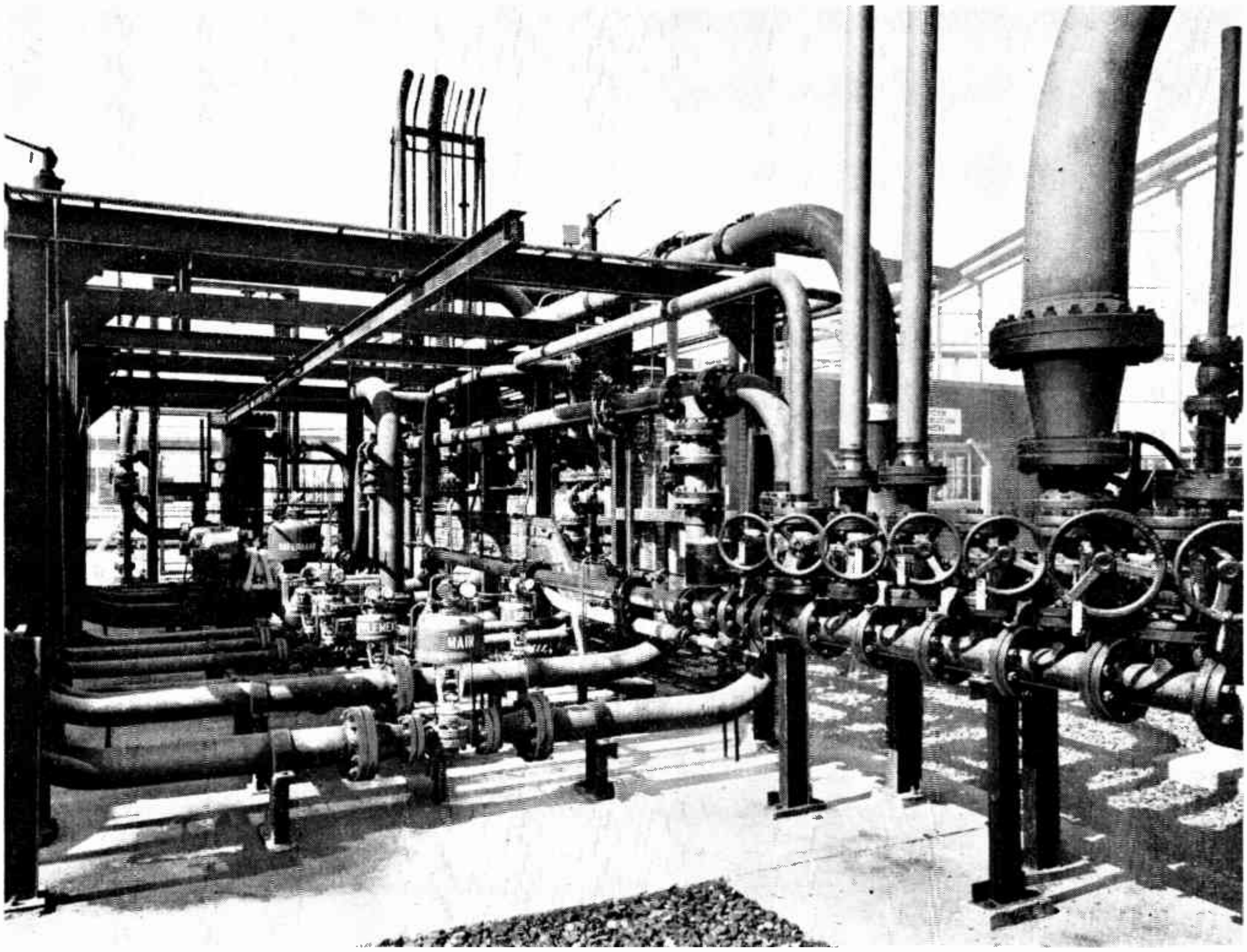


Fig. 5. In mass flow measurement a correction has to be applied to the pressure measurement and this is done by a shift of origin



The oxygen distribution centre

term pneumatic controller and a pneumatic computing relay. By feeding a signal proportional to the absolute temperature into one bellows of the relay and the output of the pneumatic controller into the other an output signal is obtained which is proportional to *h*/*t*. The sense in which the controller output is fed to the computer relay bellows decides the arithmetical action which takes place.

The required temperature signal is obtained from a mercury in steel instrument, which also includes a two-term controller and a computer relay. In order to obtain an output signal proportional to *h*/*t* it is necessary to correct the outputs of the temperature meter and of the flowmeter for absolute temperature. Each of the two computer relays has two inputs and each of these may be manual or pneumatic or pneumatic with manual shift settings. To obtain an output proportional to absolute temperature from the temperature instrument a manual ratio setting is used with an origin shift setting. The effect is illustrated in Fig. 4.

A pressure signal is obtained from a bourdon-tube instrument. Like the other instruments this includes a two-term controller and a computing relay. As in the case of the temperature instrument a shift setting is applied in order to obtain a truly proportional output signal, as shown in Fig. 5.

In the mass-flow instrument the *h*/*t* signal is fed into one bellows of the computer and the *P* signal into the other. The relay acts as a multiplier and produces as output *hP*/*t* which is proportional to the square of the mass flow. In the pen recorder part of the instrument, the chart is scaled in terms of the square-root of the deflection so that the record is direct reading in terms of true mass flow.

Figures for the ratio scale settings and for the shifts are indicated in Fig. 3 for a particular condition.

The output *hP*/*t* is fed to a two-pen bourdon tube instrument. One pen is a slave indicating the actual result on a square-root indicator. The other pen is driven by a hand control and is connected in parallel with the setting pointer of the uncorrected flow instrument to permit remote manual setting of the flow control loop.

Flow Control

The flow control system starts with a differential pressure cell which feeds a signal of 3–5 p.s.i.g. to a local bourdon-tube pressure instrument having a two-term controller output. This is the instrument having the remote control of its set point just mentioned. The output controls the valve V_{f}.

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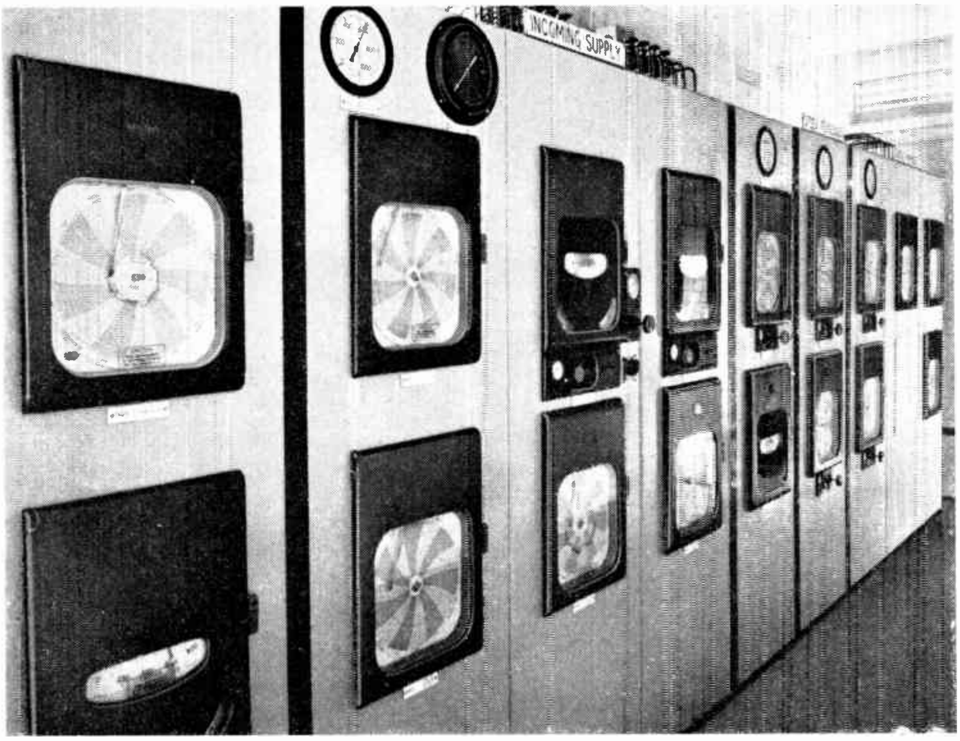


A view of the instruments in the control centre

The line valve V_5, which is upstream of the control valve V_6 is an emergency valve. It can operate as a quick on-off valve and can also be used in an emergency as a manual flow control valve.

These line valves both have Fluon seats and equal percentage plugs and they are single beat to ensure tight shut off. The valve motors are of the piston type with built-in positioners and are designed for high speed operation.

The equipment as described has been in operation now for over nine months and has performed satisfactorily. The maintenance costs have been low and all the requirements of the process have been met.

Electronic 'Conductor' for Buses

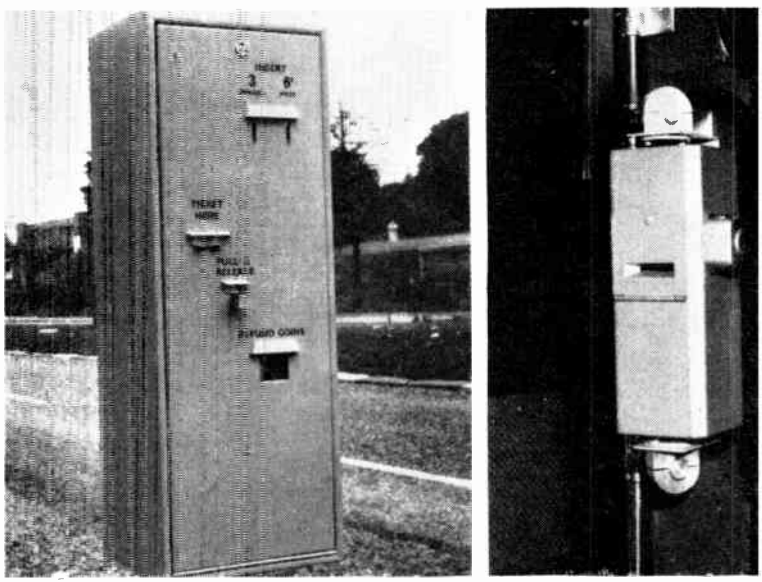
The shortage of labour and increased running costs have led to expansion in the use of one-man buses. However there remains the major time-consuming operation of issuing tickets and the giving of change by the driver. This disadvantage may be overcome in the future by an electronic ticket-recognition-and-cancelling machine which can be fitted at the bus entrance; this is being made by Ticket Equipment Ltd.

Tickets, pre-purchased from a ticket-issuing machine, are inserted in a slot in the ticket-cancelling machine. The ticket carries a metallic spot which is detected and then cut off by a guillotine. At the same time the ticket is stamped with the route number, date, etc. If a faulty ticket is inserted the driver is alerted by a buzzer.

Each cancelling machine will only handle a single coding and therefore can only be used on routes where a single standard fare is charged.

In operation, the ferrous-metal strip or spot on the ticket interrupts a magnetic field and causes a transistor oscillator to produce an output signal. The signal is amplified and rectified and the resultant d.c. used to energize a relay. Contacts on the relay control the guillotine and printer.

This system is being used at present on an experimental basis at Manchester and Frankfurt-on-Main, Germany.



Shown here is the Unimat ticket-issuing machine and the Holstimatic electronic ticket-cancelling machine

By F. BAMFORTH, A.M.I.E.E.*

SIMPLE TRANSISTOR CIRCUITS FOR INDUSTRIAL USE

(Concluded from page 589, December issue)

This short series of articles is concluded by a description of how the basic simple circuits, which have been previously discussed, are put together to form an electronic time-sharing system. One application of such a system is to the control of a group of electric welders so that the peak power required does not exceed that of one welder.

THE system to be described is intended for more specific applications than the pulse generators described last month, but serves to illustrate how relatively simple electronic circuits can be combined to perform a useful industrial function.

Shift Pulse Generator

The shift pulse generator shown in Fig. 21 makes use of a modified multivibrator. For the particular application to be considered, the p.r.f. and pulse width are not critical. However, with the component values given the pulse width is approximately 120 µsec and the pulse repetition time about 740 µsec. While such a wide pulse was not really necessary for the application, a more complex circuit would have been necessary to provide a much narrower pulse at the same repetition frequency.

* Ferranti Ltd.

Five-Input NAND Gate

The basic circuit described in Fig. 9 (November issue) is used and is shown in Fig. 22.

Two-Input NAND Gate

This circuit (see Fig. 23) is similar to Fig. 22 except that only two input diodes are used, the load resistor is replaced by a relay (with spike-limiting diode) and the response of the circuit is slowed down by the omission of the speed-up capacitor and the connection of a larger value capacitor between base and emitter.

Ring Counter

This circuit comprises three bistable circuits, a three-input NAND gate and an inverter (see basic circuits in the November issue).

A block diagram of the ring counter is shown in Fig. 24, while the complete circuit diagram consists of Tr_8 to Tr_{15} in Fig. 28.

The method of operation of this circuit is more complicated than the circuits previously given and a brief description only will be given.

At each input shift pulse, any stage of the circuit assumes the state (0 or 1) of the previous stage before the shift pulse was applied (where the NAND gate and inverter represent a single stage). The method of connection ensures that a 1 appears in only one stage at a time. A 1 therefore

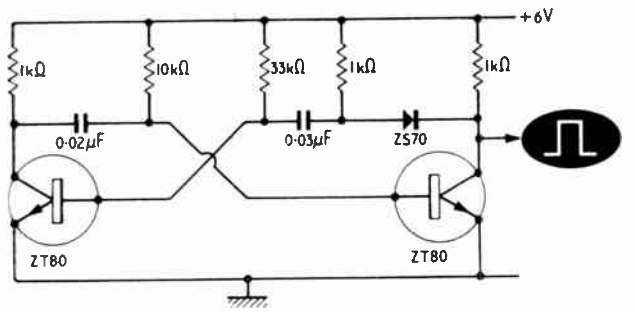
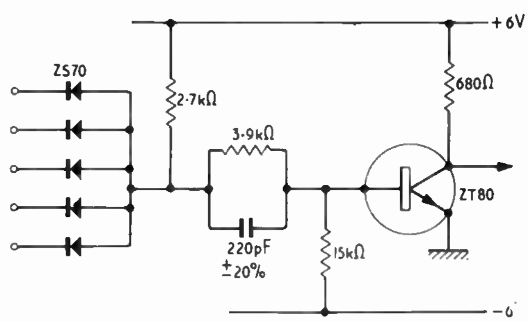


Fig. 21. The shift-pulse generator circuit is that of a modified multivibrator

Fig. 22. Five-input NAND gate



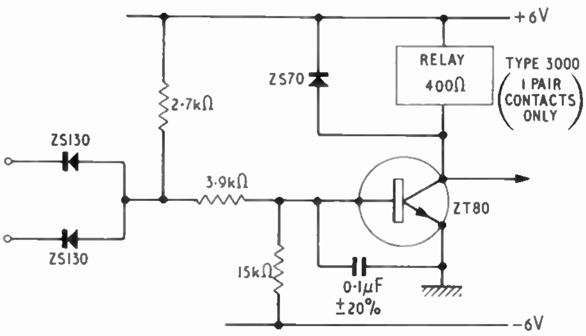


Fig. 23. Two-input NAND gate

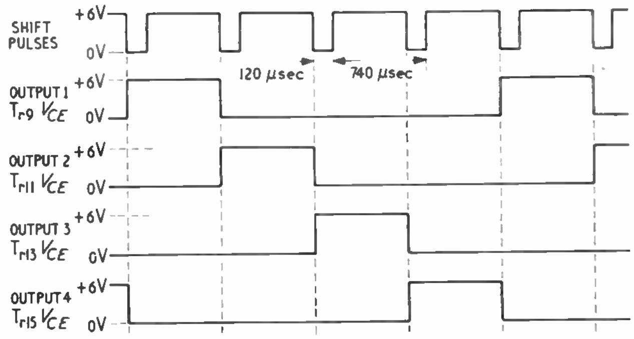


Fig. 25. Waveforms in the ring counter of Fig. 24

Fig. 24. Block diagram of a ring counter

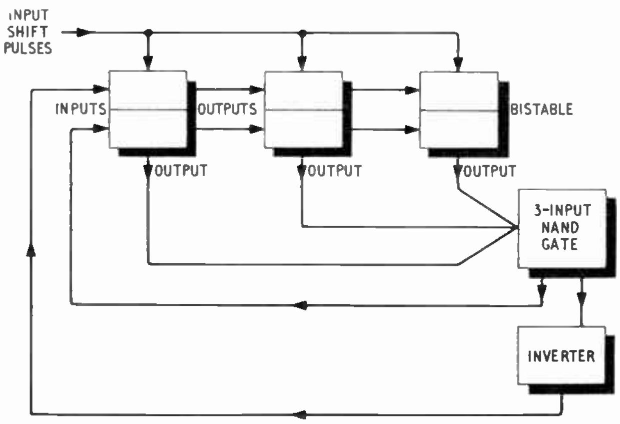


Fig. 26. Block diagram of the electronic time-sharing system

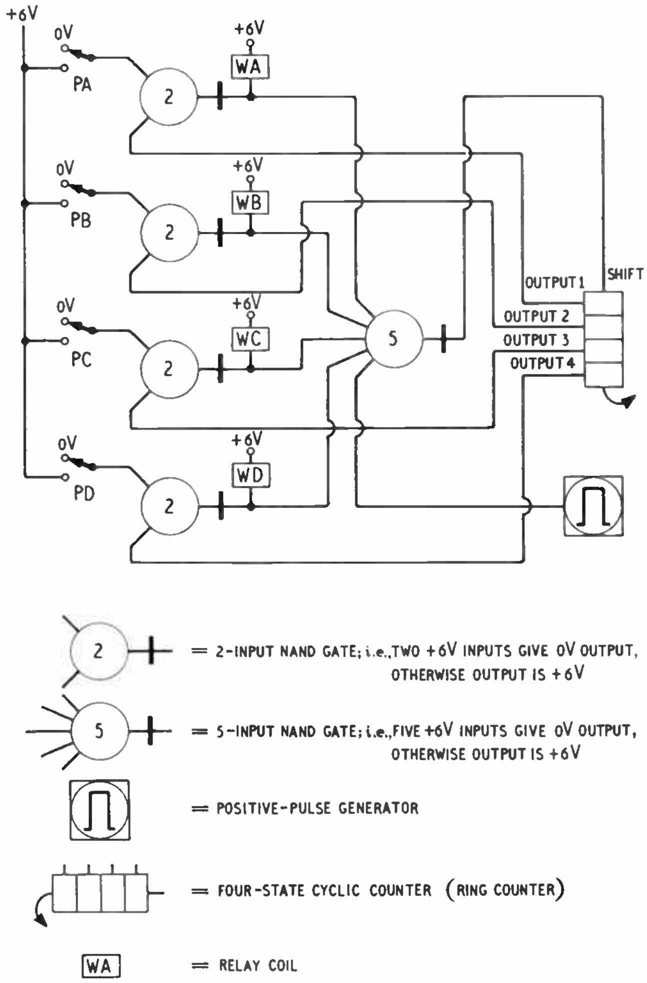


Fig. 27. Complete circuit diagram with values of components of the electronic time-sharing system. Unless otherwise stated all resistors are Dubilier type BTT, ½ watt, with a tolerance of ±10%

circulates through the four stages, progressing one stage at a time for each shift pulse, as shown by the waveforms of Fig. 25.

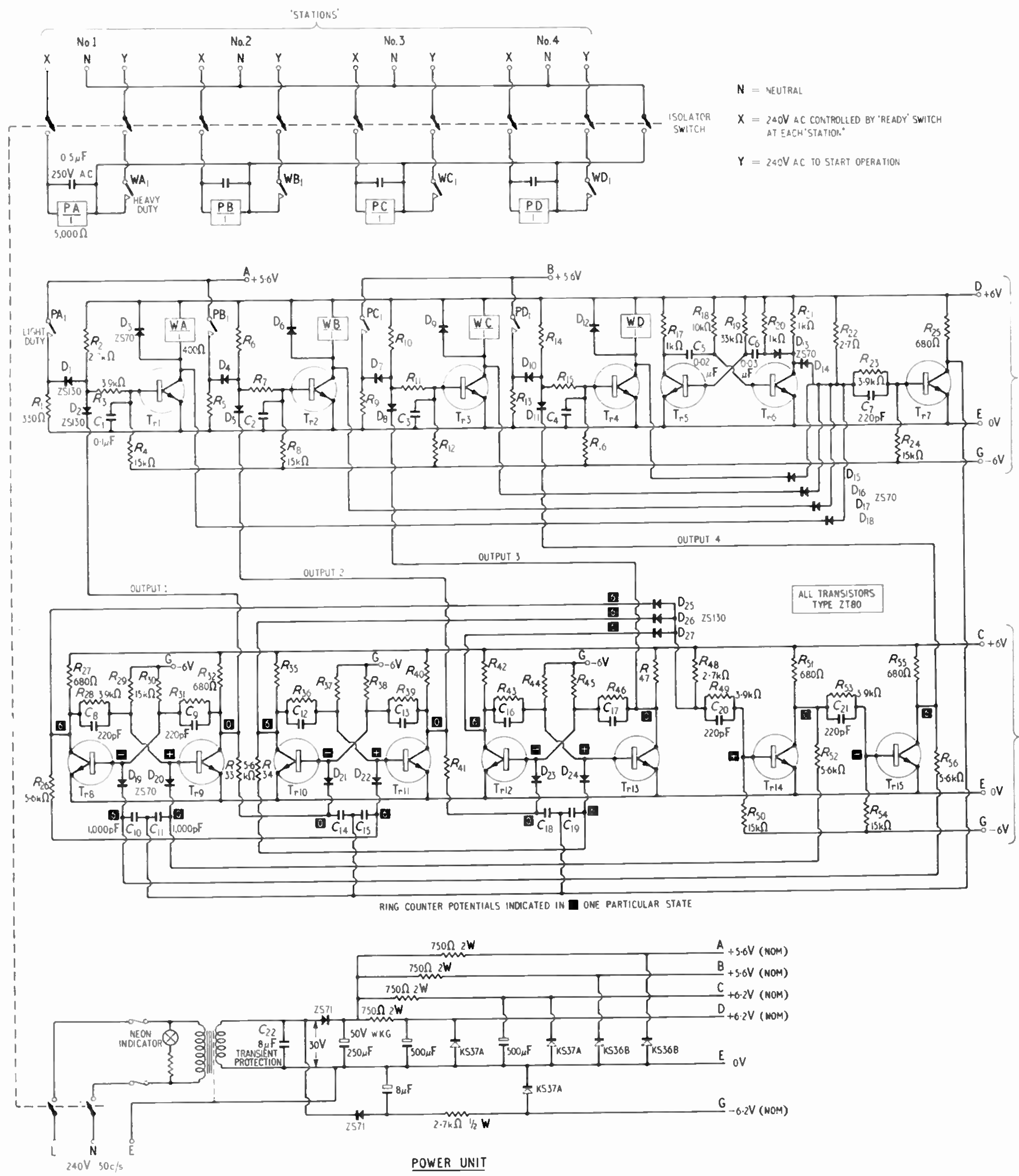
Electronic Time-Sharing System

General Scheme

The general idea of the system is as follows. There are four separate stations (or operators), A, B, C and D, each with its own relay (WA to WD) and 'ready' switch (PA to PD). A 'station' operator closes his switch when he is ready to operate, but the system arranges that only one station may operate at a time. Thus, if several operators are 'ready', they may only operate in numerical sequence (not necessarily in the order in which they closed their switches), but any stations 'not ready' will be bypassed. The only action required by the operator is to close his 'ready' switch; the actual operation is started by the switching system closing the appropriate relay when time is vacant. The applications of such a system will be discussed when the equipment has been described.

Principle of Operation

A block diagram of the complete system is shown in Fig. 26, which also explains the meaning of the symbols employed. As already mentioned, only one of the four outputs from the ring counter is at + 6 V at any particular time (see waveforms in Fig. 25), the other three outputs being near 0 V. A potential of +6 V is therefore applied in turn to one input of each of the two-input NAND gates. When one of these gates has both inputs at +6 V (due to the ready switch being closed and the presence of the ring-counter output) it switches ON and the appropriate relay is energized, which closes contacts to start an 'operation'. In addition an input to the five-input NAND gate is also changed to 0 V. As we saw in the discussion of the basic NAND gate, *all* inputs must be 1 (+6 V) for the output to be 0 (0 V). The output of the five-input NAND



gate therefore stays at +6 V (gate closed) during the time that any two-input gate has both inputs at +6 V. Since the shift-pulse generator feeds the ring counter via the five-input gate, the ring counter does not receive any shift pulses when the gate is closed. In the absence of shift pulses, the ring counter stops with +6 V from one particular output. The overall effect then, of closing one 'ready' switch, is that the ring counter operates until two +6 V inputs are applied to a two-input gate, a relay is energized to start an operation, and the five-input gate closes, which stops the ring counter. When the 'ready' switch is opened, the relay is de-energized and the ring counter starts again and continues until it finds another closed 'ready' switch. The circuit therefore performs the required function.

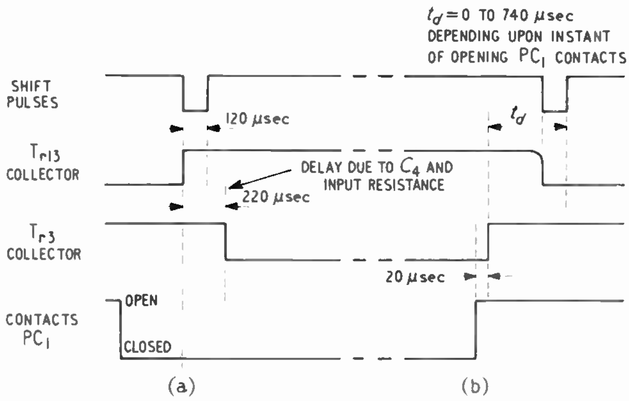


Fig. 28. Waveforms at input and output of a two-input gate

The complete circuit diagram together with a suitable power supply is shown in Fig. 27.

Special Circuit Features

Components D_1 and R_1, etc., at the input to the two-input gates are used to permit PA to PD contacts to be 'normally open'. This gives better 'fail-safe' conditions in the event of dirty contacts than would be the case with 'normally closed' contacts connected between the input and earth.

Capacitors C_1 to C_4 delay the inhibiting of the shift pulses to prevent shortened shift pulses from passing to the ring counter and giving incorrect operation. Fig. 28 shows the waveforms at the inputs and output of a two-input gate where the appropriate 'ready' contacts are closed (a) and opened (b). The long delay produced by the inclusion of a large value for C_3 is not necessary for correct operation under normal circumstances, but is deliberately chosen to reduce the sensitivity of the gate to interference such as may be generated by sparking relay contacts, etc.

High-speed switching diodes are necessary for the gate inputs which are connected directly to the ring counter, but in other circuit positions general purpose ZS70 diodes are satisfactory.

The relays should not be mounted too closely to the electronic circuits and should preferably be screened. Where electrical interference is severe, the whole circuit excluding the leads to the mains supply and the four 'stations' should be enclosed in an earthed steel case. In some cases, filters may also be necessary in the incoming leads.

In the event of period t_d in Fig. 28(b) approaching a critical value near the switching threshold of the ring counter stages and component tolerance in particular directions, it would be possible for two ring counter outputs to be simultaneously at +6 V. The three-input NAND gate would automatically correct this within one complete cycle of the ring counter. Where it is necessary to prevent this false starting, a differentiator and monostable circuit should be connected between the collector of Tr_7 and the line driving the ring counter. This circuit can be similar to the differentiator and pulse width generator shown in Fig. 18(b) December issue, except that C_4 may be fixed at 2,000 pF and the 15-kΩ variable control is unnecessary. Shift pulses to the ring counter would be taken from the 680-Ω collector load resistor.

Power Supplies

Low power reference diodes provide voltage stabilization in the presence of quite large variations of mains supply voltage. The supplies are subdivided to limit the dissipation in the reference diodes. Additional smoothing capacitors are necessary only for supplies C and D.

Slow-Speed Operation

For observation of the correct operation of the circuit or for maintenance purposes, the speed of the ring counter can be decreased to some conveniently slow rate. This can be done quite easily by shunting C_5 and C_6 in the multivibrator by capacitors of 25 μF and 50 μF respectively. The operation of the circuit can then be observed either by means of voltmeters or by operating indicators from the ring counter outputs.

