# INDUSTRIAL ELECTRONICS

JUNE 1964 5s 0d

World Radio History

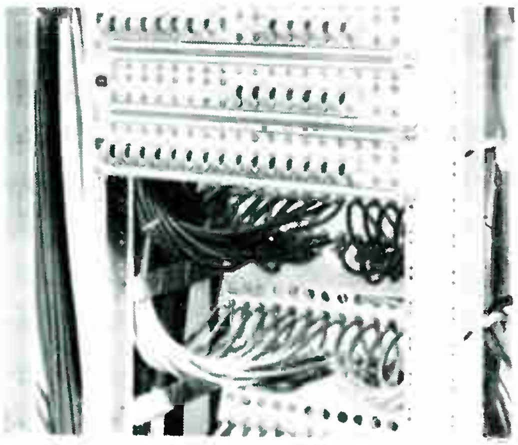
For further information circle 200 on Service Card

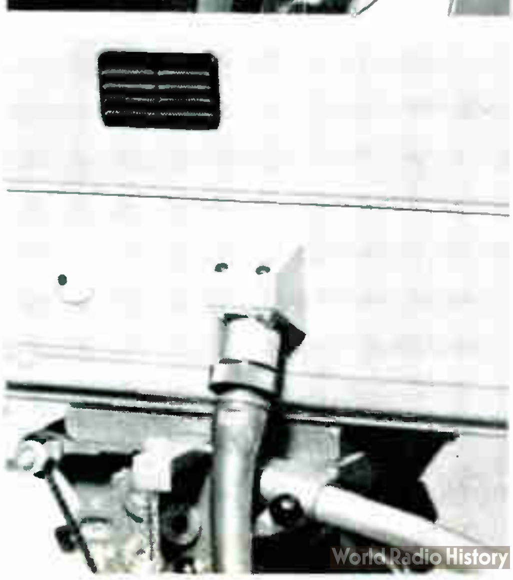
# BICC in Television

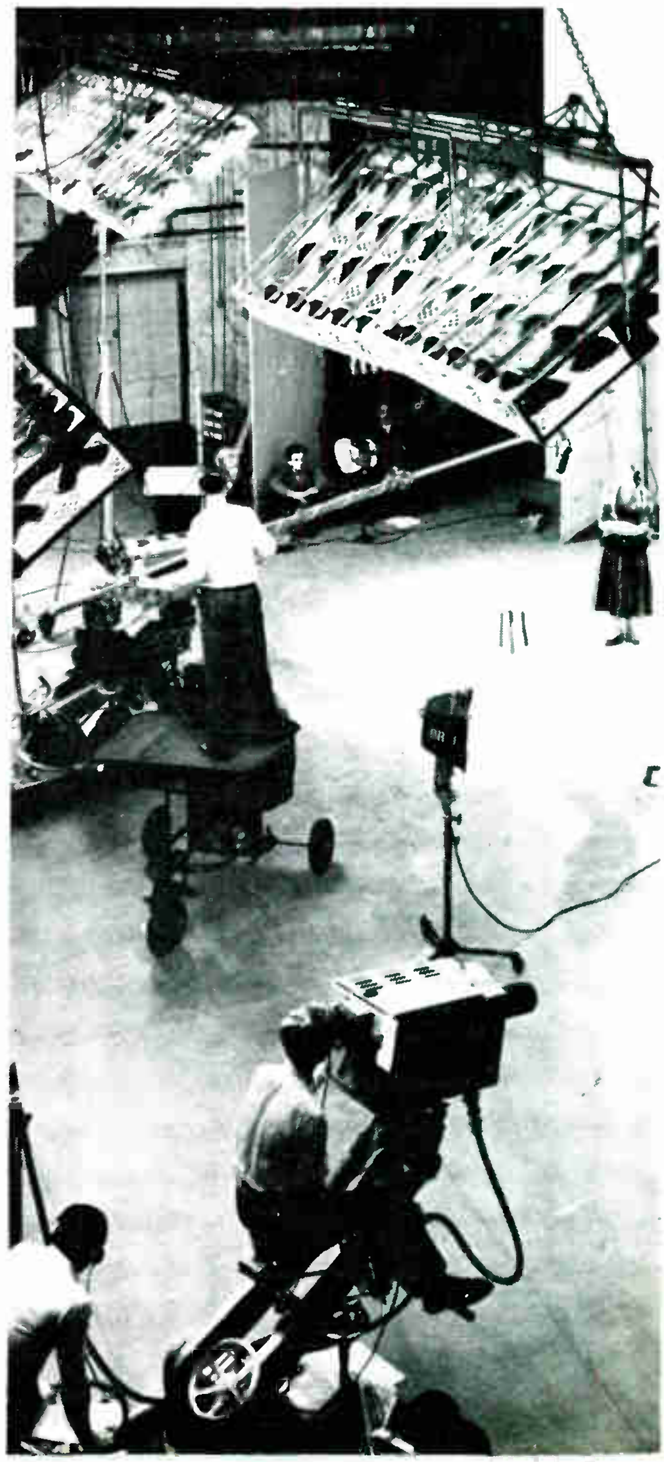
BICC manufacture every type of cable and associated product that is necessary for the transmission and reception of the visual image—including camera cables and polypole couplers, coaxial distribution cables, power cables, equipment wires and downleads. Transmitting aerial towers are supplied and erected by the British Insulated Callender's Construction Company Limited.

BICC products contribute to the development and expansion of the television industry.

British Insulated Callender's Cables Limited
21 Bloomsbury Street London WC1







World Radio History

# INDUSTRIAL ELECTRONICS

incorporating *ELECTRONIC TECHNOLOGY*

Volume 2 Number 6 June 1964

## contents

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***continued overleaf***

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World Radio History

# contents continued





## FEATURES



**OUR COVER**

*This illustrates the final testing of Avometers at the Vauxhall works of Avo Ltd. Elsewhere in the issue an article describes the manufacture of multi-range meters*

## Next Month

An article describing an electronic sequence control system which may be applied to almost any machine will appear in next month's issue. Other articles will include one dealing with the application of digital techniques to data-handling equipment for a high-speed wind tunnel.

**TO SAVE YOUR TIME**

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

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# 'METOX'

## WELWYN 'METOX' METAL OXIDE RESISTORS

**the widest range of METAL OXIDE FILM resistors available today now include a complete range to DEFENCE SPECIFICATION DEF 5115**

TYPE F931

'METOX' DEF 5115 STYLE RFG-1

TYPES F252 F202 F642 F652

'METOX' DEF 5115 STYLE RFG-2

TYPES F255 F205 F645 F655 F685

'METOX' DEF 5115 STYLE RFG-5


TYPES F64 F66 F68

'METOX' DEF 5115 STYLE RFH-1

*Each resistor shown is representative of a full range*

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*FACTORIES IN AUSTRALIA AND CANADA*



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# practical planar

**Three new silicon planar transistors, which maintain germanium saturation voltages over several decades of current, now make practical a wide range of amplifying, oscillating and switching applications. They are immediately available at practical prices and are backed with performance data and circuit design information.**

A significant feature of these transistors is that a saturation voltage of less than +200mV at 150mA, and less than 1V at 1·0A, is achieved. These voltages are typical of germanium rather than silicon devices.
The current gain – which is maintained over four decades of current – and $f_T$ of greater than 50Mc/s, enable most general purpose applications to be readily met.

A booklet, giving performance data and circuits showing typical applications, is available on request. For price and delivery information contact Mullard at the address below.

| | BFY50 | BFY51 | BFY52 | |
|---|---|---|---|---|
| $V_{CB}$ ($I_E$ = 0) | +80 | +60 | +40 | V |
| $V_{CE}$ (cut-off) | +80 | +60 | | V |
| $I_{CM}$ max. | 1 | 1 | 1 | A |
| $P_{tot}$ max. ($T_{amb}$ = 25°C) | 800 | 800 | 800 | mW |
| $h_{FE}$ ($I_C$ = 150mA) | >30 | >40 | >60 | |
| $f_T$ ($V_{CE}$ = +6V, $I_C$ = 50mA) | >60 | >50 | >50 | Mc/s |
| $V_{CE(sat)}$ ($I_C$ = 150mA, $I_B$ = 15mA) | < +200 | < +350 | < +350 | mV |
| Encapsulation | TO-5 | TO-5 | TO-5 | |

Mullard Limited,
Industrial Semiconductor Division,
Mullard House,
Torrington Place, London WC1
Telephone: LANgham 6633

**Mullard**

MIS 11C



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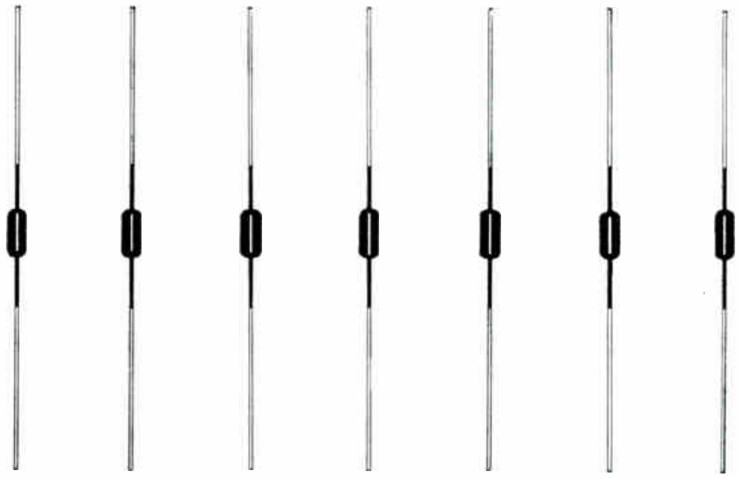

# NOW TYPE APPROVED

# STABILITY

Change in Forward Voltage over life and storage at temperature extremes:

| | |
|---|---|
| Max | 1·0mV |
| Typical Change (at 15 mA Forward Current) | <0·1mV |

## FERRANTI
## HIGH QUALITY
## miniature
## SILICON JUNCTION DIODES

**DYNAMIC LIFE TESTING**

48 hours at full rating with EVERY device

MAXIMUM RATINGS

| Type No. | ZS90 | CV7433 ZS91 | CV7434 ZS92 | CV7435 ZS94 | |
|---|---|---|---|---|---|
| P.I.V. | 50 | 100 | 200 | 400 | Volts |
| Mean Rectified Current | 250 | 250 | 250 | 250 | mA |
| Max. Reverse Leakage at 25°C | 0.25 | 0.25 | 0.25 | 0.25 | μA |
| Max. Forward Voltage Drop at 250mA | 1.1 | 1.1 | 1.1 | 1.1 | Volts |
| Derating over Temperature Range 25°C to 150°C | 2 | 2 | 2 | 2 | mA/°C |
| Ambient Operating and Storage Temperature Range | — 55°C to +150°C | | | | |

* MATCHED PAIRS AND QUADS.
* VERY STABLE FORWARD CHARACTERISTICS.
* MINIATURE SIZE.
* GLASS ENCAPSULATION.
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* EXTREMELY HIGH RELIABILITY ensured by VERY HIGH STANDARDS OF QUALITY CONTROL DURING MANUFACTURE AND TEST.
* STRINGENT TESTING INCLUDING THERMO-CYCLING BETWEEN LIMITS AND FULL LOAD.
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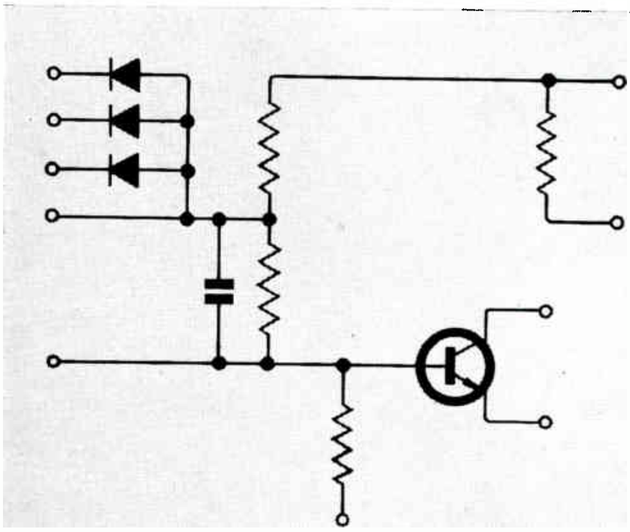
# Faster NAND/NOR logic with Mullard integrated-circuit elements

## Diode-transistor logic elements have 25ns propagation time

**Mullard introduces the first of a series of integrated-circuit logic elements for computers, data processing equipment, and high-reliability control equipment. The reduction in the labour required between the block diagram stage and the completed equipment achieved by eliminating much individual component assembly will enable many manufacturers substantially to increase their output without enlarging their production force. The integrated circuit improves reliability by replacing the unreliable soldered joints used in conventional circuitry with 'grown' joints of carefully controlled quality and predictable reliability. These two features, together with the promise of a very favourable cost per unit in production quantities, indicate that Mullard integrated-circuit elements will make an important contribution to the output of the computer industry.**

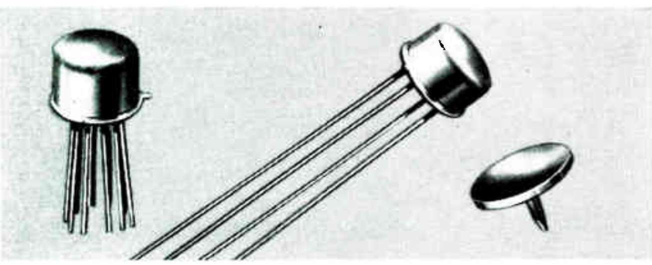
Investigation showed that two elements are in almost universal demand: inverting gates for NAND/NOR logic, and multiple diodes—several diodes with either anodes or cathodes connected together. Further it was found that the most commonly used number of 'ways' was three. For this reason the two elements introduced by Mullard are: OMY100—a three-input inverting gate, and BAY64, a common-anode triple diode.



*Circuit diagram of the three-input inverting gate OMY100*

### Three-input inverting gate

Assuming no stray capacitances, the gate circuit OMY100 has a fully-loaded propagation time of 25ns, typically, at nominal power supply and temperature. In addition to three gate inputs, it has direct connections to the diode node point and the transistor base so that fan-in can be extended if required (using for example, the BAY64) and the device can be used in trigger and delay configurations. The design gives a high noise margin—typically 0·8V over the temperature range −55 to +125°C with a fan-out of 4—and this enables the designer to use the OMY100 in a wide range of applications without special wiring or screening techniques. Fan-out is 4 over the temperature range −55 to +125°C, but where the temperature will not fall below + 25°C it can be increased to 7. The encapsulation used is a ten-lead version of the TO-5 case, but with a reduced height of 0·210in. Power supplies are +6 and −6V, ±5%.



*Mullard integrated-circuit logic elements OMY100 (left) and BAY64 (right) compared with a drawing pin*

### Improved reliability

Careful control of manufacturing environment, and the experience accumulated by Mullard, result in devices that contribute to more reliable computers with higher performance, and easier and more efficient methods of production.

Data on the OMY100 and BAY64 can be obtained from the address below, or by using the reader reply card of this journal (see reference number opposite).

## What's new from **Mullard**



World Radio History

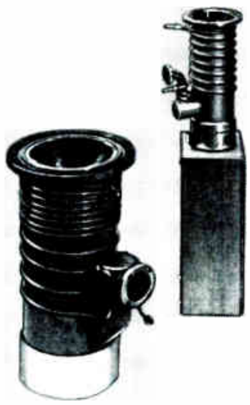
# HIGH-VACUUM DIFFUSION PUMPS JOIN RANGE

**Three fractionating oil diffusion pumps are now available for high-vacuum applications. Although these pumps have only recently been marketed, they have been used for many years in various Mullard factories, and the experience gained has enabled many 'practical' features to be built into the design.**

The pumps are constructed from stainless steel so that they are non-magnetic. A three-stage jet system is used which, combined with an integral helical cooling system, enables both a low final pressure to be obtained and the pump to operate efficiently against a high backing pressure. The helical cooling system, already familiar to users of industrial power valves, has considerable advantages over the conventional water jacket. For the same degree of cooling, the required water flow is considerably less so that a smaller and therefore cheaper circulating pump is required. The top flange of the pump can be rotated to allow easy positioning with other equipment.

The pumping speeds of the devices are 55, 300, and 3500 litres per second.

A range of measuring gauges, liquid nitrogen traps, and plate valves is available for use with these pumps.

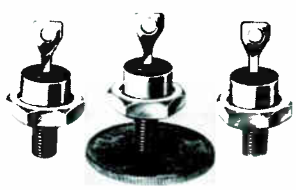


# Zener diodes for shunt stabiliser circuits

### 75W rating with excellent surge protection

The BZY91 series of zener diodes has been introduced for use in shunt stabiliser circuits, and is particularly useful in applications where equipment has to be protected from surges. The diodes in this series will dissipate 75W at a stud temperature of 65°C and the surge ratings are 4·4kW for 100µs and 170W for 100ms.

The range of zener voltages is from 10 to 75V with nominal zener voltage tolerance of ±5%. The diodes use stud mounting and are in the DO-5 encapsulation. Reverse polarity versions are also available.



# *New twelve-stage photomultiplier for Cerenkov counters*

The XP1020 twelve-stage photomultiplier is intended primarily for use in Cerenkov counters. The advanced electron-optical system used minimises the spread in electron transit times and allows the tube to deliver 2ns pulses up to a maximum current of 1A.

The tube has a plano-concave window for easy coupling to the scintillator. The caesium-antimony photocathode is highly uniform, with a typical sensitivity of 60µA/lm and a spectral response mainly in the visible region, peaking at 0·42µm.

Although only twelve stages are used the gain is $10^8$, because of the higher dynode voltages used, and the average overall sensitivity is 5000A/lm.

Transit-time difference between electrons emitted at the edge and the centre of the photocathode is 0·4ns when the maximum aperture of 42mm is used. This figure can be halved if the aperture is reduced to 30mm.

# OSCILLOSCOPE TUBE FOR DIRECT MEASUREMENTS IN BANDS IV & V

A new oscilloscope tube, the D13-23GH, has very short y-plates giving short transit time, and enabling direct observation of carrier envelopes at frequencies between 400 and 900Mc/s. Although the plates are short, sensitivity is excellent, full deflection being obtained at low input powers with a simple tuned adaptor. The adaptor uses the deflection plate capacitance as part of the tuned circuit. The power required for full deflection is least at the low end of the band—approximately 40mW at 445Mc/s—and rises to approximately 400mW at 900Mc/s. Full constructional details of the adaptors are available.

The tube has a helical post deflection system, and with final anode voltages of 6kV or above, the metal-backed screen ensures that adequate brightness is easily obtained.

The screen is flat and has a minimum useful diameter of 114mm. The fluorescence is green, and of medium-short persistence.

# Two low-noise transistors extend planar range

Two transistors, 2N929 and 2N930, extend the Mullard range of silicon planar transistors into the low-noise region with maximum noise figures of 4dB for the 2N929 and 3dB for the 2N930, measured at 10µA.

These transistors have been developed to meet the need for a low-noise transistor for use in d.c. and small signal amplifiers for strain gauges, pick-offs, control systems, etc.

# Failure Rate of 1 Tube in 1000 000 Hours

Two papers presented by Mullard engineers at a recent symposium on 'Cold Cathode Tubes and their Reliability' showed that cold cathode tubes can be confidently expected to give long reliable service in many circuits.

The first paper, 'Counting Tube Design using the Inherent Reliability of Counting Tubes', examined the construction of a typical tube and its parameters, and compared multi-stage counting circuits using transistors and cold cathode devices in the coupling stages. The life tests detailed showed a failure rate of only one tube in 1 000 000 hours.

The second, 'The Trigger Tube—Reliability and Ratings' discussed the whole question of trigger tube reliability. A comprehensive examination of four tubes was made showing the problems and tube and circuit design. When tested in a standard ring counter, failure rates of 0·05% per thousand tube hours were attained.

Reprints are available.

***FURTHER DETAILS of the Mullard products described in this advertisement can be obtained from the address below or through the Reader Enquiry Service of Industrial Electronics using the appropriate code number shown below.***

| | |
|---|---|
| Integrated-circuit elements | 206 |
| High-vacuum diffusion pumps | 207 |
| Photomultiplier tube XP1020 | 208 |
| Oscilloscope tube D13-23GH | 209 |
| Zener diode series BZY91 | 210 |
| Planar transistors 2N929, 2N930 | 211 |
| Cold cathode tube reliability | 212 |

**Mullard**

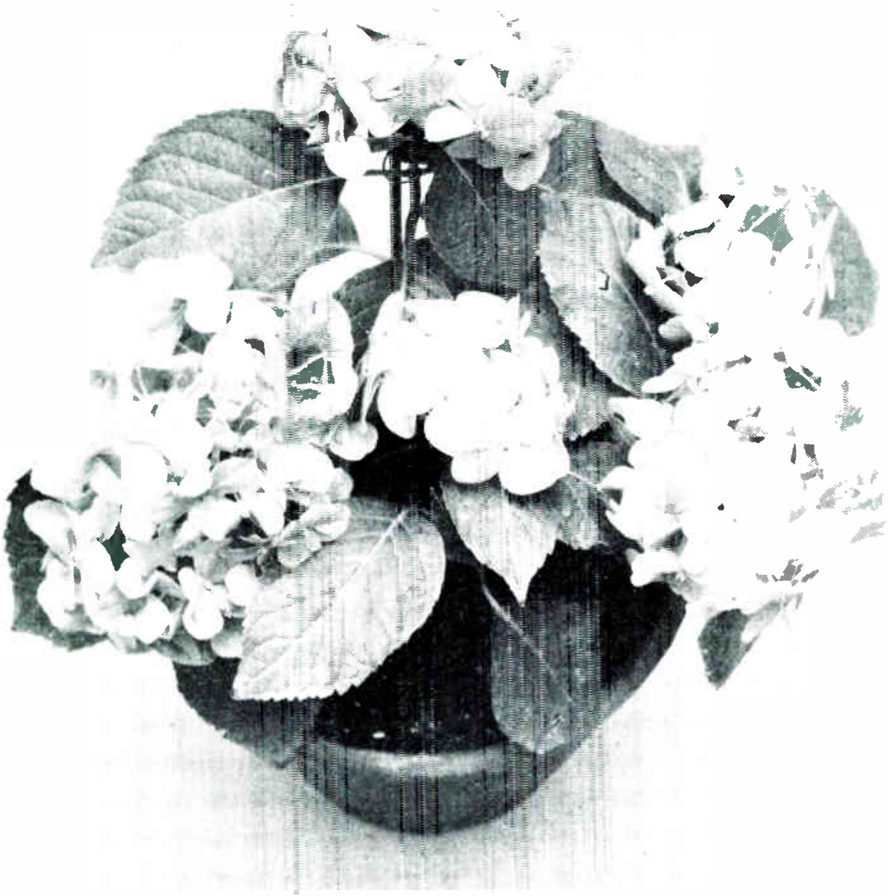
**Mullard Limited,** Mullard House, Torrington Place, London, W.C.1. Telephone: LANgham 6633

CAM 12



World Radio History

For further information circle 213 on Service Card



# A fertile plot, your laboratory?

In Bryans' new range of General Purpose XY T Plotters you will find the ideal union of modern electronic and mechanical engineering techniques, giving the ultimate in reliability and recording precision. Constant servo-loop stiffness ensures stable dynamic performance irrespective of signal source impedance. The new vacuum-bed covers the whole chart area and secures any size of chart up to 17 x 11 ins.

* Accuracy 0.1% f.s.d.
* Maximum writing speed 27 in. sec. per axis
* High impedance floating input circuits
* Precision chart centring
* Solid state semi-conductors
* Maximum sensitivity 200uV in.
* Acceleration 290 in. sec².
* Time sweeps 0.1 to 10 in. sec.
* X & Y zero check switches
* Remote control facilities

Additional Facilities

* Keyboard Point Plotter
* Curve Follower
* Symbol Printer
* Digital Analogue Data Translator

Full details from:
BRYANS LTD.,
Willow Lane, Mitcham Junction,
Surrey. Mitcham 5134

**Bryans**

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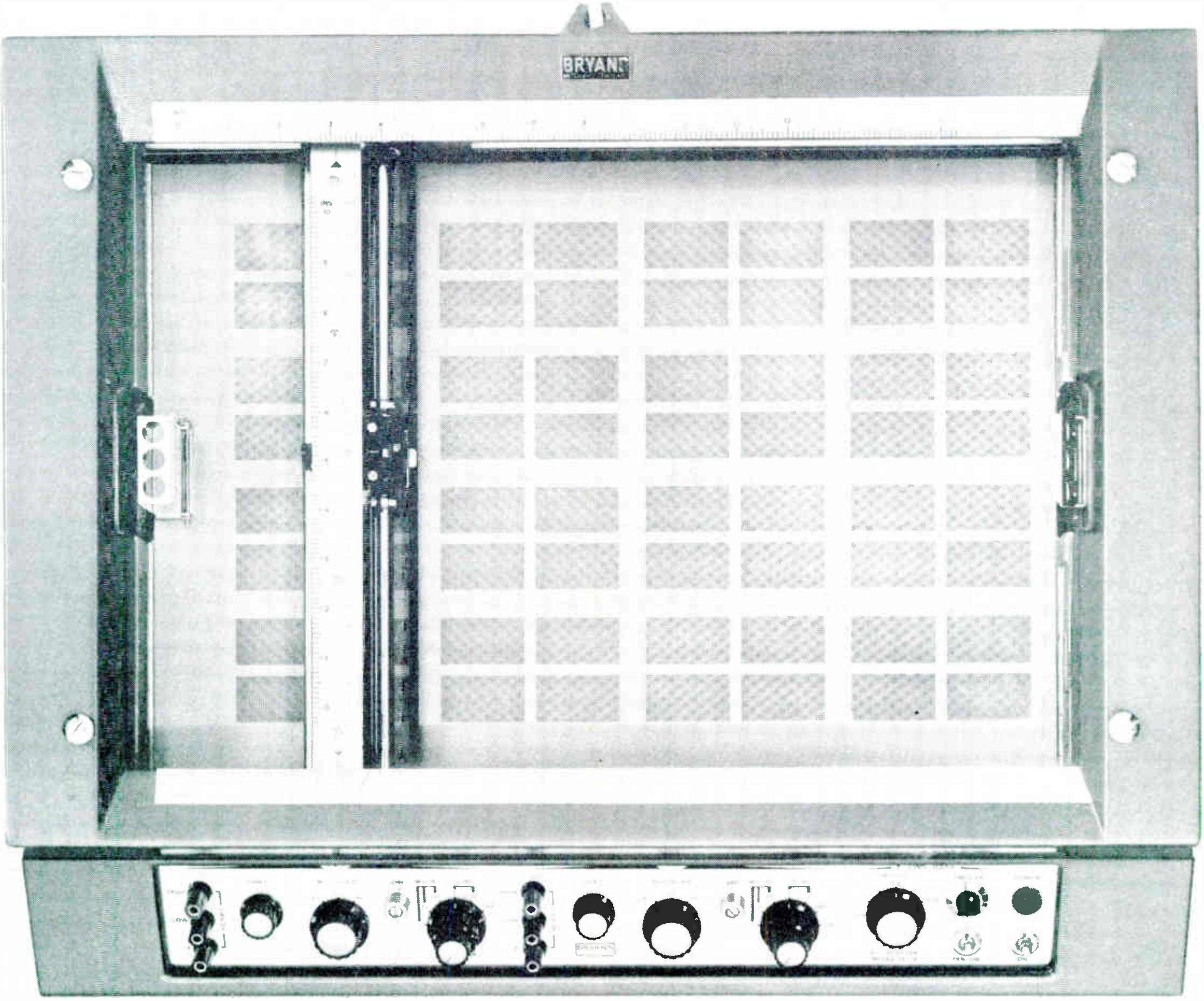



**then you need this most fertile plotter**

(from Bryans' new XY/T series)

World Radio History

For further information circle 214 on Service Card

# Potting shed?

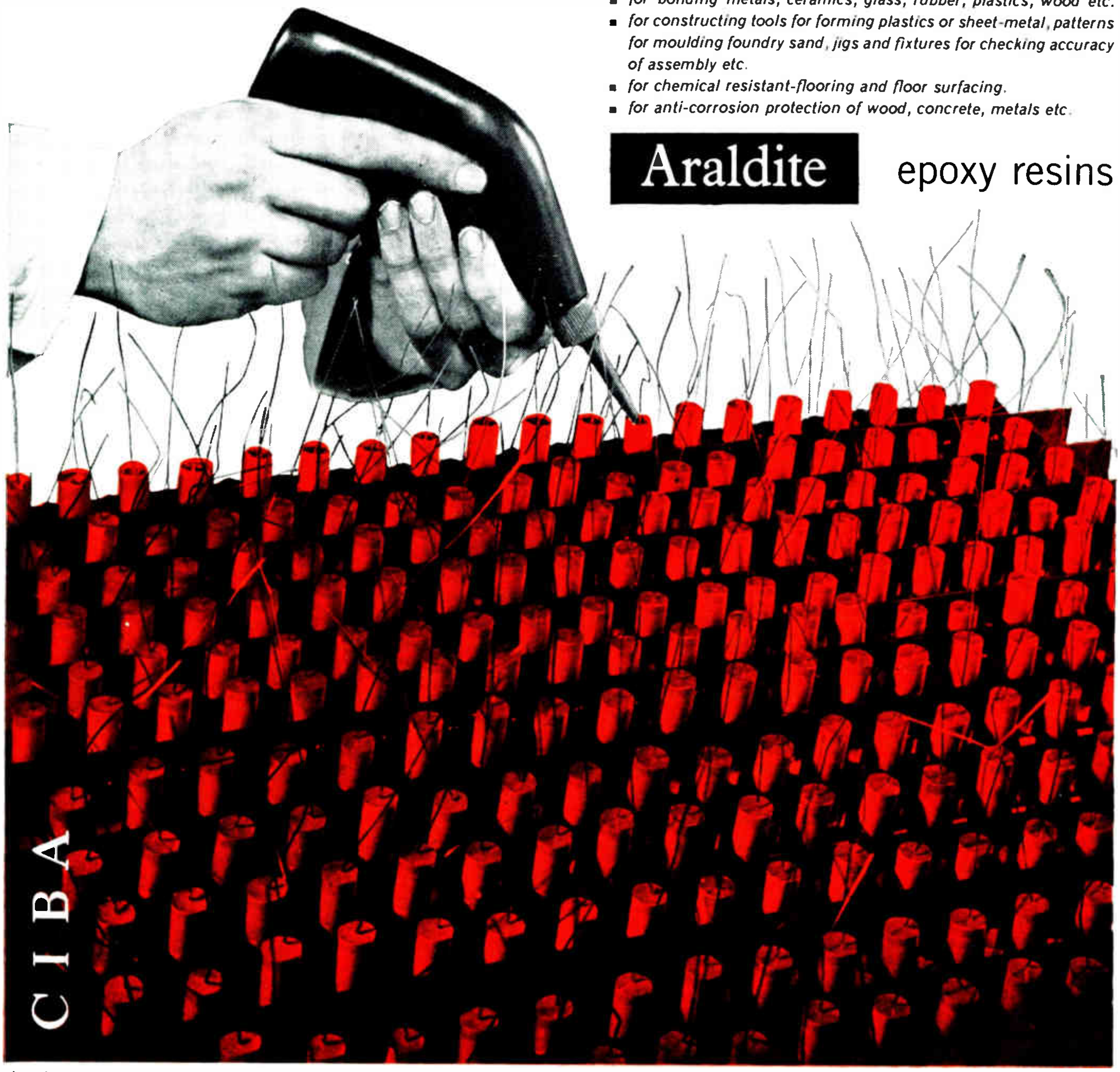
Araldite epoxy resins are ideal for potting—but this is not a potting shed. Here Araldite is being used to seal capacitor windings at Telephone Manufacturing Co. Ltd. The Araldite filler cures, with negligible shrinkage, to form a complete seal. It adheres strongly to metal surfaces—provides perfect insulation and resists tracking. It is impervious to moisture. Araldite sealing formulations pour and cure at room temperature. In many cases curing can be speeded up by heating.

May we send you a copy of our publication 'Araldite epoxy resins in the electrical industry'?

ARALDITE EPOXY RESINS ARE USED:

- *for casting large high-grade electrical insulators and insulation around equipment such as transformers, switchgear components etc.*
- *for impregnating, potting and sealing electrical windings and components.*
- *for constructing glasscloth laminates in electrical, nuclear, mechanical and aircraft engineering.*
- *for bonding metals, ceramics, glass, rubber, plastics, wood etc.*
- *for constructing tools for forming plastics or sheet-metal, patterns for moulding foundry sand, jigs and fixtures for checking accuracy of assembly etc.*
- *for chemical resistant-flooring and floor surfacing.*
- *for anti-corrosion protection of wood, concrete, metals etc.*

**Araldite** epoxy resins




*Araldite is a registered trademark* CIBA (A.R.L.) LIMITED DUXFORD CAMBRIDGE TELEPHONE: SAWSTON 2121

*AP787*

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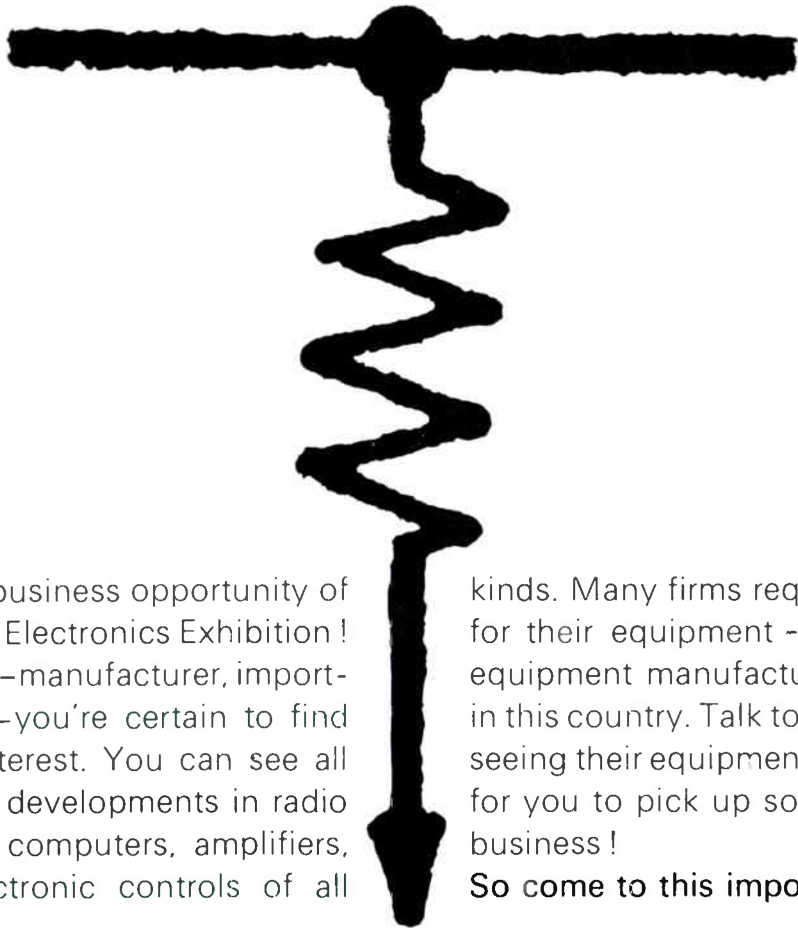
# ITALIAN TRADE CENTRE
# ELECTRONICS
# EXHIBITION



Here's your big business opportunity of 1964–the Italian Electronics Exhibition! Whoever you are–manufacturer, importer or distributor–you're certain to find something of interest. You can see all the latest Italian developments in radio and T.V., radar, computers, amplifiers, testers and electronic controls of all kinds. Many firms require British agents for their equipment - others want their equipment manufactured under license in this country. Talk to them all as well as seeing their equipment. There's a chance for you to pick up some very profitable business!

So come to this important Exhibition.

## THE ITALIAN ELECTRONICS EXHIBITION

ITALIAN TRADE CENTRE, 25 OLD BURLINGTON STREET, LONDON, W.1. REG. 2411

## JUNE 10th–19th MONDAYS TO FRIDAYS 10 a.m.–6 p.m.



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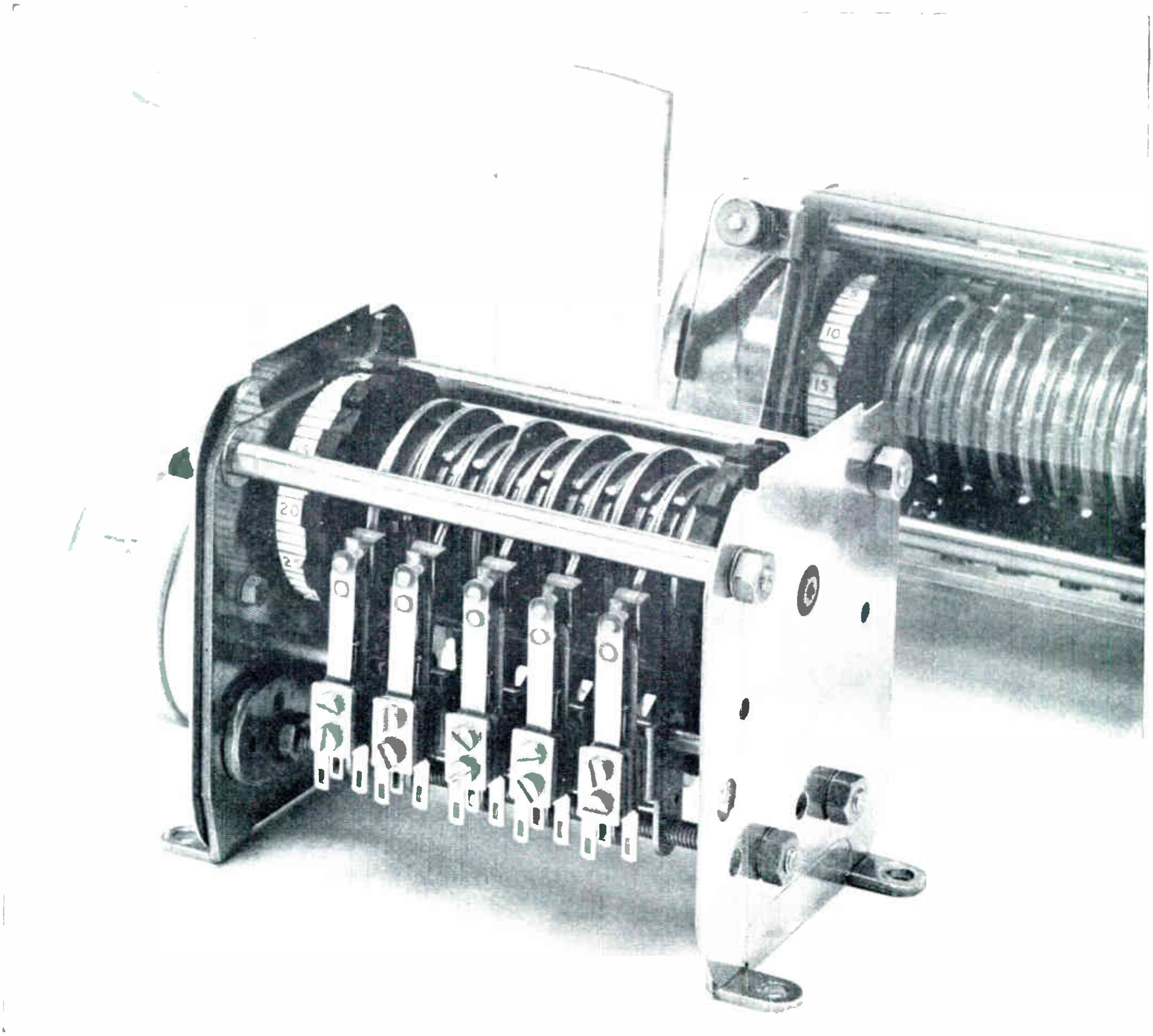
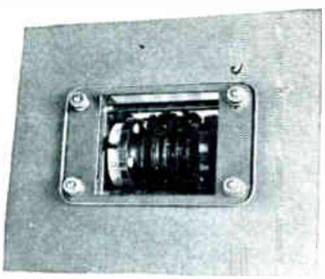



# Series 800 Sequence Timer




Outstanding ease of cam adjustment and indexing. Set Screws eliminated by good design. Although built to high standards of reliability and accuracy, the 800 Series are undoubtedly the most economically priced units available. A wide range of cycling times with 3, 5, 7, 9, and up to 24 cams available.

***ACCURATE, ACCESSIBLE, ADJUSTABLE***

**MAGNETIC DEVICES LIMITED**

Newmarket, England

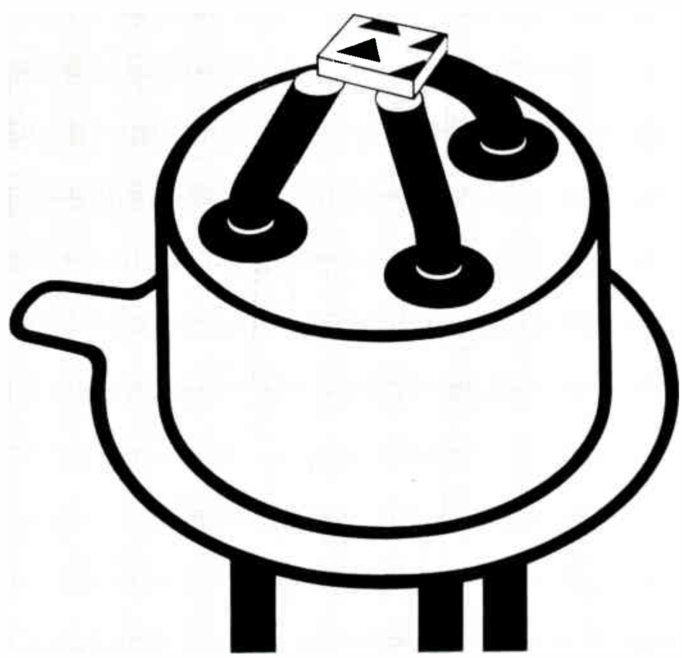
Newmarket 3451 (10 lines) Grams: Magnetic Newmarket

**MANUFACTURERS OF RELAYS, SOLENOIDS AND CONNECTORS**

P9087

JUNE 1964

# STC components review



## NEW PLANAR PROCESS CUTS COST OF SILICON TRANSISTORS

A new STC transistor assembly technique that will cut right through the price structure of the semiconductor market will enable industry to obtain silicon epitaxial planar transistors at prices competitive with germanium types. These are specifically designed, top quality, fully hermetically sealed devices.

The first transistor made with the entirely new patented fabrication process has been in quantity production since early this year. Pilot production to test the process started in October, 1963.

Using equivalent equipment and operators, output is 2½ times faster than that of conventional transistor manufacture. In addition, the new semiconductor wafer structure and connexion techniques that STC have evolved are giving a percentage yield of best quality devices that is phenomenally good for the transistor manufacturing industry.

All this will lead to lowering the cost of industrial equipment in which large quantities of transistors are used, particularly computers and control gear.

In brief, the basis of the new assembly technique is that the silicon epitaxial planar structures have been altered by a changed diffusion process, so that the base, collector and emitter are all brought out on to one side of each silicon wafer. First a metallized layer, then a silver solder dip are used to prepare the contact areas for the new fast assembly techniques.

In conventional transistor manufacture, the semiconductor material is first alloyed to the header assembly. Separate operations then follow to weld very fine contact wires from the emitter and base electrodes to the tops of the transistor leads.

With the new STC process, the prepared wafers are placed, contact areas downwards, straight on to the transistor lead wires. A brief application of heat forms the three soldered contacts simultaneously and a working, unencapsulated transistor is formed instantly.