Extension of the System

The system may be easily extended to control a larger number of 'stations' or reduced for a smaller number. For example, for six stations, two additional two-input NAND gates and two additional bistable circuits would be needed, plus two extra input diodes for gates Tr_7 and Tr_{14}.

Applications

The system described has been in use for more than a year to control a group of electric welders operating on mass production. The time-sharing method permits the peak power required by the system to be limited to that of a single welder, with obvious economic advantages. Since the actual welding operations are short compared with the preparation time, there is negligible interruption in the production, while the work tends to be shared equally between the operators.

Other possible applications of the system are:—

(1) Material distribution from a common source to separate production lines.

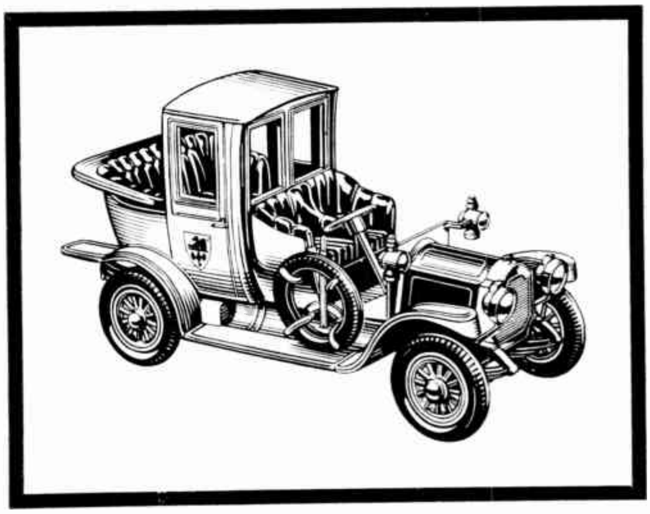
(2) Sharing of a special processing machine by a number of separate production channels.

(3) Alarm systems; e.g., continuous monitoring of temperature at a number of separate points.

In some applications slow-speed operation would be useful since it would permit a single operator to stop at any point in a cyclic scanning system.

Conclusion

This concludes the articles on switching circuits for industrial use. The possible industrial applications of switching circuits are almost limitless, but it is hoped that some indication has been given of how fairly complex functions can be performed by basically simple circuits.



LOW-COST AUTOMATION AT LESNEY PRODUCTS

A computer or similar high-cost equipment is not necessarily required in order to produce a finished product or piece part automatically. There are hundreds of processes in both large and small factories which can be speeded up or done automatically or even partially automatically at a reasonable cost. The capital cost of equipment for this purpose varies with the application and the following examples of equipment supplied to Lesney Products Co. Ltd. by Photronic Controls Ltd. show how these principles have been applied.

Problem No. 1: Multi-Station Control of Conveyors

In this case one main conveyor first splits into three conveyors and then later into a total of five conveyors (Fig. 1). These conveyors were complete with diverting mechanisms. A fully automatic system was required (with an alternative arrangement for manual operation) for guiding the pallets to their correct destinations.

Solution

A five-position card holder was fitted on one side of the pallet and a light-reflecting disc placed in the appropriate one of the five positions. At the first junction five combined photoelectric heads were fitted to view the five positions in the card holder. In operation the one with the disc reflects the light back on to the corresponding photoelectric cell which passes a signal to the control cabinet. The control unit then operates the diverting mechanism on the conveyor accordingly, diverting the pallet to one of three conveyors. Two of these three conveyors then split into two conveyors each and at these points further sets of combined photoelectric heads were fitted operating in the same way as the first set and switching the diverting mechanism accordingly. The system is also arranged so that any pallet or carton placed on the conveyor without a marker automatically follows the route of the pallet in front of it and thus it is only necessary to code the pallet when a change of destination is required. The control panel is also fitted with a series of indicator lights to show which conveyor has been selected and push buttons to provide manual operation if required. It is also designed so that every part of the system is fitted with a plug and socket thus enabling rapid changeover of components should a fault occur.

The price of such a system of course varies with its complexity but would normally be in the range of from £250 to £1,000.

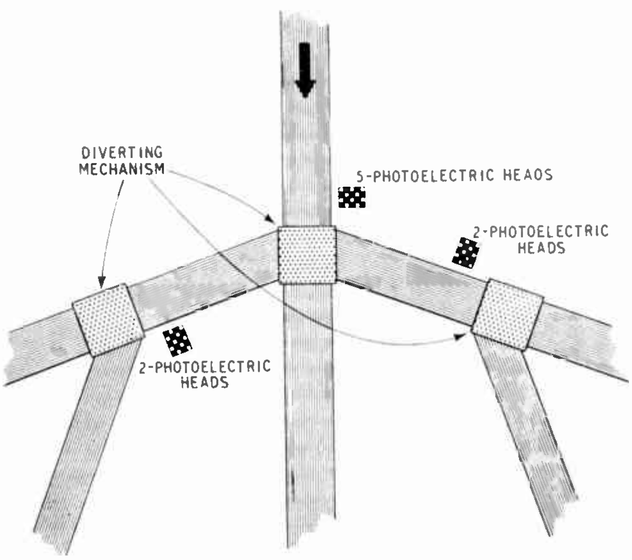


Fig. 1. Conveyor layout at Lesney Products

Problem No. 2: Automatic Switching of Artificial Lighting

In this case some 100-plus fluorescent lamps per floor were required to be switched on and off according to the level of daylight intensity, with provision for manual override.

Solution

An Autolite type LU/2 was supplied for each floor operating a 100-A per phase contactor to spread the load over the three-phase system. The photoelectric cell monitors the daylight outside the building on the north side and operates the contactor to switch the lights on or off as the level of daylight intensity decreases or increases.

ELECTRONICS
INSTRUMENTATION
CONTROL

This shows the control equipment console and the five photoelectric heads for the conveyor system of Fig. 1

The price of this type of system varies with the lighting load being controlled and can be from £5 to £50 accordingly.

Problem No. 3

Each production line was fed with supplies from an overhead conveyor and every consignment was suitably coded to its appropriate line where a ram removed the box of components from the conveyor and fed them to the production line. If the ram device should stick in the extended position, subsequent trays and carriers would collide with it causing damage and loss of production time.

Solution

A light beam projector and receiver were so positioned that the light beam was broken when the ram was in the extended position. This signal is fed into a control unit which incorporates an adjustable time delay. In normal operation the light beam is broken for approximately 1½ sec, so by setting the time delay at 2 sec no control action is obtained when the ram operates correctly. If, however, the light beam is still broken when the timer has 'timed out' then a relay action is obtained which stops the conveyor and energizes a warning light to show which unit is at fault. As a further safeguard to ensure against false operation due to 'lamp failure' a further relay circuit is incorporated to provide a warning should the projector lamp fail at any time.

This type of equipment is equally applicable to many other problems relating to the control of conveyors and is priced in the region of £25 to £35.

Problem No. 4

To check that castings and plastic mouldings are ejected from automatic machines and if any is not ejected to prevent the process continuing and causing damage to the tools.

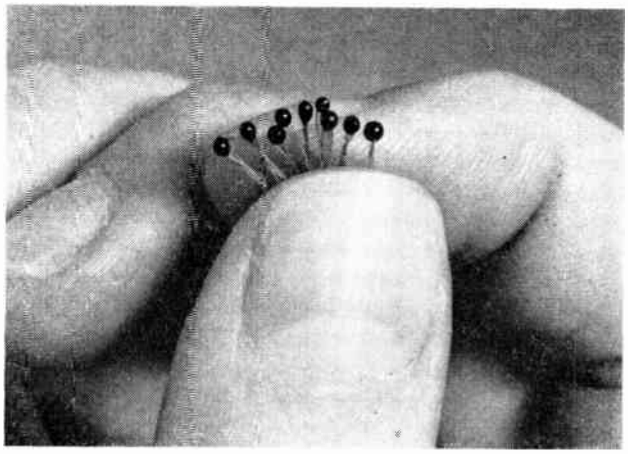
Solution

The sequence of operation is controlled by a process timer. A tool and die protection control was fitted to the machine so that the article ejected falls on to an impact plate. This enables a relay action to be obtained which is fed into the process timer. If the timer does not receive this impulse at the correct point in its cycle then it stops the machine. The sensitivity of the impact plate can be adjusted so that it operates on a tiny piece of plastic in one case, or requires a casting of several ounces before it operates in another case.

The price of this control was £35.

These examples of the application of modern control systems to existing installations show how production can be increased, bottle-necks removed and equipment safeguarded with a minimum of capital outlay.

Microminiature Transistors



This picture illustrates a collection of Mullard microminiature silicon planar epitaxial transistors, type BC112. These must surely represent the near ultimate in conventional miniaturization of transistors

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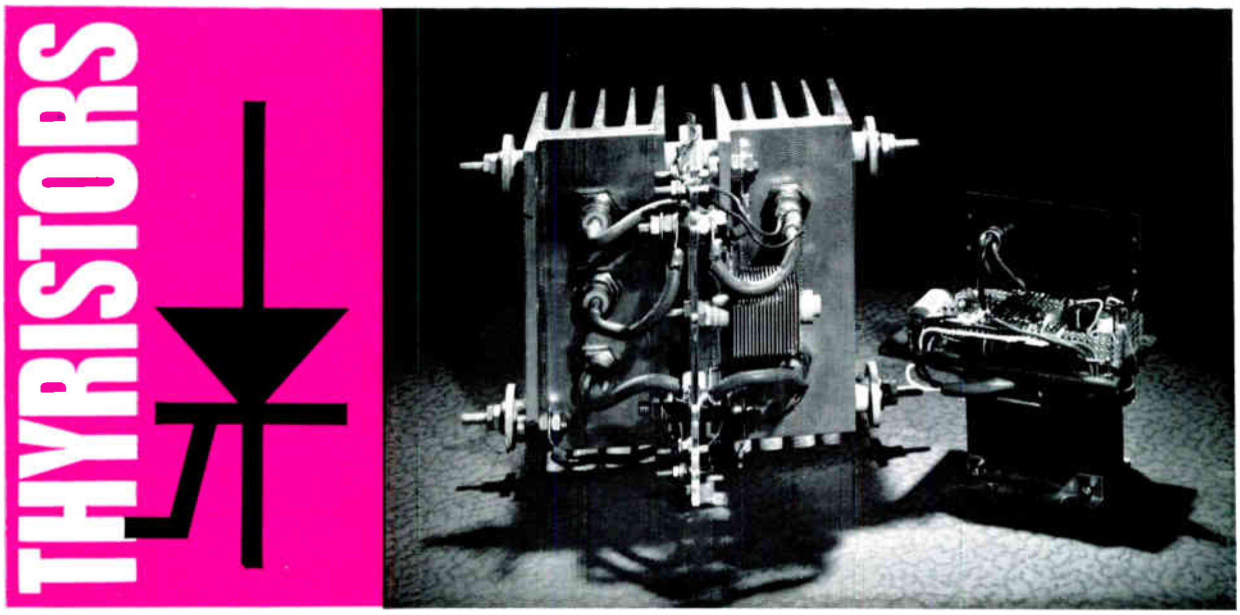

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HD1810 HD1840 HD1841 HD1870 HD1872	Gold-Bonded	PIV I_F @ 0·7V I_b @ 10V Capacitance Stored charge	up to 50V >100mA <5μA 1·5pF 65pC	
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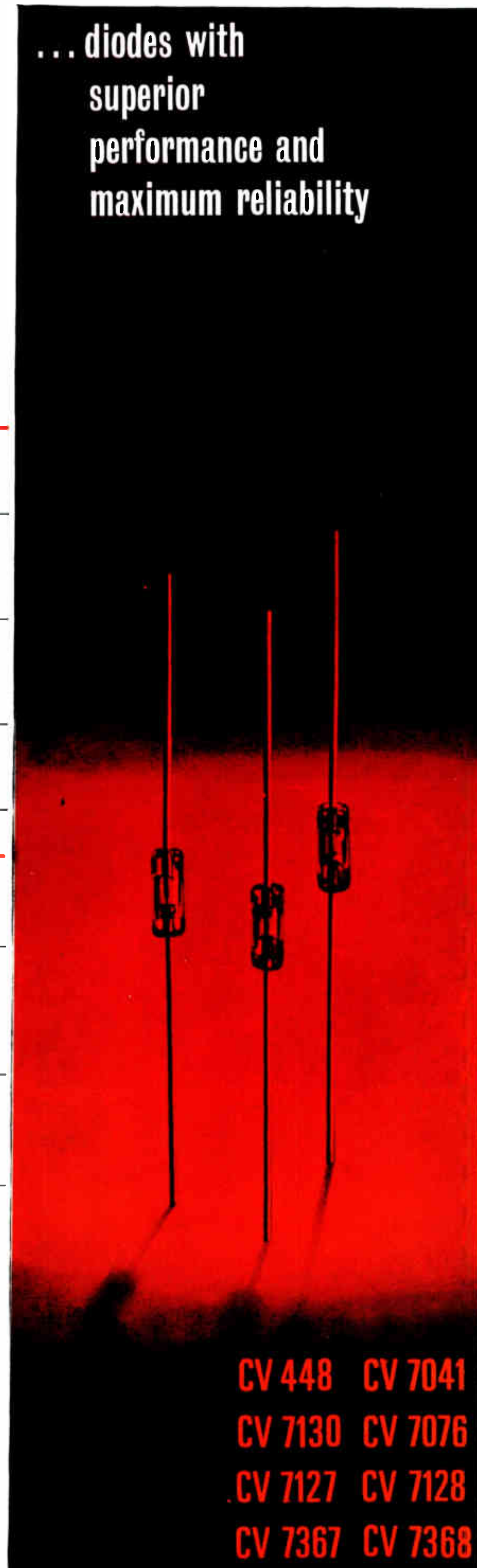


M & P HM22

A Magnetically Coupled Multivibrator

as a Voltage Controlled Oscillator

A transistor oscillator circuit is described which produces a square-wave output the frequency of which can be varied over the range 48 c/s to 37 kc/s by a voltage change from zero to 10 volts. The operation depends on the use of transformers having cores of material with a rectangular BH loop.

*By G. SMILJANIĆ**

IN some applications it is necessary to change the frequency of an oscillator. If the output waveform of the oscillator is required to be a rectangular pulse having constant amplitude, then a magnetically-coupled multivibrator may be very suitable. It has been shown[1,2] that the frequency of a magnetically-coupled multivibrator can be changed by a d.c. control current. In this article an example of frequency change over a wide range by a relatively small d.c. voltage is presented.

The circuit considered is shown in Fig. 1. The transistors Tr_1 and Tr_2 conduct alternately. The duration of the conduction periods is determined by the transformers T_1 and T_2. While Tr_1 conducts, Tr_2 is cut off, the core of T_1 is excited, being driven toward $+B_m$, and the core of T_2 is reset, being driven toward $-B_m$. This period duration T is determined by the magnetic flux change in the core T_1 from $-\Phi_m$ to $+\Phi_m$, if the current in the control windings N_c and N'_c is zero. When the core T_1 is saturated, the transistor Tr_1 cuts off, and Tr_2 begins to conduct exciting the core T_2 (drive toward $+B_m$) and resetting the core T_1 (drive toward $-B_m$). This period is determined by the core T_2.

When the current in the control windings N_c and N'_c flows, the amount of the magnetic flux of the transformers T_1 and T_2, which determines the frequency, is reduced and the frequency increases. The current I_c is controlled by a control voltage V_c. The output pulses are transmitted to the load by a linearly-operating transformer T_0.

In the case considered the transistor base-driving transformer cores (T_1 and T_2) are made of a narrow square BH loop material PERMENORM 5000 z†. The frequency ($f = 1/2T$) dependence of the multivibrator on the control voltage V_c is shown in Fig. 2.

The minimum frequency is 48 c/s obtained at $V_c = 0$. The maximum frequency is about 37 kc/s obtained at $V_c = 10$ volts. The control voltage–frequency curve depends to a great extent on the shape of the hysteresis loop of the transistor base-driving transformers. In the case considered the BH loop of the core is more or less rectangular. The frequency changes very slowly at small control voltages until the knee of the hysteresis loop is reached at approximately $V_c = 0{\cdot}4$ volt. Then a very rapid frequency increase follows for a very small control voltage increase, corresponding to the steep side of the hysteresis loop. Further increase of the frequency requires a larger control current change for a certain frequency increment, corresponding to the part of the BH loop near

* Institute 'Ruder Bošković', Zagreb, Yugoslavia.
† Vacuumschmelze, Germany.

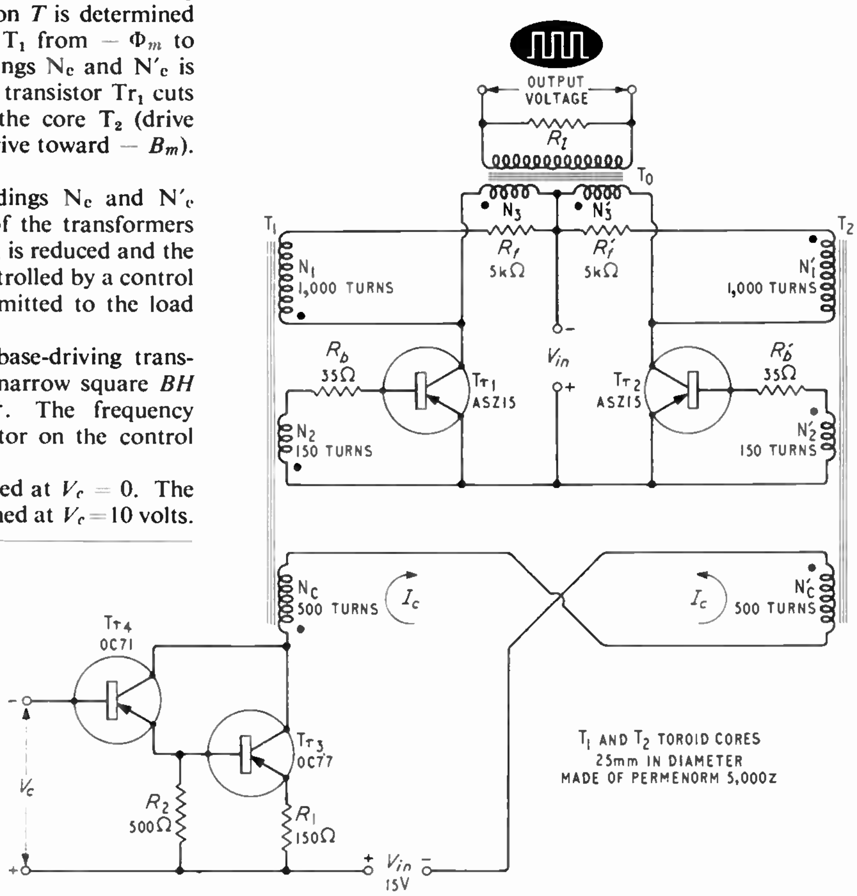


Fig. 1. Circuit diagram of the oscillator. T_1 and T_2 are wound on toroidal cores, 25 mm in diameter, made of Permenorm 5000z

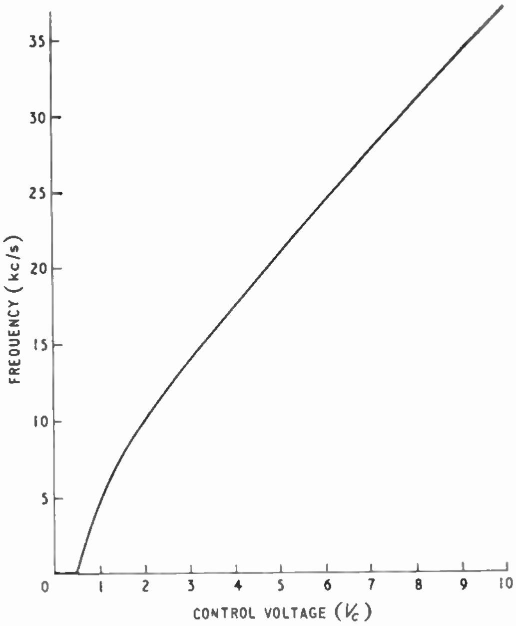


Fig. 2. Curve of frequency versus control voltage

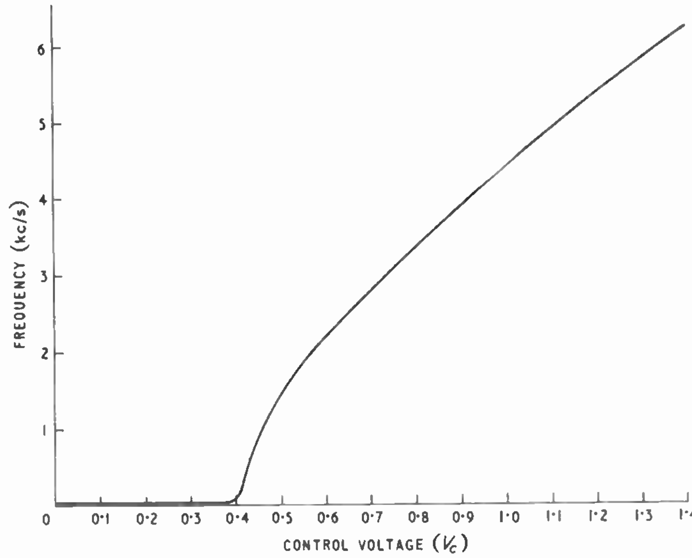


Fig. 3. The lower part of Fig. 2 redrawn to an expanded scale

saturation. The curve in Fig. 2 shows that the frequency can be changed over a wide range by a small control voltage if the transformer cores have suitable hysteresis loops and the transformer windings a sufficient number of control turns N_c and N'_c. The beginning of the voltage–frequency curve of Fig. 2 is shown to an expanded scale in Fig. 3. As explained above the shape of the voltage–frequency curve depends mostly on the shape of the hysteresis loop. From Figs. 2 and 3 it can be seen that in the particular case which is under consideration there are some limited ranges of the voltage–frequency curve that depart only slightly from linearity. It may therefore be concluded that the voltage-controlled oscillator shown in Fig. 1 has the following features:

The frequency can be varied in a wide range by a relatively small control voltage.

The input impedance for the control voltage is high. The output impedance is low.

The waveforms of the output voltage are square pulses having constant amplitude.

Immediately after crossing the knee of the hysteresis loop the frequency changes very rapidly for small changes of the control voltage. The departure of the voltage–frequency curve from linearity can be small over certain limited ranges.

References

[1] Smiljanic, G., 'A Frequency Controlled Magnetically Coupled Multivibrator', *Electronic Engng.*, Vol. 35 (1963), p. 166.

[2] Smiljanic, G., 'Operation of a Magnetically Coupled Multivibrator with Square BH Loop Cores', *Electronic Engng.* (to be published).

I.E.R.E. OFFICERS AND COUNCIL FOR 1965

The Institution of Electronic and Radio Engineers has announced that its president for 1965 will be Colonel George W. Raby, C.B.E. Colonel Raby is managing director of the United Power Co. Ltd.

The vice-presidents will be: Mr. A. A. Dyson, O.B.E. (chairman and managing director, Erie Resistor Ltd.); Mr. I. Maddock, O.B.E., B.Sc. (head of Applied Physics Division, Atomic Weapons Research Establishment); Mr. R. H. Garner, B.Sc.(Eng.), who is principal of Coatbridge Technical College; Major-General B. D. Kapur, B.Sc., who was until recently chief controller, Defence Research and Development, Ministry of Defence, Government of India; Mr. H. F. Schwarz, B.Sc. (the managing director of Decca Navigator Co. Ltd.); and Professor Emrys Williams, Ph.D., who holds the chair in electrical engineering at the University College of South Wales and Monmouthshire.

Other elections to the Council include three full members and three associate members. The full members are Mr. T. A. Cross (managing director of Redifon Ltd.); Professor W. A. Gambling, Ph.D. (of the Department of Electronics, University of Southampton) and Mr. M. James, Dip.El., who is chief engineer, Industrial Electronics Division in Great Britain of the International General Electric Company of New York Ltd.

The Associate Members are Mr. R. J. Cox, B.Sc. (head of the Control and Instrument Division, Atomic Energy Establishment, Winfrith); Rear-Admiral C. R. Darlington, B.Sc. (director of Naval Education Service, Ministry of Defence) and Mr. N. L. Garlick, M.Sc., who is head of the department of electrical engineering, Brighton College of Technology.

Mr. G. A. Taylor, head of the Engineering Division, Mullard Research Laboratories, was re-elected honorary treasurer of the Institution, a post he has held since 1953.

MINIATURE DUST-PROOF RECORDER

By **RAY FELDMAN***

This article gives some details of a miniature strip-chart recorder which is designed for industrial application. Some of the applications of the instrument are also discussed.

THERE has been a pressing need for recording instruments for on-the-job use in practically all types of industry. Since low or high voltage, current, power consumption and other variables must be known in order to avoid failure of, or damage to, major equipment, minimize down-time and maintain production, it follows that a test instrument that provides a permanent, documented, record of actual conditions can appreciably help to reduce the costs involved in electrical-equipment maintenance, repairs and replacement.

Ideally, such an instrument would be small, simple in design and low in cost and would operate reliably, be highly stable and could measure any variable-voltage, current, power, temperature, pressure, flow, etc. The miniature Amprobe Strip-Recorder has been designed to meet these requirements. It can be used as a standard indicating meter as well as a strip-chart recorder and is very economical. It offers designers, engineers and maintenance personnel a test instrument which can contribute greatly to savings in time and effort by providing recordings to pin-point trouble spots in almost all electrical equipment and processes in all industries.

This miniature recorder utilizes either an advanced-design D'Arsonval movement which is built around a new, internal-core magnet with self-shielding characteristics, or a taut band movement, depending on the model. A synchronous motor drives the movement.

Both meter movement and drive mechanism are sealed with Mylar shielding which blocks air-borne dust particles even when the paper is being changed. This feature is particularly important when it is desirable to use a recorder under conditions found in most plants, where dust, lint and other contaminants could affect efficient operation of the test instrument.

An inkless stylus makes a continuous dot-recording on pressure-sensitive paper which is unaffected by moisture, heat, cold or fumes. The paper is loaded into the recorder with even greater ease than film loads into a camera. One roll provides for 360 hours of continuous recording at 1 in. per hour. Feed speeds of 6 in. or 12 in. per hour are also available. A simple chart feed eliminates the possibility of the paper tearing or binding.

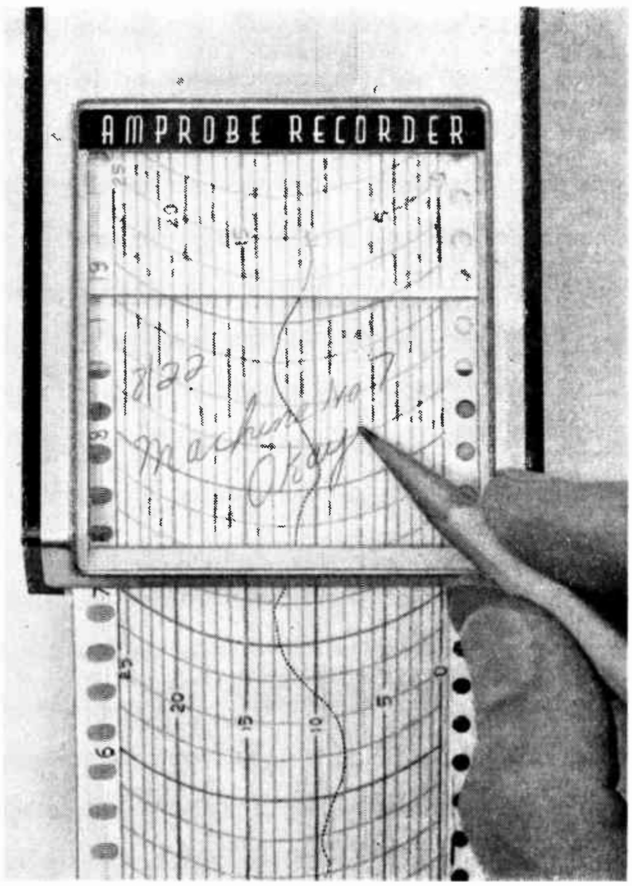
The viewing window of the Amprobe Recorder extends part-way down the chart, permitting the operator to make explanatory notes on the paper while the instrument is in operation. When no paper is loaded, the recorder can be used as a standard indicating meter, since the stylus is always visible.

Extremely portable, the recorder is available in leather cased and flush-mounting versions. The leather cased recorder measures only $5\frac{7}{16}$ in. × $6\frac{7}{8}$ in. × 2 in. and weighs approximately 11 ounces. The flush-mounting versions for permanent panel installations measure $3\frac{3}{8}$ in. × $6\frac{11}{32}$ in. × $1\frac{13}{16}$ in. and weigh 20 ounces.