The new low cost transistor has been achieved with no sacrifice in reliability or mechanical ruggedness. Devices made with the new method are fully capable of meeting military life and environmental requirements. The resistance weld and glass-to-metal seals are completely hermetic and show no leaks on the helium mass-spectrometer test. The new transistors meet or surpass the performance of conventional planar devices for shock, vibration, temperature cycling, moisture resistance, lead bending and lead solderability. No failures have occurred on 25,000g centrifuge tests.

STC's first silicon epitaxial planar transistor to be made by the new process is the BSY95 for high speed switching operations. It is available from stock.

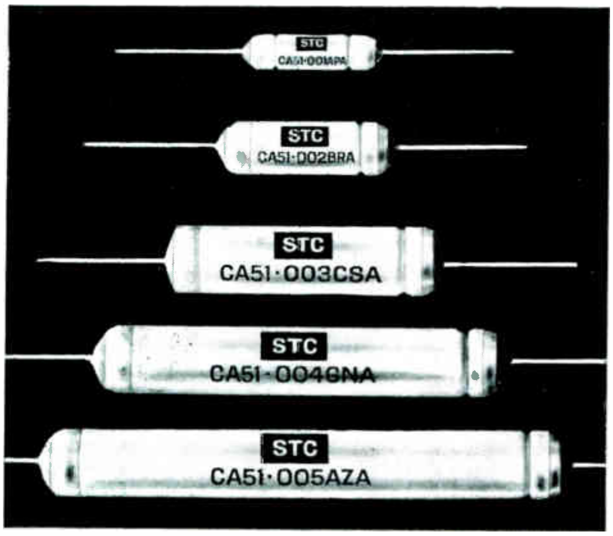
| | | |
|---|---|---|
| **BSY95 Brief Data** | $f_T$ at 10mA, 9V, 100 Mc/s | 200 Mc/s (min) |
| | $h_{FE}$ at 1mA, 0·35V | 30 (min) |
| | $h_{FE}$ at 10mA, 0·35V | 50 (min) |
| | $I_{CBO}$ at 16V | 50 nA (max) |
| | $V_{CBM}$ | 20V |
| | $V_{CEM}$ | 15V |
| | Outline | JEDEC TO-18 |

More transistors will be added to the low-cost silicon range shortly.

*Full specification and prices from STC Semiconductor Division (Transistors), Footscray, Sidcup, Kent. Telephone FOOtscray 3333. Telex 21836.*



World Radio History

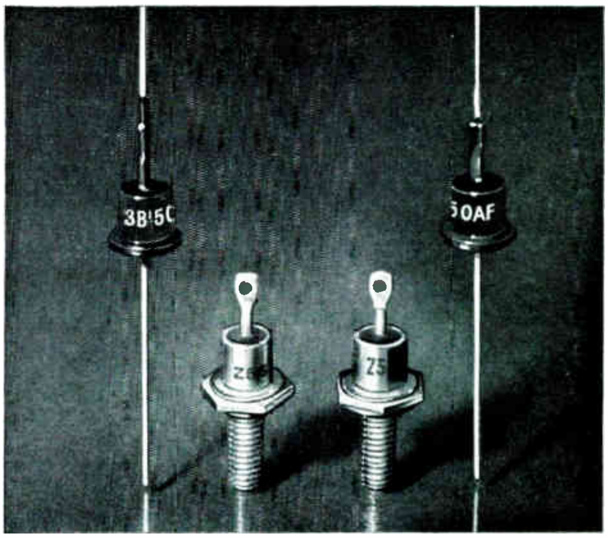



# ETCHED FOIL TANTALUM CAPACITORS

INCREASED CAPACITANCE/VOLUME RATIO is a prime feature of the new STC range of Etched Foil Tantalum capacitors. Etched capacitors have up to four times more capacitance than equivalent plain foil types and, for a given capacitance and voltage, are over twenty times smaller than miniature foil paper types of similar quality. Where miniaturization is important, STC Etched Tantalum Foil capacitors can be used in place of foil/paper, metallized paper, aluminium electrolytic and, of course, plain tantalum foil capacitors.

There are over one hundred components in the preferred range and a choice of capacitance values is available at rated voltages of 6, 16, 25, 40, 63, 100 and 160V.

*Write, 'phone or Telex for Data Sheet MC/124 to STC Capacitor Division, Brixham Road, Paignton, Devon, or London Sales Office, Footscray, Sidcup, Kent. Telephone FOOtscray 3333. Telex 21836.*



# ZENER REFERENCE DIODES— 1·5 W AND 10 W

**1·5 Watts 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 |

**10 W 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 essentially 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 | 10 W |
| **TEMPERATURE RATINGS** | |
| Maximum working junction temperature | 150 C |
| Storage temperature range | −65 to 150 C |
| Standard outlines | IEC 1-103<br>VASCA SO-10<br>JEDEC DO-4 |

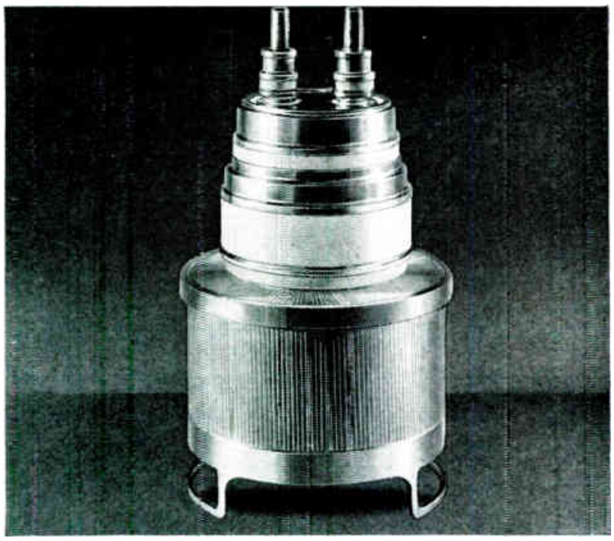
*Write, 'phone or Telex for Data Sheets to STC Semiconductor Division (Rectifiers), Edinburgh Way, Harlow, Essex. Telephone 26811. Telex 81146.*

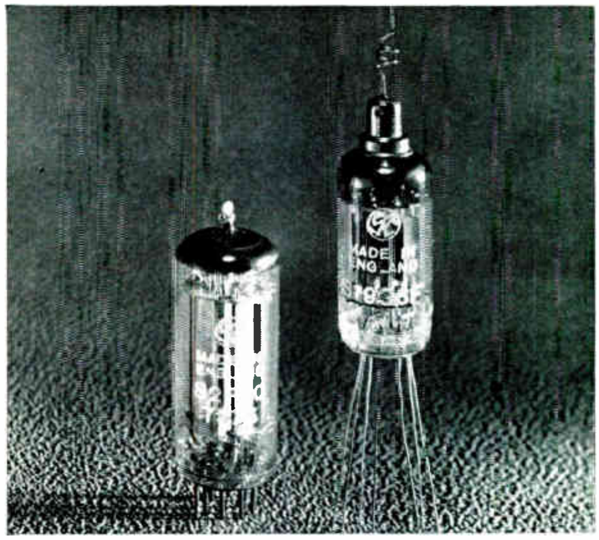
**STC components review**



World Radio History

For further information circle 220 on Service Card





# VHF TETRODE 7007 REPLACEMENT

An r.f. power amplifier which is a direct replacement for the American 7007 is the new forced-air-cooled tetrode from STC. Primarily intended for power amplifier use, especially in Class B television service, the STC 7007 has a ceramic/metal envelope to ensure robustness and low electrical loss. Anode dissipation is 12kW and the maximum supply ratings apply at frequencies up to 220 Mc/s.

| ABRIDGED DATA ARE GIVEN BELOW | | |
|---|---|---|
| RF POWER AMPLIFIER CLASS B TELEVISION SERVICE | | |
| **MAXIMUM RATINGS** | | |
| DC anode voltage | 7 500 | V |
| DC screen grid voltage | 2 000 | V |
| DC anode current | 4·0 | A |
| Anode input | 24 | kW |
| Screen grid input | 400 | W |
| Anode dissipation | 12 | kW |
| Control grid dissipation | 300 | W |
| **TYPICAL OPERATION IN GRID DRIVE AND CATHODE DRIVE CIRCUITS** | | |
| Power output approx. | | |
| 100% level | 12 | kW |
| 75% level | 6·8 | kW |
| 30% level | 1·0 | kW |
| LINEAR RF POWER AMPLIFIER IN CLASS AB SSB SUPPRESSED CARRIER SERVICE | | |
| Maximum signal anode power output (single tone modulation) | 11 | kW |
| ANODE MODULATED RF POWER AMPLIFIER IN CLASS C TELEPHONY | | |
| Approx. power output (grid driven) | 6·0 | kW |
| RF POWER AMPLIFIER—CLASS C | | |
| Approx. power output (grid driven) | 12 | kW |
| Approx. power output (cathode driven) | 6·0 | kW |

*For full information, 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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| *Type* | *CV Number* | *Description* |
|---|---|---|
| S2P20 | 4097 | Quick heat, filamentary tetrode for transistor hybrid circuits. |
| S6F17<br>S6F17F* | 4040<br>4041* | Low impedance beam tetrodes for use as pulse or linear amplifiers. |
| S6F33<br>— | 4064<br>4083* | Pentodes with short suppressor base for gate, transitron, and phantastron circuits. |
| S11E12 | 4060 | Beam tetrode for use as regulator valve. |
| S19G6<br>S19G6F* | 4057<br>4042* | High vacuum e.h.t. rectifiers. |

*Flying lead versions.

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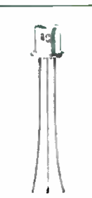
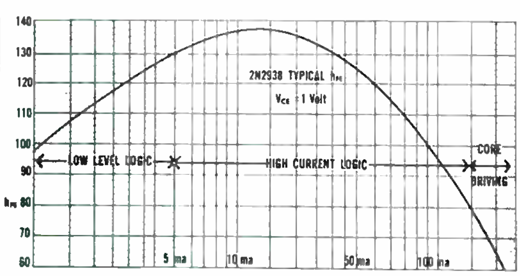
Featuring high gain-bandwidth product and low capacitance, RCA 2N2938 is part of RCA's line of high-speed silicon switching transistors covering the range from 0.1 ma to 1 amp.

Assuring high beta over an extra wide range of collector currents, these types provide excellent switching speeds at high currents.



TO-18 PACKAGE




TYPICAL CHARACTERISTICS OF RCA ULTRA-HIGH-SPEED SWITCHING TRANSISTORS

| | 2N2475 | (TA-2090A) 2N2938 | 2N2477 |
|---|---|---|---|
| $f_T$ Typical | 800 Mc | 690 Mc | 300 Mc |
| $C_{OB}$ Typical | 2.4pf | 3.5pf | 8pf |
| Watts dissipation at 25°C FA | 0.3 | 0.3 | 0.6 |
| $V_{CE}$ (Sat) Max. | 0.4 volt at 20 Ma | 0.4 volt at 50 Ma | 0.65 volt at 500 Ma |
| $h_{FE}$ Min. | 30 at 20 Ma | 30 at 50 Ma | 40 at 150 Ma |
| Turn-On Time Max. | 20 nsec (20 ma) | 30 nsec (50 ma) | 25 nsec (150 ma) |
| Turn-Off Time Max. | 15 nsec (20 ma) | 30 nsec (50 ma) | 45 nsec (150 ma) |

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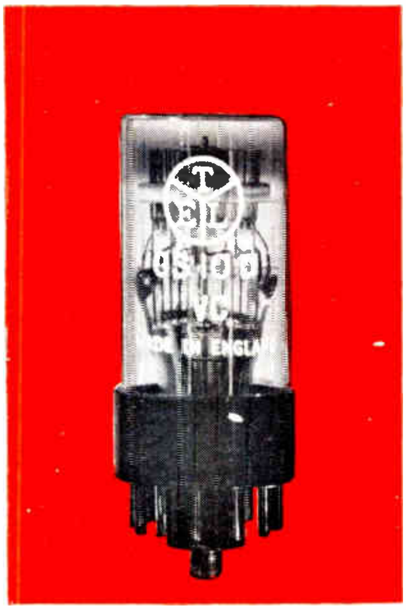

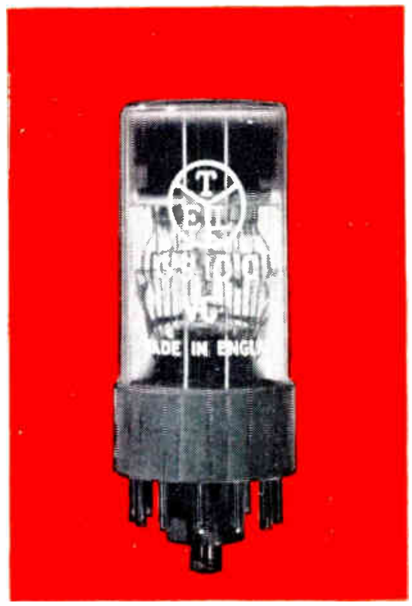

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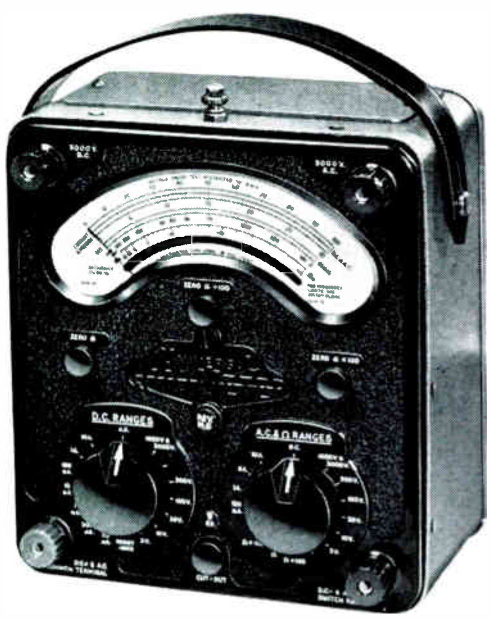

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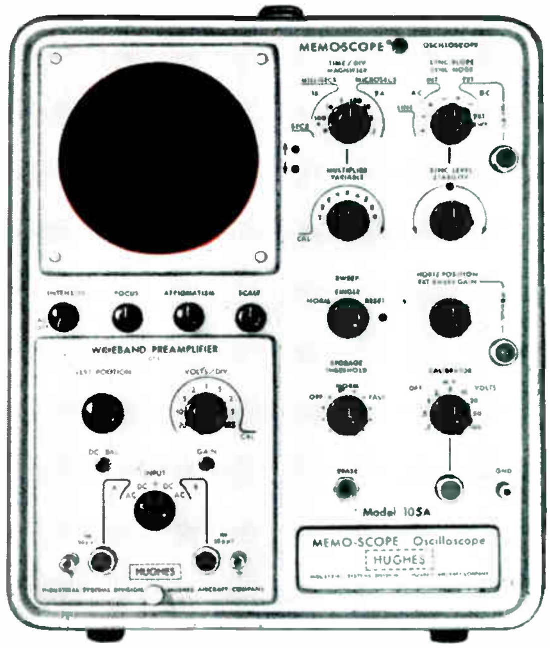


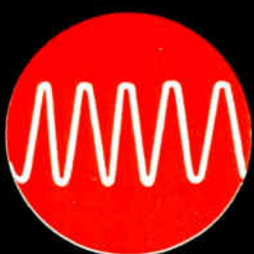

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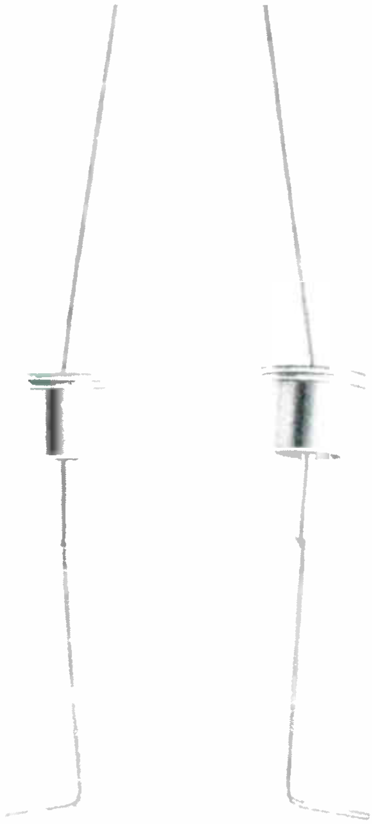

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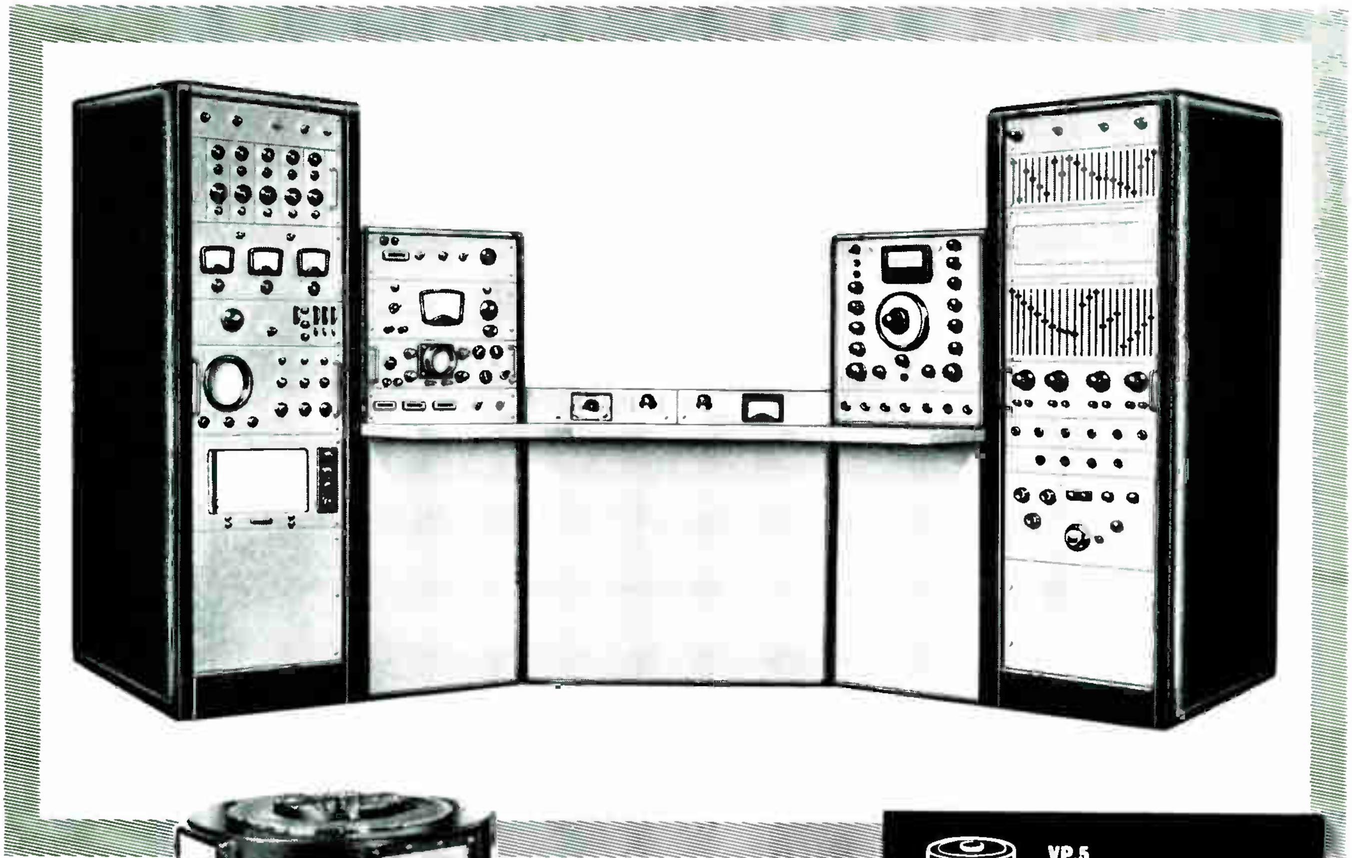

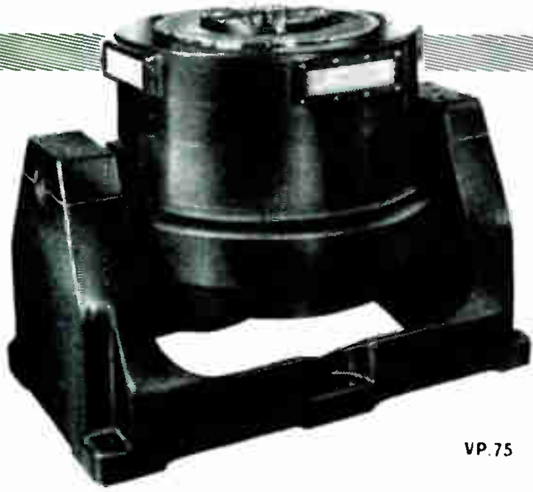

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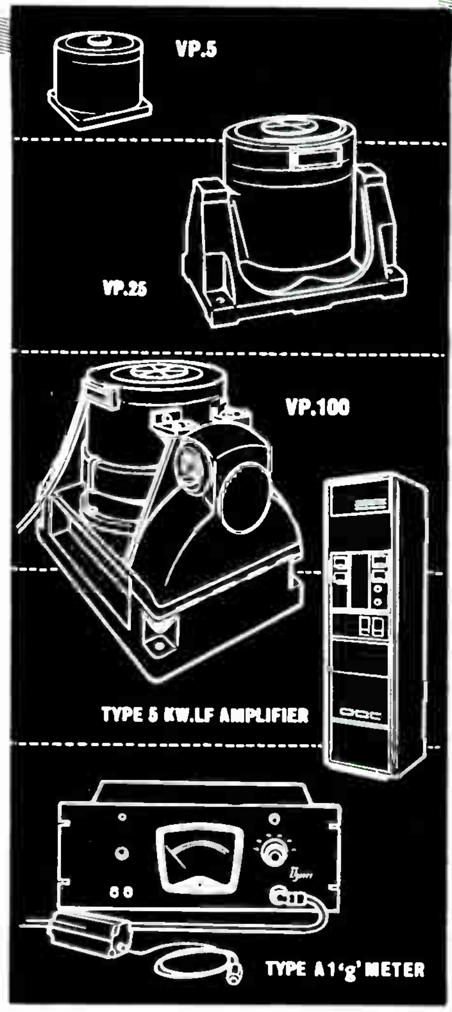