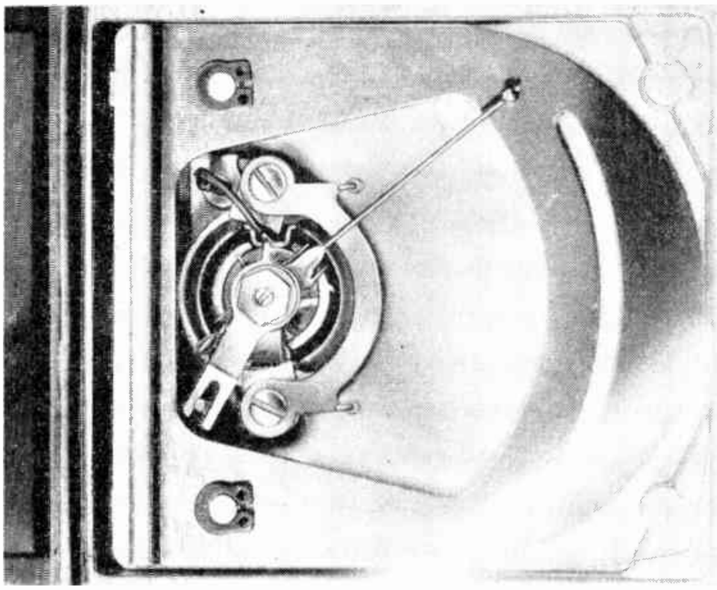
The multiple uses of this miniaturized strip-recorder are limited only by the ingenuity of the user. They are currently applied to electronic equipment such as ultrasonic cleaners, photocell proximity switches, computers, high-speed counters; closed-circuit TV and other TV-radio applications; all types of fluorescent, incandescent and vapour lighting; infra-red equipment; motors, rectifier loads; magnetic devices; power distribution equipment; resistance-welding equipment and other devices ad infinitum. By using the proper sensing element (or transducer), it is possible to measure and record almost every known electrical value, physical phenomena or event.

One application suggested is the use of this recorder in hospitals to keep a continuous check on a patient's pulse, temperature and respiration. One staff member could

* Canadian Instruments and Electronics Ltd.



Easy access to chart paper below viewing window enables operator to make notes, while the instrument is in operation, directly on the chart with stylus, pencil or pen



Pressure-sensitive chart papers eliminate need for ink reservoirs, pens or carbon ribbons, and enable the instrument to function in any position

ascertain these functions in several patients without disturbing them—and by remote reading through tiny sensors applied to the patient or to the bed.

As an aid to management and in production control, this recorder can be utilized to determine the efficiency of men and machines by measuring increases and decreases in machine loads as well as variables which affect machine operation. Time-motion studies can be conducted by means of periodic readings without interfering with labour–management relations. The permanent written record supplies needed proof of production deviations. Management can also keep a closer check on general conditions, determine off-voltage before machines and/or motors are damaged or the quality of the work being done is seriously impaired.

Another use is for trouble-shooting in the electric appliance service field when the serviceman cannot be present. The recorder is attached to air-conditioning units, refrigerators, freezers, ranges, oil burner motors and other appliances to test and record voltages, amperage, temperature, and other variables to detect trouble without wasting time and effort.

The problems and solutions which follow are indicative of the scope of this recorder in industry:

Problem: It was thought that an oversize die in a punch press might over-load the motor if the stock size was not controlled.

Solution: An a.c. current recorder was used to provide current readings throughout the production cycle. A high-current reading indicated oversize stock; the chart showed if a dangerous amount of oversize stock was being used.

Problem: Timing of voltage changes in electronic equipment was needed so that a preventive maintenance programme could be devised.

Solution: A high-voltage miniature strip-chart recorder was installed in place of an existing voltmeter and elapsed-time meter. It produced a continuous permanent record of voltage conditions and gauged accurately at what point preventive maintenance should be performed.

Problem: A factory experienced a series of breakdowns during mid-afternoons in summer months.

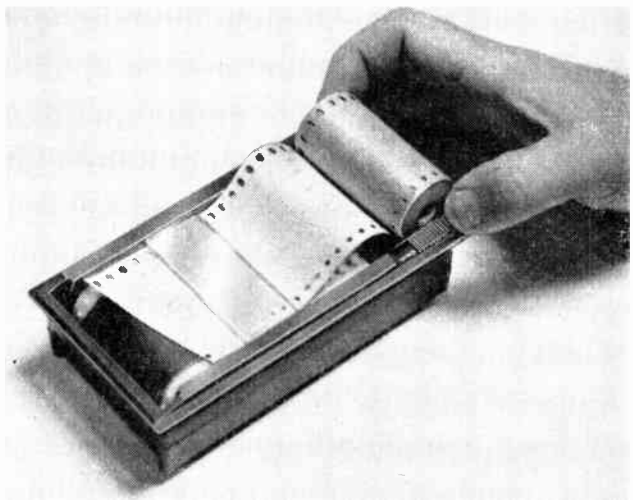
Solution: A high-voltage recorder was hooked up at the incoming source for 48 hours. The chart record indicated low line-voltage periods during this time, providing documented proof of voltage variations. Downtime was eliminated by changing the production schedule to balance machine loads.

Problem: Production on knitting machines running 24 hours a day fell off alarmingly. No unusual machine failure was noted.

Solution: Recorders were installed in the knitting room for a 24-hour period. It was found that a definite pattern of current variations occurred about one hour before shift changes. Upon studying these periods, it became apparent that the machines were not receiving the required attention from operators and in some cases were being left down for the next shift to restart. After the matter was taken up with the shift leaders, a definite increase in production was noted. A recorder is now installed in the plant manager's office to enable him, at any given time, to study the strip chart and ascertain production cycles without visiting the plant in person.

It is impossible to list all the applications possible for this miniature dust-proof strip-recorder. But from research laboratories to nuclear power installations, from truck refrigeration to elevator controls, from transformers to milk plants—only the ingenuity and need of the user can limit its many uses.

Mylar shielding seals the most critical parts of the recorder, the meter-movement and drive mechanism, to keep it dust proof



MEASUREMENT OF LIQUID FLOW IN PIPELINES

By J. C. McVEIGH, M.A.(Cantab.), M.Sc., Ph.D., A.M.I.Mech.E., A.F.R.Ae.S.*

This article describes a number of different types of flowmeter and explains their operating principles. Some experimental types are also included in the discussion.

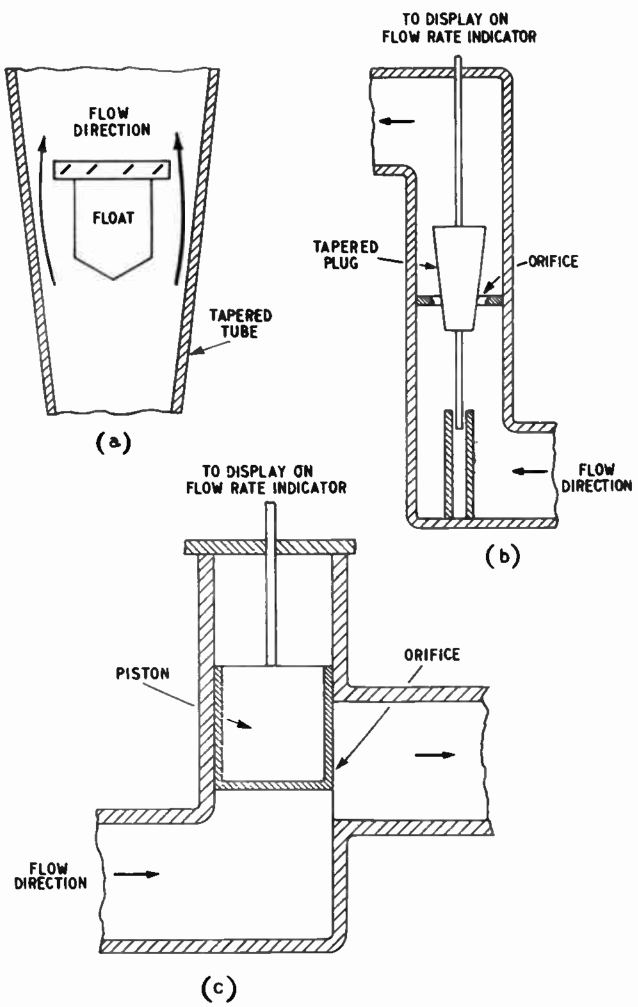
APART from the differential pressure[1], there are many other types of flowmeter of which the four main groups are discussed in this article.

Variable-Area Flowmeter

With all types of variable-area flowmeter, the area of the flow passage varies with the flow rate while the differential pressure remains approximately constant. This contrasts with the differential pressure meter where the rate of flow is proportional to the pressure drop across a flow passage of constant area. With variable-area flowmeters the flow rate is measured by the displacement of the element which alters the flow area. Such meters are becoming increasingly used in applications where the corrosive or dirty nature of the fluid makes the use of a differential-pressure type undesirable.

The tapered tube and float type, also known as the rotameter, is shown in Fig. 1 (a). It consists of a specially-shaped float which is free to move vertically in a tapered tube. This tube has its largest diameter at the top and must be mounted vertically. When the fluid flows vertically

*Borough Polytechnic.



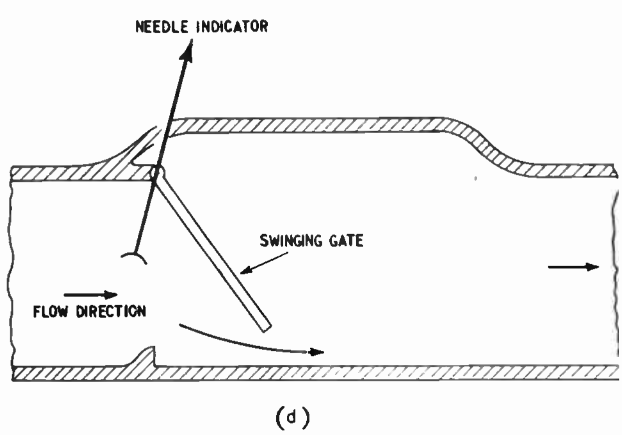


Fig. 1. Various types of flowmeter; (a) the rotameter, (b) the taper-plug meter, (c) the piston meter and (d) the hinged-gate type

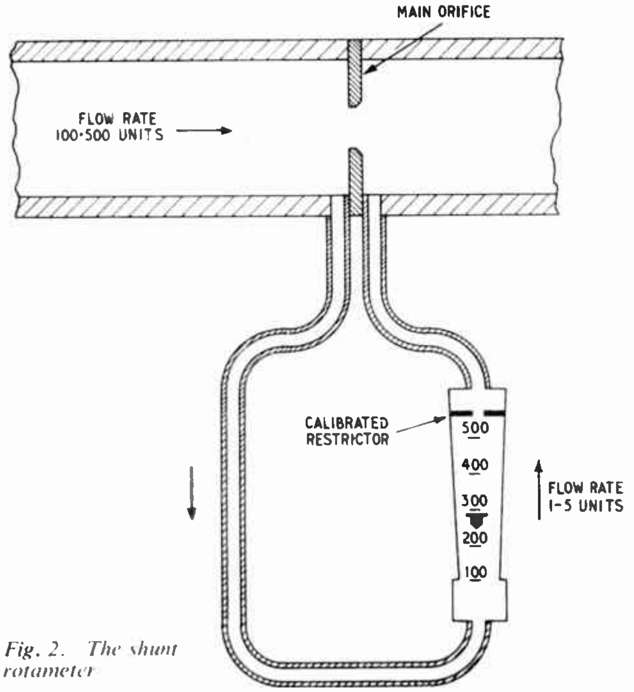


Fig. 2. The shunt rotameter

upwards through the tube, the float takes up an equilibrium position where the downwards thrust caused by its weight is balanced by the combined differential pressure, viscous and buoyancy forces. Attempts have been made to simplify the relationship between the flow rate Q, the height of the float above its datum position h, the density of the float ρ_f and the density of the fluid ρ_g by ignoring viscous effects and deriving the relation

$$Q \propto h \sqrt{\frac{(\rho_f - \rho_g)}{\rho_g}}$$

and assuming that the angle of taper is very small. This approximate relation is of little practical significance and the use of dimensional analysis provides the only satisfactory method of studying the relationship between all the variables. Series of curves can be drawn for any particular tube relating flow rates, different density fluids and floats and the height h.

The simple construction of the rotameter allows it to be made in a wide variety of materials. In many applications the prime requirement is for an instantaneous reading of the flow rate while a knowledge of the condition of the fluid is desirable. This is achieved by using a glass tapered tube. Standard materials for the float include stainless steel, duralumin, titanium and rigid p.v.c. Continuous development of specially hardened glass has increased the maximum allowable fluid pressure to above 500 lbf/in.^{2} for the smallest tubes while working temperatures can reach 400 °F with safety.

Photo-electric cells can be used for control purposes with the glass tubes, but when high pressures and temperatures are required the tube must be made of metal and some form of indirect reading of flow-passage area is needed. The range of the rotameter for many applications is 10 : 1 but unless it is specially calibrated, its accuracy is quoted within a certain percentage of the full-scale reading. This can lead to trouble if the lowest flow-rate readings are critical. For example, a percentage accuracy of $\pm 2\%$ on a full-scale reading of 100 units/hour could mean that at an indicated scale reading of 10 units/hour the actual flow rate was between 8 and 12 units/hour, a percentage error of $\pm 20\%$.

Among other forms of variable-area flowmeter are the taper-plug type, Fig. 1 (b), the piston-type, Fig. 1 (c) and the swinging vane or hinged-gate type, Fig. 1 (d). In the taper-plug type, the function of the rotameter float is carried out by the tapered plug. Many forms of spring-loaded taper-plug meter have been developed for use in the aircraft industry. With the piston type, the differential pressure across the meter lifts the piston which covers the orifice. The piston may be loaded by weights or by a spring. All forms of spring loading can give rise to forced vibrations and provision has to be made for adequate damping in some cases. The swinging vane or hinged-gate type is a simple instrument with a lower accuracy than the other types and is usually coupled directly to a dial indicator.

For metering fluids in large pipes a combined orifice plate/rotameter arrangement can be used as shown in Fig. 2. A British Standard orifice plate is installed in the main pipeline, producing a differential pressure directly proportional to the square of the fluid-flow rate. In the shunt pipe a small rotameter is fitted with an accurately-calibrated restrictor. The greater part of the pressure drops across the shunt-pipe system occurs at this restrictor. The flow rate in the main pipeline is indicated on the shunt rotameter. With careful installation an accuracy of $\pm 2\frac{1}{2}\%$ of the full-scale reading can be achieved over a range of 5 : 1.

Positive-Displacement Flowmeter

These meters are volumetric in operation, the volume of fluid passing through the meter during each cycle being directly proportional to the displacement of the detecting element. The number of cycles is recorded on a counting system. They are commonly used where a small, cheap and reasonably accurate measurement of flow is required. The recent survey[2] carried out by the National Engineering Laboratory shows that they come second to the differential pressure meter in numbers of meters in service for both liquid and gaseous flows. One of the main types used for metering liquids is the oscillating or semi-rotary piston type, the cycle of operations of which is shown in Fig. 3.

The liquid enters the space B from the inlet port A, displacing the hollow cylindrical piston C in an anti-clockwise direction. The piston is constrained by the diaphragm D and is guided by the spindle which rotates in the channel

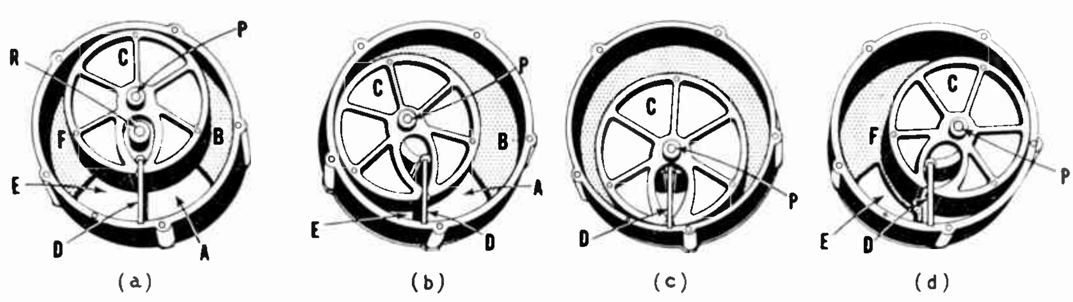


Fig. 3. Four stages in the cycle of operation of an oscillating piston flowmeter

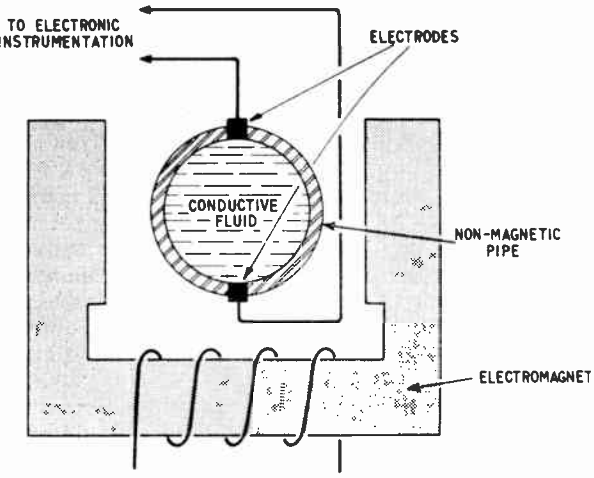


Fig. 4. Electromagnetic flowmeter for use with conductive fluids

between the roller R and the fixed cylindrical inner chamber wall shown chain dotted. As this happens, the fluid in space F is displaced through the outlet port E as shown in Fig. 3 (a and b). In Fig. 3 (c) the liquid is in the two spaces between the inner chamber wall and the inner wall of the piston and is also directly in contact with the two ports. The cycle is completed with the uncovering of the outlet port and results in a smooth non-pulsating continuous motion. The rotation of the central spindle P is transmitted to the counting system through a gear train. The same principles are used in the nutating disc type where a circular disc is pivoted in the centre of a circular working chamber which has hemispherical sides. The disc is restrained from rotating by a radial partition. A spindle passes through the centre of the disc and follows a circular path as the disc nutates with the flow of liquid. The circular motion of the spindle is again transmitted through a gear train to the counting system.

The various types of reciprocating piston meter can be thought of as reversed reciprocating piston pumps with the liquid providing the power to drive the piston. The volumetric flow can be calculated from the cylinder dimensions and the number of working cycles. Very high volumetric efficiencies are common with this type. Multi-piston arrangements are normally used and there are many different versions.

The rotating lobe type is similar to a gear pump in design and operation. The fluid causes the impellers to rotate as a result of the differential pressure across the meter and a known volume of fluid is displaced during each revolution. The rotating-vane type works on a similar principle.

Inferential Flowmeter

All inferential meters have a rotor directly in contact with the fluid. Recent advances in the development of the turbine meter[3], as defined in the following paragraphs, have greatly increased the importance of this type in a wide number of industrial applications. Turbine meters have a free-running rotor mounted coaxially on the centre line of the pipe and sweeping practically the whole pipe area. The angular velocity of the rotor is very nearly directly proportional to the pipe velocity and hence to the volumetric flow rate. Accurate determination of the rotor speed is achieved by a pick-up coil located in the outer casing. The type of pick-up coil influences the rotor design. Magnets are placed in the rotor blades of inductance meters and when flow occurs these induce pulses in the coil. With a reluctance meter the coil contains the magnet and the rotor tips must be sufficiently magnetic to generate the pulses. The accuracy of the meter depends partially on the number of pulses recorded per unit flow and slow running meters sometimes have more blades than the faster running meters. The use of several pick-up coils or a serrated ring over the blade tip can also compensate a slow-running meter. With a digital read-out, the accuracy over a 10 : 1 flow range is quoted as better than $\pm 0{\cdot}3\%$ by all leading British manufacturers.

One of the main advantages of turbine meters over the differential pressure type is that the turbine meter has a considerably lower head-loss coefficient based on pipe velocity where the orifice or nozzle area ratio would be less than 0·5. The other main advantage is that the read-out from the turbine meter is directly proportional to the velocity and that the lower range of flow rates can be extended beyond 10 : 1 with high accuracy. Practically the entire flow profile is integrated but some tests at the National Engineering Laboratory[3] on the effect of bends fitted immediately upstream of the meter revealed that great care must be taken to ensure that this upstream velocity profile is not distorted. Special turbine flowmeters have been designed to deal with temperatures below −200 °C and above 500 °C and with pressures up to 40,000 lbf/in^2. Other types of inferential flowmeter have a direct mechanical connection between the rotor and the counting mechanism. These meters are generally used for applications where the initial cost of the meter far outweighs the need for high accuracy.

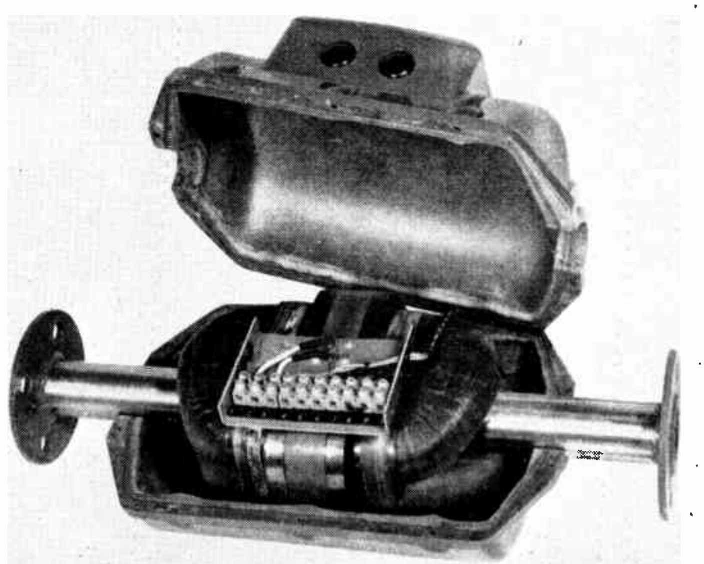
Electromagnetic Flowmeter

The electromagnetic flowmeter operates on the basis of Faraday's law of electromagnetic induction:—

'When an electric conductor moves through a magnetic field in a direction perpendicular to its length and also perpendicular to the lines of force, an e.m.f. is set up in the conductor which is proportional to the number of lines of force cut by the conductor in unit time. The relationship is $E = H\, l\, v \times 10^{-8}$, where E is the e.m.f. in volts, H is the magnetic field strength in c.g.s. units, l is the length of the conductor in cm and v its velocity in cm/sec.'

The electromagnetic flowmeter, Fig. 4, consists of a short section of non-magnetic pipe fitted with two point elec-

A 1½-in. bore 'Emflux' detector-head shown with half its fibre-glass housing removed to show the field coils, magnetic element and terminal block



trodes diametrically opposite each other. These electrodes are made with their surfaces flush with the inner surface of the pipe so that the fluid can pass through the pipe without any restriction. The pipe is enclosed by an electromagnet so that the fluid in passing through the magnetic field acts as the conductor and generates a voltage which is directly proportional to the flow rate. Recent developments in the electronic industry have enabled fluids with conductivities in the region of 5 micromhos/cm to be handled with standard equipment depending on the size of the meter and the length of the transmission cable. It has been claimed that special purpose meters have operated down to conductivities as low as 0·1 micromho/cm[3]. The diameters of standard electromagnetic flowmeters range from 0·1 in. to 6 ft, but at least one manufacturer is prepared to provide larger sizes. A feature of the electromagnetic flowmeter is its high accuracy over the entire scale for ranges of mean flow velocity as low as 0 to 2·0 ft/s. An accuracy within $\pm 1\%$ of full scale is the standard and specially calibrated meters have achieved better than $\pm 0{\cdot}2\%$ of full scale over a 10 : 1 range.

As the meter can measure the true mean flow velocity by electrical averaging, it is not affected by the upstream velocity profile, which can be laminar or turbulent, or by variations in viscosity or density. It can therefore deal with non-Newtonian fluids and could be installed next to a valve or even a discharging pump without loss of accuracy provided no entrained gases are carried through. The main disadvantage of all electromagnetic flowmeters is that the fluid must be conductive. Another disadvantage is the relatively higher initial cost compared with any other type of flowmeter.

Some Other Flowmeters

A considerable amount of development work has been carried out on the ultrasonic flowmeter and some success has been achieved with laboratory trials. In this type, a sound wave passes through the fluid and the changes in flow velocity cause changes in the measured velocity of the sound wave. Commercial development in this country has not proved economical in view of the rapid developments that have recently taken place with both turbine and electromagnetic flowmeters.

The vortex-velocity meter is a comparatively new meter developed for the measurement of gaseous flows. The principle of this meter is based on creating and maintaining a free vortex in an offset vortex chamber at right angles to the main pipeline. The peripheral motion of the vortex depends on the velocity of the fluid. By mounting a squirrel-cage rotor in the vortex a linear relationship can be obtained between the fluid velocity in the main pipeline and the number of revolutions of the rotor. Its range is limited to about 10 : 1, but it has the advantage that it is less sensitive to wear than turbine or positive-displacement meters. It has been claimed that volumetric flow rates measured with the vortex-velocity meter will agree within $0{\cdot}2\%$ of flow rates measured with an orifice plate meter.

A true mass-flow meter has been made by using an impeller, driven at a constant rotational speed, to impart angular momentum to the flowing fluid. The rate of change of angular momentum of the fluid as it leaves the impeller is proportional to the mass flow rate. The reliability of these meters has yet to be proved in this country where they have only been used on an experimental basis in a few industries.

Acknowledgment

The diagrams for Fig. 3 are reproduced by permission of J. C. Newberry Ltd., Ifold, Sussex.

References

[1] 'The Differential Pressure Meter', J. C. McVeigh. *Measurement and Control*, December 1964.

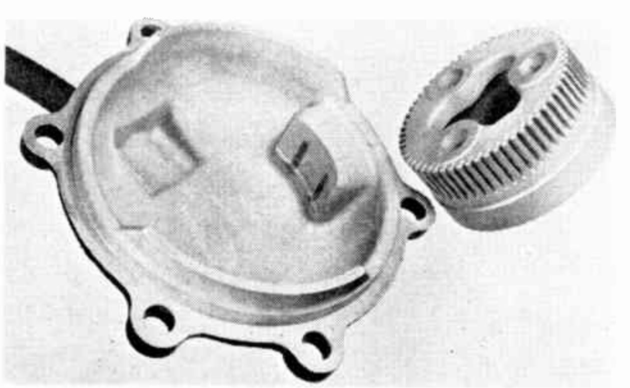
[2] 'A survey of industrial flow metering', W. J. Ramsey. N.E.L. Report, No. 134. February 1964.

[3] 'A survey of turbine flowmeters', D. J. Myles and P. Harrison. N.E.L. Report No. 91. June 1963.

Anti-Skid Devices for Trains

Increase in train speed and the trend towards automatic control on railways throughout the world mean that consistent braking is increasingly vital. It has long been realized that as brakes improve, there is an increasing liability to overbrake and lock the train wheels, particularly under conditions of low wheel-to-rail adhesion when the track is slippery. Wheel slip not only causes loss of braking, but it also causes excessive wear of both the wheel tread and rails. It is for this reason that Girling Ltd. have continued the development, and are now marketing a range, of anti-skid devices which were originated by Lucas.

Illustrated here is the pick-up unit comprising a toothed wheel, which is mounted on the axle, and an electromagnet which is embedded in the axle cover



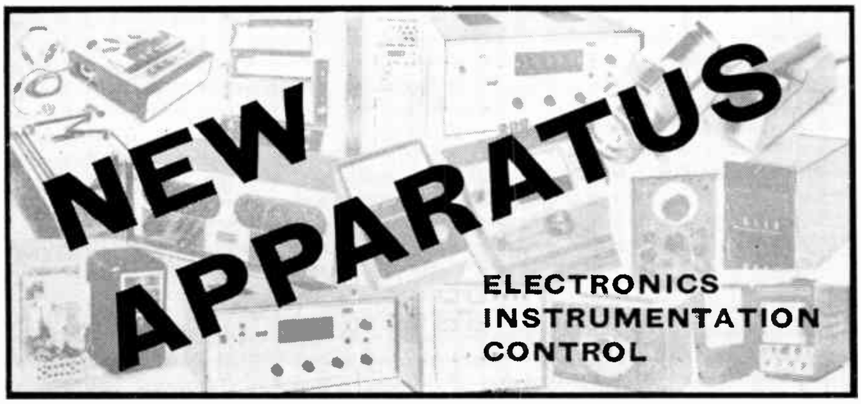
There are two main equipments:

The first provides wheel-slide protection. This relieves the brakes automatically as soon as wheel deceleration exceeds that attainable during maximum braking.