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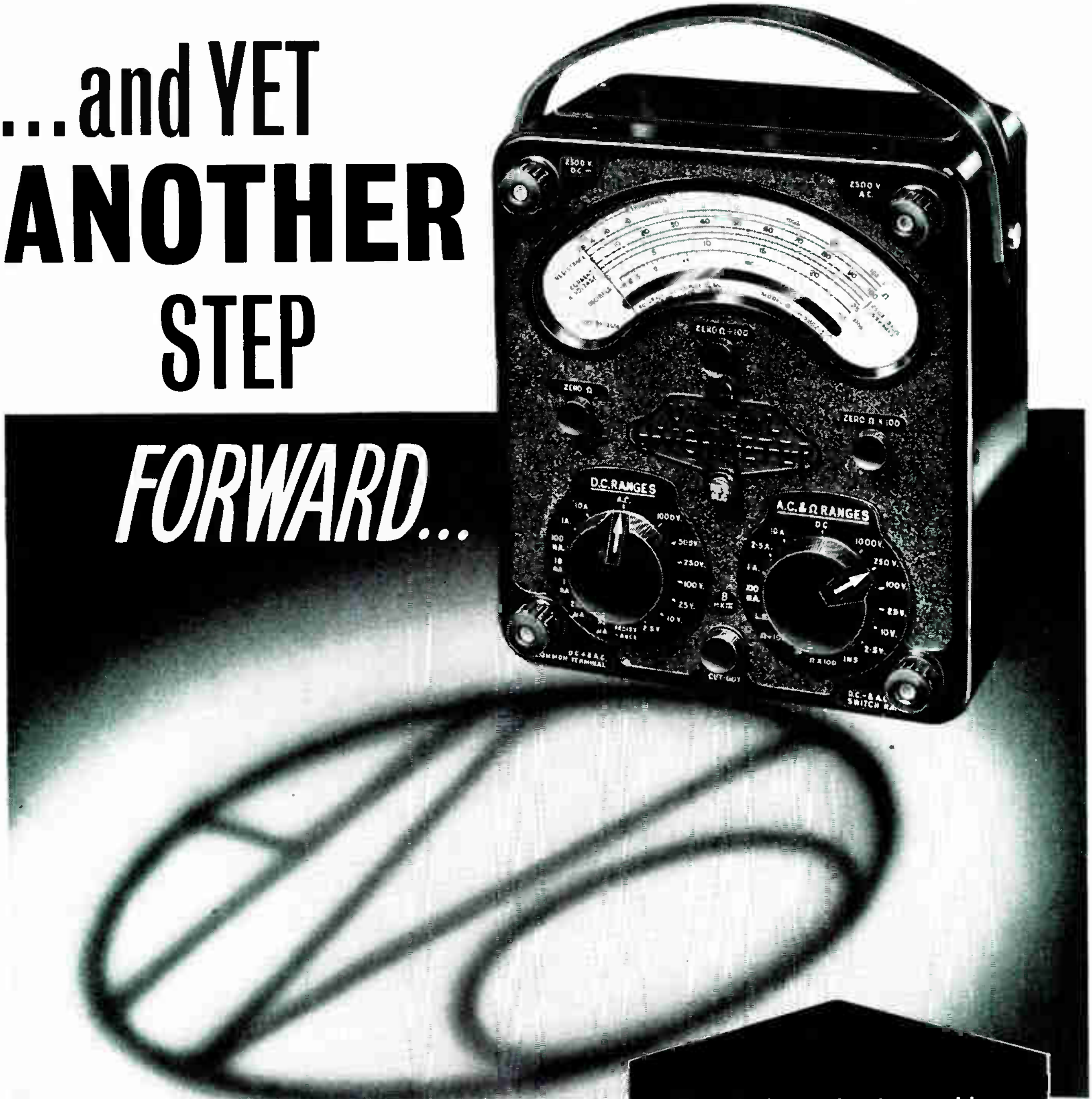


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## Comment

Recently a two-day symposium on lasers was held at the National Physical Laboratory at which both gas and solid-state types were discussed. *L*ight *a*mplification by *s*timulated *e*mission of *r*adiation is a subject which is at first sight rather outside our field. It is as much electronic as most semi-conducting and gaseous devices, however, and even if it were not the laser requires associated electronic apparatus.

New developments in lasers occur continually and we have reported many in these columns. The N.P.L. symposium, however, was more concerned with applications than with the devices themselves. A great many applications have been suggested, including micro-welding, micro-machining, radar, ground and space communications, range-finding and angular measurement. It has even been suggested that the laser could be the basis of a practical 'death ray'!

Some of these suggested applications have been tried out experimentally. In very few, if any, of them has the laser yet been found to offer sufficient advantage over other methods to justify its use commercially. It is still, of course, early days in laser technique and we certainly do not wish to imply that the laser will never find industrial application. It is highly probable that it will do so in time.

One successful application is in the medical field. The laser has proved of value in eye surgery, where it has been used to coagulate retina; that is, in effect, to spot-weld and seal-off diseased parts of the retina of the eye.

In measurement, too, the laser has proved successful for the very accurate measurement of length and, by using a ring of three lasers, the accurate measurement of angular displacement is possible.

The laser has been described as a sophisticated solution looking for a problem! Even if this were wholly true, which we very much doubt, we feel quite certain that the problem to which it is the solution will eventually turn up.

In spite of the present apparent lack of application for the laser, therefore, it is desirable to keep an eye on its development. The first to see its real application may well find it highly rewarding.

### Phone Television

The domestic and business telephone cum television is very old as an 'idea of the future'. It has been technically possible for a long time but impracticably costly on anything but the smallest scale.

A demonstration has been carried out by Bell Telephone Laboratories between the New York World's Fair and Disneyland in California. The system is called 'Picturephone'. Technical details are not as yet available. The viewing screen is $4\frac{3}{8}$ in. by $5\frac{3}{4}$ in. high and produces a full view of the head and neck of the person at the other end. The picture quality is stated to appear as sharp as if the image occupied one-half the height of a well-adjusted home television screen.

No details of the bandwidth needed are available, but we cannot see that it can be small enough for anything but special application. It seems unlikely that the device is yet suitable for



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general use as a supplement to the ordinary telephone.

### Decimal Multipliers

We recently came across a unit of capacitance new to us, or rather, an unfamiliar sub-multiplier. Written fF it was obviously of the same family as nF and pF, but what did the 'f' stand for? A little research brought to light the fact that it is actually a standard symbol in the list produced by the International Commission on Weights and Measures. It is, of course, not often used, which is why we did not recognize it.

The 'f' stands for 'femto' and means $10^{-15}$, so fF, or femtofarad, is $10^{-15}$ F, one-thousandth of a pF.

In looking into this we found still another, viz., 'a', which stands for 'atto' and means $10^{-18}$!

The complete list runs from $10^{12}$ to $10^{-18}$ and, although most of the multipliers and sub-multipliers contained in it are familiar to all of us, we give it below for reference. Some of the items are used only in certain specialized parts of our field and may not be familiar to everyone.

| | | |
|---|---|---|
| $10^{12}$ | tera | T |
| $10^{9}$ | giga | G |
| $10^{6}$ | mega | M |
| $10^{3}$ | kilo | k |
| $10^{2}$ | hecto | h |
| 10 | deka | da |
| $10^{-1}$ | deci | d |
| $10^{-2}$ | centi | c |
| $10^{-3}$ | milli | m |
| $10^{-6}$ | micro | $\mu$ |
| $10^{-9}$ | nano | n |
| $10^{-12}$ | pico | p |
| $10^{-15}$ | femto | f |
| $10^{-18}$ | atto | a |

### Superconductivity

In the superconducting state a current, once started in a circuit, flows indefinitely because there is no resistance loss. The property of superconductivity has been known for quite a long time, but there is now a great deal of interest in it and a great deal of work is being done on it. This is mainly directed towards producing high-intensity magnetic fields.

Westinghouse have produced a magnet which produces 30,000 gauss. It weighs 25 lb, has an outside diameter of 6·2 in. and a field uniformity of 8% within a 4-in. diameter sphere. The operating temperature is 4·2 °K, obtained with liquid helium.

This is by no means the limit for it is reported that Westinghouse have developed a magnet with a field of 100,000 gauss. In this case, the field is produced in a one-eighth inch hole through the centre, but the outside diameter is only 7 in. The wire of the coil is partly of niobium-zirconium and partly of a new alloy known as HI-120.

Some people are inclined to dismiss superconductivity as impracticable because of the need for such low temperatures. However, these are not difficult of attainment nowadays. It is easier and cheaper to obtain a magnetic field in this way than by a conventional magnet weighing several hundred tons and dissipating a megawatt or so.

The current in a superconducting electromagnet does not need an external e.m.f. to keep it flowing, but it does need one to start it. In one case, at least, the generator has itself been made superconducting and produces about 800 A.

In one model several magnets rotate close to and parallel with a set of superconducting flat plates connected together by superconducting wire. The magnetic fields cause a local loss of superconductivity in the plates producing, as it were, a series of 'holes' of normal conductivity in the otherwise superconductive material. As the magnets move over the plates, the 'holes' move with them and current is generated.

In one model there are no moving parts. Three fixed electromagnets are used and fed with alternating current to produce a rotating magnetic field.

### Concert Halls

We have just learnt that some experiments have been going on at the Festival Hall with a new way of modifying the acoustic properties of the hall. They have been carried out without either audience or performers knowing about them, and the provisional reactions have been favourable. The effects have been noticeable and liked.

The object has been to increase the reverberation time at the lower frequencies. To do this at a specific frequency a microphone is mounted in a Helmholtz resonator and suitably placed in the body of the hall. Its output is amplified and fed to a loudspeaker which reinforces the original sound. An experimental system has 100 such channels each tuned to a specific frequency, the frequencies being 3 c/s apart and the whole covering up to 300 c/s.

Further experiments in the Festival Hall are to be carried out and the work is being done by the Building Research Station of D.S.I.R.



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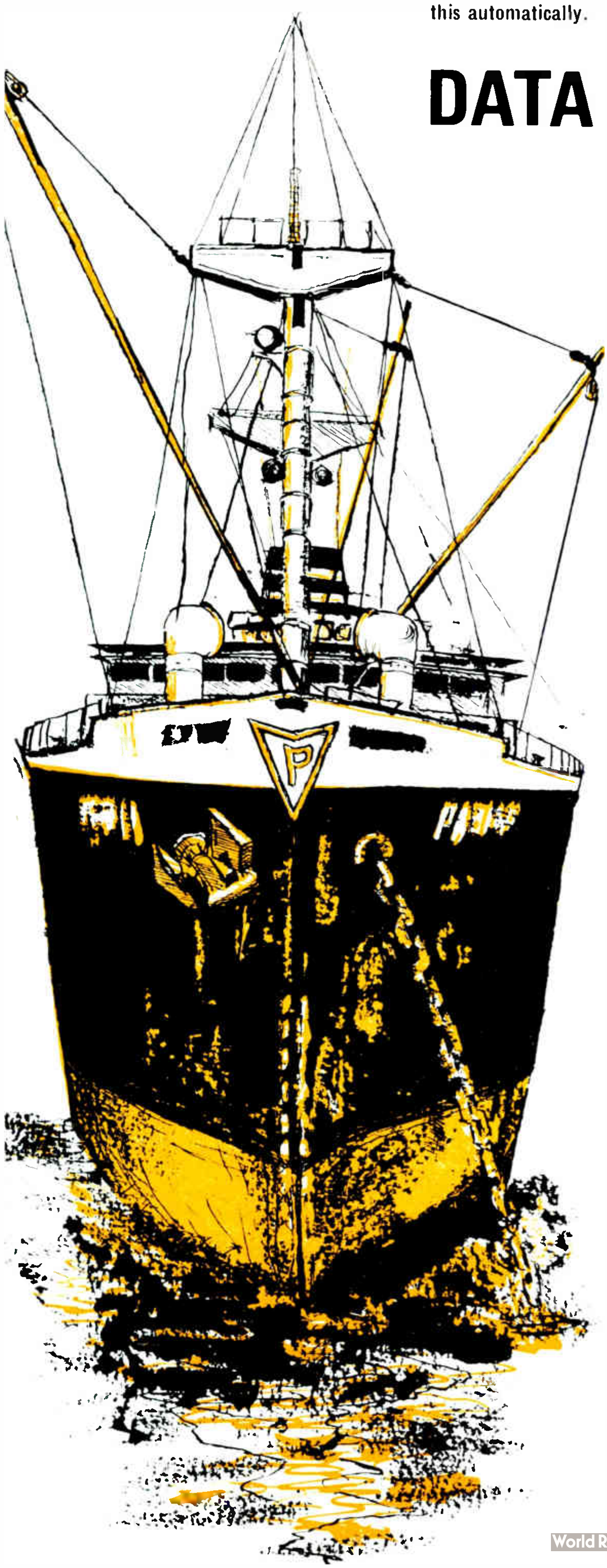
**In ships carrying chilled or frozen cargo it is necessary to measure and record the temperature of the cargo once every four hours. To do this, measurements at some 80 different points are needed. This article describes equipment which does this automatically.**



# DATA LOGGING ON BOARD SHIP

**By *A. J. BOSELEY, B.Sc., Graduate I.E.E., M.S.I.T.****

IT is true to say that shipowners have been slower than land-based industrialists in adopting new methods of control for the engines and plant they own. This is explained by the necessarily conservative approach to equipment carried at sea. It is essential that the safety of a vessel comes before all else and, to ensure that this is so, many functions are still carried out by hand that would have been automated on land plants long ago.

In addition to the shipowners' caution, would-be manufacturers of control equipment for ships are faced with testing conditions for operation at sea. Their equipment must be reliable, ruggedly built, withstand bad atmospheric conditions, work over considerable temperature changes, be very easily serviced and last but not least often meet Ministry, legal or—for insurance purposes—Lloyd's approval.

Several factors are now causing owners and manufacturers to take more interest in automation on ships. For instance, with an overtonnage in the world, shipping is very competitive and ships must be operated as economically as possible. Economies are being made in crew members, while at the same time the number of men desiring a career at sea is diminishing.

To meet the labour situation some owners are attempting to improve conditions and save manpower by striving for a normal working day, with monitoring and alarm systems taking over during the night watches.

Drayton-Southern provide these systems for the shipowners and a description of monitoring equipment in use or currently going into service on nine ships will show how the pattern is being set to reduce routine work.

The ships in question are all equipped to carry chilled or frozen cargo which must be insured against any deterioration during a voyage. Lloyd's condition of insurance states that the temperature of the cargo must be measured and logged with equipment having an accuracy of ±0·2 °F at 32 °F or ±0·1 °C at 0 °C according to the scale used. In the past, a complete log of temperatures has been recorded once every 4 hours during a voyage. The Chief Freezer or one of his staff would read a galvanometer-type instrument and record in a log book somewhere in the region of 160 temperatures each watch.

Fig. 1 shows the Drayton-Southern Data Logger that now does this work automatically, an interesting point being that for the 80-input logger illustrated the case size is only 3 ft square and 9 in. deep. Cables from the logger plug into the junction box, which is used for terminating the ship's wiring. An I.B.M. Series 73 typewriter is used for log recording. This typewriter has the new moving 'golf

* Drayton-Southern Ltd.



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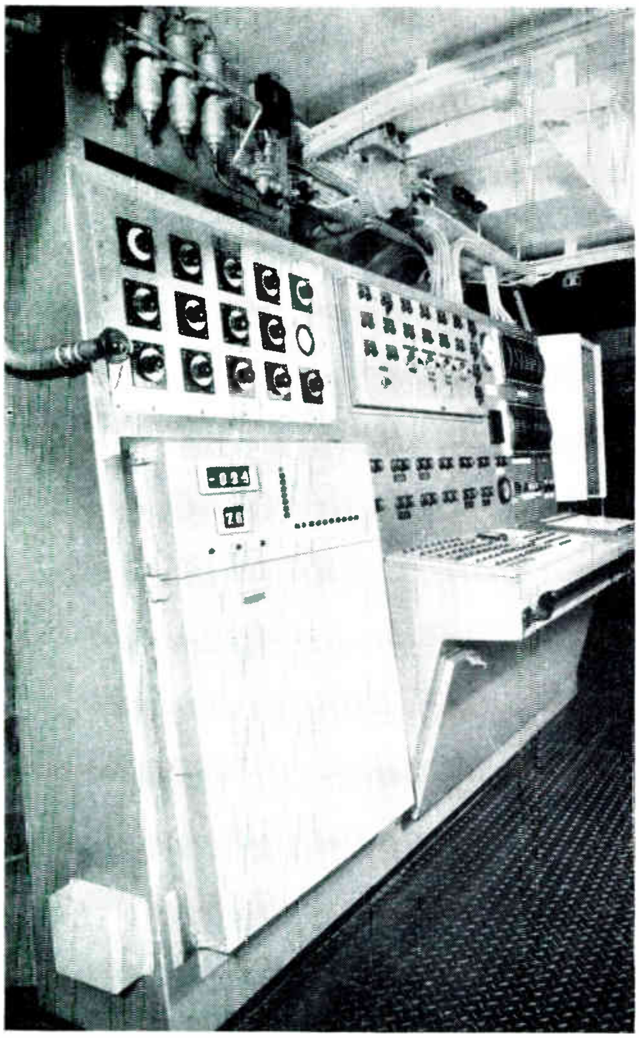

*Installation on board M.S Antilope of Salenrederierna, Stockholm*

ball' type face and stationary carriage. It is not affected by ship's movement.

The distribution of temperature measuring points is such that approximately half are located in the refrigerated holds and the remainder in the ducts and cooling batteries feeding cooled air to these holds. Thus by using two data-logging equipments one on each set of points and recording on a single typewriter, should one equipment fail the other will give sufficient information to enable the cargo temperature to be correctly monitored.

Fig. 2 shows two types of thermometer used and the junction boxes for joining them to the ship's wiring. The measuring element is platinum wire wound within a glass capsule. The accuracy of this element is selected to be within ± 0·01 ohm of 100 ohms at 0 °C. Each thermometer is connected by a three-wire compensating circuit to a current source that is highly stabilized, but contains a feed-back circuit to give a correction for the non-linear characteristic of the platinum wire. With the 3-wire system it is necessary to have balance between the two 'measuring' wires within 30 milliohms for zero accuracy. The third wire can be an order higher than this without affecting the span appreciably. The limits are attained using 3/029 or 3/036 cable according to run length.

Fig. 3 shows the module construction employed in the equipment. Above the modules are display windows showing the temperature and point being monitored. Points are numbered 0 to 79 and selected by buttons on two axes of a legend plate. Temperatures can be within the range —99·9 to 399·9 using a span of 200·0 that is positioned within the range according to a preset programme. Below the display are control buttons selecting manual, auto or log.

On manual a selected point is interrogated and the display changed every 4 seconds. On auto all points are scanned continually at a rate adjustable between every 2 seconds and every 16 seconds and selected by the knob on the right-hand module. On log all points are scanned once in sequence and the values recorded on the typewriter.

The module construction is designed for simplicity of manufacture, robustness, ease of insertion and adaptability. The latter feature is shown in Fig. 4 where two typical

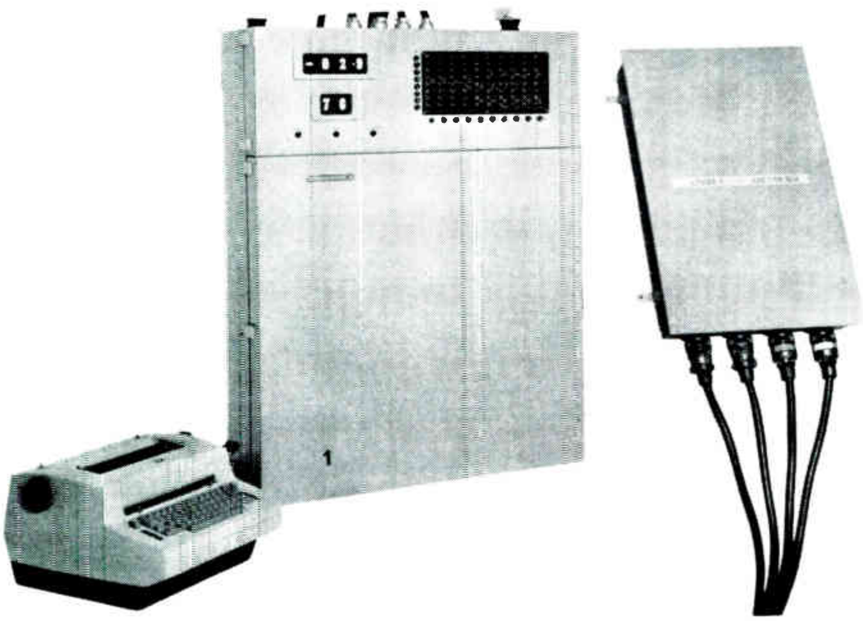

*Fig. 1. Data logger for 80 inputs with junction box on the right and typewriter on the left*



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modules are shown in exploded form. Standard Post Office uniselectors, with gold-plated input contacts, in scanner modules select incoming signals. Relay modules decode to digital output and drive the typewriter. Printed-circuit modules, operating up to 45 °C contain the logic, counting and time generating circuits. A module of hybrid construction provides A-F conversion and double-height ones the power supplies. Gold-plated pins and sockets up to a maximum of 150 ways connect each module.

Dealing now with the mode of operation of the logger, the simple block diagram of Fig. 5 shows the main route paths. Incoming signals in the form of a resistance value are selected by the scanners, and fed to the analogue frequency (A-F) converter. The potential across this resistance due to the stabilized current source is used to vary the frequency of two phase-opposition oscillators. The resulting frequency output of 10 kc/s to 20 kc/s full span is counted for 400 msec and divided by 2 to give the 200 span of the equipment. To eliminate zero drift, this count is made twice, the first time in reverse against a standard resistor equivalent to zero temperature and the second time against the resistance thermometer. The first count will be a negative equivalent to any zero drift in the system: the second count, coming immediately after, will contain the same zero drift, but positive, plus the wanted reading, thus cancelling out the zero drift. The total conversion time > 800 msec is long but of little consequence to a process with a time constant measured in hours.