The second is a wheel-slide indicator which indicates when slip occurs so that the driver or automatic control can take what remedial action is necessary.

Both devices include an electromagnetic pick-up and an electronic unit. The pick-up is mounted on the end of the axle and comprises a toothed wheel (on the axle) and an electromagnet embedded in the axle cover. Signals from the pick-up are fed into the control box which houses the deceleration and/or acceleration computing circuits, as required. These are transistor circuits, having no moving parts other than a final relay which energizes an electro-pneumatic valve.

For further information circle 52 on Service Card



1. Molecular Bonder

The Weltek model 800 'molecular bonder' is claimed to do the equivalent of thermocompression bonding of very fine wire without the aid of a heat column. The equipment is suitable for bonding wire from 0·0005 in. to 0·004 in. in diameter to microcircuits, thin films, integrated circuits, and other semiconductor devices. In addition to the regular 'nail head' type of bond, the machine is also capable of making 'stitch' bonds and 'wedge' bonds.

A constant-current variable-pulse power supply is used to charge the one-piece electrode tip through which the wire is fed, and a closely-controlled force is applied on the wire during the current pulse. The resultant bond produced between the wire and the base material (which may be any conductive material) is stronger than the wire itself.

The company claims several advantages for this technique: faster bonding rates, more efficient use of power, a high degree of repeatability, fast set-up changes, and the ability to bond to all types of thin films (even indium and lead), crystals, and other materials that cannot be bonded to using conventional thermocompression techniques.

The model 800 molecular bonder is supplied complete with work table, power supply, bonding head, 16 to 1 micro-positioner, fine wire feeder, wire cut-off and Bausch & Lomb stereo-zoom viewer with magnification from ×7 to ×30 or ×14 to ×60.—*Weltek Division, Wells Electronics Inc.*, 1701 *S. Main Street, South Bend, Indiana* 46623, *U.S.A.*

For further information circle 1 on Service Card

2. Large Legend Indicator

Bulgin have introduced a version of their large industrial-type legend indicator with two mains switches (s.p.m.-b.). This unit conforms to the general specification of the non-switched type, which is: strong grey ripple-finished diecast frame, resistant to distortion and firmly seating four M.E.S. or M.B.C. clip-in lampholders, which accept suitable lamps of up to 50 V each.

The escutcheon supplied is standard satin-finished stainless steel and is available in several types of bezel; e.g., single-legend area, double-legend area (split), etc. Front message plates may work at up to 100 °C, and provide bright silhouetted messages. The symbols are engraved and filled with black, or colour, on a translucent white or coloured plate. Alternatively, 'secret-until-lit' engraving may be supplied by special arrangement.—*A. F. Bulgin & Co. Ltd., Bye-Pass Road, Barking, Essex.*

For further information circle 2 on Service Card

3. Count-Down Relays

Rodene have recently introduced a range of count-down relays. Each incoming pulse (a.c. or d.c.) energizes a solenoid which indexes a ratchet wheel one position. When the preset number has been reached, a micro-switch is operated which re-directs any further pulse to a separate resetting coil or to the user's external circuit.

Each relay can be set to count any number up to 20, and two or more relays can be connected in cascade to give decade counting. Versions are available with either automatic or manual reset. Auto-resetting types have a pointer which remains at the preset position during timing. The pointer of the manual reset types indexes at the same rate as the ratchet wheel, thus giving visual indication of the number of pulses received.

One or two switch banks can be

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fitted instead of, or in addition to, the microswitch and can be used to initiate a series of external circuits throughout the entire cycle. Any pulse length over 25 msec will operate the relay. Maximum stepping rate is 5 steps per sec and the life of the relay is approximately 3 million operations. All models are available with 'AMP-Faston' connectors, and are priced in the £5 to £7 bracket.—*D. Robinson & Co. Ltd., 5/7 Church Road, Richmond, Surrey.*

For further information circle 3 on Service Card

4. Inertially Damped Motors

Two new types of size 08 inertially damped motors for 400-c/s operation are offered by Bowmar. Reference voltages of 115 V or 26 V and control voltages to customer requirements are available.

Type IM83-002 has a control winding of 33 V split-phase, stall torque of 23·5 gm cm, and no-load speed of 6,500 r.p.m. Fly-wheel inertia is 4·6 gm cm^2 with damping of 245 dynes/cm/sec. Type IM82-001 has a 33-V centre-tapped control winding, stall torque of 21 gm cm, and no-load speed of 5,500 r.p.m. Fly-wheel inertia is 1·6 gm cm^2 with damping of 30 dynes/cm/sec.

Both units have 12-in. lead-out wires and 13-tooth 120 DP splined output shafts, and will operate in an ambient temperature of −65 to +125 °C. These motors can be supplied with gearheads with ratios up to 2,000 : 1. Size 11 units are also available with similar winding voltages and damping factors.—*Bowmar Instrument Ltd., Sutherland Road, London, E.17.*

For further information circle 4 on Service Card

5. Mercury-Wetted Relays

STC have announced a range of mercury-wetted relays with an action basically different from that of the established tilting mercury switches used in many types of control equipment. These switches have their contacts permanently covered with a film of mercury. The contacts are renewed with each operation because mercury feeds along the contact blades by capillary action from a small reservoir in the base of the relay.

The switches are of the reed type, with contacts in thick-walled glass envelopes, filled with hydrogen and containing the mercury supply. Unlike conventional mercury switches, the new relays remain operational when tilted as much as 45°. Principal advantages of the units are their superior contact rating for small size and very long life span with full reliability.

These mercury-wetted relays can be obtained as basic switch units but are usually supplied complete with coils, the whole unit being potted ready for insertion in printed-circuit boards or encased in steel cans and built on to standard octal plugs. The basic switches are shown in the foreground of the picture.—*STC Electromechanical Division, West Road, Harlow, Essex.*

For further information circle 5 on Service Card

6. Miniature Precision Cutter

The Swiss-made 'Microkopt', now obtainable from Henri Picard & Frère, is a precision cutter intended for use on delicate work either in the laboratory or on miniature assemblies in the electronic and watch industries. Less than 4 in. long and 1 in. wide, it fits comfortably into the palm for continuous accurate use.

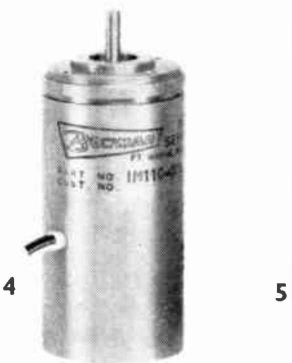
The Microkopt features a shaped composition body into one end of which the cutting jaws are firmly anchored. These are of toughened steel, sprung to give an opening between the cutters of approx. 0·5 mm and shaped to give an unobstructed view of the work piece. A pincer action is used to obtain a maximum cutting width of approx. 2 mm, the necessary leverage being applied at right angles by two plastic-covered levers, pivoted near the cutting head, which are compressed into lengthwise recesses in the body of the tool.

All parts of the cutter are resistant to perspiration and other sources of corrosion, and, because the cutter blades are clear of the surface when the tool is on the work-bench, the risk of accidental damage is minimized.—*Henri Picard & Frère Ltd., 34/35 Furnival Street, London, E.C.4.*

For further information circle 6 on Service Card

7. Torque Sensing Platform

A torque transducer recently introduced by Mechatronics has been designed particularly to provide simplified testing of f.h.p. motors, hydraulic pumps and motors, generators and alternators. It is basically a torque



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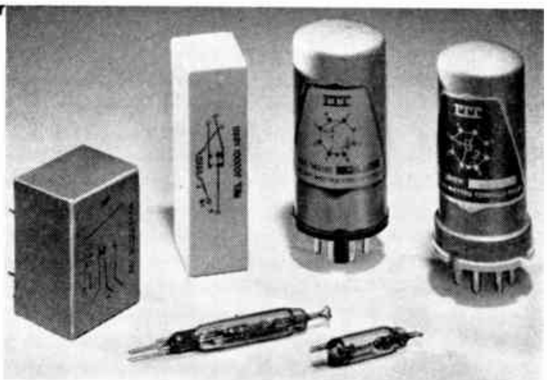

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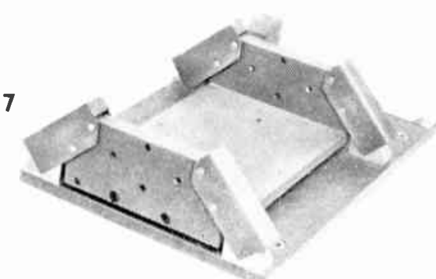

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measuring structure which eliminates the need for the conventional bearing of a reaction dynamometer; it provides both the support for the power device and an electrical signal proportional to the reaction torque.

The equipment consists of a plate supported from a fixed mounting base by means of torque-sensitive springs. Electrical strain gauges are bonded to these springs to form a strain-gauge bridge. Since there are no bearings or slip rings, the torque platform has no friction loss and no speed limitation. This feature allows it to be used at very low torque without friction errors.

Calibrating arms are furnished which extend a fixed distance from the centre of rotation. Static calibration readings are valid under dynamic conditions. It is possible to zero-suppress the torque up to the full-scale capacity of the table by suspending weights from one of the calibration arms, thus extending its capability beyond the specified range.

The five ranges currently available will measure torque from zero to 3, 10, 30, 100 and 300 lb in., respectively. —*Mechatronics (London) Ltd., 317 Kennington Road, London, S.E.11.*

For further information circle 7 on Service Card

8. Hellerine Oil

Hellermann Electric have introduced a new grade of Hellerine oil—a lubricant specifically prepared to assist with the fitting of sleeves and cable markers and any rubber, synthetic rubber and p.v.c. components.

Hellerine grade M (formula 66) has greater lubricity and does not dry out quickly giving greater scope for planning assembly procedure for cable looming work or, when fitting other components, greater scope for adjustment. It is fungistatic, is a non-conductor of electricity, non-staining and non-toxic.—*Hellermann Electric Ltd., Gatwick Road, Crawley, Sussex.*

For further information circle 8 on Service Card

ELECTRONICS

9. Electroluminescent 'Tape Light'

The Sylvania 'Panelescent Tape-Lite', to be marketed in the U.K. by Thorn, has applications in the field of low-level lighting and luminous indicators. It is a plastic-based electroluminescent light source that may be twisted, coiled or bent while illuminated. A thin strip of aluminium foil, a layer of phosphors and a transparent conductive coating are sandwiched between protective layers of clear plastic, providing a flexible light source $\frac{3}{16}$ in. in thickness and $1\frac{3}{4}$ in. wide.

Suitable for operation on 110–120 V 60-c/s a.c. supplies, the Tape-Lite emits up to 7 lumens per square foot (about 1 lumen per foot of tape). Samples up to 10 ft in length in blue, green, white, yellow or red will be available early in 1965.—*Thorn Electrical Industries Ltd., Special Products Division, 105-109 Judd Street, London, W.C.1.*

For further information circle 9 on Service Card

10. Portable Radio-Telephone

Aero Electronics are offering the AEL.507 fully-transistorized v.h.f. radio-telephone, which will provide an r.f. output of 1 W giving up to 20 miles communication with a base station, or up to 10 miles between two AEL.507s.

Part of an integrated system, this radio-telephone is available with a

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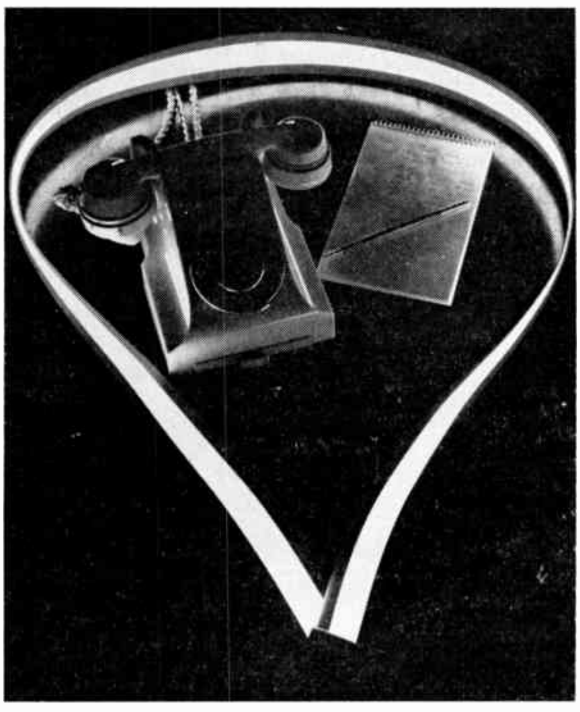

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mains power unit, a battery charger, and also in the 'Maxiflex' form which allows full portability to be retained while permitting the use of the equipment in vehicles, aircraft, or as a fixed station unit. Another variant of the equipment is a repeater version employing two separate external aerials and a large capacity external rechargeable battery; the talk-through facilities resulting from the use of these units in a network increase the range of the system at a minimum of extra cost.

The AEL.507 is normally supplied with a self-contained 8-V rechargeable battery, but special versions are produced to match customers' needs. Various canvas or leather cases are available.—*Aero Electronics Ltd., Gatwick House, Horley, Surrey.*

For further information circle 10 on Service Card

11. Miniature Magnetic Transducer

Advance Controls have added the miniature magnetic transducer type MT3SR to their range. It contains no moving parts and will generate pulses from rotating shafts or gear wheels without any physical contact.

This transducer is hermetically sealed in a robust brass housing suitable for almost all industrial environments. It is 2 in. long and threaded $\frac{3}{8}$ B.S.F. With the recommended gap setting between 0·03 and 0·06 in. (allowing for some bearing play) pulses of more than 300-mV amplitude are generated with peripheral speeds as low as 2 in./sec; d.c. resistance is 600 Ω. — *Advance Controls Ltd., Imperial Lane, Cheltenham, Glos.*

For further information circle 11 on Service Card

12. Pulse Generator

Recently announced by E-H Research Laboratories is the model 120E pulse generator, which will provide two simultaneous output pulses of 20 V peak amplitude into a load impedance of 50 Ω. An inverting pulse transformer supplied with the instrument provides positive-going output pulses.

Output amplitude is controlled by two front-panel attenuators and a continuously-variable vernier control. Pulse width is continuously variable from 10–100 nsec. Risetime is less than 1·3 nsec at 20 V and less than 1 nsec at 10 V. The 120E generates pulses with less than 4% peak-to-peak pulse top aberration and less than 3% pulse top droop.

Other features include automatic overload protection, and operation in gated, triggered or free-running modes. The instrument is marketed in the United Kingdom by Livingston Laboratories and is priced at £670 excluding duty.—*Livingston Laboratories Ltd., 31 Camden Road, London, N.W.1.*

For further information circle 12 on Service Card

13. Semiconductor Switches

E.A.C. announce the introduction of their 'Solicon' static switching units designed for small systems such as industrial electric motor control, to replace conventional relays and timers by more reliable units with no moving parts.

Solicon units are transistor switches mounted on international octal valve bases and operating at 12 V. Standard units include NOR type static switches (illustrated), delayed NOR units for timing, and output units in a convenient range to operate signal lamps, solenoids and contactors. Any unit can switch any six other units, including all power-output units; and the output units switch the line side, not the earth side, of the components they control.

Apart from variable-speed motor control, applications of the system include sequence control for presses, water treatment plant, automatic weighing systems and refrigerating plant.—*The Electrical Apparatus Co. Ltd., St. Albans, Herts.*

For further information circle 13 on Service Card

14. Dual Power Supply

The K.L.B. P.300 regulated power supply offers in one unit, facilities for working on either conventional valve circuitry where it will provide 0–400 V d.c. at up to 150 mA or 0–50 V d.c. for operating transistorized equipment.

Two meters are incorporated which offer comprehensive monitoring of both voltage and current. In addition to the above supplies the P.300 provides the usual heater voltages and a low-current negative bias supply. Price: £47.—*K.L.B. Electric Ltd., 335 Whitehorse Road, Croydon, Surrey.*

For further information circle 14 on Service Card

15. M.o.A. Approved Shaft Encoders

Moore, Reed and Company announce that their range of size 18 shaft encoders has received M.o.A. type approval for airborne military use. These encoders are of the contact type

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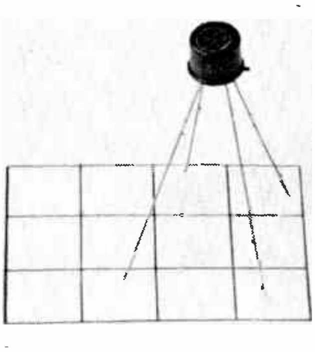

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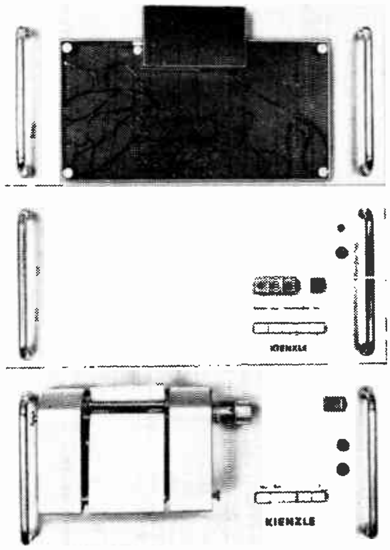

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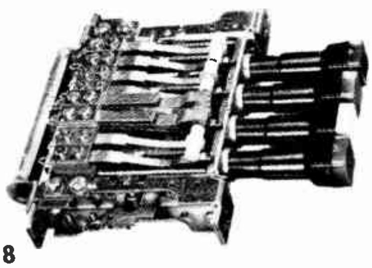

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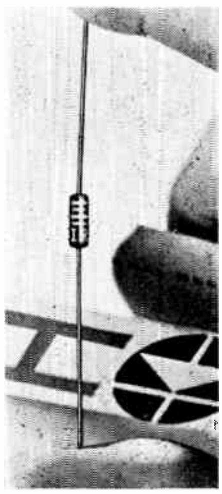


in binary V scan, 13-bit with two coded discs geared in ratio 64 : 1, 19-bit with three coded discs and two sets of 64 : 1 gearing, and a binary self-select unit with a total count of 2^{13}.

The test certificates cover vibration, acceleration and shock testing, temperature/pressure/humidity cycling, ice formation, endurance to 5 million revolutions at 85 °C, tropical life, mould growth, salt spray, fuel and oil contamination and sand/dust tests.

It is claimed that these are the first shaft encoders in Europe to receive full approval for military airborne use. —*Moore, Reed & Co. Ltd., Woodman Works, Durnsford Road, London, S.W.19.*

For further information circle 15 on Service Card

16. Silicon Controlled Switch

Now available from Jermyn Industries is the General Electric 3N58, a silicon controlled switch designed for use in industrial and military digital computer and control applications. It is a four-layer device (n-p-n-p) with all four layers accessible.

The TO-12 (TO-5 with 4 leads) isolated case package, extremely high firing sensitivity, and 40-V rating make it suitable for applications including sensitive voltage level detectors, bistable memory elements, binary counters, shift registers, ring counters, telemetry oscillators, time delay generators, pulse generators, low-level s.c.r. and low-level complementary s.c.r. circuits. — *Jermyn Industries, Vestry Estate, Vestry Road, Otford Road, Sevenoaks, Kent.*

For further information circle 16 on Service Card

17. Digital Magnetic-Tape Store

Radiatron are marketing a digital tape recorder unit to extend the application range of the Kienzle printer. The D100 is a magnetic-tape device which enables events to be recorded digitally at a maximum rate of fifty 8-digit numbers per second for a duration of 30 seconds. The recorder can be operated from either a counting unit or an analogue-to-digital converter for the measurement of voltages, currents, temperatures, etc.

When recording is completed the tape is played back at a lower speed into the Kienzle printer which will print out up to a maximum of three 14-digit lines per second or, in cases where a carriage model is used, at a speed governed by the carriage.

The combination of the D100 with the Kienzle printer is particularly suitable for monitoring transient phenomena associated with breakdowns and failures of a plant. A fault signal will trigger the tape-recording system, so that the immediate sequel to the fault is automatically and accurately printed. If desired the tape can continuously record and cancel recordings until the fault signal stops the cancellation, so that instead of subsequent events, those immediately preceding the fault are recorded.—*Radiatron, 7 Sheen Park, Richmond, Surrey.*

For further information circle 17 on Service Card

18. Multiple Pushbutton Switches

Multi-station pushbutton switches manufactured by Switchcraft are now offered by Lectropon as sole concessionaires. Roller-action operation ensures long life and robust operation for industrial and military electronic applications.

These switches can be fitted with a simple lock-out bar which will ensure that only one button can be pressed at a time. Assemblies with 1–37 stations are available, and variations include square or round buttons (which may be illuminated), palladium or silver contacts in various arrangements, and solenoid relays where required.—*Lectropon Ltd., Kinbex House, Wellington Street, Slough, Bucks.*

For further information circle 18 on Service Card

19. Silicon Power Diodes

International Rectifier have introduced a range of subminiature silicon power diodes, series 1N645–1N649, available from 200 to 600 p.i.v. and rated at 400 mA average at 25 °C ambient, and 150 mA at 150 °C ambient.

High transient reverse voltages and extremely low leakages (0·2 μA at 25 °C) are features of these glass-encapsulated subminiature diodes.—*International Rectifier Co. (Great Britain) Ltd., Hurst Green, Oxted, Surrey.*

For further information circle 19 on Service Card

20. P.T.C.R.

Thorn Parsons are now manufacturing a wide range of positive temperature-coefficient resistors (p.t.c.r.). These are made from barium titanate and have the characteristic that below the Curie temperature resistance remains approximately constant while above this temperature resistance increases sharply.

The p.t.c.r. is suitable, amongst other things, for excess temperature detection; with the added advantage that the unit incorporating it will automatically fail-safe should the resistor or its associated circuitry become 'open circuit'. It can also be used as a constant-current device over a considerable voltage range; current can be controlled at a selected value from a few mA to approximately 100 mA.

Resistors with varying coefficients can be produced with extremely sharp resistance changes over selected temperature ranges, or smaller resistance changes over larger temperature ranges. Standard versions have a tolerance on room temperature of ±10% but devices with ±5% tolerance can also be supplied.—*Thorn Parsons Co. Ltd., Wellington Crescent, New Malden, Surrey.*

For further information circle 20 on Service Card

21. R.F. Bulkhead Receptacle

A subminiature bulkhead receptacle featuring hermetic sealing has been added to the Sealectro 'Conhex' line of r.f. connectors. The 75-Ω impedance H-6132 snap-on connector features a turret type of connection for soldered leads.

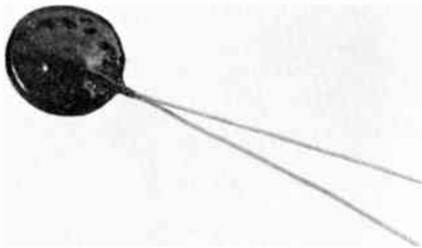
This unit features glass-to-metal sealing, and will provide a true hermetic seal when it is soldered to the bulkhead. A silicone 'O' ring is provided for applications where bulkhead soldering is not desirable. Additional features include 'D' mounting for a rigid anti-torque capability, 0·0001-in. gold plating and Teflon insulation.—*Sealectro Ltd., Hersham Trading Estate, Walton-on-Thames, Surrey.*

For further information circle 21 on Service Card

22. 5-in. Oscilloscope Tube

Mullard announce a further addition to their range of oscilloscope cathode-ray tubes which should be of particular interest to designers of small general-purpose oscilloscopes and the 'built-in' type of monitor. The D13-27GH is an inexpensive 5-in. tube with an overall length of under 14 in.

This tube has a flat-faced medium-persistence green phosphor screen with a helical post-deflection accelerator. In common with other recent types, a separate electrode arrangement permits direct beam blanking to be accomplished. The deflection-blanking voltage required is 60 V maximum under 3-kV operating conditions. The deflection sensitivity, also under 3-kV operating conditions, is better than



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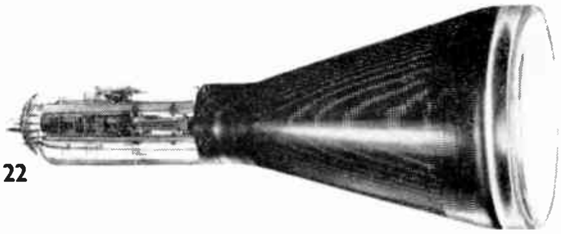

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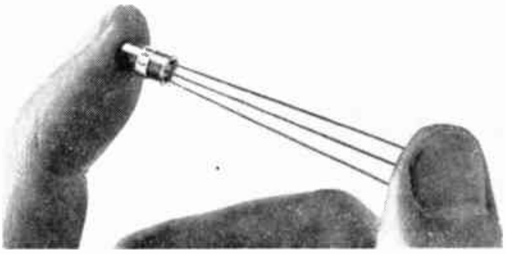

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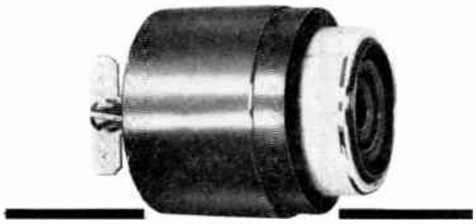

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27 V/cm for the X direction and 13 V/cm for the Y direction. The maximum picture size is 10 × 8 cm.—*Mullard Ltd., Mullard House, Torrington Place, London, W.C.1.*

For further information circle 22 on Service Card

23. Field Effect Transistors

A range of six unipolar field-effect transistors, mounted in the standard SO12B package, has been announced by Semitron. These transistors have been designed to meet the requirement for high input impedance amplification, and values in excess of 100 MΩ can be achieved. This property enables the devices to be coupled to piezo-electric transducers, pH cells and other high impedance voltage sources.

The whole range features a close control on anode current and a very high maximum anode-voltage rating. As with any f.e.t. the frequency response is limited by input and output capacitance, but when operated in emitter-follower configuration a flat response up to 10 Mc/s can be obtained.—*Semitron Ltd., Cricklade, Wiltshire.*

For further information circle 23 on Service Card

24. Audible Warning Devices

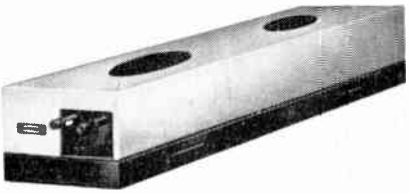
Highland Electronics are now producing a mains-operated version of the 'Sonalert d.c. solid-state audible indicators'. These are devices which have been designed for signalling, monitoring, alerting and warning.

The basic unit comprises a transistor oscillator and a ceramic transducer or speaker. An a.c. input signal causes the unit to emit a high-pitched tone of either 2½ or 4 kc/s, depending on the model. The input signal requirements are pre-set at 6 to 28 V, 110 V, or 240 V a.c. The complete unit measures 1 11/16 in. in diameter by 2¼ in. long.—*Highland Electronics Ltd., 26-28 Underwood Street, London, N.1.*

For further information circle 24 on Service Card

25. High-Power Continuous Laser

A high-power continuous-wave argon laser operating in the single transverse mode (TEM_{00}) is now available from Raytheon. The model LG12's 1-W power output is over the range 4,545 to 5,145 Å in the blue-green portion of the visible spectrum with the principal lines at 4,880 and 5,145 Å.



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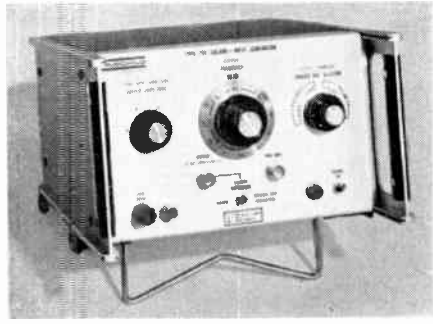

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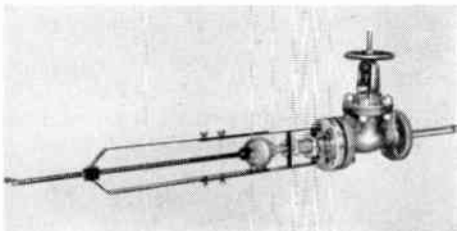

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The water-cooled laser head measures 40 in. long by 12 in. wide by 10 in. high, and weighs less than 100 lb. Power supply inputs at the 1-W level are 208/120 V a.c. 3-phase at 60 c/s; 50 A maximum.

Potential applications for this commercially-available laser are in reconnaissance systems, optical data-processing systems, bright display work, underwater signalling, tracking and other oceanographic applications. —*Raytheon-ELSI, S.p.A., Villagrazia, Palermo, Italy.*

For further information circle 25 on Service Card

26. Square-Wave Generator

Aveley Electric announce the Fairchild type 791 square-wave generator which provides 6 nsec rise time and 3 nsec fall time, with an operational frequency range of 7 c/s to 10 Mc/s.

The source impedance can be selected to provide 50 Ω or 600 Ω output. The square-wave amplitude is continuously variable from 250 mV to 40 V. A coincident trigger signal is provided in addition to the square-wave output.

The weight of the generator is 9 lb and the power consumption is 20 W at 110–220 V a.c. 50/400 c/s. Price: £168.—*Aveley Electric Ltd., South Ockendon, Essex.*

For further information circle 26 on Service Card

27. Telephone Loudspeaker

M. I. Sinclair & Co. have introduced a simple battery-operated device which enables a normal telephone conversation to be carried on with both hands free.

The 'Speak-R-Phone' consists of a small loudspeaker unit and a cradle in which the telephone handset is placed; no electrical connections are required and the transistorized amplifier switches on automatically with no warm-up period. The volume can be adjusted as required.—*M. I. Sinclair & Co., 'Gates House', 14a New Broadway, London, W.5.*

For further information circle 27 on Service Card

28. High Pressure Conductivity Cell

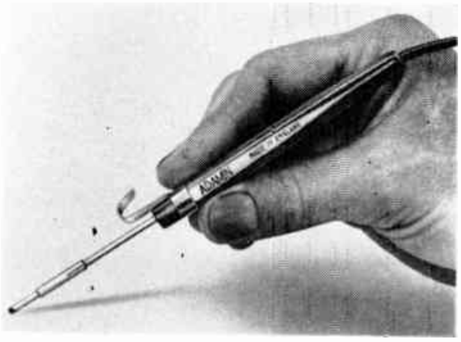
The CEL-1 (SS) series of cells available from D. A. Pitman, are designed for the measurement of conductance in systems under pressure which cannot be shut down or drained to permit removal of the cell for inspection or repairs; one application, for example, is checking the purity of return steam condensate. The CEL-1 (SS) 002 is a high-pressure insertion type conductivity cell for service up to 600 p.s.i. The valve and retractable cell element are constructed of type 316 stainless steel. The electrodes are platinized gold plated nickel. An integral automatic temperature compensator and thermocouple connector head are included in the cell.—*D. A. Pitman Ltd., 91 Heath Road, Weybridge, Surrey.*

For further information circle 28 on Service Card

29. Switchable Waveguide Circulator

Marconi announce the development of a three-port switchable circulator in waveguide size No. 15, covering the frequency range 7·75 to 8·5 Gc/s. High-speed switching of the direction of circulation is achieved electromagnetically.

The F1045-01 has been designed for use with microwave communications equipment, and offers improvements in reliability, speed of operation and space saving, over previous switching



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methods that employed mechanical devices. It is suitable for all two-way waveguide switching applications, a typical example being the branching networks connecting microwave transmitters and receivers with their aerials.

The electromagnet and circulator body are specially constructed to allow the magnetic field to be rapidly reversed by a normal transistor switching circuit. The switching time of the circulator is governed by the power supplied to the magnet: switching times of less than 0·5 msec may be achieved with a 25 W supply. Insertion loss is 0·5 dB.—*The Marconi Co. Ltd., Chelmsford, Essex.*

For further information circle 29 on Service Card

30. Improved Soldering Irons

Light Soldering Developments announce that their 'Adamin' range of miniature soldering instruments has been re-styled and technically improved. All types are now fitted with an unbreakable red Nylon handle weighing 5 gm, which is unaffected by most chemicals and solvents, withstands considerable heat without softening and is self-extinguishing.

Modifications have been made to the elements to improve performance and reliability, and the copper bits are now heavily chromium-plated to prevent surface scaling and wetting of the sides by solder.—*Light Soldering Developments Ltd., 28 Sydenham Road, Croydon, Surrey.*

For further information circle 30 on Service Card

INSTRUMENTATION

31. Dynascope Engine Analyser

Crypton have introduced a new motor-car engine analyser based on the earlier model but incorporating many improvements. Known as model BDX 118, it provides faster and more accurate readings and greater operator convenience.

This analyser is designed to provide mechanics with all the information required when testing and adjusting engines. With this comprehensive instrument, the ignition system can be checked and adjusted; this includes the measurement of the h.t. on each plug and timing, contact breaker condition, etc. Facilities for checking the power contributed by each cylinder are also available and battery-charging rate can be measured. A built-in exhaust-gas analyser makes adjustment of the carburettor a simple job.

The complete unit is built into a console on castors with storage compartments for spares and tools.—*Crypton Equipment Ltd., Bridgwater, Somerset.*

For further information circle 31 on Service Card

32. Air Pollution Monitor

A sensitive method of measuring and recording the level of air pollution in the atmosphere has been developed by Fleming Instruments. Using a simple and inexpensive technique that interprets pollution in terms of pressure, the system is suitable for a wide variety of applications including clean-air rooms, exhaust-stack monitoring, ventilation systems, etc.

The level of air pollution is translated into pressure by use of a filter-paper tape reeled continuously past an aperture, through which air is drawn by a diaphragm vacuum pump. This creates a pressure differential across the filter paper which increases as particles in the air clog the paper.

Pressure variations are measured by a standard Arkon 1600 pressure recorder, a product of Walker Crosweller & Co., which will maintain a continuous day and night record of the degree of pollution, automatically, for periods of up to a month without need for further attention. The monitor can be set to trigger off an external alarm in the event of the density of pollution going beyond a predetermined point.

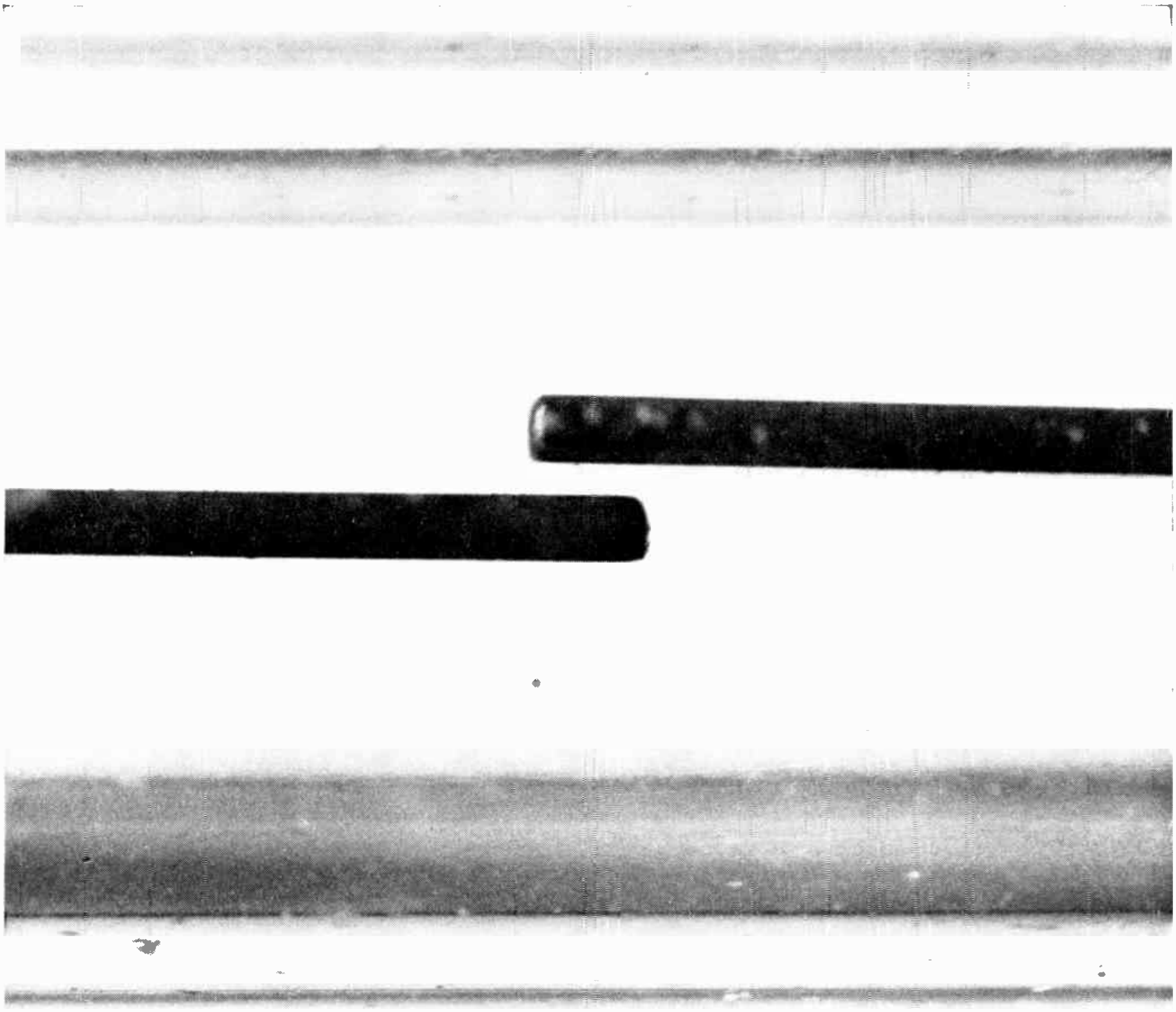
An advantage of this method of monitoring is that it can be carried out without reference to a comparator and without visual examination of stains deposited on the filter paper. Thus the instrument will also detect colourless particles.—*Fleming Instruments Ltd., Caxton Way, Stevenage, Herts.*

For further information circle 32 on Service Card

33. Battery Wall Clocks

Smiths are offering a range of transistorized 'Sectronic' battery wall clocks suitable for installation in all types of commercial, industrial or public premises. They require no wiring and no winding, and the single 1·5-V battery will give at least a year's service.

The movement, which is protected from dust and steam, uses a transistor and moving-coil balance assembly. This moving-coil balance is suspended between poles of a powerful magnet and carries two coils in which electric pulses are generated by the transistor



Close-up view of gold plated reed blades magnified 40 times circuit. There are no contacts or brushes.

There are 24 models to choose from, in a variety of metal or plastic cases. Several models are available in a choice of colours so that decorating or departmental colour schemes can be matched. Sectronic clocks can be supplied with 24-hr dials, if required. In the model illustrated, the 'Delvin', the figures are printed on the inside of the glass, so that they are never obscured by the hands; it measures $6\frac{3}{4}$ in. in diameter and has a depth of $3\frac{1}{2}$ in.—*Smiths Clock and Watch Division, Sectric House, Waterloo Road, London, N.W.2.*

For further information circle 33 on Service Card

34. Improved Valve Tester

Taylor Electrical Instruments have introduced a modern-styled valve tester, model 45D, to supersede the model 45C. Main features of the 45D are the ten valve bases which enable tests to be carried out on the latest types of valve.

The appearance of the instrument has been improved by using a case with a sloping front and a 'clarity' meter. A valve chart is included which gives testing data for over 7,000 British, American, Continental and Russian valves. — *Taylor Electrical Instruments Ltd., Montrose Avenue, Slough, Bucks.*

For further information circle 34 on Service Card

35. Decimal Counters

Bowmar Instrument have introduced a range of decimal counters with three, four or five drums with optional graduations on the input drum. Numerals are 0·187 in. high and are white on dull black.

The use of die-cast anodized aluminium frames, Delrin drums and pinions, stainless steel shafts and phosphor-bronze bearings, give low transfer torque at operating speeds of 500 r.p.m. continuous and 2,500 r.p.m. intermittent. — *Bowmar Instrument Ltd., Sutherland Road, London, E.17.*

For further information circle 35 on Service Card

36. Manual Recording Microbalance

A high-precision microbalance which is rapid in response, easily portable and convenient in setting up and operation, has been introduced by Research & Industrial Instruments Co.

The RIIC Electromicrobalance features a total capacity of 5 gm, sensitivity of 0·1 μgm, and accuracy better than 0·05%. In addition to manual operation, the balance can also be used with a potentiometric recorder to give permanent records of weighings or weight changes and scale expansion up to $\times$100.

The balance is provided with eight weighing ranges: 0–1, 0–2, 0–5, 0–10, 0–20, 0–50, 0–100, and 0–200 mgm. Samples up to 200 mgm may be weighed directly by single-pan operation and, if over 200 mgm, differentially up to a total load of 5 gm on the balance beams.

Two models of the Electromicrobalance are available, one for mains and the other for battery operation. Both models consist of a balance unit and a control unit, as shown in the illustration. The units may be stacked one on top of the other, placed side by side or operated by remote control. —*Research & Industrial Instruments Co., 116 Lordship Lane, London, S.E.22.*

For further information circle 36 on Service Card

37. A.C./D.C. Valve Voltmeter

One of the latest additions to the range of test equipment stocked by I.M.O. (Electronics) is an a.c./d.c. valve voltmeter for laboratory and production use.

The Technix model 304B covers voltage ranges of 5 mV–1,500 V a.c. and 100 mV–1,500 V d.c. with an input impedance of 11 MΩ on both ranges. Resistance can be measured from 0·1 Ω to 1,000 MΩ, and a dB scale is provided. The instrument also features a built-in 1-kc/s test source oscillator. An additional a.c./d.c. switch is mounted in the probe.

This mains-operated voltmeter measures $5\frac{1}{2} \times 3 \times 6$ in. high and weighs $5\frac{1}{2}$ lb. Price complete with probes is £35.—*I.M.O. (Electronics) Ltd., 313 Edgware Road, London, W.2.*

For further information circle 37 on Service Card

38. Strip-Chart Recorder

Aveley Electric announce a portable transistorized potentiometric recorder featuring a 10-in. calibrated chart and 0·1% linearity. Designated the Brush recorder mark 10, it is designed for laboratory and general-purpose use. The writing system is completely smudge-free, producing traces with heated ink which dries instantly on contact with the recording paper. Charts are reproducible by Ozalid as well as all photographic and office-copier methods.

The electronics include a modular plug-in signal conditioning preamplifier providing recording range in 15 steps from 5 mV to 200 V full scale. Full-

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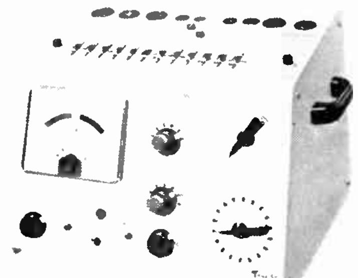

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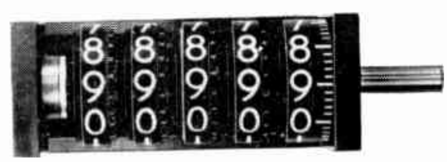

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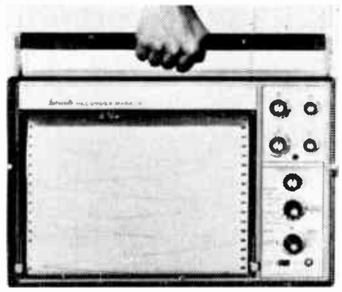
scale pen travel is 10 in. Inputs are fully floating with 1 MΩ input impedance, and input isolation permits acceptance of common-mode voltages up to 500 V. Ten chart speeds, from 1 in. per hr to 20 in. per min, are electrically controlled. A variable filtering control permits filtering of 60 c/s and time constants of 0·5, 1, 2 and 5 sec. Calibrated zero suppression up to 10 times full scale is available.—*Aveley Electric Ltd., South Ockendon, Essex.*

For further information circle 38 on Service Card



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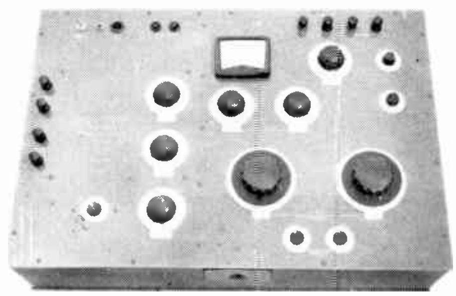

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39. Gas Chromatograph Test Set

A. M. Lock & Co. announce a gas chromatograph test set with a reference signal source, which enables the chemist or instrument engineer to check the operation and performance of a gas chromatograph easily and, if it is shown to be faulty, to locate the source of the trouble quickly.

No electrical knowledge is needed to use this test set, which is supplied in a leather carrying case complete with instructions for use and with interconnecting leads for most makes and types of gas chromatographs. Price: £39 10s 0d.—*A. M. Lock & Co. Ltd., Prudential Buildings, Oldham, Lancs.*

For further information circle 39 on Service Card

40. A.C./D.C. Comparator

Cambridge Instrument Co. have recently introduced a self-contained mains-operated instrument designed to measure the r.m.s. values of alternating currents and voltages to an accuracy of ±0·05% over a frequency range of 25 c/s to 20 kc/s. Eight voltage and current ranges are provided, covering values from 0·5 to 300 V and from 5 mA to 3 A respectively.

A single vacuo-junction, having an a.c. to d.c. transfer error of less than 0·01%, is used as a transfer element, and the circuit is compensated so that replacements can be fitted without the need for recalibration.

The only external units required are a standard cell and a suitable reflecting galvanometer, the instrument being otherwise self-contained with its own built-in potentiometer circuit. To avoid overloading the vacuo-junction, a built-in meter enables the approximate value of the unknown signal to be determined prior to setting the controls.

An advantage of the design is that the unknown voltage or current is rapidly balanced against an adjustable d.c. potential, which can then be accurately measured at leisure using a d.c. reference current calibrated to give the true r.m.s. value of the applied signal.—*Cambridge Instrument Co. Ltd., 13 Grosvenor Place, London, S.W.1.*

For further information circle 40 on Service Card

41. R.F. Voltmeter

Recently announced by Boonton Electronics Corporation and available through Livingston Laboratories is the 91DA r.f. voltmeter. This instrument is capable of measuring voltage from 300 μV to 300 V over a frequency range from 20 kc/s to 1,200 Mc/s (usable to over 2,500 Mc/s). It has an accuracy of ±2% of full scale up to 100 Mc/s, ±5% to 400 Mc/s and ±10% up to 1,200 Mc/s.

The 91DA responds to the r.m.s. value of input signals below 3 V. Applications include the measurement of high-frequency characteristics of transistors and r.f. networks and determining the v.s.w.r. and return loss of transmission systems. — *Livingston Laboratories Ltd., 31 Camden Road, London, N.W.1.*

For further information circle 41 on Service Card

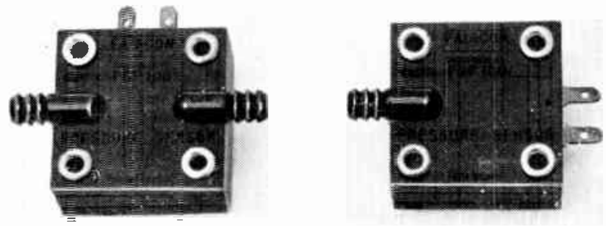
CONTROL

42. Simple Pressure Transducer

A simple low-cost pressure transducer, which can function as a switch, fuse or detecting element, has been introduced by Fairchild Controls. It measures 1 × 1 × $\frac{11}{32}$ in. and weighs 10 gm.

The PSF100 can sense level changes in liquids equivalent to less than ½ in. of water and can be utilized in detecting air flows of the same magnitude. It is insensitive to shock, vibration and acceleration. The operational temperature range is −65 to +200 °F.

Typical applications include detecting interruption or slowing down of



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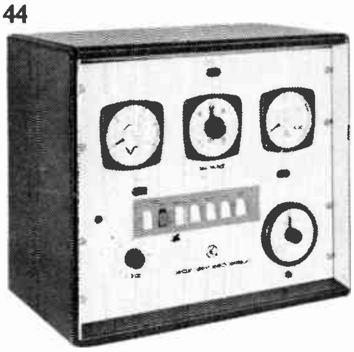

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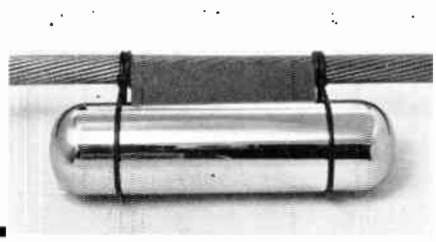

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airflow from small blower systems, detecting the presence of water in critical locations, and sensing changes in level of liquids in storage tanks, etc. Other applications for the device would be in bottling industries where exact levels have to be maintained in containers, or in the plastics moulding industry to control pressure.—*Elliott Brothers (London) Ltd., Servo Components Division, Century Works, Lewisham, London, S.E.13.*

For further information circle 42 on Service Card

43. Teleprinter Motor Control Unit

A semiconductor timing device to control the power to a teleprinter and thereby reduce maintenance costs is announced by Pulse Communications Inc. This unit measures $2\frac{1}{2} \times 6\frac{1}{2} \times 3\frac{5}{8}$ in. The power plug of the teleprinter to be controlled is connected to one output socket while associated equipment which must retain power full-time is connected to a separate socket.

The unit is arranged to cut the power at the end of a preset period of time (1 to 20 min) whenever the teleprinter line is idle or open. Any pulse will reset the timer and only the first character will be garbled on reconnection of power. The unit provides a complementary device in the semiconductor field for fixed timed periods to the mechanical timing unit.—*Pulse Communications Inc., Alexandria, Virginia, U.S.A.*

For further information circle 43 on Service Card

44. Automatic Power Controllers

Kent Precision Electronics have produced a range of semiconductor automatic controllers for use with motorized regulators. They operate with a calibrated instrument for proportional control of a d.c. commutator motor. For large errors the motor is switched fully ON and, within the proportional band of approximately 2%, slows down to attain the set point with no overshoot or hunting. A dead space of less than 0·5% is easily achieved in all normal applications.

Programmed operation, as for example when constant current density is required for electroplating, is available by the introduction of secondary operational inputs. A constant-current density controller is shown in the photograph. The instruments are available as panel or rack-mounting units.—*Kent Precision Electronics Ltd., Vale Road, Tonbridge, Kent.*

For further information circle 44 on Service Card

45. Remote Control Receiver

The Electronetics control receiver model R-600 is designed as a companion to telemetry transmitters and for any independent radio remote-control function which requires reliability, ruggedness and extreme durability of the receiver. It is completely encapsulated in epoxy resin with a single vibration-proof frequency tuning screw. Drawing less than 200 μA, it will operate for approximately a year and a half on the appropriate 8·5-V battery.

The unit incorporates two tuned circuits for ON and OFF, eliminating all ambiguity from the control system. As normally supplied, a momentary ON signal produces a circuit trigger which latches the output ON. With no further transmitted signal the relay remains ON until the OFF signal is received.

The receiver, which is designed to operate in extremely noisy locations (e.g., on a high-voltage transmission line), is available at any specified radio frequency from 3 to 300 Mc/s.—*Industrial Electronetics Corporation, Post Office Box 862, Melbourne, Florida, U.S.A.*

For further information circle 45 on Service Card

46. Packaged Lighting Controller

Photoelectronics (M.O.M.) Holdings have introduced a packaged controller intended for applying automatic lighting control to factories, office blocks, warehouses, etc. This is a completely self-contained unit with a maximum capacity of 120 kW, which operates from a normal 3-phase supply and will control as many as 30 lighting circuits.

As the floors of multi-storey buildings tend to divide naturally into three zones of light intensity, the controller is provided with three individually adjustable daylight switches; the point on each at which the lights are switched ON is preset independently from the setting for 'lights out'. The wall-mounting waterproof photocell units are adjustable for north/south location.

Key-switch remote control for limited lighting at night when the main system may have been turned off, is included as standard. Indicators show the condition of the control at any time and emergency override buttons, 'stop', 'start' and 'full lighting', are accessible without having to unlock the doors of the cabinet.

At the time of ordering, small variations in the number and arrangements of circuits can be incorporated at no extra charge, or reduced capacity units can be supplied at lower cost to meet individual requirements.—*Photoelectronics (M.O.M.) Holdings Ltd., Oldfields Trading Estate, Oldfields Road, Sutton, Surrey.*

For further information circle 46 on Service Card

47. Miniature Precision Gearboxes

P.S.B. Instruments have developed a range of miniature precision gearboxes which have a range of applications in the electrical and mechanical fields, from timing and control instrumentation to the opening and closing of valves, gates, etc. The range of speeds varies from 1 r.p.m. to 1 rev. per day, and higher reductions up to one revolution a week could be developed if required. Silent and smooth running is ensured by the cut brass gears and steel pinions, rotating on hardened steel pivots between stainless-steel shims.

The model shown in the photograph is fitted to a Mullard synchronous motor designed for use in a timing instrument. The initial gear is fibre with 40 teeth so that, when fitted to a synchronous motor running at 250 r.p.m. with a 10-tooth pinion, an overall reduction of 10,000 to 1 is obtained; i.e., one revolution of the output shaft every 40 minutes. The direction of rotation can be either clockwise or anti-clockwise. — *P.S.B. Instruments Ltd., Palmerston Road, Wealdstone, Harrow, Middlesex.*

For further information circle 47 on Service Card

48. Autopilot for Small Vessels

Apelco have introduced an electronic fully-automatic pilot for steering vessels up to 90 ft in length. The AP-15 has an electronic servo system with magnetic compass azimuth reference. Control functions include 'dodging', which allows temporary course deviation to port or starboard to avoid other boats, buoys, etc.; the autopilot then returns the boat to its initial preset course.

The AP-15 can be operated from either master or remote stations. A switch at the master control offers high, medium and low sensitivity for best steering under the existing sea conditions. The circuitry is all solid-state and the magnetic compass which controls the electronic servo system is sealed. The course-sensing signal produced by this compass is applied to the servo system by capacitive coupling.

Available for 12, 24 or 32 V d.c. operation, the AP-15 autopilot consists of a master control station, remote control capsule with 9-m cable, binnacle unit, and power drive unit with solenoid operated clutch.—*Ad. Auriema Ltd., 125 Gunnersbury Lane, Acton, London, W.3.*

For further information circle 48 on Service Card

49. Pneumatic Time-Delay Relay

An electrically-actuated pneumatically time-delayed relay made by the Elastic Stop Nut Corp. of America is now available in the U.K. Known as the 2000 series Agastat, it features time-calibrated ranges, instant recycling capability, high repeat accuracy, and modular assembly. The timing action of the Agastat is initiated by solenoid energization and regulated by restriction of air flow through an adjustable orifice located in the timing chamber. Because of pneumatic action, the timing adjustment is smooth and precise, and unaffected by vibration, fluctuating voltages or environmental extremes.

The relay consists of three main components, a sealed pneumatic timing head with time-calibrated dial, an encapsulated solenoid assembly for starting the timing cycle and a d.p.d.t. switch unit for transferring the load on completion of the delay period. Each of these components forms a self-contained interchangeable module so that selective assembly affords a wide choice of operating types, coil voltages and timing ranges.

Eight dial head models are available and provide uninterrupted coverage from 0·1 sec up to 30 min, all models being furnished with an accurately time-calibrated dial according to the delay period required.—*The Cressall Manufacturing Co. Ltd., Cheston Road, Aston, Birmingham 7.*

For further information circle 49 on Service Card

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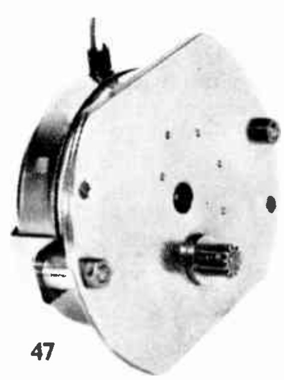

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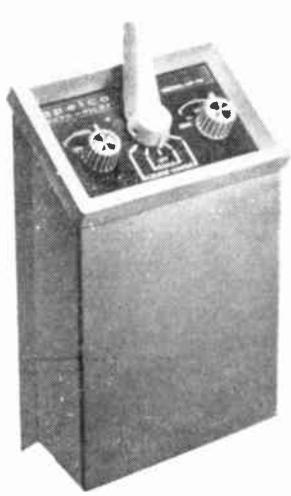

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49

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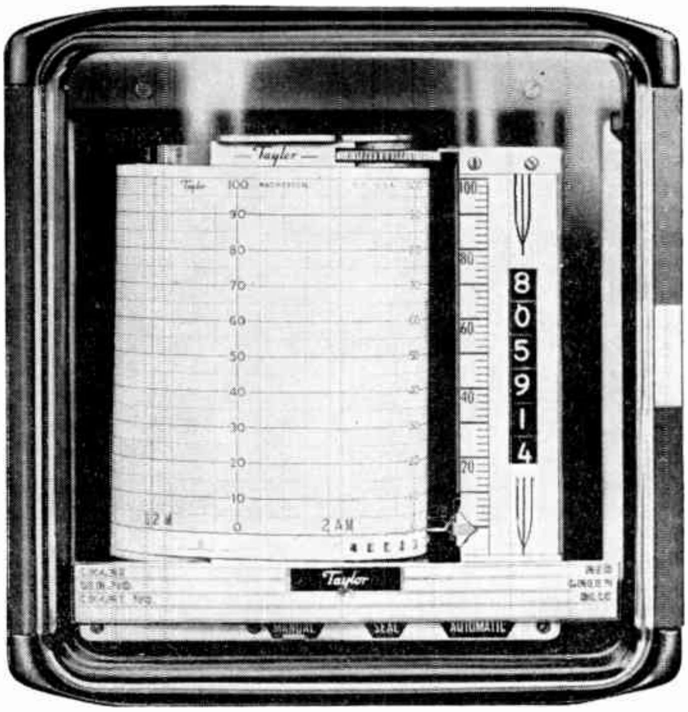

90J Series

The recorder that gives continuous signals on the chart—plus integrated total on scale either linear or square root.