The frequency signal is counted in binary form during the conversion process in the totaliser module. Amplifiers within this transistorized module operate relays in the decoder module, the amplifiers being gated by the signal to change the digital display.

Besides the operation of the digital display, the decoder provides the digital information to the serializer that in turn drives the typewriter.

The typewriter has an interlock contact for each operation it makes. Thus if the carriage is returned a contact will be open circuit until the carriage has come to rest in the returned position. Signals to solenoids operating the typewriter are fed through these interlock circuits, the solenoid operates a mechanical lock, and the subsequent typewriter action breaks the interlock chain. As soon as the action is completed the chain is re-made, and the next signal can be fed through the typewriter. Thus the typewriter is self-regulating and operates at its maximum speed of 15 characters a second.

The modules of the system not mentioned in the sequence of operation are required to power the equipment and control the sequence of events. To provide the square-wave pulses that operate the logic circuits a 10-kc/s crystal and transistorized divider boards, all housed in the timing generator, produce various timed waveforms repeating over a 100-msec period. The sequence of events is controlled by the timing control, another fully transistorized module whose mode of operation is controlled by the operator's press button. Power supplies are divided into two groups, the unstabilized supplies for relays and uniselectors and the stabilized ones for transistors. Of the latter group special stabilized supplies are provided for the resistance thermometers and part of the converter circuit.

When designing this data logger special attention was paid to the need to produce a standard equipment that would sell at a standard price. In this way cost has been reduced both by avoiding special engineering for each project and by enabling production to run on reasonable size small-batch quantities. It was therefore necessary to provide a degree of flexibility in the design to meet customers' variations without making alterations to the equipment.

As mentioned, the 200·0 span can be positioned anywhere between −99·9 and 399·9, but other input variations can be provided.

The decimal point can be omitted or positioned one digit forward as a range-change device. Three different inputs can be handled by a converter, e.g. resistance thermometer, potentiometric pressure transducer, and load current transducer with voltage output. According to the nature of the inputs it is possible to have somewhere in the region of six different ranges, spans, or input, on the same data logger.

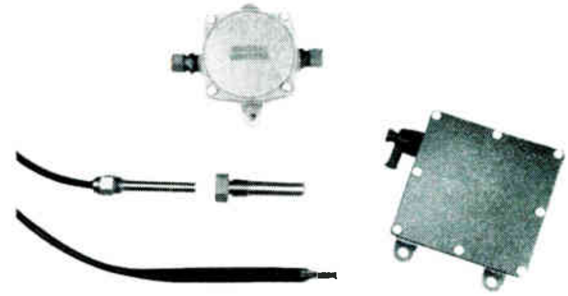

*Fig. 2. Two types of thermometer and junction boxes are shown here*

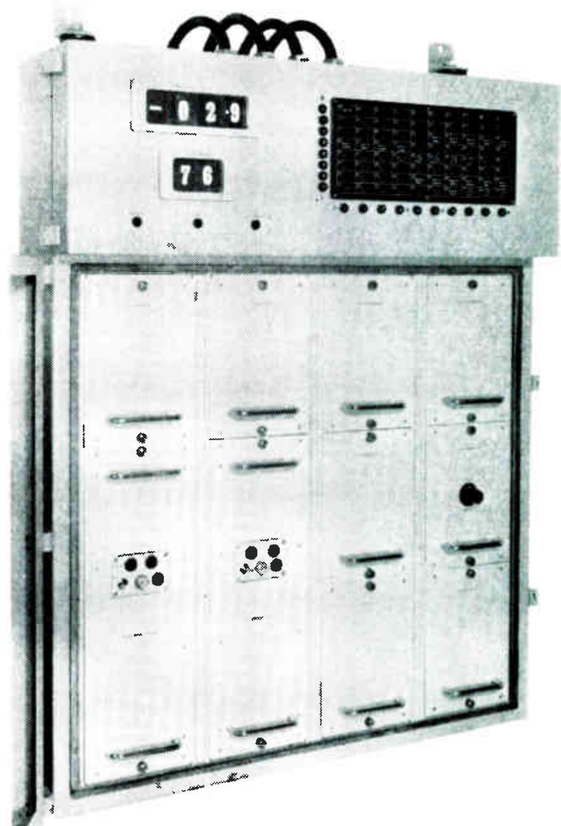

*Fig. 3. In this photograph the door is open to show the modular construction. Sealing strip is fitted to make the case moisture proof when the door is closed*



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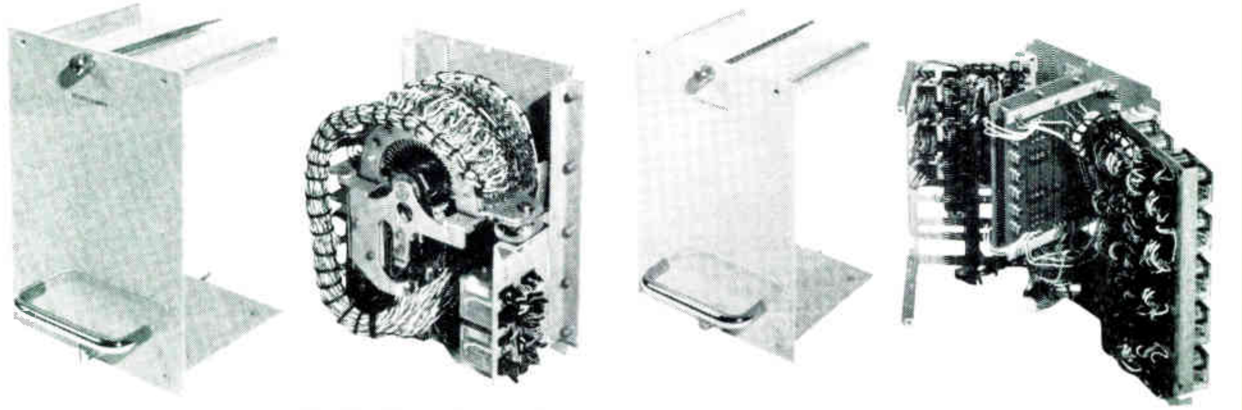


*Fig. 4. These pictures show two of the modules in exploded form*

Outputs also vary. Besides the I.B.M. Model 735 Typewriter an I.B.M. Model B Typewriter or a Creed Model 25 Tape Punch can be driven.

The record on punched tape contains the point identity before each reading and is fully programmed for replay on a standard teleprinter.

The typewriter record is made on a preprinted sheet so that point identity is not required. Considerable flexibility is possible in the sheet layout by presetting tabulating positions on the typewriter to give the record in the vertical columns chosen. Where a second line is beneath the first several tabulate commands can be employed to pass columns tabulated in the previous line. Hence every other column could be used in the first line but only every third in the second.

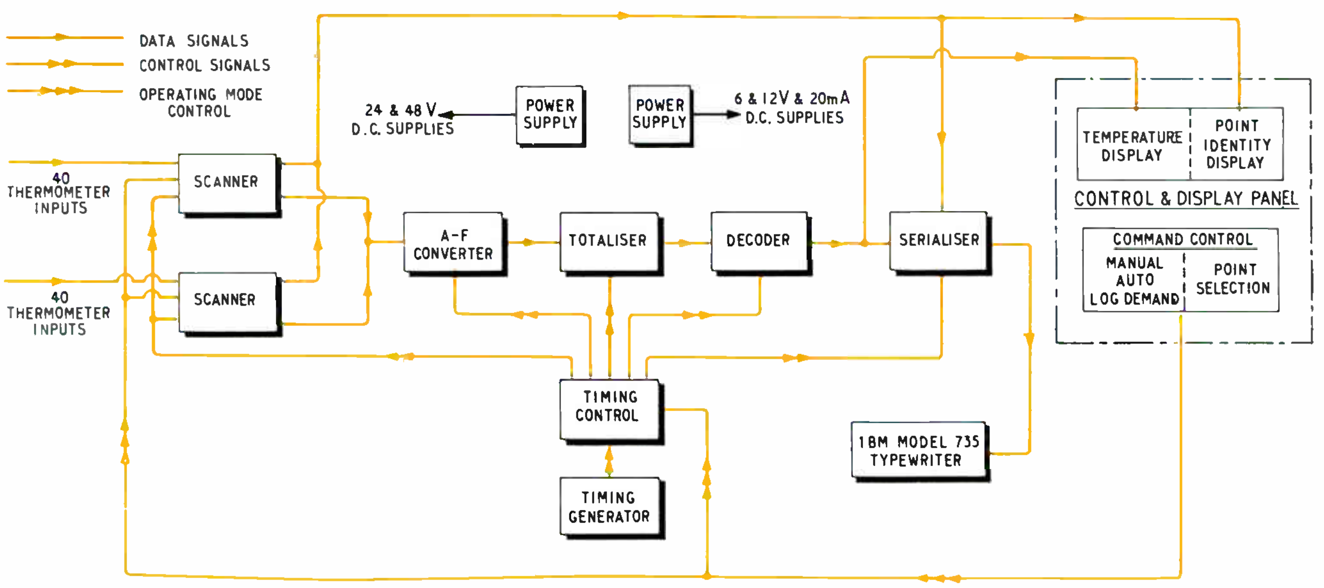
Normal type record contains five characters including the decimal point, the most significant figure becoming the minus sign for negative temperatures. For those who wish to get more information into each line a short form of three characters can be programmed. In this case the negative sign, the decimal point and either the least or most significant figure is omitted, e.g. temperatures of high accuracy have the tens, units and tenths figures printed and if negative are in red, while higher temperatures record the hundreds, tens and units figures. In order that there can be several copies of the log record a pin platen is fitted to the typewriter.

Optional extras built into nine-inch square junction boxes enable the typewriter to be located remotely on the bridge and controlled from there. If two loggers are employed they can feed into one recording device in sequence, being controlled from the first logger only.

The reception given to this data logging equipment has been most encouraging. The crew welcome it as a means of reducing monotonous work, the owners are pleased to have a record without a human element and Lloyd's have accepted the accuracy of the measurement for their certificate.

Work is now in progress on similar equipment for ships' engine rooms. The approach will be similar to the first equipment, but requirements are far more difficult to determine, with each shipping line having its own ideas about the information needed on a log record. However, difficulties such as these will be overcome in time.

*Fig. 5. Block diagram of the equipment*



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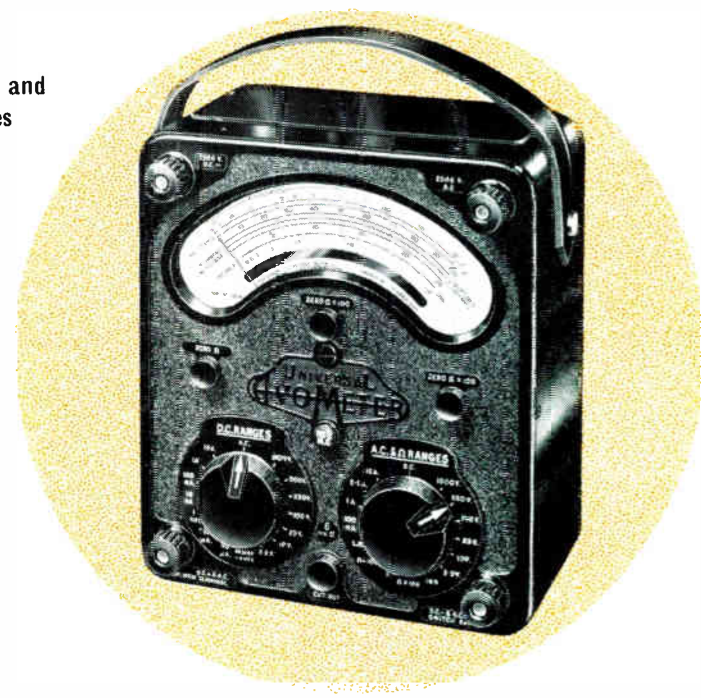
**Test apparatus for electronic equipment can be highly complex and is itself often electronic. The basic tests, and they are the ones most commonly employed, however, are simple measurements of voltage, current and resistance. This article describes the manufacture of one well-known instrument suitable for such basic tests.**




*Avometer model 8*

# Manufacturing Multi-Range Meters

**By *AINSLEY CATTLE****

ALTHOUGH the multi-range instrument of today is one of the most frequently used pieces of test equipment throughout all spheres of industry, research and learning, its ability to meet high-accuracy requirements in an ever increasing list of applications is often taken for granted. Little thought is given to the refinements and highly-skilled techniques necessary to manufacture a robust, stable and accurate measuring instrument.

### Background

Instruments produced over forty years ago were capable of very limited application, mainly being used for direct-current measurement only.

In the early 1930's a pioneer company in the manufacture of measuring instruments Avo Ltd. (M.I. Group) produced one of the first multi-range meters which included facilities for the measurement of a.c. and was a fully universal instrument.

The expansion of the electrical industry encouraged development still further, the emphasis being on the provision of a wider range of measurement and higher sensitivity combined with robustness and accuracy.

The birth of the electronics industry, a world industry whose growth rate is only exceeded by that of aeronautics, created a demand for multi-range meters having still greater adaptability and sensitivity. With the rapid growth and further advancement of electronics, sub-sections of the industry have grown to such proportions that today specialized sophistication has become necessary in the manufacture of measuring instruments.

An example of present-day production is the 'Avometer' range of instruments, capable of a wide range of a.c./d.c. voltage and current measurement, and sensitivities of 20,000 Ω/V. Accessories such as movement reverse action, eliminating the need to disconnect an instrument from a circuit under test, overload cut-out systems to protect the instrument, anti-magnetic shields to enable instruments to be used in the vicinity of strong magnetic fields, etc., are but a few examples of the facilities available today.

### Meter Movement

In discussing the characteristics and manufacture of a multi-range instrument the Avometer Model 8, which is illustrated in one of the photographs, will be taken as an example. One of the most important assemblies in such an instrument is the movement, for it requires specialist skill and knowledge for its production.

Manufacture of the movement for the Avometer commences with the winding of the moving coil, usually on an aluminium former using copper wire supplemented with Constantan to reduce the temperature error. In many cases the wire used is much finer than a human hair; No. 49 s.w.g. (0·0012 in. diameter) wire is used and the aluminium former on which the coil is wound is not continuous but is gapped to avoid overdamping the movement. To prevent movement of the wire it is impregnated with a suitable varnish.

### Moving-Coil Assembly

The moving-coil is pivoted on hardened and highly-polished steel pivots between conical spring-loaded jewels and swings in a gap energized by two powerfully magnetized and 'aged' blocks (to ensure magnetic stability) associated with mild-steel pole pieces. The pivots, which to the naked eye appear to have a sharp point, have in fact a carefully shaped tip, with a radius of 0·0003 in. The pivot holders are fixed to the moving coil with a special adhesive and it is, of course, necessary to ensure that they are in line on the mechanical axis of the coil. The two ends of the coil are soldered one to each pivot holder.

To reduce friction to a minimum the bearings for the pivots are manufactured from a very hard material such as synthetic sapphire.

The knife-edge pointer assembly is fitted so that the

* Avo Ltd.



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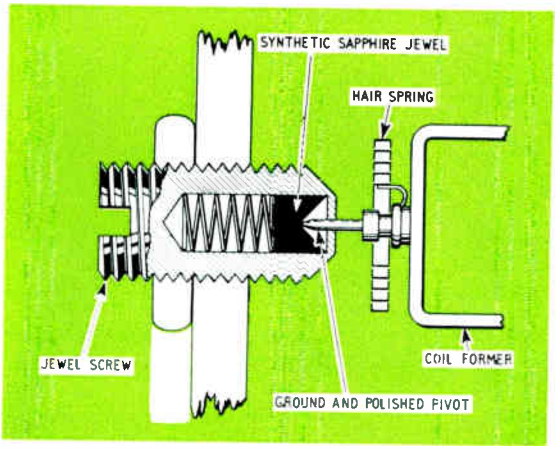


*Fig. 1. Details of one of the pivots and its bearing*

*Fig. 2. Air-conditioned zone in which movement assembly and final testing are carried out*

blade of the pointer lies in the same plane as the mechanical axis of the coil in order to minimize parallax error. The pointer and coil are balanced to ensure accuracy in any position. Two phosphor-bronze hairsprings provide controlling torque. These must first be carefully matched to ensure that both the top hairspring and the bottom hairspring have equal torque and are then fixed by means of a small collet soldered to the hairsprings.

It is essential that the hairsprings are fully unwound when they are soldered to the zero adjuster to prevent inaccuracies in calibration.

The coil is assembled into the frame of the movement and the magnetic pole pieces are fitted into position. These are not magnetized until final adjustment has been made and the coil can swing freely in its bearings.

When assembly is complete the pole pieces are magnetized. To ensure that the pole pieces are magnetized to a stable point on the magnetization curve, they are magnetized well above the level required and artificially aged until a condition is reached which will ensure the constancy of the flux for many years.

## Components Assembly

Although considerable attention has been paid to the movement, the remaining components such as switches, series multipliers, parallel shunt resistors and the multitude of other small components must not be overlooked. Where possible, components conforming to the Ministry of Defence Standard Component Specifications are used. To assist calibration the bobbins are always wound with extra turns of wire. The values are then accurately adjusted using Wheatstone bridges and mirror galvanometers and, after adjustment, any surplus turns of wire are carefully removed.

For instruments having high sensitivities the values of series multiplier resistors must of necessity be much greater than previously used on lower sensitivity instruments. While modern techniques make it possible to produce compact wirewound resistors, they are costly due to their high ohmic value. To avoid this unnecessary cost, high-stability carbon resistors are used with a low value resistor in series. The resistance of the low value resistor may then be carefully adjusted to give the correct overall value within a very close tolerance.

## Air-Conditioned Zone

Movement assembly and final testing are carried out in an air-conditioned zone of the factory, Fig. 2. This zone is controlled to keep the temperature constant at 21 °C and the humidity not exceeding 55%. The air is iron dust and sulphur free.

The instrument meets the requirements of BS 89/1954 with the exception that accuracy on d.c. voltage ranges is only 2% of full-scale deflection. Accuracy on d.c. current ranges is 1% f.s.d. in accordance with BS 89/1954 and on the a.c. voltage and current ranges 2·25% of f.s.d.

On a.c. ranges a bridge rectifier is used for rectification. The rectifier does not operate linearly over the whole of its characteristic, having a knee point of approximately 0·3 V introducing non-linearity at this point. To avoid the need for a specially-calibrated scale for the voltage ranges where readings fall within the knee of the characteristic, a current transformer is used in conjunction with the bridge rectifier to maintain linearity and the instrument is designed so that only the linear portion of the rectifier current–voltage characteristic is utilized. When using a bridge rectifier the highest degree of efficiency is obtained when the forward resistance of each element is as low as possible and these conditions are carefully checked in the factory, due allowance being made in the original calibration of the instrument for the small leakage currents which also exist.

An additional surge suppression rectifier is connected across the bridge rectifier to provide an additional measure of protection against short-duration transient overloads from pulse sources.

## Automatic Cut-Out

A high degree of overload protection is afforded by the automatic cut-out incorporated in the instrument. The overload mechanism is brought into action by the moving-



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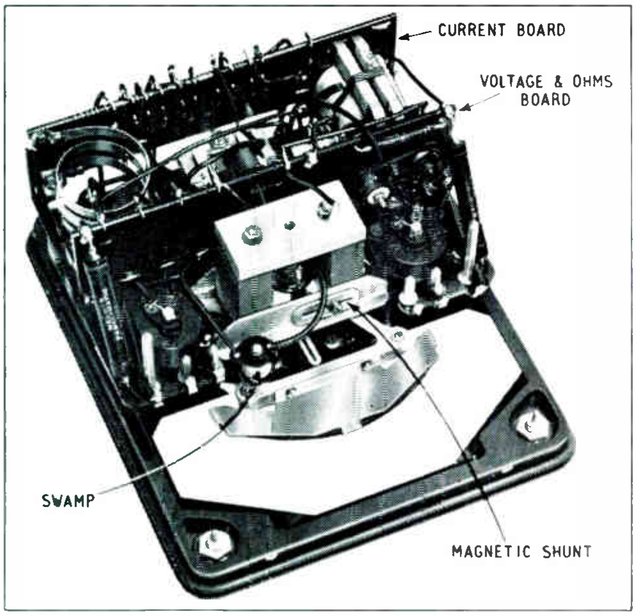
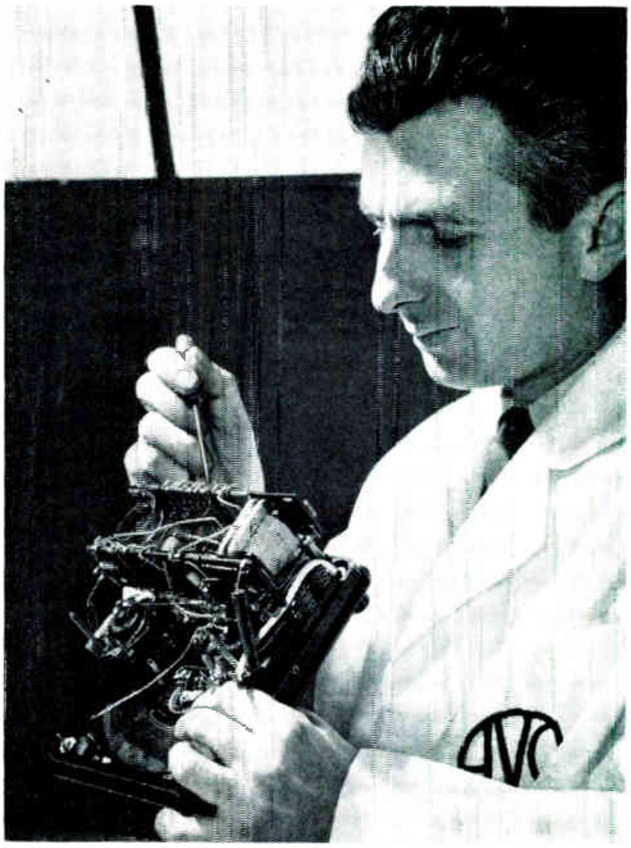



*Interior view of Avometer*



*Inspecting voltage-dropping resistor panel*

coil coming into contact with a trigger connected just beyond the full-scale position and, in addition, there is a second release at the zero end, so that the cut-out is also tripped if the meter is overloaded in reverse.

Prior to assembly on the cut-out table (Fig. 3) the reset lever is prepared by burnishing and levelling, and an undercut is formed to provide a point which will rest against the jewelled section of the crank lever.

The lever return spring is formed on a jig, and the plunger polished before being fitted with a sleeve.

These and other component parts are then jig-assembled on to the cut-out table, the return spring fitted and thrust rod inserted. (The thrust rod is made and fitted to the panel at an earlier stage.)

Finally, the heavy current contacts are fitted at a further point along the assembly line.

### Calibration

Calibration test sets are employed in an air-conditioned zone to calibrate instrument movements, and, at the same time, are utilized to provide pin-point marks on preprinted scales so that these points can be employed as references at the stage where line markers are hand written on to the scale plate.

The basic information such as amps, volts and ohms ranges is preprinted on the scale, all main lines and subdivisions on each range being lined in by hand.

### Hand Lining

An instrument scale plate which, at this stage, has the reference points minutely marked upon the face, is checked for cleanliness before being placed in a brass jig (Fig. 4). This jig is used in conjunction with a suitable template by the operator to provide even distribution of division space between the calibration pin-points. These may be either logarithmic or linear, depending upon the particular range being lined; i.e., the metal template (foreground of Fig. 4) is used to give accurate spacing of line markers between a set number of reference points and the brass jig holds the scale plate in such a position that varying

*Fig. 3. Details of the cut-out for overload protection. The operating sequence is: 1. On overload the coil former strikes the toggle hard. This operates the push rod spring and push rod. 2. The push rod rotates the jewel crank lever, releasing the knife-edged reset lever. 3. The knob spindle recess is freed. The contacts are released. 4. Operation of reset knob re-engages knife-edged jewel lever and contacts. Cut-out is returned to status quo*

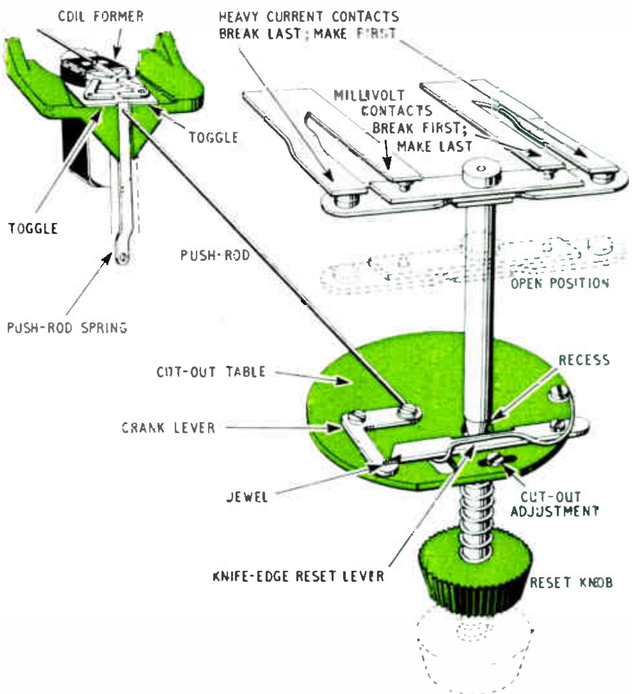





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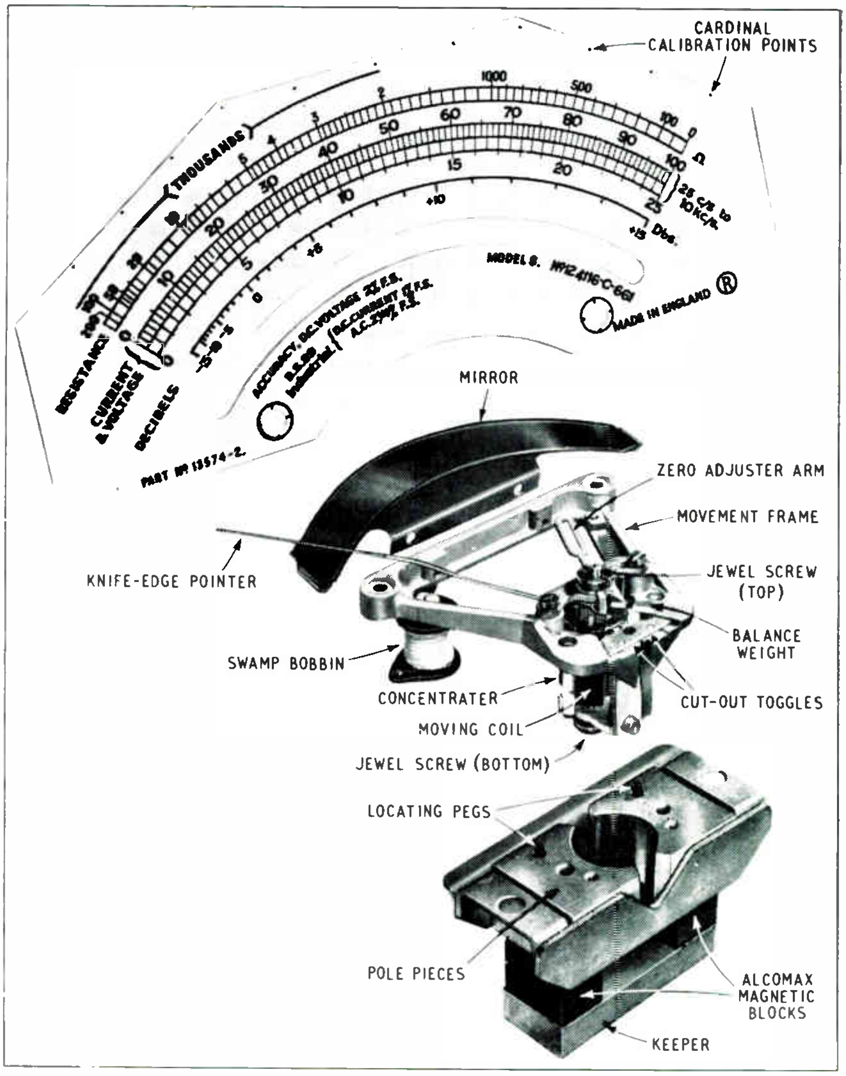
*Fig. 4. Hand lining a scale plate*




*Meter movement, scale and magnet assembly*

sections of scale ranges can be accurately lined. Different templates are used for a number of ranges.

## Final Testing

Final testing of the fully-assembled instruments is carried out without removing them from the air-conditioned floor. The front cover depicts the Avo Standard Test Console on which all instruments are finally tested to ensure the accuracy of the completed instrument to BS 89 Industrial Grade. This test console was specially built for the testing of the AvoMeters and combines in one instrument all the necessary electrical testing facilities to ensure their accuracy of calibration.

As can be seen (front cover) the console is of desk construction, all circuitry is completely enclosed and all controls are readily to hand for ease and simplicity of testing. Provision is made for testing all ranges of voltage, current and resistance.

Values of voltages and current are selected by range switches mounted on the control panel and a 15-way multiplier enables each range to be multiplied by a factor enabling scale characteristic checks to be made. A standardizing facility maintains the accuracy of these ranges within very close tolerance. Indication is by null deflection of a mirror galvanometer.

The calibration of the d.c. voltage and current ranges of the test set with the galvanometer at its null indication point is correct to $\pm 0{\cdot}2\%$ and the a.c. voltage and current ranges to $\pm 0{\cdot}4\%$. The resistance of any tapping on the multiplier is correct to $\pm 0{\cdot}1$ ohm of its nominal value.

## Future Trends

Developments in Avo Ltd. have resulted in the introduction of a number of new instruments, some for the electrical and electronic fields, others for a more recent addition to the industries of today, that of nucleonics. The demands which this industry is already making to instrument manufacturers are being met by the introduction of nucleonic instruments for the measurement of atomic radiation and monitoring equipments for use in nuclear plants and uranium recovery factories to provide safety alarm systems.

The manufacturing problems associated with production of new measuring instruments to keep up with the progress achieved in research can readily be appreciated and it is a challenge which has no foreseeable ending.



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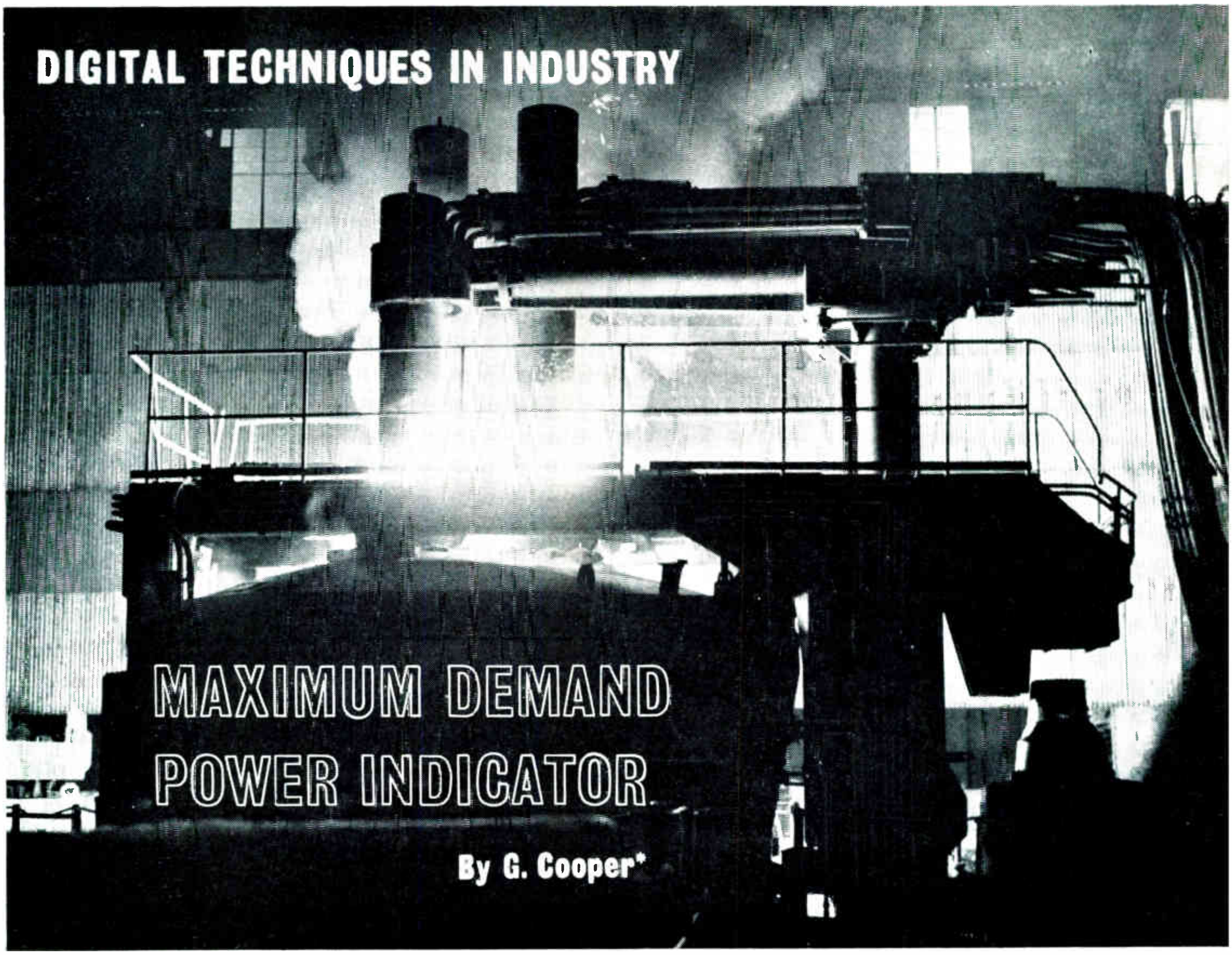

# DIGITAL TECHNIQUES IN INDUSTRY

# MAXIMUM DEMAND POWER INDICATOR

**By G. Cooper***

**Following recent articles on digital techniques in industry, an application of these techniques is described here. The apparatus indicates the total electrical energy used in the previous half-hour, the indication changing every five minutes, and also the energy which may be used in the next five minutes without exceeding a required maximum.**

THE cost of electrical energy to large-scale users is commonly made up from two elements. The first is proportional to the total quantity of energy used over the relevant month or quarter, and is charged at a flat rate of pence per kilowatt-hour.

The second element of charge is based on the maximum peak load which the user imposes on the supply system. This is measured as the highest consumption of energy by the user over any one short period (typically half an hour) during the month or quarter for which the account is being assessed. This charge is intended to recompense the supply authority for the amount of capital plant it must keep available to satisfy the peak demand of the user.

* Lancashire Dynamo Electronic Products Ltd.

In this country, 'maximum demand' is assessed as the 'maximum kWh consumption during any half-hour period'. The half-hour periods start at a fixed time, say on the hour and half-hour, and the distribution of the demand over the half-hour period is not considered. Thus measurement of maximum demand, and its corollary, prediction of the amount of energy available within a required demand, is relatively simple, requiring only an integrating energy meter, reset at the end of each measurement period.

Some large Italian energy users, however, work on a five-minute measurement period, the maximum demand being calculated as the highest group of six adjacent five-minute periods. This method raises obvious complications in predicting what energy is available at any given time. This prediction is of considerable importance in such applications as large-scale induction-furnace installations, to permit maximum furnace utilization to be obtained at minimum energy cost. A digital equipment designed to present precisely this information to the plant foreman, and to log the energy consumed has been supplied to an Italian steel-producing company, Breda Siderurgica, of Milan, which uses some 36 MW of induction furnaces.

In operation, a calculation must be carried out at the end



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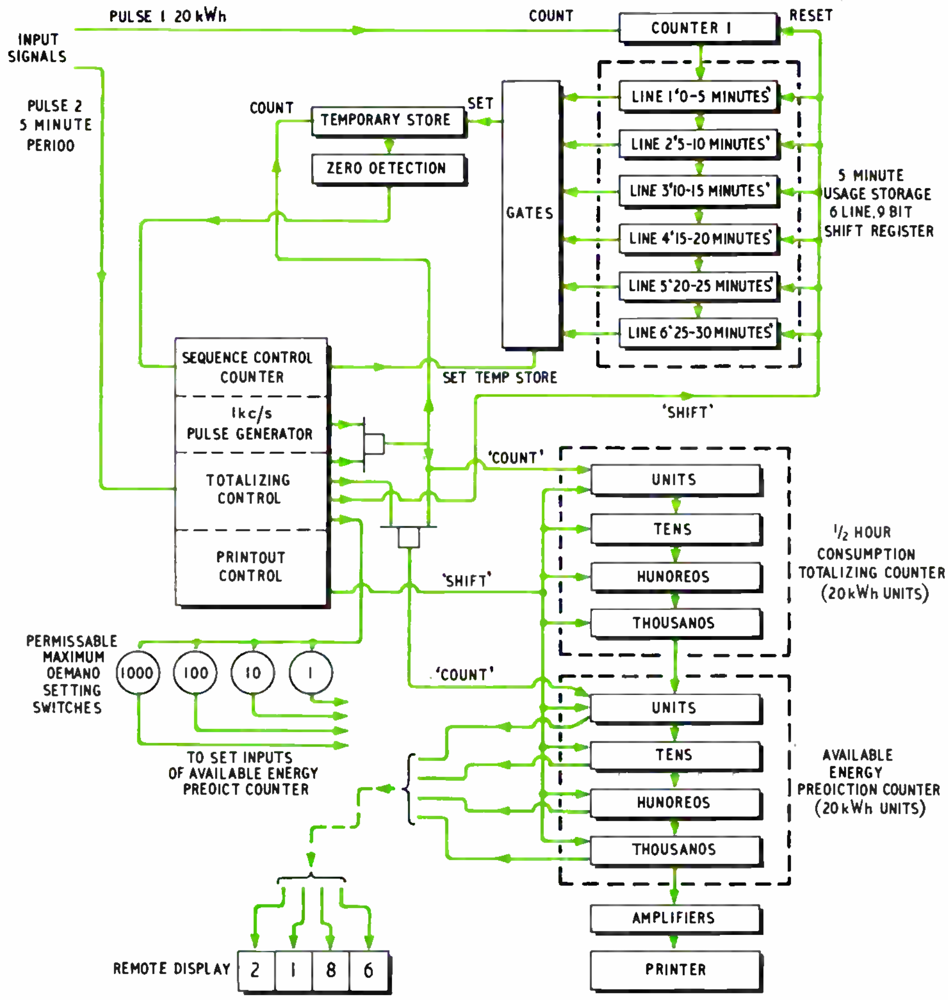


*Fig. 1. Block diagram of maximum demand power indicator*

of each five-minute period, to give a prediction valid for the next five minutes, and the method of this calculation is as follows:

1. The five-minute energy consumptions are stored at the end of each period.
2. To obtain the 'available energy', the most recent five five-minute consumptions are successively subtracted from the predetermined desired maximum demand. The remainder is then the available energy, and this is displayed on numerical indicators.
3. For logging purposes, the most recent six five-minute period consumptions are totalled as the 'last half-hour consumption'; i.e., the maximum demand for that period. This information, together with the displayed 'available energy' information is then fed at the end of the five-minute period to a printer, which produces a permanent record.

### The Equipment

The block diagram of Fig. 1 shows the main functions of the system. Two input pulses are fed in on separate lines from the supply authorities' maximum-demand equipment. Pulse 2 defines the start of each five-minute period. Pulse 1 has a significance of 20 kWh and is derived from a conventional integrating energy meter. Counter 1 is a 9-bit pure binary counter; that is, it has a capacity of 511 ($2^9-1$) counts. The counter is built up from nine identical standard binary circuits, four of which are mounted on one plug-in 8-in. × 6-in. printed-circuit unit (the three binaries left over are used elsewhere in the system). The binary circuit is shown in Fig. 2. Basically it consists of two common-emitter transistor stages coupled back-to-back so that the circuit is stable in two states, $VT_1$ conducting to saturation and $VT_2$ cut-off being one state, $VT_2$ conducting to saturation and $VT_1$ cut-off the other. The stability is ensured by correct choice of the cross-coupling resistors $R_3$ and $R_4$.

The application of a negative potential ('1' signal) to the set input forces $VT_1$ to conduct, and hence due to the effect of $R_3$ and $R_1$ turns $VT_2$ off. Output '0' now generates a '1' signal, and the binary is in the ON or set state. Application of a '1' signal to the reset input will now reverse the state of the binary into the OFF or reset condition.

These inputs are used to preset binaries before and reset them after counting operations. For binary counting the gate inputs are linked to the '0' and '1' outputs. The effect is that while the diode associated with the conducting transistor is open, the other diode, associated with the non-conducting transistor, is heavily reverse biased. Thus, when a positive-going step of voltage (usually obtained from a '1' signal being switched to '0') is applied to the shift input, it is steered through the open diode to the base of



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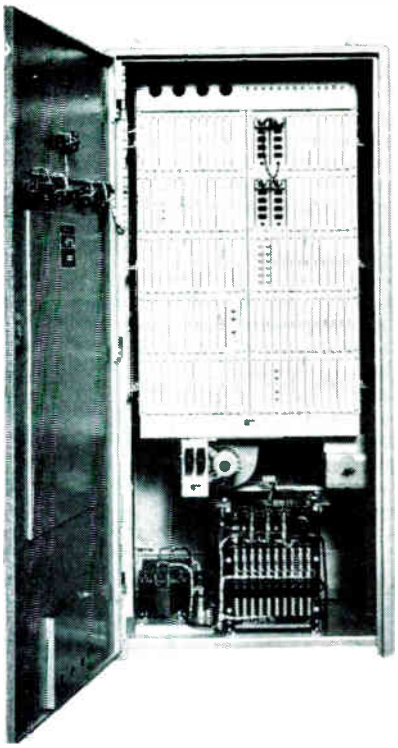

*Maximum demand indicator cubicle, showing required maximum demand setting switches and alarm level setting switches on the panel above the racks*

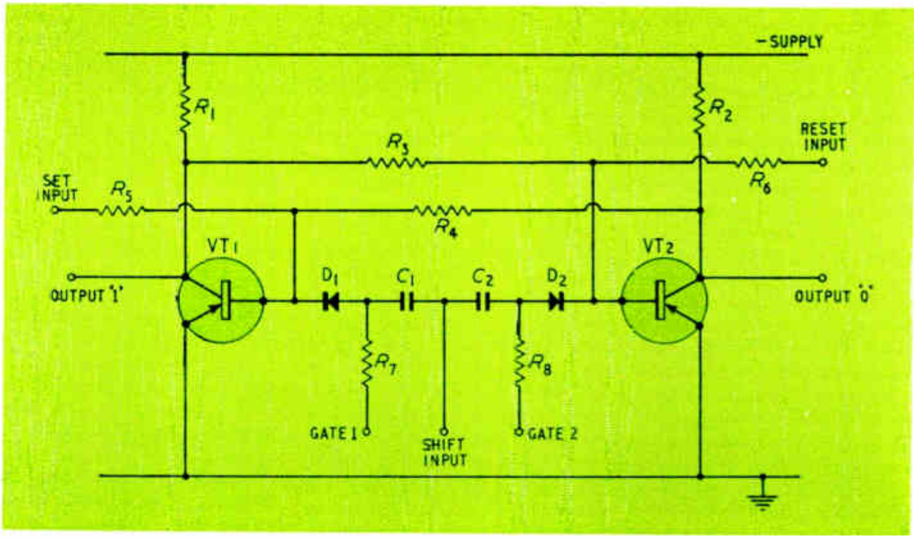


*Fig. 2. Circuit of binary stage. Such stages are used in considerable numbers in the counters and stores*


*Maximum demand indicator display of permissible power consumption rate in 0·01-MW hr units*

the conducting transistor which it turns off, thereby reversing the state of the binary. If a second positive-going step is now applied to the shift input, it is now steered to the opposite transistor (which is now the one conducting), and the binary reverts back. For two complete cycles of the input signal (ON-OFF-ON-OFF), the binary has completed one cycle (ON-OFF). The term 'binary' is derived from this divide-by-two action, and it will readily be seen that the connection of binary units in a chain, the shift of each being derived from the '0' output of its predecessor, will result in a 'binary' scale counter, the outputs of successive elements dividing the input cycles by 2, 4, 8, 16, 32, 64, etc. (i.e., $2^1$, $2^2$, $2^3$, $2^4$, $2^5$, $2^6$) and the number of pulses counted can be read off as the state of the binaries on the binary scale. The input pulses are totalled in this counter over a five-minute period, and hence the count at the end of the five minutes is a measure of the energy used over that five minutes in units of 20 kWh.