Optional pulse feature can be used to operate remote counters and/or timers for batching operations.

The integrating servo positions the pen or pointer for visual reading of instantaneous values of flow. Total flow is read on the integral or remote counter.

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WEATHER PROOF	Panel or Field Mounting
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AVAILABLE INTEGRAL WITH 90J OR 100 K Series	Saves Panel Space and Panel Cost
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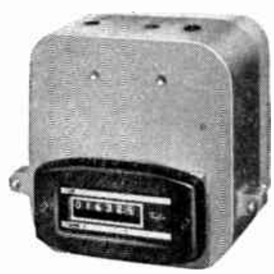
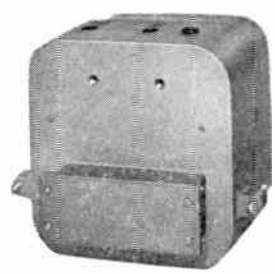


107N Integrator with Counter



108N Integrator without Counter but with Pulse Transmitter

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* *The above example assumes a modest rate of growth of BST Units having regard to the past performance of the Trust.*

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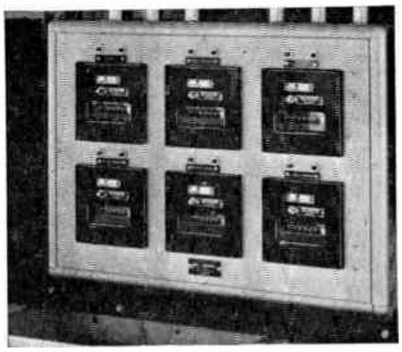

for London Airport Car Park

Photographs by courtesy of the Witton-Kramer division of GEC (Engineering) Ltd.

Sodeco counters were chosen by GEC for their photo electric control equipment at London Airport multi-storey car park.

For administrative convenience two remote reading counter cabinets are installed, one at the car park entrance, the other in the superintendent's office.

These automatically record the progress of cars from floor to floor. With two entrances and exits on central floors it is necessary for the counters to be able to register simultaneous movement at four points on each floor. When only ten car spaces are left on any floor an automatic alarm is sounded and an indicator shows the floor concerned.

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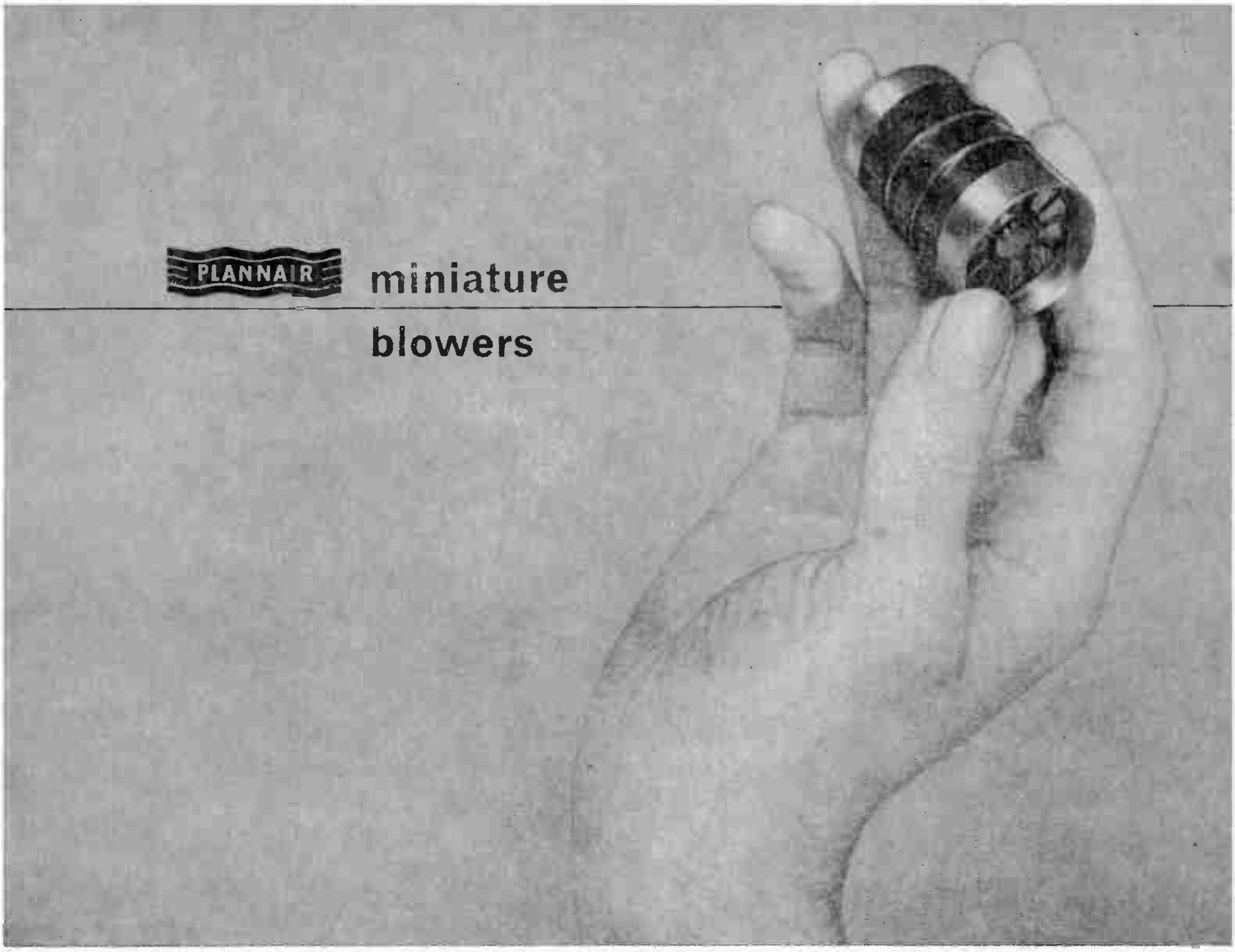
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Lag Measurements in Process Control Electrical and Mechanical Systems

By N. G. MEADOWS, B.Sc., A.M.I.E.E.*

THE determination of transfer functions of certain linear systems can be achieved using frequency-response data at selected frequencies. Many process-control systems and electrical or mechanical networks are adequately specified by a transfer function comprising a gain term K_1 and one or more exponential lags, each of which introduces a term of form $k/(s + a)$.

A wide class of such systems has a low-pass filter action, so that terms in s are absent from the numerator of the output/input transfer function $F(s)$. The general form of transfer function considered is $F(s) = K/P(s)$ where $F(s)$ is the output/input ratio, K a gain factor and $P(s)$ a polynomial in s. For stability all powers of s must be present, although a term in s^n, for n an integer, may be factored out. The coefficients of $P(s)$ must also satisfy Routh's criterion[1] for the system to be stable.

The particular cases considered here are for $P(s)$ up to fourth order. Although in principle the technique can be extended to higher-order systems the precision of the frequency response test gear required increases with the order of the system and an accurate digital type of transfer function analyser may then be essential.

The method is applicable to interacting or non-interacting systems and to those having quadratic denominator terms with complex factors; i.e., for real and complex poles.

Single Lag System

For a single lag

$$F_1(s) = \frac{K}{s + a} \qquad \text{............(1)}$$

and the frequency response expression, with $s = j\omega$, is

$$F_1(j\omega) = \frac{K}{a + j\omega} \qquad \text{............(2)}$$

Typical systems which this transfer function approximates are a simple Velodyne, an RC network or a first-order process-plant reaction or instrument lag.

The frequency response locus is a lagging semi-circle, as shown in Fig. 1. For any one vector OA at a measured lagging angle ϕ_1 and modulus M_1, occurring at a known angular frequency ω_1, eqn. (1) gives

$$M_1 = \frac{K}{\sqrt{a^2 + \omega_1^2}} \qquad \text{............(3)}$$

and

$$\tan \phi_1 = \frac{\omega_1}{a} \qquad \text{..............(4)}$$

These equations yield $K = M_1\omega_1 \operatorname{cosec} \phi_1$ in polar form and $K = M_1^2\omega_1/y$ in resolved component form, where y is the imaginary part of $F_1(j\omega)$. Eqn. (4) gives $a = \omega_1 \cot \phi_1 = \omega_1 y/x$, where x is the real part of $F_1(j\omega)$.

Henc

$$F_1(s) = \frac{M_1\omega_1 \operatorname{cosec} \phi_1}{s + \omega_1 \cot \phi_1} \qquad \text{..........(5)}$$

or

$$F_1(s) = \frac{M_1^2\omega_1/y}{s + \omega_1 y/x}$$

for the polar and Cartesian forms, these results being expressed in terms of the test data.

Practical Details

The phase angle and modulus measurements are obtained in the usual way with sinusoidal excitation of the system under test, using, for example, an oscillator and c.r.o. or transfer-function analyser for determining the steady-state

* Battersea College of Technology.

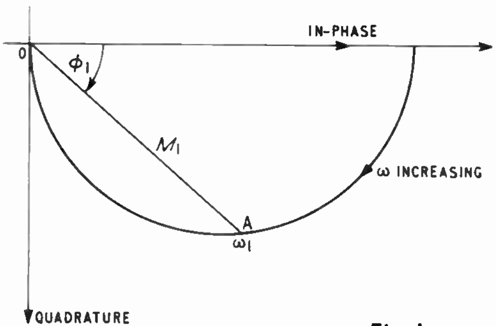

Fig. 1

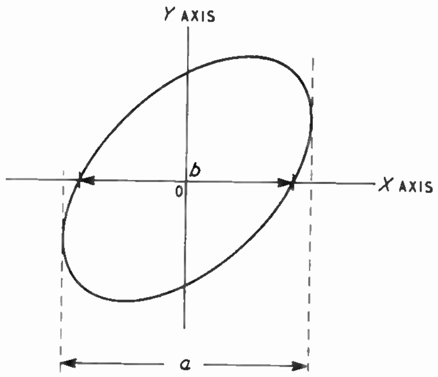

Fig. 2

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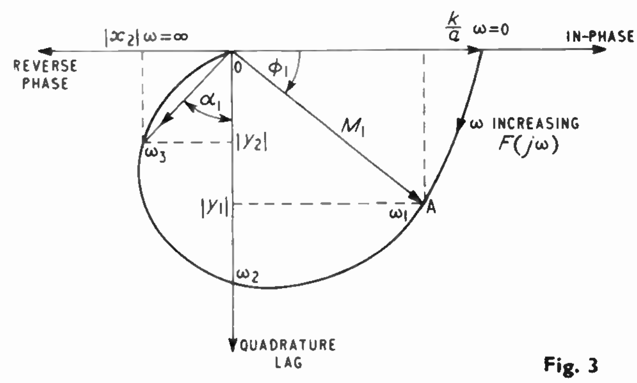


Fig. 3

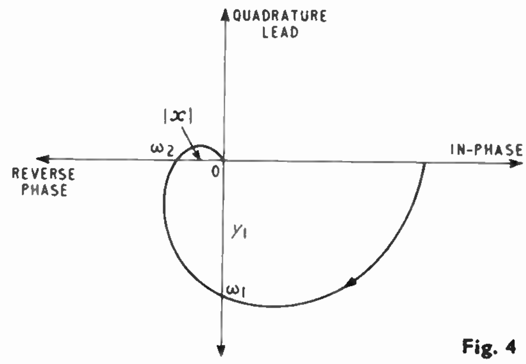


Fig. 4

Cartesian or polar components of the output/input sinusoidal signals. If a phase ellipse method is used, as indicated in Fig. 2, then $\sin\phi = b/a$ giving $\operatorname{cosec}\phi = a/b$ and

$$\cot\phi = \sqrt{\left(\frac{a}{b}\right)^2 - 1}$$

in equation (5).

For many systems, such as single-lag RC circuits, $K = 1$. Eqns. (1) or (2) are then individually adequate for the determination of a.

For increased accuracy results may be obtained for more than one frequency and average values of a and K derived. Additional test-frequency readings are used merely to ensure that the system is adequately characterized by eqn. (2) and these readings need not be determined very accurately.

Two-Lag Systems

Here

$$F_2(s) = \frac{K}{s^2 + as + b} \qquad \ldots\ldots\ldots\ldots(6)$$

and

$$F_2(j\omega) = \frac{K}{b - \omega^2 + ja\omega}$$

with a frequency-response locus as shown in Fig. 3. The response is quadrature lagging when

$$b = \omega_2^2 \qquad \ldots\ldots\ldots\ldots(7)$$

and then

$$y_2 = K/a\omega_2 \qquad \ldots\ldots\ldots\ldots(8)$$

At a frequency $\omega_1 < \omega_2$,

$$\tan\phi_1 = \frac{a\omega_1}{b - \omega_1^2} = \frac{a\omega_1}{\omega_2^2 - \omega_1^2}$$

from eqn. (7);

$$\therefore \quad a = \frac{(\omega_2^2 - \omega_1^2)}{\omega_1}\tan\phi_1 \qquad \ldots\ldots\ldots\ldots(9)$$

and hence from eqns. (8) and (9)

$$K = a\omega_2 y_1 = \frac{\omega_2}{\omega_1}(\omega_2^2 - \omega_1^2)y \qquad \ldots\ldots\ldots(10)$$

Here $\tan\phi_1 = y_1/x$, in resolved component form.

Note

In these and subsequent formulae the x and y components used are modulus values.

For a frequency $\omega_3 > \omega_2$, in terms of the angle α, shown in Fig. 3, the expressions become

$$\tan\alpha_1 = \frac{a\omega_3}{\omega_3^2 - b} \text{ and } a = \frac{\omega_3^2 - \omega_2^2}{\omega_3}\tan\alpha_1 \qquad \ldots(11)$$

with

$$K = \frac{\omega_2}{\omega_3}(\omega_3^2 - \omega_2^2)y_2 \qquad \ldots\ldots\ldots\ldots(12)$$

Here

$$\tan\alpha_1 = x_2/y_2$$

Expressions (7), (9) and (10) or (7), (11) and (12) enable the transfer function of eqn. (6) to be expressed in terms of the test data.

Three-Lag Terms

For this condition

$$F_3(s) = \frac{K}{s^3 + as^2 + bs + c} \qquad \ldots\ldots\ldots\ldots(13)$$

and

$$F_3(j\omega) = \frac{K}{(c - a\omega^2) + j\omega(b - \omega^2)}$$

giving a frequency response locus of the type shown in Fig. 4. Use of the real conditions gives

$$b = \omega_2^2 \text{ and } x = \frac{K}{a\omega_2^2 - c}$$

For the quadrature state

$$a\omega_1^2 = c \text{ and } y = \frac{K}{\omega_1(b - \omega_1^2)}$$

These equations yield $a = \omega_1 y/x$, $b = \omega_2^2$ and $c = \omega_1^3 y/x$ with $K = y\omega_1(\omega_2^2 - \omega_1^2)$ to give the transfer function as

$$F_3(s) = \frac{y\omega_1(\omega_2^2 - \omega_1^2)}{s^3 + \frac{y}{x}\omega_1 s^2 + \omega_2^2 s + \frac{y}{x}\omega_1^3}$$

The cubic in the denominator can be factorized by an appropriate numerical method to give the factors explicitly if desired.

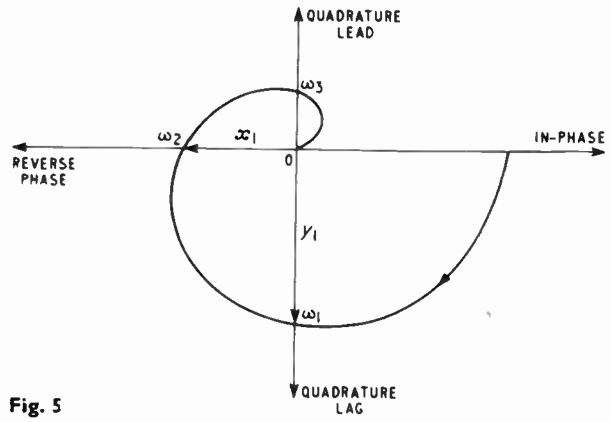


Fig. 5

Four-Lag Condition

The transfer function considered here is

$$F_4(s) = \frac{K}{s^4 + as^3 + bs^2 + cs + d} \quad \ldots\ldots(14)$$

where K, a, b, c and d are to be determined. Various combinations of test data may be chosen: the values used here are those which give the simplest resulting formulae and test procedure, by using in-phase and quadrature conditions only.

Fig. 5 shows a typical frequency response locus for

$$F_4(j\omega) = \frac{K}{\omega^4 - b\omega^2 + d + j\omega(c - a\omega^2)} \quad \ldots(15)$$

i.e., with $s = j\omega$ in eqn. (14).

For quadrature conditions $\omega^4 - b\omega^2 + d = 0$ which must factorize to the form $(\omega^2 - \omega_1^2)(\omega^2 - \omega_3^2) = 0$ to give the two possible quadrature frequencies shown in Fig. 5. Then $\omega^4 - (\omega_1^2 + \omega_3^2)\omega^2 + \omega_1^2\omega_3^2 = 0$ on expanding. Equating coefficients of these equations then gives

$$b = \omega_1^2 + \omega_3^2 \quad \ldots\ldots\ldots\ldots(16)$$

and

$$d = \omega_1^2\omega_3^2 \quad \ldots\ldots\ldots\ldots\ldots(17)$$

The real modulus condition is

$$x_1 = \frac{-K}{\omega_2^4 - b\omega_2^2 + d}$$

giving $K = b\omega_2^2 - (d + \omega_2^4)$. Substituting for b and d from eqns. (16) and (17) gives, on reduction,

$$K = (\omega_2^2 - \omega_1^2)(\omega_3^2 - \omega_2^2)x_1 \quad \ldots\ldots\ldots\ldots\ldots(18)$$

To determine the coefficients c and a, choose the quadrature lag value of y, as this will be relatively large compared to y_2, then, from eqn. (15),

$$y_1 = \frac{K}{\omega_1(c - a\omega_1^2)}$$

For the real condition, $c = a\omega_2^2$. These two equations in conjunction with eqn. (18) then give

$$a = \frac{(\omega_3^2 - \omega_2^2)x_1}{\omega_1 y_1} \quad \ldots\ldots\ldots\ldots(19)$$

and

$$c = \frac{\omega_2^2}{\omega_1}(\omega_3^2 - \omega_2^2)\frac{x_1}{y_1} \quad \ldots\ldots\ldots\ldots(20)$$

Eqns. (16) to (20) therefore enable the transfer function of eqn. (14) to be expressed in terms of the test data.

Relation to Open- and Closed-Loop Conditions

The transfer functions considered may be closed-loop transfer functions of type O control systems, or open-loop transfer functions of type 1 systems. For a feedback system of open-loop transfer function $F(s)$ and closed-loop transfer function $G(s)$, with loop closure via unit negative feedback then

$$G(s) = \frac{F(s)}{1 + F(s)} \quad \ldots\ldots\ldots\ldots(21)$$

If the system has a regulator action $F(s)$ will not contain a term $1/s$; i.e., will have no pole at the origin. This is characteristic of many process-control systems. For position control and other systems a pole at the origin may exist. In these cases the methods given can be used to deduce the open-loop transfer function of a stable system from the closed-loop frequency response test results. Thus if the closed-loop transfer function $G(s)$ is determined then the open-loop form is

$$F(s) = \frac{G(s)}{1 - G(s)} \quad \ldots\ldots\ldots\ldots\ldots(22)$$

As an example, for the $F_3(s)$ of eqn. (12,) which becomes $G(s)$ in eqn. (22), then

$$F(s) = \frac{K}{s^3 + as^2 + bs + c - K}$$

Frequently for unity zero frequency transmission $c = K$ and then

$$F(s) = \frac{K}{s(s^2 + as + b)}$$

giving an open-loop pole at the origin.

Conclusions

It has been shown that transfer functions can be obtained for certain classes of systems using restricted frequency-response data. The use of real and quadrature conditions simplifies the test procedure and derived formulae, but formulation in terms of other vectors is readily achieved. The method enables an open-loop form to be derived for a stable closed-loop system and gives data from which open-loop poles may be obtained. These can be used as the basis for root-locus plots or for pole-zero cancellation techniques of compensation if desired. Direct open-loop tests on type 1 systems are possible if the system is unstable on closed loop.[2,3]

References

[1] 'An Introduction to the Mathematics of Servomechanisms', by J. L. Douce, E.U.P. 1963.

[2] 'Transfer Functions from Frequency Response', by N. G. Meadows, *Control Eng*. Vol. 11, No. 6, p. 95 (1964).

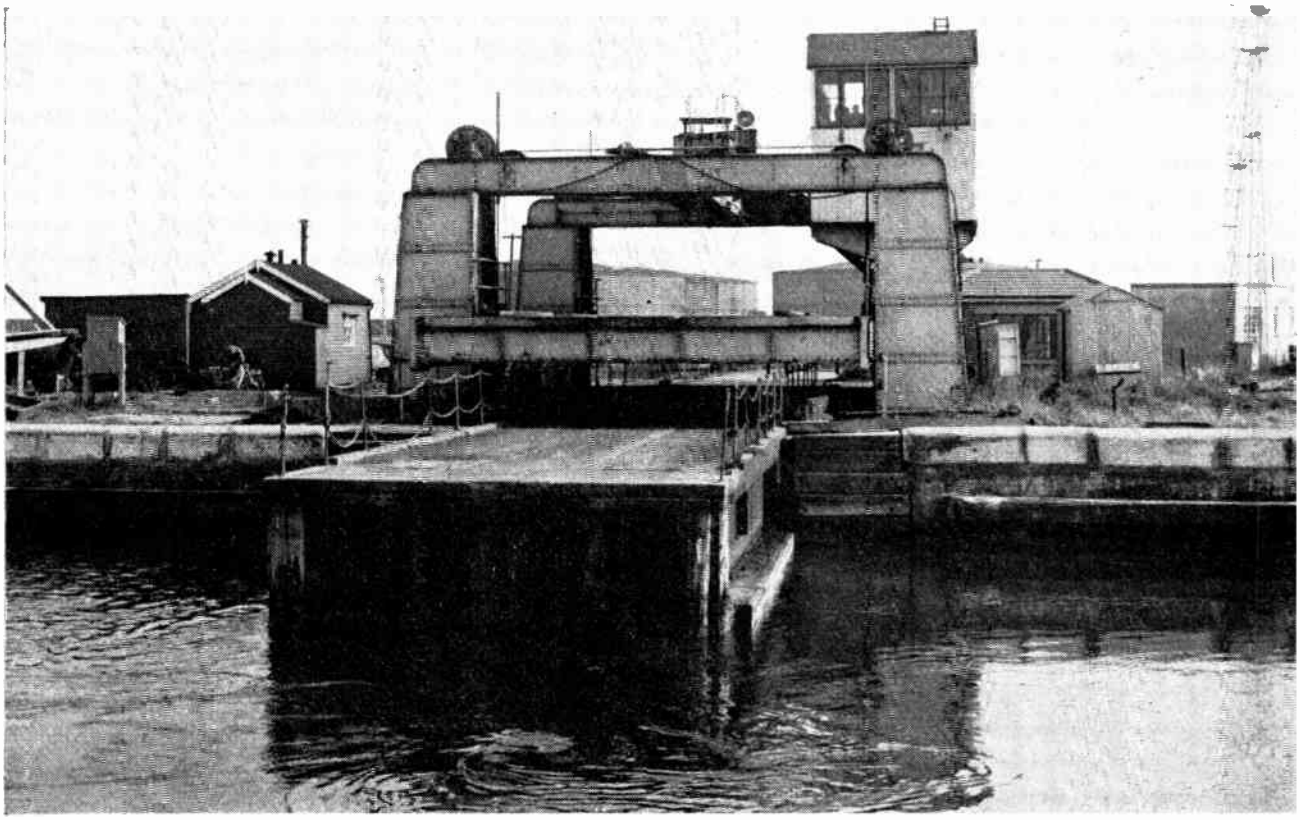
[3] 'Determining Damping Ratio and Natural Frequency', by N. G. Meadows, *Measurement and Control*. Nov. 1964.

S.E.R.T. Issues Membership Forms

The newly-formed Society of Electronic and Radio Technicians has now circulated membership-application forms and regulations to all enquirers. The first completed applications have been received.

Membership of S.E.R.T. is open to qualified and experienced technicians in the field of electronics and radio. The object of the Society is the advancement of the techniques and practice of electronic and radio technology.

Any technicians who wish to obtain a membership application form should write to the Society at its new address, 33 Bedford Street, London, W.C.2, telephone number Covent Garden 1152.



The cut at Grangemouth Docks being freed for shipping. In this picture the south part of the bridge is seen above the caisson which is being pulled by electric motor into the 8 ft high recess formed by the raising of the southern part of the bridge. The Sonac units are below ground level on either side of the recess into which the caisson moves

Ultrasonics Controls Bridge Movement

The installation at Grangemouth Docks of a Westool 'Sonac' ultrasonic sensing and switching device has overcome a problem which faced engineers of the British Transport Docks Board.

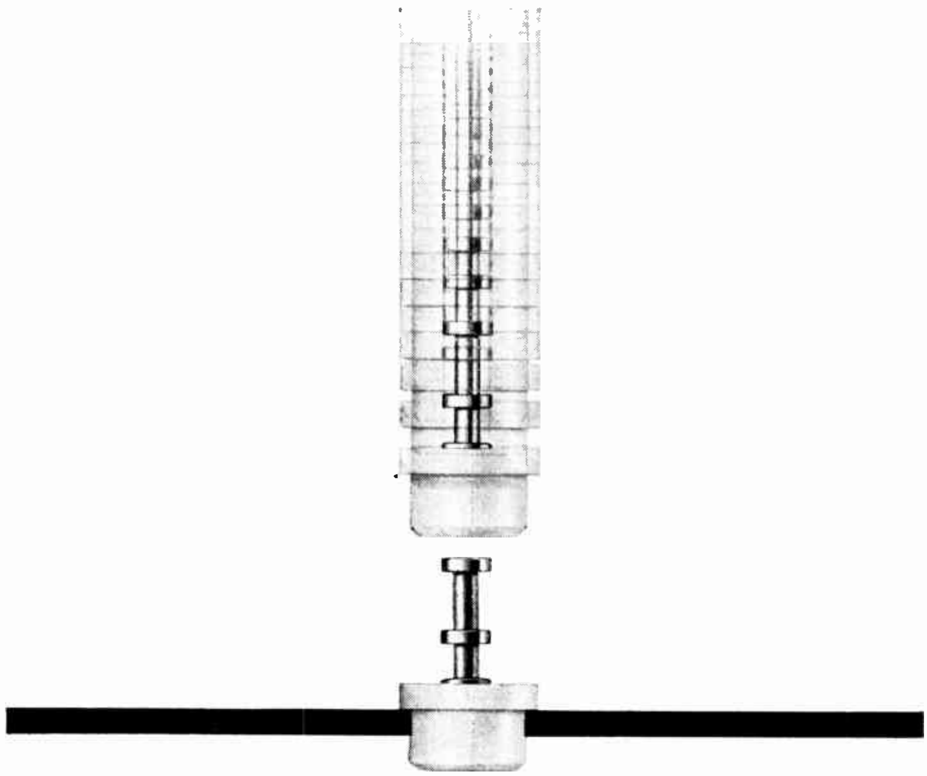
One of the ultrasonic sensing units being fitted in position

Focal point of the problem was the floating caisson section of the road and rail bridge linking the north and south sides of the dock at the East Cut. The 80-ft caisson forms the northern half of the bridge; to the south is a 90-ft top deck. When vessels are plying between the Eastern Channel and the Grange Dock the top deck is raised by wire ropes and the caisson, spanning the cut which divides channel and dock, is hauled by winches into the recesses. The cut is thus freed for shipping.

Originally, hydraulic power was employed in hauling the caisson into position under the top deck. This was superseded by an electric motor driving the winch barrels through a gear box and fluid coupling. It was found that, on bringing the caisson against the superstructure at the extreme end of the recess, unnecessarily high stresses were being made upon the hauling machinery. It was decided that a means of cutting the power before making contact was necessary, and this was effected by the installation of ultrasonic sensing units.

The Sonac devices, installed at a distance of 1 ft from the buffer stops, come into operation immediately the electric motor commences to haul the gate into the recesses. When the acoustic beam path is broken by the moving caisson, the power is automatically switched off and can only be restored by manual operation. The caisson, thereafter, glides gently under its own momentum to the final stage of contact with the superstructure without any jarring. The entire process of raising the top deck and hauling the caisson into the recesses is completed in approximately six minutes.

For further information circle 53 on Service Card



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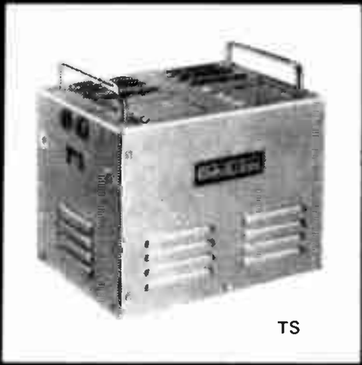

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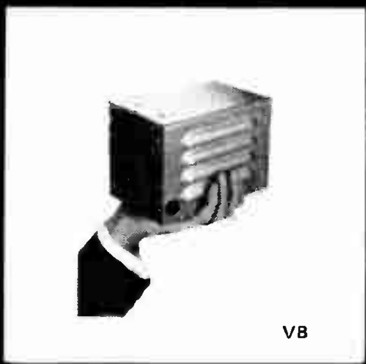

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High-speed distortionless servomechanical types, Series TS. Accuracy ± 0·25%. Unaffected by load, frequency or power factor changes. 1 to 120 kVA single phase, 3 to 360 kVA three phase.

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Inexpensive tap-changing types, Series VB. No distortion. Unaffected by load, frequency or power factor changes. 600 VA to 2·4 kVA.

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High-current stabilised d.c. power supplies, Series PST and PSS. 6 to 50 volts d.c., 200 W to 10 kW.

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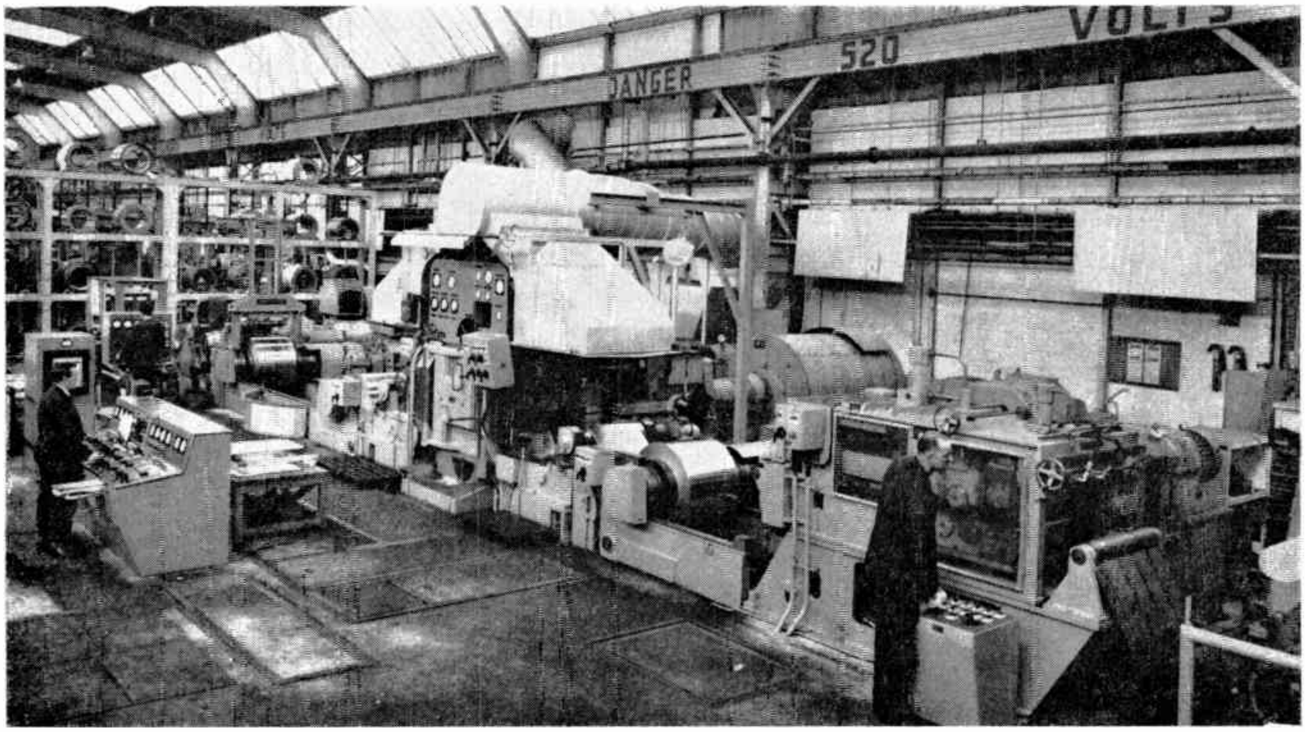


This Sendzimir mill rolls strip up to 24-in. wide and 0·12 to 0·003-in. thick at speeds up to 1,000 ft/min. Control of thickness is automatic. A Beta gauge is used for thin gauges and a flying micrometer is used for the thicker gauges

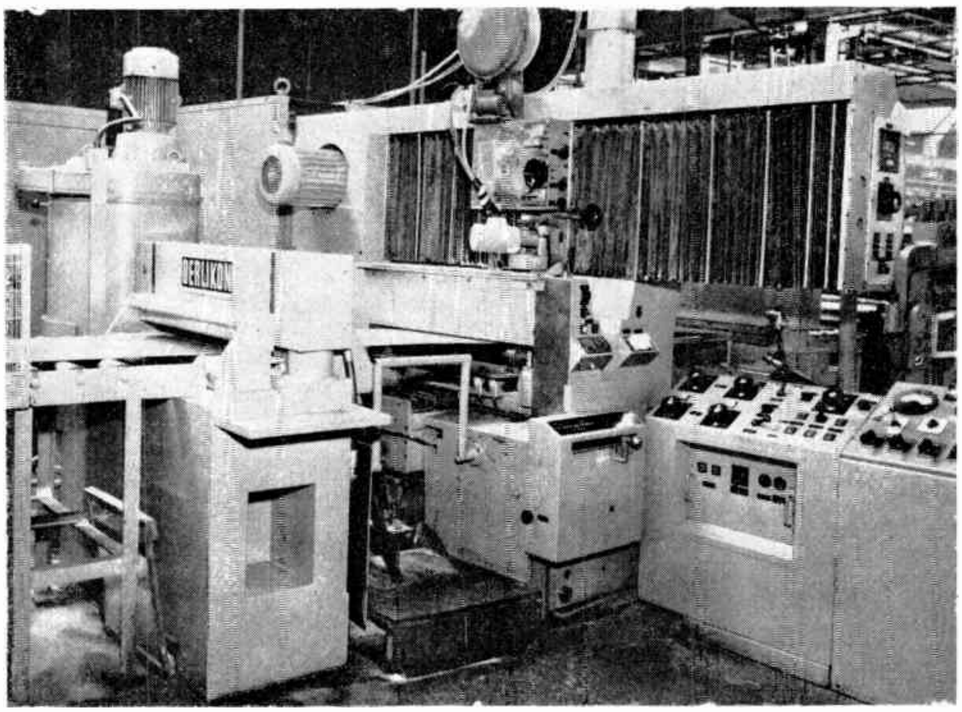
Europe's Largest Non-Ferrous Strip Mill

The recently-modernized IMI strip mill at Witton, which occupies an area of 260,000 sq ft and employs over 500 people, is now the largest production unit of its kind in Europe.

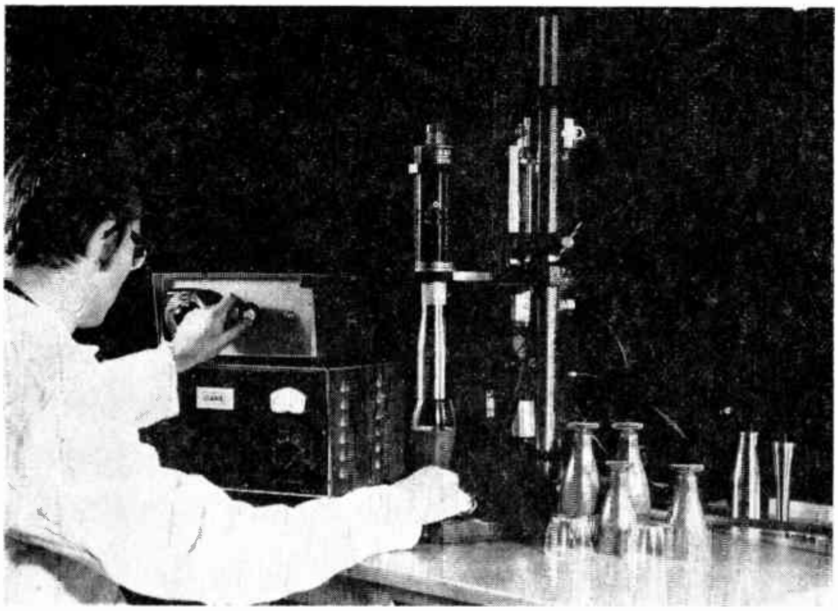
Representing a capital investment of £5 million, its unique range of equipment includes some of the world's most advanced plant for making brass and copper strip. Output already runs into many thousands of tons a year.

Control systems of all kinds are used throughout the plant. In the main, conventional and well-known methods of control are used, but where it is advantageous to do so, electronics are used.

Illustrated here are two of the many automatic machines which are fully integrated into the Witton production line.



Shown here is a completely automatic welder which butt-welds strip to provide the longer length now being demanded



ULTRASONIC WELDING OF PLASTICS— *The picture shows a Dawe type 1133 'Sonicwelder' which allows the welding of rigid thermoplastics to be carried out without the use of heat, chemical solvents or adhesives. The basic equipment consists of a transistorized 250-W generator and a lead zirconate transducer, operating at 20 kc/s. Full automation of all the parameters affecting the weld is achieved by an automatic timer and pneumatic stand complete with pressure, weld and 'hold' time controls. The vibrating plastic remains cool, except at the seam where there is rapid dissipation of energy. Welding occurs almost instantaneously around the periphery of the object and not where the tip is touching. Sealing two parts without touching the joint area offers a number of advantages, including ease of handling and saving on jigs and fixtures.*

For further information circle 54 on Service Card

to an Honours Degree in mechanical engineering, electrical engineering, electronics, production engineering or some related applied science, followed by, post-graduate awards to the value of £825 a year to scholars who get a 1st or 2nd Class Honours Degree and have completed a year's practical training within the English Electric Group. The post-graduate grants will cover such courses as a year's technical study at University or College of Technology at home or abroad, business or management studies, industrial experience overseas or social service abroad. The first of these new awards will apply to the academic year beginning in October 1965. Up to ten scholarships will be awarded each year to cover fees and maintenance and they are not subject to any means test by the company.

Endoscopes for Hire

A hire scheme for large Endoscopes has been introduced by P. W. Allen & Co. This service is expected to be of interest to works and maintenance engineers who often need to examine the inside of plant and pipe work.

Hire charges are low, for the first fortnight the smaller units cost £16 and the larger Endoscopes £23, subsequent weeks are at £5 for all types reducing for long-period hire.

The Endoscopes are supplied complete with low-voltage transformer, spare lamps, etc., and are contained in a fitted hardwood carrying case with strong outer returnable packing case.

Endoscopes are long slim tubular optical instruments that have the effect of 'transferring' the user's eye to the opposite end of the instrument, thus enabling the user to see the inside of cylinders, pipes and similar hollow parts which have only small openings. Illumination is provided by low voltage lamps fitted at the objective end.

Endoscopes are produced with diameters of $\frac{1}{4}$ to $1\frac{1}{2}$ in. and from a few inches to 30 ft long.

For further information circle 55 on Service Card

Honeywell Open Computer Centre in Frankfurt

The first Honeywell Electronic Data Processing centre on the Continent was officially opened recently at Frankfurt, Germany.

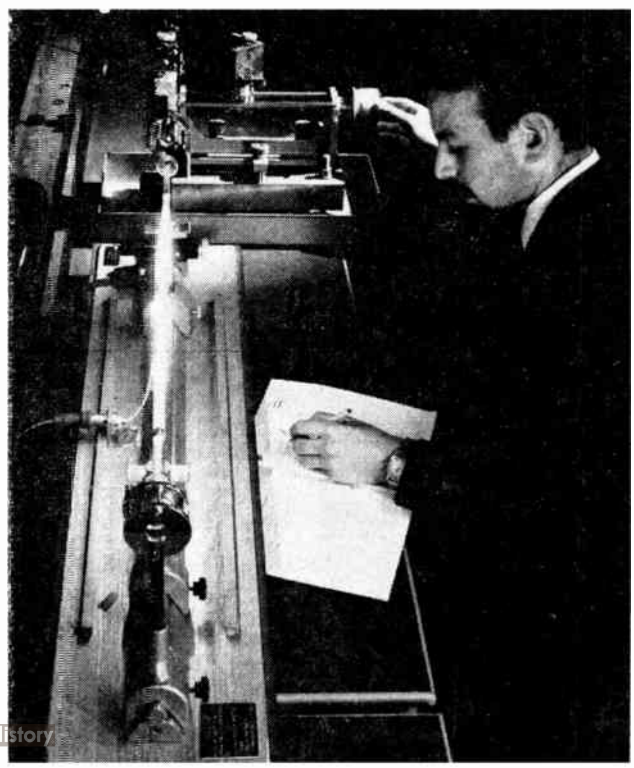
The computer centre will provide 'hardware' and 'software' demonstrations for prospective customers and training facilities for field service, operating and sales personnel.

Douglas Kane Group Move

All four companies in the Douglas Kane Group have now moved from their five separate premises in Highbury, London, to Swallowfields, Welwyn Garden City. Their telephone number is now Welwyn Garden 26381.

'Loctite', the liquid polymer for locking, retaining and sealing engineering assemblies, which is marketed by Douglas Kane, will now be bottled in the new factory and laboratory testing facilities will be available as part of the advisory service on Loctite technology.

LASER CONTROL FOR MACHINE TOOLS— *Research into the application of laser beams to control machine tools to accuracies of within half a wavelength of red light is being carried out in Elliott-Automation's laser laboratory at Frimley*



NEW BOOKS

Telecommunications

Vol. 1. Principles of Telecommunications

By J. BROWN and E. V. D. GLAZIER. Pp. 370 + xiv. Chapman & Hall Ltd., 11 New Fetter Lane, London, E.C.4. Price 45s.

This is the first volume of a series under the general editorship of Professor H. M. Barlow, F.R.S. After a quite elementary introductory chapter, which covers the principles of telecommunications, the authors go on to discuss the nature of the signal. This takes the reader into deeper waters for a great deal of the chapter is devoted to binary coding and sampling.

Chapter 3 deals with modulation and is largely descriptive save for the usual trigonometric formulæ. The properties of communication channels are dealt with quite simply but the response of linear channels takes the reader into much more involved mathematics. Chapters 6 and 7 deal with noise and information theory, while chapter 8 covers communication systems. Rather surprisingly, chapter 9, which deals with the principles of position fixing by radio, includes radar. While radar is undoubtedly a branch of radio it seems surprising that it should be considered as a part of telecommunications.

The authors say that the book is intended to meet the needs of University and Technical College Students reading for a first Degree or Diploma in Technology. The level of treatment does seem to be about right for this, but it is difficult to assess the general content and treatment because this is the first volume of a series and no indication is given of the nature of any of the succeeding volumes. Nothing is said about their titles nor even about how many volumes there are to be.

Frequency Filter Methods

By TORBERN LAURENT. Pp. 320. John Wiley & Sons, Glen House, Stag Place, London, S.W.1. Price 132s.

The coverage of this book is aptly described by the note on the title page which says: 'Application of image parameter theory and frequency transformation in the illustration of the conformity to law of ladder filters, in systematic calculation of optimum LC filters and in the treatment of external filter problems. Application of the dynamic transfer factor in the treatment of transients in filters with in-band and out-band signalling'.

Although much less mathematical than many books on filters, it is certainly a book for the filter specialist.

Electronic Digital Integrating Computers

By F. V. MAYOROV. Pp. 382 + xvii. Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1. Price 85s.

Having the sub-title 'Digital Differential Analyzers', this book is a translation from the Russian and has been edited by Dr. Yaohan Chu, of the Radio Corporation of America. There are ten chapters of which the first deals with the principles of digital integration. The next covers the methods of solution of mathematical and logical problems. Succeeding chapters cover digital computer circuits and storage devices.

Serial binary and serial decimal integrating computers are discussed, as well as analogue-to-digital converters, input-output devices, a high-speed parallel computer and the applications of integrating computers.

The treatment is largely descriptive but thorough, and not nearly as mathematical as one might expect. It should be readily understood by anyone seriously interested in the subject.

Methods of Test for the Determination of the Insulation Resistance of Solid Insulating Materials

I.E.C. Publication 167 : 1964. Available from the British Standards Institution, 2 Park Street, London, W.1. Price £1 0s 3d.

This describes procedures for determining rapidly the values of insulation resistance to give a general indication of quality, when great accuracy is not required. The rapidity of these methods is due to the ease with which the test specimens can be prepared.

These methods give values of resistance which include both volume and surface resistance. They consequently do not give well-defined constants for the materials, in contrast to the recommended methods of test for volume and surface resistivities given in I.E.C. Publication 93. However, they give empirical values which can be used for comparing the quality of different insulating materials. They are very useful for determining the influence of moisture on hygroscopic insulating materials, in which conditioning appreciably modifies not only the insulating properties of the surface but also those of the body of the material.

Proceedings of the Conference on Signal Recording on Moving Magnetic Media

Edited by GABOR HECKENAST. Published by Akadémiai Kiadó, Budapest, and distributed in the U.K. by Collet's, 44 & 45 Museum Street, London, W.C.1. Price £5 5s.

This volume comprises the full text and figures of the conference held in Budapest from 15th to 18th October 1962. The papers are published in the original languages—most of them in German and English. The subjects discussed in the paper cover the whole field of magnetic recording.

Engineering Drawing Practice

B.S.308 : 1964 (and abridged edition B.S.308A). Pp. 101 and 45, respectively. Published by British Standards Institution, 2 Park Street, London, W.1. Price 12s. 6d. (complete edition), 5s. (abridged edition).

The 1964 edition of B.S.308, perhaps the best known of the British Standards for fundamental engineering practices has now been published. The aim of B.S.308 is to provide a standardized means of communication between the designer and those who are responsible for translating his concept into reality.

The changes introduced in the new edition of B.S.308 have been made to simplify the text of the standard, or to remove anomalies, or to take account of developments in the international standardization of drawing practice.

On one point, the inclusion of alternative systems of drawing projection, no progress has been made. The 1953 edition of the standard did not state a preference between the first and third angle systems. Opinion is still fairly evenly divided on this issue, and the alternatives have, therefore, been retained with equal status.

There are some changes in the section dealing with methods of indicating limits of size. The 1953 edition specified that, where both limits of size are given, the maximum material limit should be given first, whereas the new edition states that the larger limit should appear first irrespective of whether the feature concerned is a hole or a shaft. This is in line with an ISO Recommendation now nearing publication. Reference is also made in this section to the ISO 'limits and fits' system (given in B.S.1916, Part 1).

Throughout the world there is an increasing interest in the use of symbols to denote geometrical tolerances and the matter is under study by the ISO and the ABC Committees on drawing practice. Recommendations have not yet been finalized, although some of the symbols are already being used in some countries. Those symbols tentatively established in the U.S.A. and in ISO draft documents are given in an appendix.

It has been agreed at ABC Conferences and at ISO Technical Drawing Committee meetings that there is a need for symbols to indicate machining requirements and surface texture on drawings. The symbols given in B.S.308 are those adopted at the 1962 ABC Conference and tentatively agreed by the ISO Committee.

An abridged edition of B.S.308 was published in 1958 especially for students. It omitted some of the more complicated concepts of drawing practice. To meet the continuing need for a publication dealing with the basic methods with which all engineering students must be familiar, an abridged version of the 1964 edition of B.S.308 has also been prepared.

Manufacturers' Literature

'Powerstat' Variable Transformers. Spectrum Electronics are introducing to the U.K. the 'Powerstat' range of variable voltage transformers and voltage control equipment manufactured by The Superior Electric Co., U.S.A. This 16-page brochure lists range of variable transformers which are available with power ratings from 0·72 to 332 kVA.
Spectrum Electronics Ltd., Deneway House, Darkes Lane, Potters Bar, Middlesex.
For further information circle 56 on Service Card

Hepworth Hydraulic Copying Equipment for Lathes. This four-page leaflet gives the basic specification for the Hepworth hydraulic copying equipment type 150. Suitable for lathes with up to 12 in. diameter capacity, the equipment provides accurate copying from templates.
The Hepworth Iron Co. (Engineering) Ltd., Hazelhead, Nr. Sheffield, Yorks.
For further information circle 57 on Service Card

Noble-Metal Thermocouples. Described in this eight-page booklet, number 7550/2, is the current range of JMC standard and special-purpose thermocouples. The standard units are suitable for temperature measurement in the range 1,000 to 1,850 °C and the special types cover temperatures up to 2,000 °C.
Johnson, Matthey & Co. Ltd., 73-83 Hatton Garden, London, E.C.1.
For further information circle 58 on Service Card

Magnets for Reed Switches. This 12-page booklet lists 19 types of magnet for reed switches. Operating distances are included with a range of switches of differing size and sensitivity. Various modes of operation of switches employing linear and rotary movement of the control magnet are described.
Morrison & Catherall Ltd., Forge Lane, Killamarsh, Nr. Sheffield, Yorks.
For further information circle 59 on Service Card

Sasco Catalogue 1964-65 : Electronic Components. Now available to industry, this 452-page catalogue gives specifications, illustrations and prices of all electronic components stocked by
Stewart Aeronautical Supply Co. Ltd., Gatwick Road, Crawley, Sussex.
For further information circle 60 on Service Card

STC Semiconductor Devices. Publication M/106X summarizes, in 46 pages, the essential ratings and characteristics of all current STC semiconductors. Thermistors and selenium rectifiers are not included.
Standard Telephones and Cables Ltd., Components Group, Footscray, Sidcup, Kent.
For further information circle 61 on Service Card

Sperry Stepper Motor. Advanced data on a 28 V d.c., 30° step-angle motor in a size 11 case is given in this four-page leaflet.
Sperry Gyroscope Co., Components & Systems Group, Brentford, Middlesex.
For further information circle 62 on Service Card

BICC Radio Frequency Cables. Section 1 of this 32-page brochure deals with the current range of BICC coaxial cables and subsequent sections list details of BICC-Burndy connectors and terminations.
British Insulated Callender's Cables Ltd., 21 Bloomsbury Street, London, W.C.1.
For further information circle 63 on Service Card

Venner Lightweight Silver-Zinc Accumulators. Outlined in this 12-page publicatioin VA53 are the features of Venner silver-zinc cells which are claimed to be the smallest and lightest in the world.
Venner Accumulators Ltd., Kingston-Bypass, New Malden, Surrey.
For further information circle 64 on Service Card

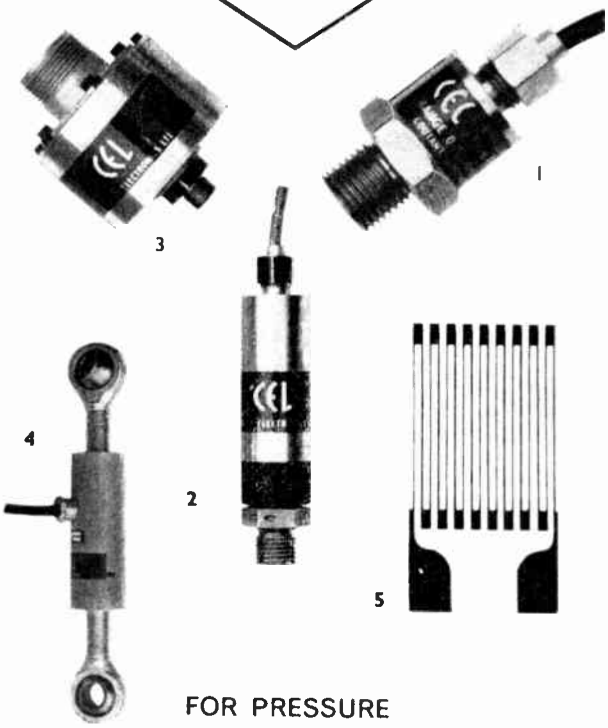
'The Crystal' Auto-Reset Dial Timer. In eight pages this leaflet, list No. 200, gives full details of a compact auto-reset dial timer. These units are available with time ranges from 0-10 sec to 0-48 hr.
Electrical Remote Control Co. Ltd., The Fairway, Bush Fair, Harlow, Essex.
For further information circle 65 on Service Card

National-Elliott 803B Digital Computer Price List. In eight pages this catalogue No. 83 briefly covers rental arrangements, maintenance service, prices, etc., for the 803B computer and peripheral equipment.
Elliott Brothers (London) Ltd., Borehamwood, Herts.
For further information circle 66 on Service Card

WHAT'S ON AND WHERE?
This new forthcoming-events feature is to be found facing the inside back cover.

For further information circle 246 on Service Card

CEL



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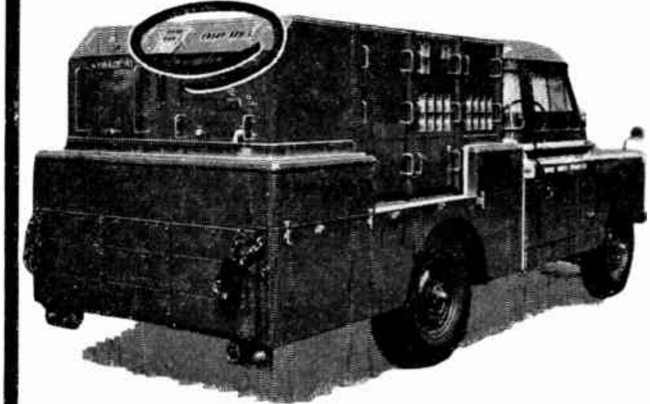
CLEAR INDICATION BY KGM



TRACE 242

This may not be the largest portable tester in the world, but it must be one of the most comprehensive. It is a Tape Controlled Recording and Automatic Check-out Equipment by Hawker Siddeley Dynamics Ltd. and

the version shown was recently demonstrated at a R.E.M.E. Symposium on Automatic Testing. Similar equipment has been ordered by B.O.A.C. for use with the V.C.10 fleet.

K.G.M. Indicators read out the results to the operator in bright digits, to give a CLEAR INDICATION of the results of the punched tape programme of testing.