### Five-Minute Usage Storage

At the end of the five-minute period, the contents of counter 1, Fig. 1, are transferred to line 1 of the shift register which is used to store the successive five-minute totals. This is accomplished by using the same binary circuit in the following manner.

Instead of connecting the gate inputs of the binaries back to their own outputs, the gate inputs of the binaries forming line 1 are connected to the '0' and '1' outputs of counter 1 so that when a 'shift' input is applied to all the 'shift' inputs of the line 1 binaries in parallel, the binaries of line 1 take up the state of the binaries forming the counter. The shift signal is actually derived from the 'end of five-minute signal' (pulse 2). This pulse is also used to reset all the binaries of counter 1 to the OFF state, so that the net effect is to transfer the counter into the store, and to make counter 1 available for the next five-minute count of 20 kWh signals. The outputs of line 1 are connected to the gates of line 2 and so on, and the shifts of all lines are fed in parallel, so that at the end of half an hour, line 6 contains the energy used 25–30 min ago;—line 5, 20–25 min; line 4, 15–20 min; and so on. The system now contains all the information needed to enable it to calculate the available energy over the next five minutes, and to log the energy used over the last half-hour.

### The Totalizing Operation

Since the information stored in the shift register will be used in six totalizing operations before it becomes out-of-date, the transfer of the information to the totalizing system must be 'non-destructive', and the technique described above for the transfer of information is not directly applicable. The information is, therefore, transferred into a



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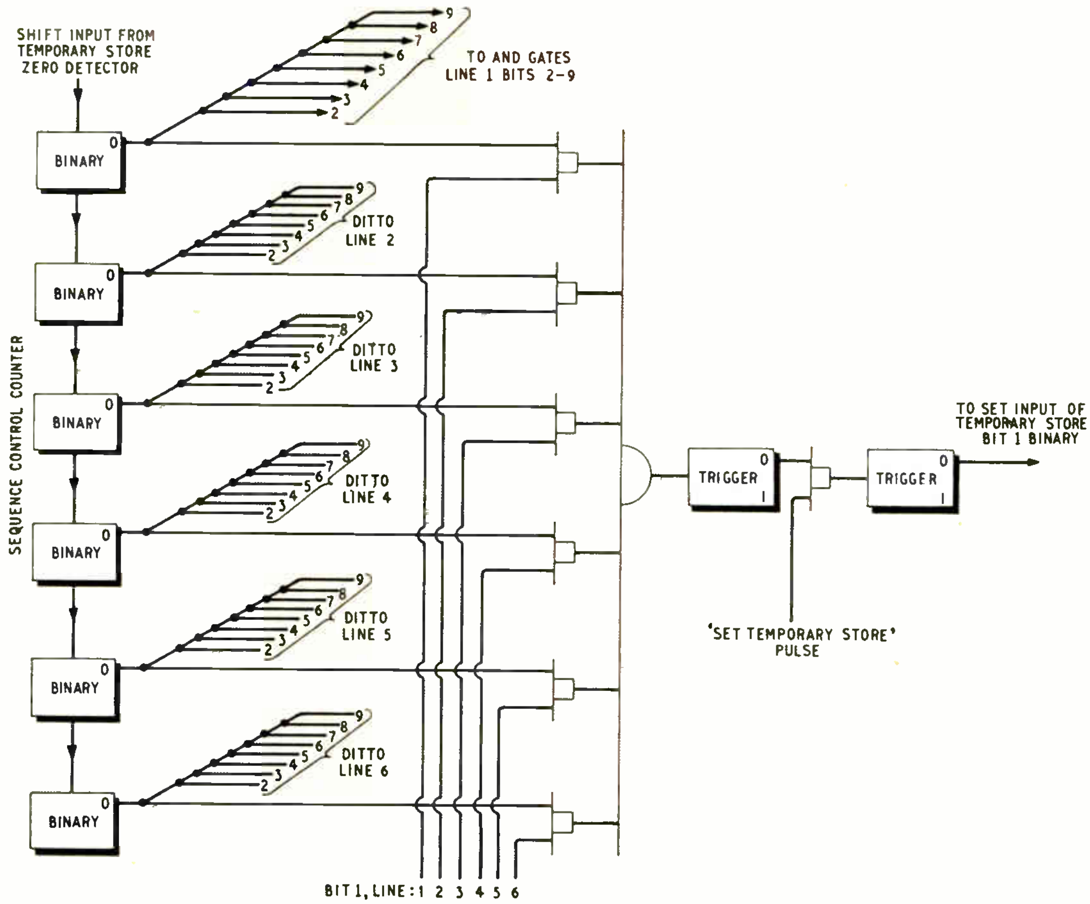
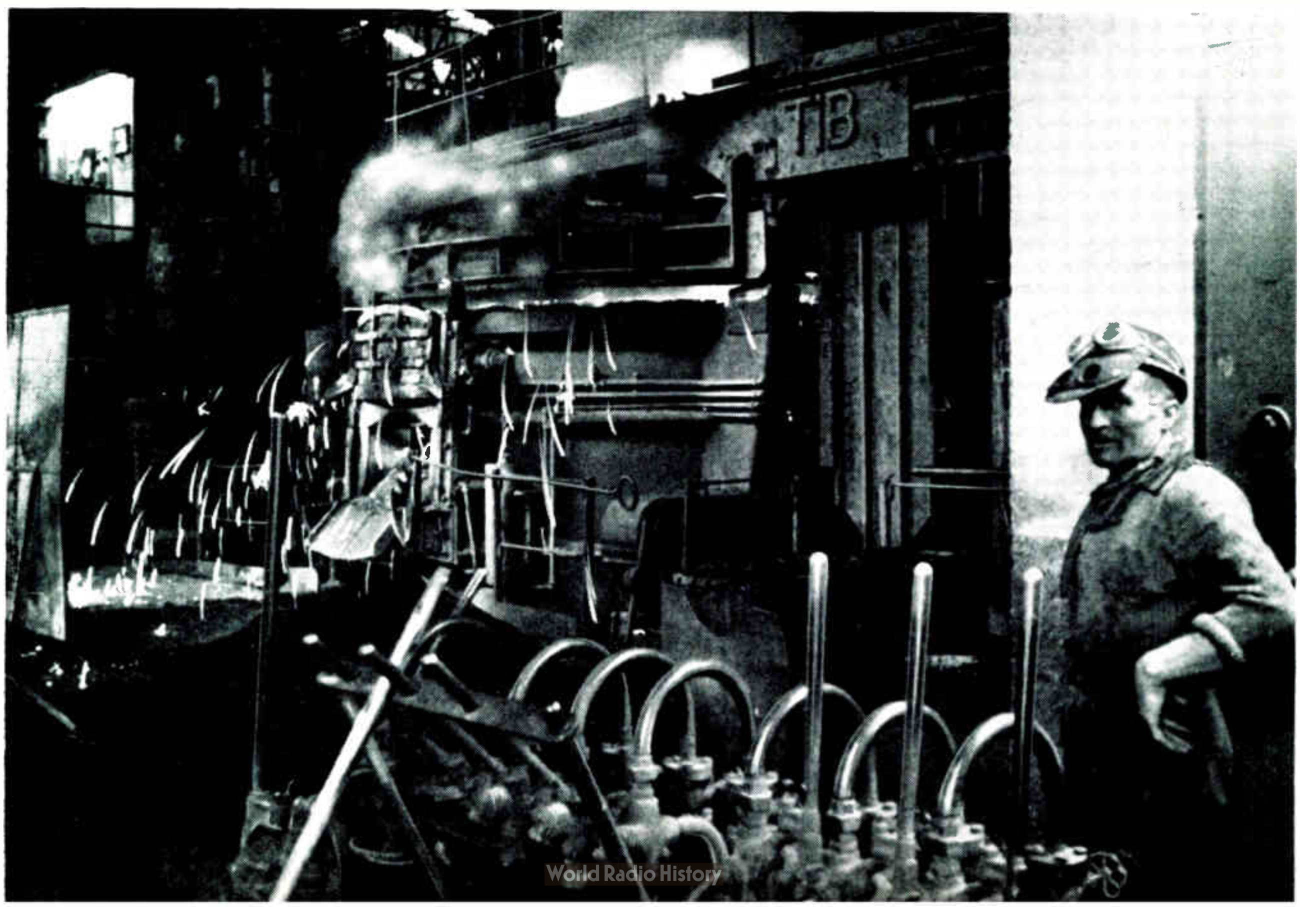



*Fig. 3. This diagram shows the form of the temporary store setting logic*

*This illustration and the title block show the arc furnace plant of Breda Siderurgica which the maximum demand equipment is monitoring*



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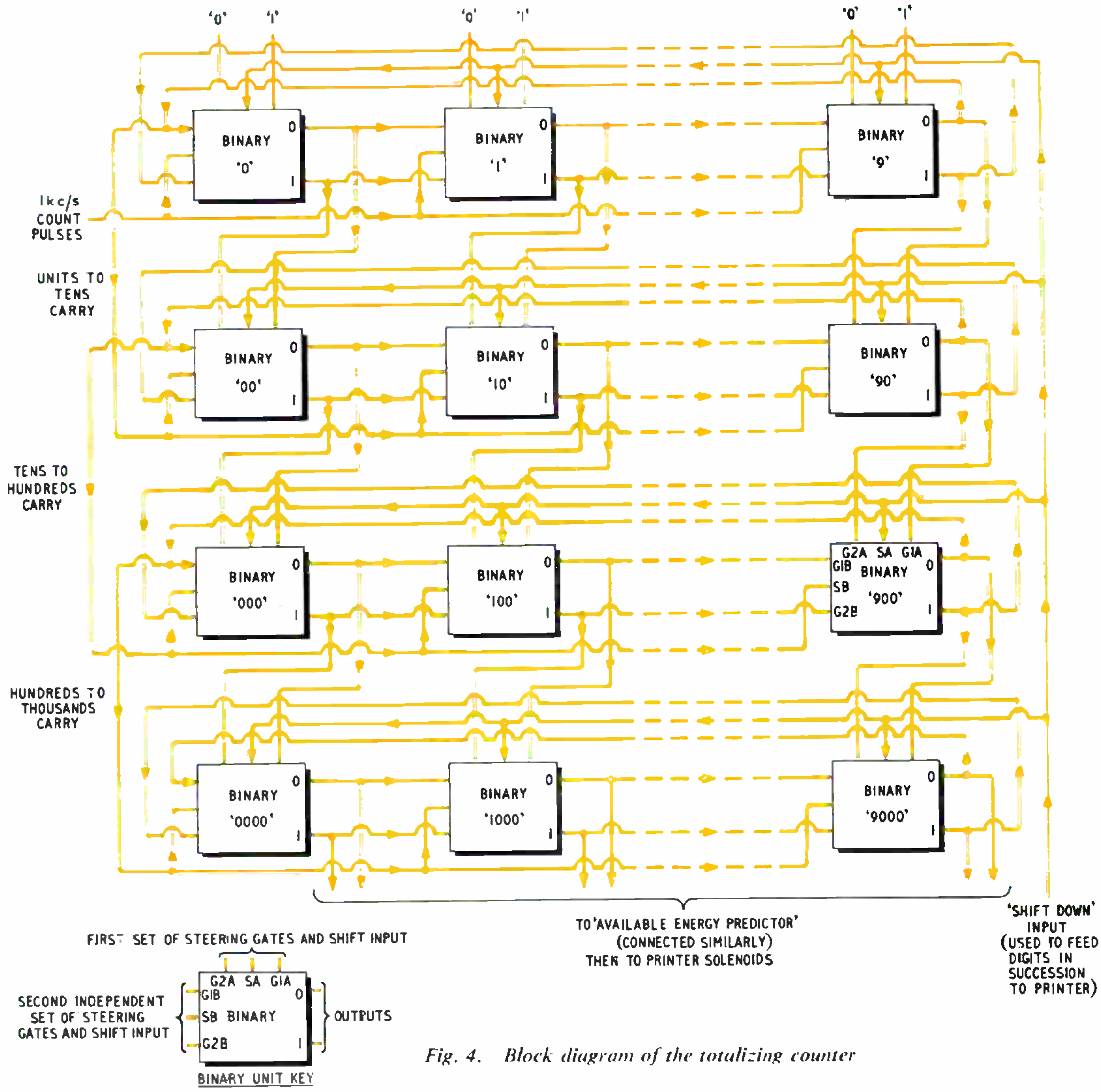


*Fig. 4. Block diagram of the totalizing counter*

temporary store (which is effectively a 9-bit 'counting-down' binary counter), a line a time, and the pulses required to count the temporary store back to zero after each transfer are also fed to the totalizing counter. This will, after all lines have been transferred and run-out, contain the sum of all line contents.

This is done through the logic shown in Fig. 3, which is repeated nine times, one for each bit of the temporary store. The sequence control counter (s.c.c.) consists of six binaries connected in a chain and so arranged that initially only the top binary is in the ON state. Thus the state of the bit in line 1 is fed through to the OR output, the states of lines 2–6 being isolated by the missing AND signal. As shift signals are fed to the s.c.c., the single ON state steps down the chain, setting up the OR output successively to the state of the appropriate bit in lines 2–6.

If, therefore, with the s.c.c. in the initial condition a 'set temporary store' pulse is applied to the AND input as shown, the temporary store will be set to the count existing in line 1.

The 'count' input of the temporary store is fed via an AND gate with 1-kc/s pulses, derived from a pulse generator made up from suitably timed standard pulse and delay units. These pulses are also fed from the AND gate output into a totalizing counter, which will be described later.

When the temporary store receives the 1-kc/s pulses it counts down towards zero from the preset number, and when it has reached zero, the number of pulses which have been fed to the totalizing counter is equal to the content of line 1. The condition of zero in the temporary store is detected by feeding all the '0' outputs into an OR gate. When the counter is at zero, the OR gate output disappears and a shift pulse is fed to the s.c.c.

The s.c.c. steps down one, and application of a further 'set temporary store' pulse sets the temporary store to the content of line 2. This count in turn is run out by the 1-kc/s pulses, and the process repeated until all six lines have been transferred and run to zero.

The condition of the s.c.c. at line 6 and temporary store at zero is used to detect the completion of totalizing, and the 1-kc/s pulse train is inhibited until the next totalizing operation in five minutes' time.

The number of 1-kc/s pulses fed to the totalizing counter is now equal to the total consumption of the last half-hour, and it should be noted that the transference of the data from the shift register to the totalizing system has



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been carried out non-destructively, the information in the shift register being retained unchanged for use in the next totalizing operation in five minutes' time.

The 1-kc/s pulses fed to the totalizing counter are also fed to the available energy predictor except that an additional gate is used to exclude the count from line 6, which is out-of-date for prediction purposes.

### Half-Hour Totalizing Counter

The totalizing counter is used only to drive the printer, which requires its numerical information fed in digit by digit in decimal form on its 0–9 digit input solenoids. Instead of working in binary or binary-decimal code, therefore, the totalizing counter is built up of 'rings of 10' binaries.

Fig. 4 shows how this is achieved. Effectively each 'decade' ring is a 10-line, 1-bit shift register, the gates of each binary being fed from the '0' and '1' outputs of the previous binary. The pulses to be totalized are fed in at all the shift inputs of the 'units decade' in parallel. Hence if, when the counter is reset, the '0 digit' binary is ON, and the other nine are all OFF, successive pulses will cause the single ON state to step along the 1, 2, 3, 4, etc., binaries. On the tenth pulse, the single ON state will step from the '9' to the '0', and this will cause a shift to be fed to the similarly connected '10s' decade. The same priniciple is followed through in the 100s and 1,000s decades.

The counter is reset to zero by each 'five-minute' pulse, and therefore after the totalizing operation contains the usage over the last half-hour ready for driving the printout.

### Available Energy Predictor

The available energy predictor is constructed like the totalizing counter in decade rings, but since its function is to indicate what *remains* of a fixed quantity (the permitted consumption over half-hour), it is set to this fixed quantity by a pulse fed to its set inputs at the start of each totalizing sequence, and is counted backwards by the 1-kc/s pulses. Thus, at the end of the totalizing sequence the count remaining is the quantity of energy which may be used. Each binary drives a 0·3-A 24-V amplifier, which in turn drives the appropriate digit lamp of a numerical indicator of the 'edge-lit type'. Thus a direct display is obtained of the available energy, and this is presented to the plant foreman.

### Print-Out System

The printer, as previously stated, is controlled from ten solenoids, selecting the numerals 0–9. To print a multi-digit number, therefore, each digit must be fed to the printer in turn at suitably timed intervals, to enable the print mechanism to index between digits. If a second multi-digit number is required on the same line, two indexing pulses are fed in succession without intervening numerical information, to produce a space, and the digits of the next number are then fed in sequentially. To gate in turn the necessary digits required to print out both 'energy used' and 'energy available' on to the numerical solenoid amplifiers would call for quite a mass of AND/OR logic. However, the use of 'double entry' binaries, which have two entirely separate sets of shift and gate inputs, enables the same binaries used for totalizing to be used as a shift register to feed the information in the correct order to the printer by using one set of inputs to shift across for counting, the other set to shift down for presenting the data to the printer. Figure 4 shows the block diagram for this arrangement.

Since the 'available energy predictor' is used to drive the display, the printout cycle is not in fact carried out until the end of the five-minute period to which the prediction relates. In other words, the first action of a 'pulse 2' is to initiate a printout cycle, before the totalizing counters are cleared in readiness for the next totalizing cycle.

### Construction

The photograph shows the actual equipment, which contains 92 standard plug-in logic units of ten different types. All binary outputs can be monitored on the lamp display units which can be seen on the logic rack, thus permitting rapid system reinstatement in the event of a fault.

### Recent Developments

Since the equipment described above was built, it has become clear that there is a need in this country for a similar type of monitoring.

An 'anglicized' version has now been constructed, giving two digital displays, one of 'Permissible Load to end of Summation Period' (½ hour), the other of 'Actual Load' (averaged over 1½ to 3 min). The relative values of these two displays is of course a direct indication of the power consumption status at any time, and an early warning of approaching over-consumption.

# A.E.I. Control System for Radio Telescope

The main electrical contract, worth £350,000, for Canada's largest steerable radio telescope has been placed with A.E.I. Electronics by the National Research Council of Canada. The control system, which will be designed and made at Trafford Park, Manchester, will ultimately be sited at Algonquin Park, Ontario.

A.E.I. Electronics was faced with a major engineering problem in designing a system to control the 150-ft reflector and its mounting—weighing 800 tons—to the high degree of accuracy required for astronomical work, in winds of up to 50 m.p.h. The problem was solved by mounting the telescope in vertical and horizontal axes and making it follow the apparent motion of a master equatorial unit mounted at the intersection of the telescope's axes.

The master equatorial unit will be driven at a rate equal to the earth's speed of rotation, pointing steadily at the target star or radio source. Accuracy in pointing will be better than 10 seconds of arc. Any difference between the position of the telescope in either axis and the master equatorial unit will cause a correcting signal from the error detector to be fed into the servo control system amplifiers.

The extreme cold, usual in Canadian winters, has been taken into account by design and erection engineers for installation and commissioning. Site work is already advanced and the radio telescope should be in operation by mid-Summer next year.

This is A.E.I. Electronics' third major contract in the radio telescope field. It designed and supplied the control system for the most accurate radio telescope in the world, the 210-ft instrument at Parkes, Australia. It also received the main £250,000 contract for the 82-ft satellite tracker now being erected at Chilbolton, Hampshire.



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# THE APPLICATION OF FIBRE-OPTIC FACEPLATES IN CATHODE-RAY TUBES

By L. S. ALLARD, B.Sc., F.Inst.P.*

**Fibre optics can usefully be applied to the cathode-ray tube to enable photographs of traces to be taken more readily and, in some cases, to correct for certain aberrations. This article describes the requirements for fibre-optic light guides.**

A FIBRE optic can be defined as a light guide capable of transmitting light by total internal reflection with little loss of light along its length. Straight or curved light guides operating on this principle can be made from glass or plastic material and have been used when it is necessary to illuminate a restricted area in an otherwise darkened enclosure. The main requirement to enable a greater amount of the total light to be trapped by total internal reflection is that the medium surrounding the light guide should have a lower refractive index. In the example given above, air is the surrounding medium, but other materials can be used, such as another glass, provided that its refractive index is lower than that of the light guide.

If now many light guides, each suitably coated with the correct material, are gathered together, it is possible to transmit an image from one plane to another. Naturally, unless the diameter of the individual fibres is very small, the definition of the transmitted image will be poor. However, in practice, glass fibres of about 5 $\mu$m diameter can be made, and the resulting definition is of sufficient quality for most applications. Bundles of these small-diameter light guides are generally classified as fibre-optic stacks and are being developed for use in cathode-ray tubes. Fig. 1 is a photograph of a stack showing that the image of the two white lines is transferred to the top surface of the fibre-optic stack. Fig. 2 shows a cathode-ray tube which incorporates a fibre-optic faceplate.

*The General Electric Co. Ltd.