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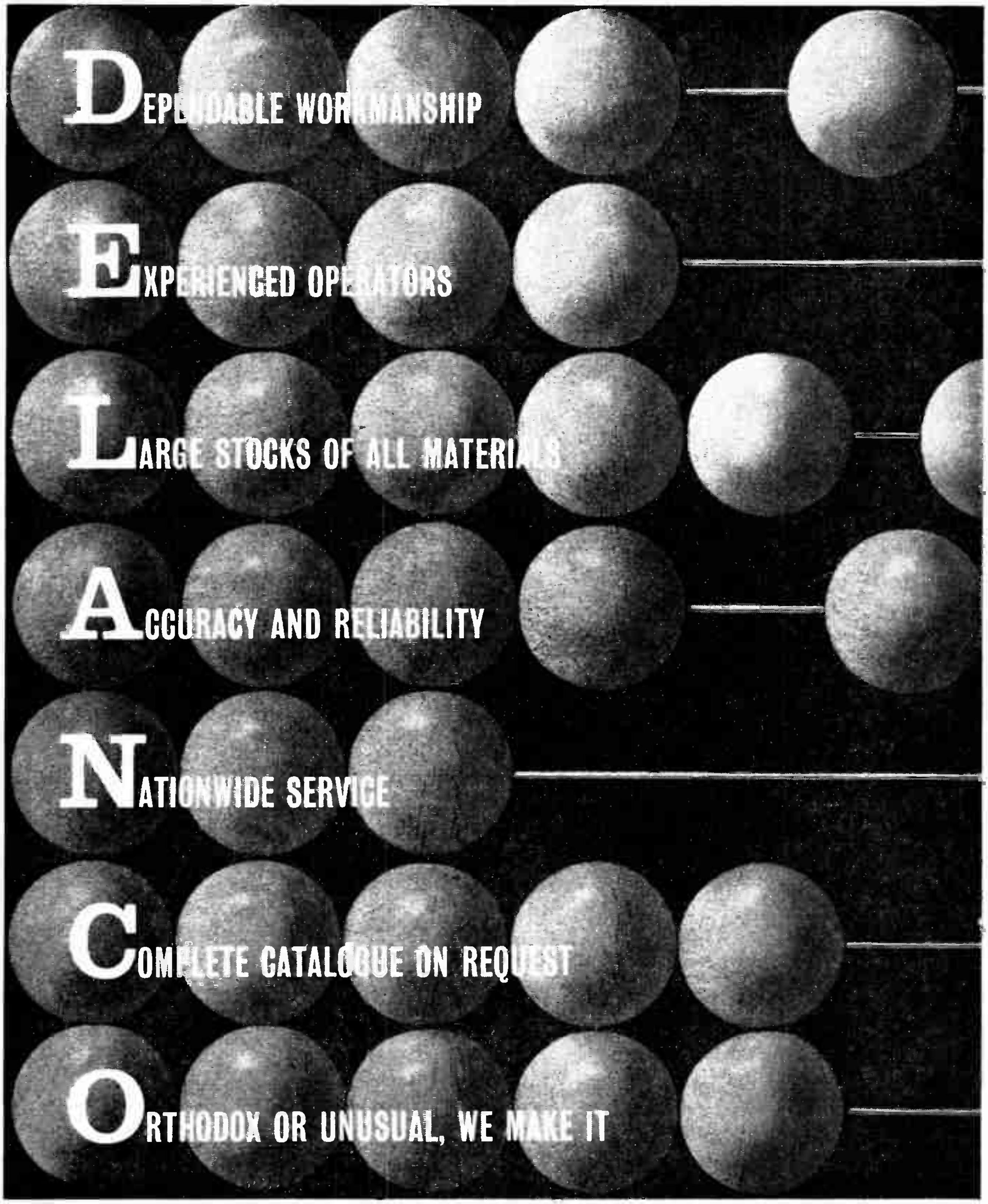

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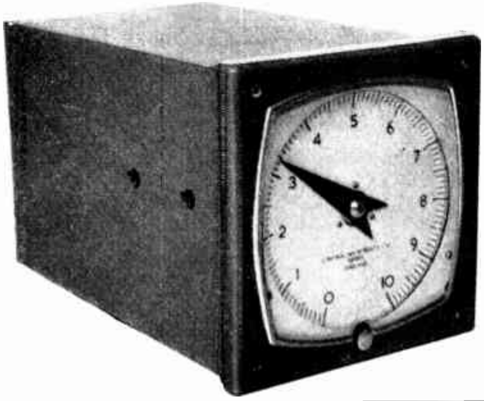

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Modern techniques result in a high gain, high power servo system with low current consumption and superior temperature stability. 'Plug in' printed circuits are used for easy maintenance; 'plug in' range units ensure quick, accurate adjustment to suit individual needs.

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Range	5 mV min. to 100 mV max. or temperature equivalent. 'Plug in' range facilities with variable zero and span controls.
Calibrated Accuracy	± 0.5% of F.S.D.
Sensitivity	20 μV.
Slide-wire Resolution	0.1%.
Scale Diameter	104.8 mm (4⅛").
Effective Scale Length	289 mm (11⅜").
Response Time	5 sec. for total range excursion.
Input Resistance	Off balance, 1.5 K ohms minimum. On balance, approaching infinity.
Maximum Source Input Resistance	1 K ohms.
Maximum Ambient Temperature	10°C to 50°C.
Supply Voltage	240v. ± 15%.
Input V.A.	17.
Control Facilities	On/off single point control. On/off two point control.

CONTROL INSTRUMENTS LIMITED

Alfreton Road, Derby. Grams: Continst Derby. Phone: Derby 47676. Telex: 37580

For further information circle 250 on Service Card

HIGH QUALITY
TRANSISTOR AUDIO AMPLIFIER
for home construction

A breakthrough in fine sound reproduction from records or radio is marked by the new high-quality transistor audio amplifier described in constructional articles in WIRELESS WORLD, beginning in January issue. The Mark II version of a famous amplifier originally featured in WIRELESS WORLD, it incorporates every latest refinement, eliminating the need for an output transformer. January issue includes full circuit explanation and diagrams. February—detailed constructional drawings.

Also in this issue:

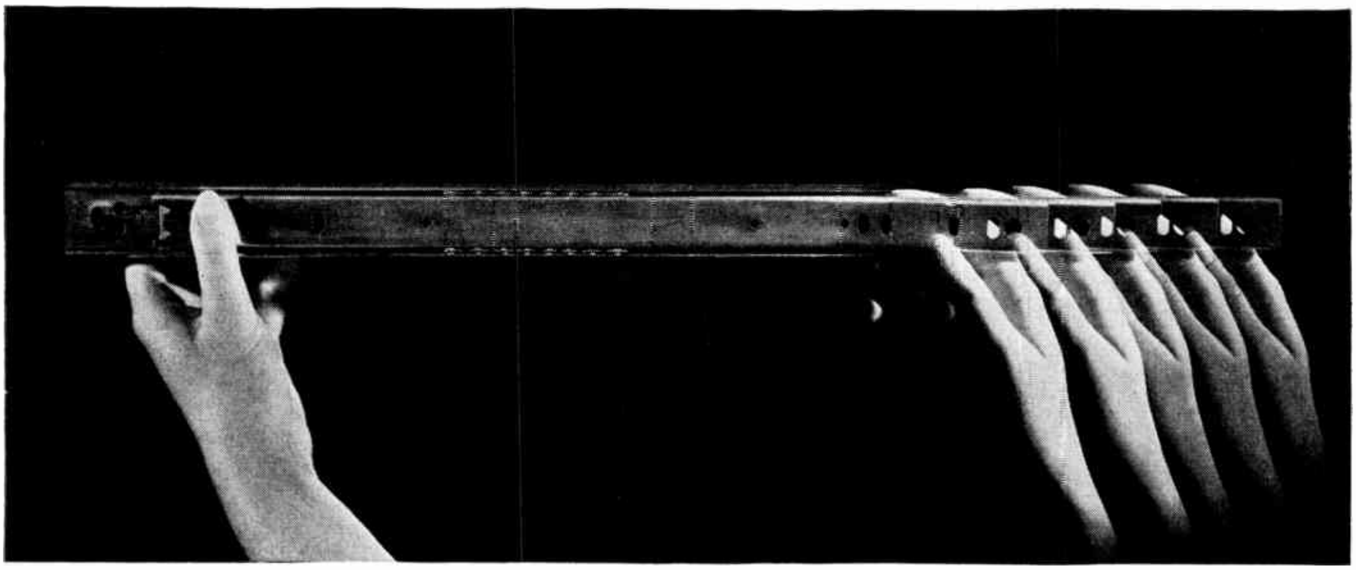
- Electronic Laboratory Instrument Practice—first in a series by T. D. Towers providing a comprehensive well-organised course on the handling of the fundamental instruments of the electronic laboratory. An invaluable series for students and all beginning an electronics career.
- Preparing to receive Oscar III—forthcoming amateur radio satellite.

JAN. issue out 28 Dec.

Enlarged page size from January issue — price increased to 3s.

Wireless World

low cost high precision



New from Imhofs – Imslide Accuride Series; a range of superb telescopic runners which have been designed to offer you a lower priced slide with a high degree of accuracy and versatility. Made to constant and precise tolerances from high tensile steel with a bright nickel finish, giving an excellent appearance that will enhance any equipment to which they are fitted. Unique stainless steel retainers keep the bearings evenly spaced and give an extremely smooth movement of the slide. Seven different models to choose from – including automatic disconnect – each in three standard lengths. Capable of carrying loads of up to 170 lbs according to model. Prices from £1.14.2. a pair. Send today for full details of the Imslide Accuride Series; also new models in the 300 and 500 Series of Imslide Telescopic Runners.

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A8/9

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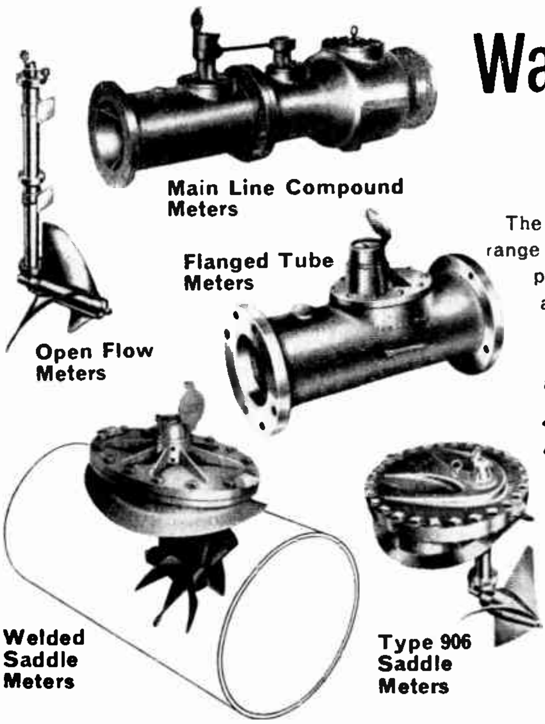
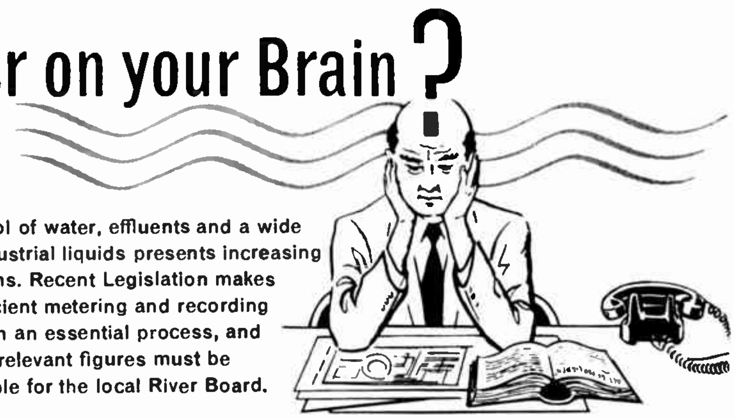


Water on your Brain?



The control of water, effluents and a wide range of industrial liquids presents increasing problems. Recent Legislation makes an efficient metering and recording system an essential process, and all relevant figures must be available for the local River Board.

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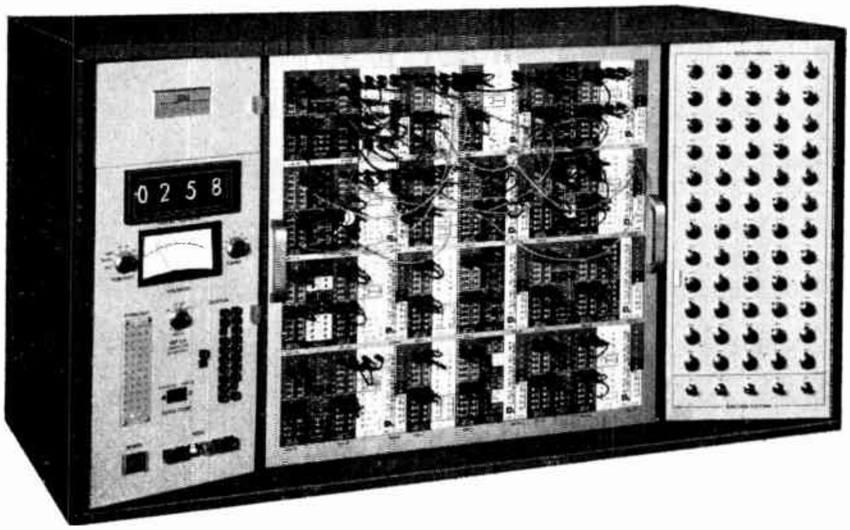
TR 48



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1 Expandable to at least 60 amplifiers in one console, with no loss in accuracy, stability or performance.

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5 Fused potentiometers with locking mechanism. No accidental disturbance of programme.

6 Solid state advantages of compactness, low power consumption and reliability. Available with specially fitted desk for full portability.

Electronic Associates supply complete computation systems, including 'X-Y' VARIPLOTTERS, multi-channel recorder, and oscilloscope for monitoring outputs.

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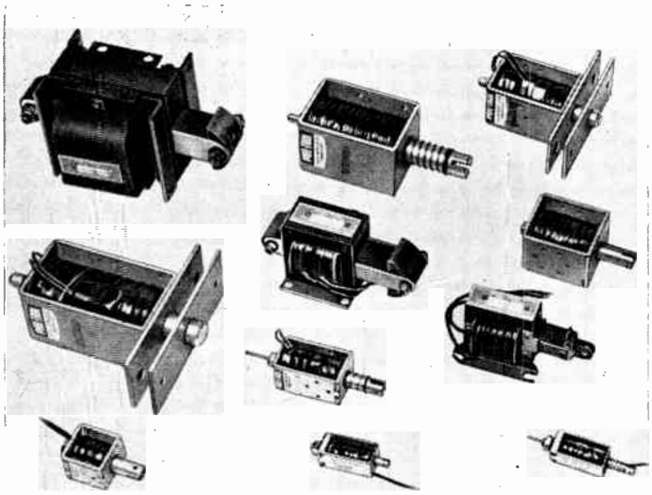

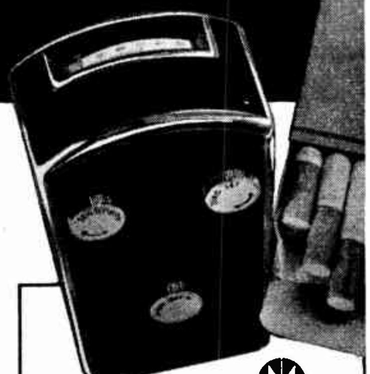

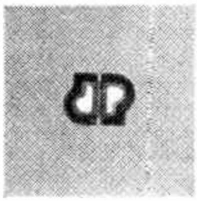

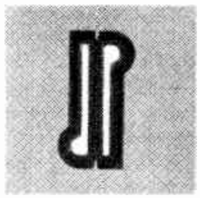

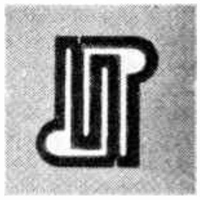

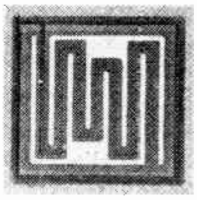

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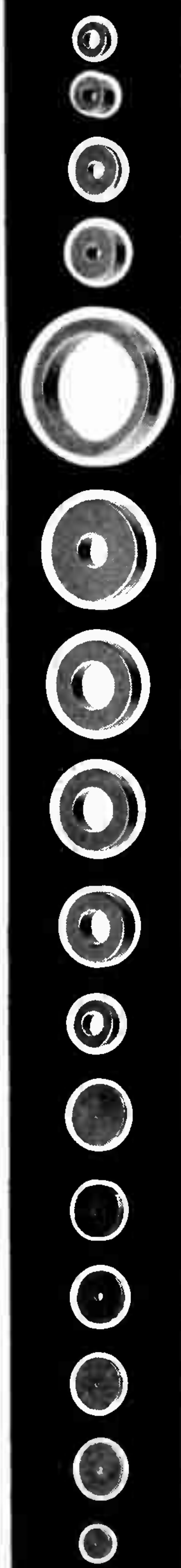

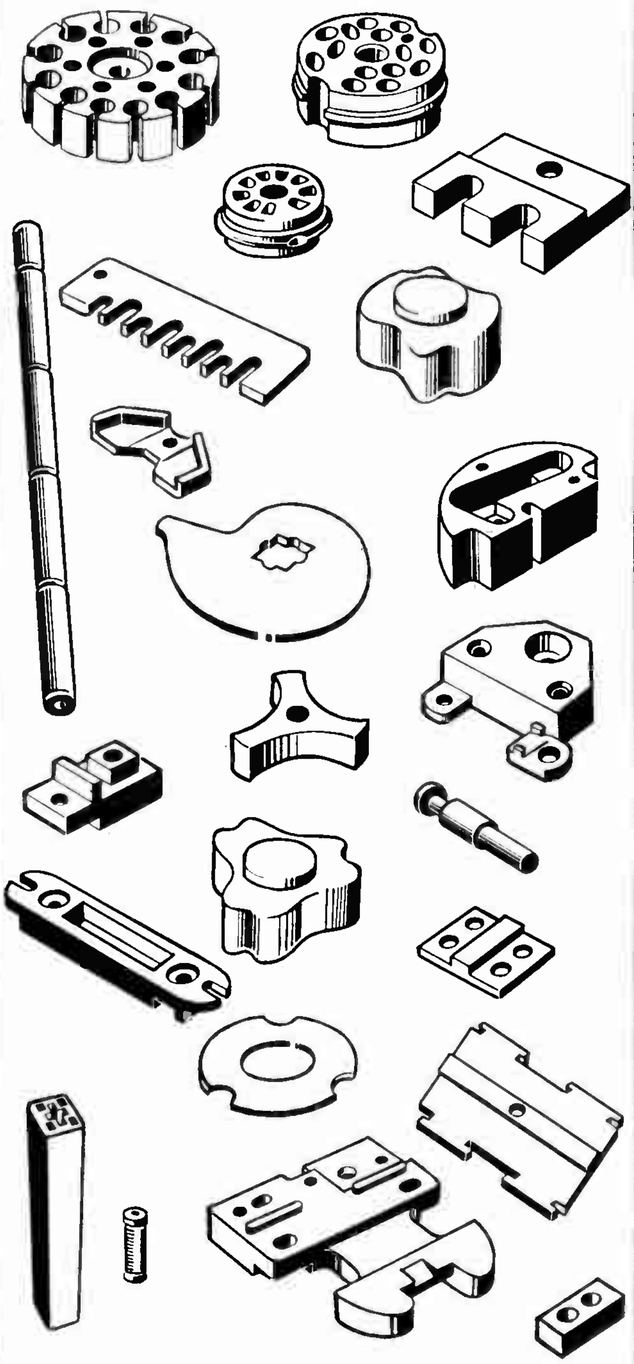

INDEX

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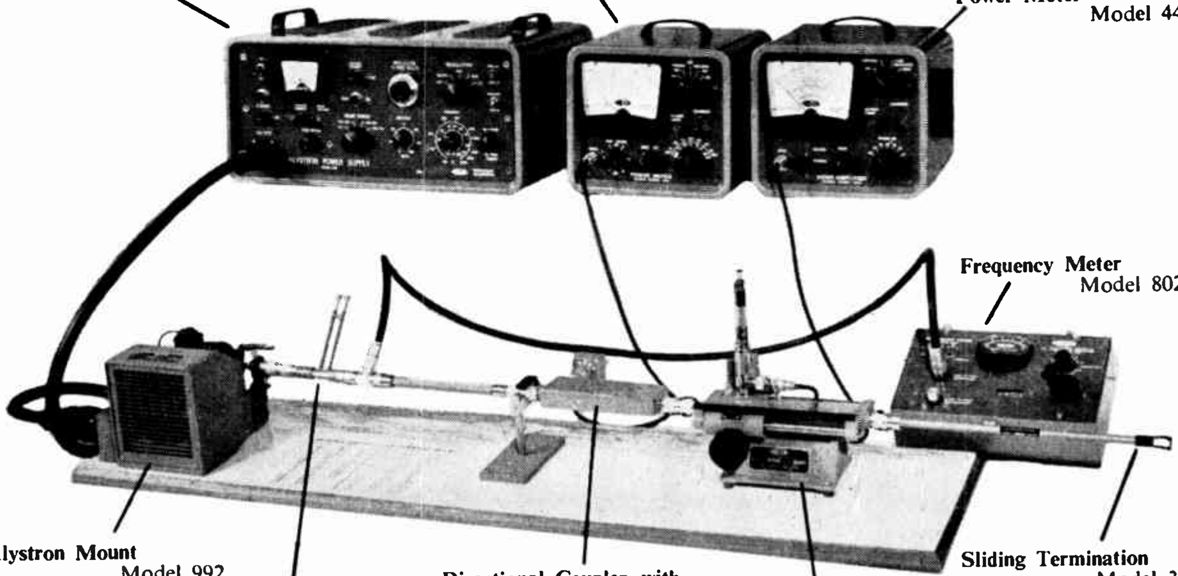

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Meetings

Institution of Electronic and Radio Engineers

All meetings will be held at 9 Bedford Square, London, W.C.1, and tickets will be required, unless otherwise stated.

(W) 13th Jan. 5.30 p.m. Joint I.E.E./I.E.R.E. meeting at the I.E.E., Savoy Place, London, W.C.2. 'Potential Levels in the Central Nervous System'.
(W) 20th Jan. 6 p.m. 'Acoustic Communication Underwater'.
(W) 3rd Feb. 6 p.m. Joint I.E.R.E./I.E.E. discussion on 'Safety of Operating Theatre Equipment'.
(W) 17th Feb. 6 p.m. 'Transistorized Equipment Designed for Television Exploitation of Radar Information'.
(W) 24th Feb. 6 p.m. at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1. 'A Low Cost Video Tape Recorder for Professional Applications'.
(W) 3rd Mar. 6 p.m. Discussion on 'Teaching of Control Engineering'.
(W) 10th Mar. 6 p.m. at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1. 'Problems in Listening'.
(F) 12th Mar. 5.30 p.m. Joint I.E.E./I.E.R.E. discussion at the I.E.E., Savoy Place, London, W.C.2. 'The Training of Computer Engineers'.
(W) 17th Mar. 6 p.m. Joint I.E.R.E./I.E.E. discussion on 'Implanted Stimulators for Bladder and Rectum'.

Institution of Electrical Engineers

All meetings will be held at 5.30 p.m. at Savoy Place, London, W.C.2, unless otherwise stated.

(Tue) 12th Jan. 'Detection and Measurement of Discharges in Insulation'.
(W) 13th Jan. Joint I.E.E./I.E.R.E. meeting. 'Potential Levels in the Central Nervous System'.
(Tue) 19th Jan. Discussion on 'The Performance of Hill-Climbing Systems — The Gradient Estimation Problem'.
(Tue) 26th Jan. 'Electrostatic Generators'.
(F) 29th Jan. 'Measurement of Earth Electrode Resistance with Particular Reference to Earth Electrode Systems Covering a Large Area'.
(Tue) 2nd Feb. 'The Refurbishing of Engineers in the U.S.A.'.
(W) 3rd Feb. 6 p.m. Joint I.E.R.E./I.E.E. discussion at the I.E.R.E., 9 Bedford Square, London, W.C.1. 'Safety of Operating Theatre Equipment'.
(W) 10th Feb. 'Radar—Present Position and Future Trends'.
(Th) 11th Feb. Discussion on 'The Electrometer Amplifier: Its Design and Applications'.
(Tue) 16th Feb. Discussion on 'Universities Under Fire'.
(M) 22nd Feb. 'Layer Structure of the Troposphere'.
(Tue) 23rd Feb. Discussion on 'What is Systems Engineering?'.
(F) 12th Mar. Joint I.E.E./I.E.R.E. discussion 'The Training of Computer Engineers'.
(W) 17th Mar. 6 p.m. at I.E.R.E., 9 Bedford Square, London, W.C.1. Joint I.E.R.E./I.E.E. discussion on 'Implanted Stimulators for Bladder and Rectum'.

Institution of Mechanical Engineers

All meetings will be held at 6 p.m. at 1 Birdcage Walk, London, S.W.1, unless otherwise stated.

(Th) 7th Jan. 7.30 p.m. at The Upper Deck, The Ship Hotel, Duke Street, Reading. 'Job Evaluation'.
(Th) 7th Jan. Discussion on 'Electrostatic Hazards in Factories'.
(Th) 14th Jan. Discussion on 'British Standard B.S.1042: Code for Flow Measurement'.
(Th) 21st Jan. 4 p.m. Discussion on 'Keeping the Engineer Up-to-Date and Finding Information'.

Conferences, Symposia and Colloquia

(F) 22nd Jan. 5.30 p.m. at I.E.E., Savoy Place, London, W.C.2. Colloquium on 'Network Analysis'. Tickets required.
(M) 25th Jan. 2.30 and 5.30 p.m. at the I.E.E., Savoy Place, London, W.C.2, joint I.E.E./I.E.R.E. colloquium on 'Logic Circuits'.
(Tue) 26th Jan. 3 p.m. at the I.E.E., Savoy Place, London, W.C.2. Joint I.E.E./I.E.R.E. colloquium on 'The Achievement of High Accuracy in Analogue to Digital Conversion'.
(M-Tue) 8th-9th Feb. at the I.E.E., Savoy Place, London, W.C.2. Conference on 'Electronics Design'. Registration is required.
(M) 15th Feb. 3 p.m. at I.E.E., Savoy Place, London, W.C.2. Colloquium on 'The Design of Solid State Power Supplies'. Registration is required.
(Th) 18th Feb. 2.30 and 5.30 p.m. at the I.E.E., Savoy Place, London, W.C.2. Joint I.E.E./I.E.R.E. colloquium on 'Automatic Aids to Fault Finding in Computers'. Registration is required.
(F) 19th Feb. 2.30 and 5 p.m. at the I.E.E., Savoy Place, London, W.C.2. Colloquium on 'Electrostatic Precipitators'. Registration is required.
(M) 5th Apr. 2.30 and 5.30 p.m. at the I.E.E., Savoy Place, London, W.C.2. Joint I.E.E./I.E.R.E. colloquium on 'Design of Real Time Computer Systems'.
(M-Th) 17th-20th May at the I.E.E., Savoy Place, London, W.C.2. Joint I.E.E./I.E.R.E. international conference on 'Components and Materials used in Electronic Engineering'. Registration forms and further information from the I.E.R.E., 9 Bedford Square, London, W.C.1.

Exhibitions

(Tue-F) 18th to 21st May. Radio and Electronic Component Show at Olympia, London. Organized by Industrial Exhibitions Ltd., 9 Argyll Street, London, W.1. 'Phone: Gerrard 1622.
(Tue-F) 28th Sept.-1st Oct. Medical Electronic and Instrumentation Exhibition (in conjunction with The European Symposium on medical electronics) at Exhibition Hall, Brighton, Sussex. Organized by Events Promotions Ltd., Ashbourne House, Alberon Gardens, London, N.W.11. 'Phone: Meadway 5555.

Courses

Commencing 14th Jan. at 6.30 p.m. 'Basic Microwave Techniques'.
Special course of 12 lectures given Thursday evenings.
Commencing 14th Jan. at 2 p.m. 'Printed Circuit Techniques'.
Special course of 12 lectures given Thursday afternoons.
Dept. of Electronics and Telecommunications, Northern Polytechnic,
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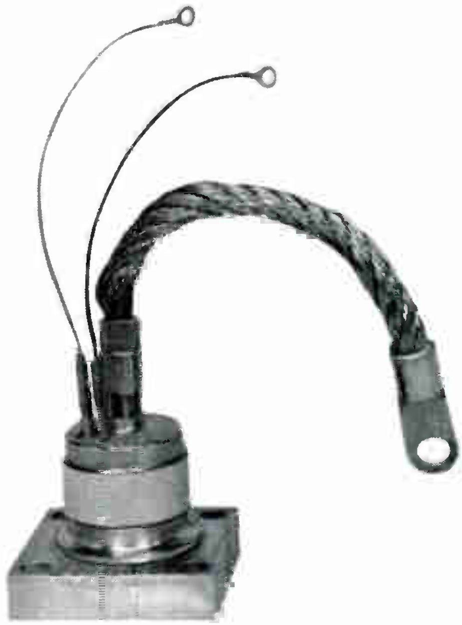

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