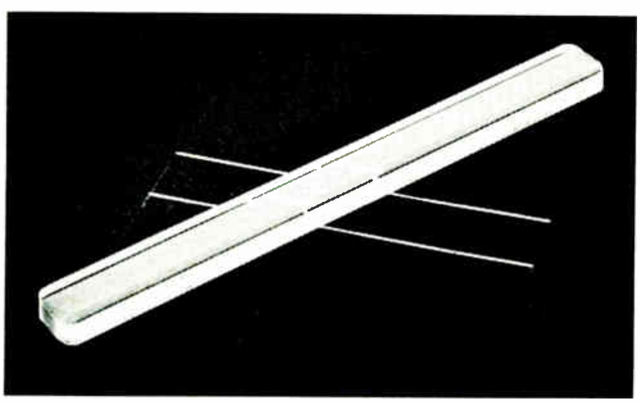

*Fig. 1. Fibre-optic stack*

During the past four years a considerable number of papers dealing with fibre optics has been published in America, indicating that much work has been undertaken in an endeavour to develop and produce stacks of acceptable quality. It is interesting to note however that the earliest description of the possible use of fibre optics was published in a British Patent granted to J. L. Baird in 1927. Fibre-optic stacks are now commercially available from George Elliott Laboratories Ltd., Sunbury-on-Thames, in this country, and from several manufacturers in America.

### Required Properties of Fibre-Optic Stacks

The requirements for satisfactory fibre-optic stacks are governed by optical and technological considerations. Optically, the sole requirement is to transfer an image from one plane to another without introducing any distortion. This means that the fibres have to be aligned accurately if there is to be a one-to-one correspondence between the two planes. The fibre-optic stack should also have a large collection angle for light and exhibit no cross talk between the fibres, otherwise the contrast and resolution will be reduced. The resolution requirement will naturally depend upon the application, but values of spatial frequency response[1] as high as 300 cycles per cm have been achieved from fibre stacks. Some reduction in the resolution performance can take place when a phosphor is applied to the stack but values of about 150 cycles per cm have been achieved. This value of spatial frequency response corresponds to a spot size of about 0·001 in. Naturally, in order to achieve this degree of resolution, high-quality electron guns and fine-grain fluorescent screens also have to be used in the cathode-ray tube.

It can be shown that the light gathering ability of the stack is a function of the refractive indices of the fibre and cladding glasses. If $\mu_f$ and $\mu_c$ are the refractive indices of the fibre and cladding glasses respectively, then the acceptance angle is given by $\sin^{-1}\sqrt{\mu_f^2-\mu_c^2}$. This quantity is conventionally called the numerical aperture of the stack. The significant and perhaps surprising fact about the numerical aperture of fibre-optic stacks is that only a small difference between the refractive indices is required to allow a substantial cone of light to be accepted. For example, if $\mu_f$ is 1·75 and $\mu_c$=1·52, the total included angle of the collected light is about 120°.



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*Fig. 2. Experimental cathode-ray tube incorporating fibre-optic faceplate*

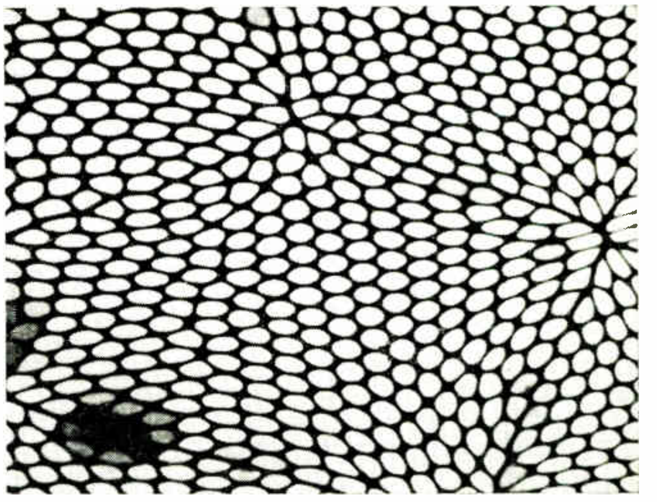

*Fig. 3. Photomicrograph of fibre-optic stack*

The technological requirements of fibre-optic stacks are that the stacks should be vacuum tight, capable of being sealed to conventional glass envelopes and capable of withstanding a baking temperature of about 400 °C during the subsequent processing of the tube. It should be noted that these technological requirements may differ if the stacks are intended for use in camera tubes or image intensifiers. Naturally there are conflicting requirements between the manufacturers of the fibre stacks and the cathode-ray tubes. Virtually all cathode-ray tubes currently being produced are made of soft glass (L 92), having an expansion coefficient of about $9 \times 10^{-6}$ per °C and hence it is desirable for the stack to have a similar expansion coefficient to enable a conventional glass seal to be made. Unfortunately the commercially-available glasses possessing the correct optical properties which are suitable for stack production also have lower expansion coefficients at about $6 \times 10^{-6}$ per °C, thus not sealing easily to the usual type of soft glass. Because of this limitation of the expansion coefficient, graded-seal techniques have had to be developed for sealing the fibre-optic stacks to the soft-glass envelopes. It should also be noted that the expansion coefficient of conventional hard glass (B 37) is about $3{\cdot}75 \times 10^{-6}$ per °C and hence the fibre-optic stacks also do not seal easily to this glass. The terms 'soft glass' and 'hard glass' do not refer to any mechanical properties of the glasses, but to their expansion coefficients, soft glass expanding more than hard glass when heated.

The problems of vacuum tightness and the ability to withstand baking during the subsequent processing of the tube have been largely overcome without further recourse to the original techniques used by some American manufacturers, of coating either or both sides of the fibre-optic stack with a thin layer of glass. However, a possible technical advantage[2] in using a thin coating layer of glass on the inner surface of the stack is that, provided the refractive index of this glass layer is lower than that of the fibre and cladding glasses, a greater amount of light can be conducted by the fibres from the phosphor to the outer surface of the stack.

## Fibre-Optic Stack Manufacture

Naturally in a new and expanding technology many various esoteric production techniques are being pursued, and until production becomes established one will find very few published details concerning manufacturing problems. However, some details have been given in a recent paper[3], describing the work undertaken at George Elliott Laboratories Ltd., and A.W.R.E., Aldermaston. Perhaps the most important feature required of the glass rods from which the fibres are drawn, is the high quality surface finish of the rod. The rod, supported in the lower refractive index glass sheath, is heated in an electrically-heated hollow cylindrical furnace, and is drawn under gravity on to a winding drum rotating about a horizontal axis. The coated fibres produced by this technique are then taken in bundles and again drawn by a similar process to produce an individual fibre diameter as low as 5 $\mu$m. One can see the pattern of these bundles of fibres in the photomicrograph of a complete stack shown in Fig. 3.

## Future Trends

In this article no consideration has been given to the use of fibre-optic stacks in image intensifiers or camera tubes, the latter having been covered in a recent paper.[4] It is virtually certain that fibre-optic stacks will only be used in tubes required for special applications. Quite apart from any technical considerations, the comparatively high cost of the stacks currently being produced will preclude a more general use of stacks in conventional cathode-ray tubes.

The main use of fibre-optic stacks in cathode-ray tubes will probably be for those applications where photographic records of traces are required, and in which so little light is available from the fluorescent screen that the use of inefficient optical systems for imaging the trace on the film is precluded. The fibre-optic stack allows contact photography to be used, thus enabling a considerably greater use to be made of the available light. It has been shown that when comparing the photographic record obtained from a cathode-ray tube having a fibre-optic faceplate with that obtained from a conventional cathode-ray tube in conjunction with a $f/4$ lens working at unity magnification, the exposure required by the former method is one two-hundredth of that required by the latter method, to produce equal density traces on the film.

A further use of fibre-optic faceplates in cathode-ray tubes could be as field flatteners, for both optical and electron-optical applications. If a cathode-ray tube has to be used in conjunction with a large aperture optical system, it is sometimes beneficial to have the object plane curved to minimize aberration. This can be achieved quite easily with a fibre-optic faceplate in which the outer surface is curved to the correct contour while the inner surface can be planar or have a different contour. In addition, from electron-optical considerations, the inner surface can be curved to overcome any deflection-defocusing aberrations,



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thereby enabling an image in optimum focus to be obtained on the front surface of the stack without having to resort to any re-focusing of the electron beam as it is deflected.

Recent demonstrations have also shown the possible use of fibre-optic stacks in cathode-ray tubes for applications where the tube has to be observed under conditions of high ambient illumination. In this instance, the individual fibres are also coated with a layer of opaque material which absorbs the incident light without reducing the visibility of the displayed trace.

While fibre-optic stacks are now commercially available from both the United Kingdom and America, further development is still necessary before stacks can be produced completely free from defects. Probably the main limitation, on which work is being actively maintained, is the elimination of black spots within the stack. A black spot can be seen in Fig. 3 which is a photomicrograph of a fibre-optic stack. The effect of these black spots is shown in Fig. 4 which indicates the variation in light output as the electron beam is scanned across the tube face.

The large-amplitude signal corresponds to the beam passing over one of the black spots in the stack. The exact cause of these dead fibres is not known accurately, but by exercising greater control in the production of the stacks the quality of the stacks is being improved.

Perhaps one factor which has limited the development of fibre-optic stacks is the limited range of commercially-available glasses which have normally been developed for other specific applications. It is possible that by giving serious consideration to, and initiating the development of, new types of glass having the required refractive indices, expansion coefficients and working ranges of temperature, the availability of good quality stacks at a lower price might be accelerated.

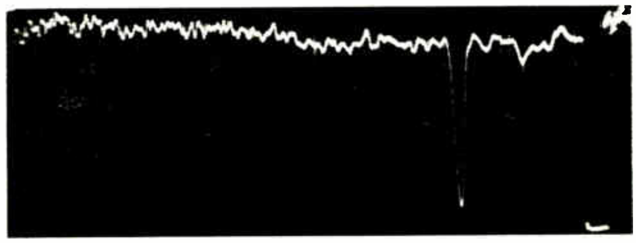

*Fig. 4. Variation in light output as electron beam scans across fibre-optic stack*

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[1] W. A. Woodley and D. Rogers, 'Research at R.R.E. No. 2, High Resolution and Fibre Optic Cathode-Ray Tubes', *British Communications and Electronics*, Vol. 10, No. 9, p. 696, September 1963.

[2] American Optical Company: British Patent Specification 934, 183.

[3] 'Fibre Light Transmission', *Design and Components in Engineering*, February 1962.

[4] A. C. Dawe, 'Vidicon Camera Tube with a Fibre Optic Window', *Industrial Electronics*, p. 576, August 1963.

# Sun Powers New Radio Warning System

A solar-powered v.h.f. radio alarm system designed to broadcast instant warnings of power network failures, high water levels or other danger conditions, has been developed by companies in the Plessey Group.

This is believed to be the first commercial application in this country to make use of the sun's energy.

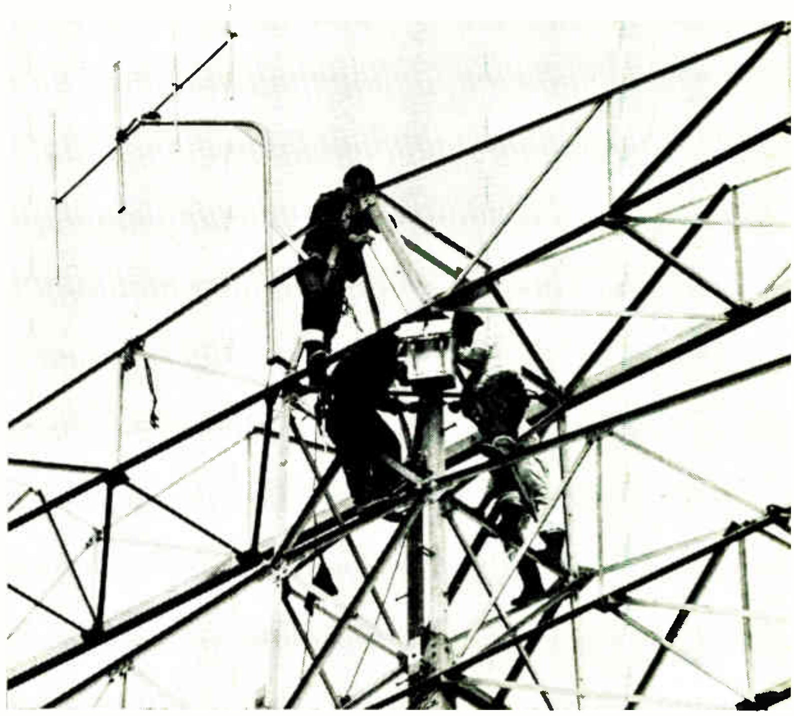
Even on the dullest days, sufficient radiation penetrates the atmosphere to activate the highly-sensitive solar cells which keep the nickel-cadmium battery—the only power supply needed—fully charged. If a normal mains supply is available a battery charger can replace the solar convertors.

The compact, fully-transistorized radio transmitter with its bank of solar convertors can be mounted on top of remote high-voltage transmission-line towers or in similar exposed locations where normal power supplies are not available.

The instant a pre-determined danger point is reached, alarm contacts operate and bring the transmitter into operation and warning signals are flashed to a central control point.

Known as the type 68 system, the equipment has been designed to operate in conjunction with the v.h.f. radio control networks now operated by many public utilities. Use is normally made of the frequency allocated to the mobile-to-base channel of these networks, so that alarm facilities can be provided without the need for additional radio channels.

**For further information circle 42 on Service Card**



*This shows one of the solar-powered transmitters being mounted on a high voltage transmission-line tower*



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# EXHIBITION REPORT

**As a logical sequel to last month's 'I.E.A. Preview', included here is a further report on some of the more interesting products which were demonstrated and shown at the International Instruments, Electronics and Automation Exhibition from 25th to 30th May.**

THE 1964 I.E.A. Exhibition opened in a truly expansionist mood with the combined electronics, electrical and instruments industries having achieved new export records, showing an increase of 6½%. Export turnover of the combined industries is now almost one million pounds a day. This report went to press before the final attendance figures were available, but it was anticipated that the earlier estimates of 100,000 visitors should be achieved and possibly exceeded.

Although the latest mechanical, electro-mechanical and electronic devices were to be seen in profusion at the exhibition, electronics in all shapes and forms dominated the show.

### Industrial Control and Measurement Devices

The application of electronics to industrial and scientific processes and problems invariably means the provision of control and measurement facilities. These were more than amply evident around Olympia—in fact the theme could well have been measurement and control. It was particularly pleasing to see so many relatively simple electronic devices which have been designed to do a useful job of work. One such device is the Electrolevel (43) which was demonstrated by the British Aircraft Corporation. This is an electrical remote reading 'spirit level' that can supplement or replace the conventional spirit level. The principle of the Electrolevel has been derived directly from the spirit level. A glass vial, with its upper surface ground to a uniform radius, is provided with three electrodes and is partly filled with an electrically-conducting fluid. Movement of the bubble changes the resistance values of the electrical paths between the electrodes. These resistance changes are detected by a simple bridge circuit, amplified and displayed on a meter with a scale calibrated to give gradient. The instrument is provided with scale ranges giving a gradient range 0·005 thou. per in. (1 arc sec) to 10 thou. per in. (33 arc min). Facilities are also provided for an auxiliary remote indicator or recorder and for use of six or more sensing heads via a selector switch. Sensitivity is such that a bubble movement of only 0·001 in. can be readily displayed.

Level indication of a different kind was featured by Fielden Electronics with their range of level gauges and monitors. One instrument, known as the Telstor 62 series continuous level gauge (44), indicated to visitors the trend in this form of instrumentation for the continuous indication and measurement of levels of liquids or granular solids. In this, the transistorized circuit is so small that it may be incorporated as a completely potted unit in the head of a standard electrode. In operation, the probe is inserted in a vat or tank and forms a capacitor with the side of the tank. The dielectric of the capacitor will be air when the tank is empty and the liquid or granular solid when the tank is full. The change in dielectric from air to the material being monitored produces a change of capacitance which is a direct measure of the level of the contents. With the Telstor 62 the capacitor formed by the probe and vessel is charged from a low-impedance source and then rapidly switched by the transistor circuitry to discharge into a low impedance. The mean discharge current, which is a direct measure of the capacitance, is monitored and provides a continuous and accurate indication of the level of content of the vessel. The read-out meter can be remote from the measuring head.

Another unusual approach to an industrial measuring problem was demonstrated by the Wool Industries Research Association. This was in the form of a small and easily handled tension meter (45) which can be used on machines where the yarn is not accessible to more conventional meters. Designed for measuring tensions of running threads in textile processes, it gives steady readings of the average tension irrespective of the rapid tension fluctuations inherent in the process. The meter uses a conventional 3-pulley system, the centre sensing pulley being mounted on a cantilever. The strain in the cantilever is measured by silicon strain gauges, which form two arms of a normal resistance bridge. The change in resistance of the gauges with tension is sufficiently high to measure the resultant out-of-balance bridge current with a microammeter when the bridge is fed with stabilized 6 V d.c. Average tension measurement is obtained by damping the meter with a capacitor.

To keep pace with the ever-increas-



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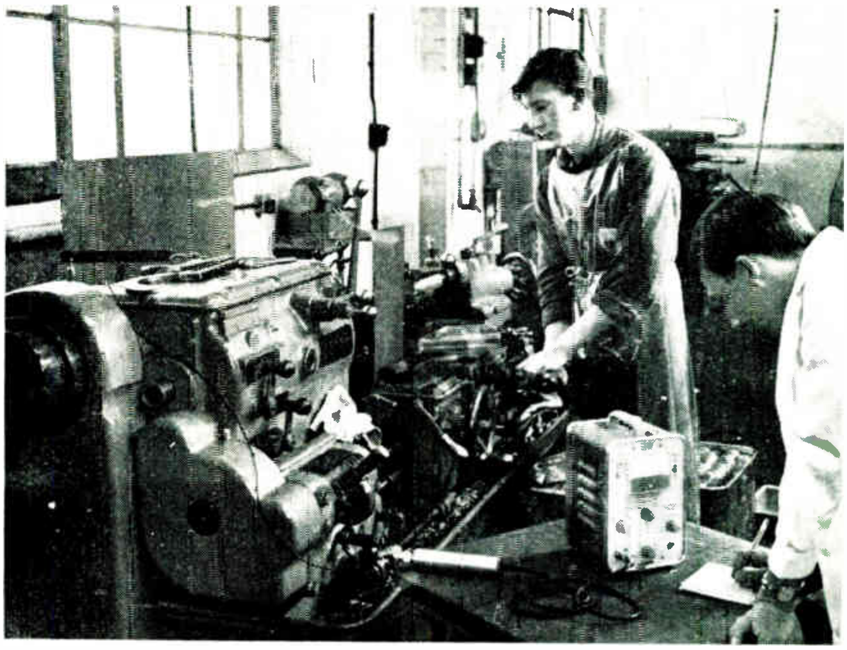
ing need in industry for improved quality control more manufacturers are turning to non-contact gauges to improve dimensional tolerances during production. Many such devices were to be seen around the exhibition, some using beta sources, others using X-rays and, of course, optical gauges. Daystrom were showing both X-ray and optical devices. Their 'Xactray' gauge (46) has been designed for use with rolled or web products. This gauging system comprises an X-ray generator and X-ray pick-up, and a pick-up amplifier and output meter. When installed the X-ray generator emits a thin beam of X-rays through the material being gauged. The small proportion of the beam energy emerging from the strip is received by the pick-up, amplified and fed to a meter which has its dial calibrated in material thickness. Alternatively the output signal can be fed to a printer or to an automatic thickness control device. Five models of the 'Xactray' gauge were shown giving a range from 0·00035 in. for aluminium foil to 2 in. for steel plate; any one model has a thickness range of up to 200 : 1. Accuracy is better than ±1%.



*Illustrated here, measuring vibration on the headstock of a lathe, is the Dawe type 1433 vibration meter. Introduced at the show, it is a portable industrial instrument which gives a direct reading of displacement, velocity, acceleration and jerk (53)*

For process control Photoelectronics featured their type S.S.T.I. solid-state switch (47) which combines a photoelectric switch with an electronic timer. This provides a photoelectric switch action when an object causes the light intensity from an associated light transmitter falling on the photocell or phototransistor to change. In addition, the timer, operating as a delayed-time device, holds-on the switching action for a pre-set period, irrespective of the input conditions. The standard unit is adjustable between 0·1 and 10 sec delay time.

Yet another facet of electronics that has made great strides in the past few years is data transmission over telephone lines, primarily for remote monitoring and control. Notable among these is 'Teleshift'—a frequency shift l.f. multiplex system (49) shown by G.E.C. Electronics. This is designed to give higher data transmission speeds with efficient transmission despite poor line conditions. It uses 24 separate channels 120-c/s apart between 420 and 3,180 c/s. Information is transmitted by shifting the carrier frequency either up or down within the pass-band of the receiver filters. This system is used for the G.E.C. 'Teleducer' (50), a system intended for long-distance transmission of analogue quantitative information simultaneously with control and alarm facilities. Also it is used for 'Telescan' (51), a time-division multiplex system for economical transmission of on-off information over long distances.

Industrial process control and monitoring were not forgotten: in walking around the exhibition it was possible to see a great deal of equipment designed for analysis. To quote three of the many—Perkin-Elmer were showing five instruments of particular interest to the chemical analyst. Plessey offered a new analytical process control concept in metal production, and Pullin showed a fully automatic densitometer which checks operator radiation exposure in 14 seconds. One of the instruments for chemical analysis shown by Perkin-Elmer was their model 521 infrared spectrophotometer (54). This covers, in one continuous scan, the entire spectral region from 4,000 to 250 cm$^{-1}$ (2·5 to 40 $\mu$). High resolution spectra, presented on a linear wave number basis, are obtained completely automatically. Features such as speed suppression, automatic gain control and ordinate scale expansion are included to increase both speed of recording and accuracy. Plessey-U.K. highlighted the American-made Kaman nuclear generator A900 (55) and their 'Analox' analysis system (56). This is claimed to be the first such analysis system to be developed using neutron activation to determine automatically the oxygen content of metal samples. The A-900 generator takes the form of a mobile accelerator with a control

*Honeywell's new on-line mass flow computer introduced at the show. It is built from standard plug-in modules and accepts input signals from a variety of devices. The accuracy is ±0·5% over the temperature range 30°F to 120°F (48)*

*New for the show—the Epsylon MR1080 magnetic recorder. This is fully transportable with record and replay facilities up to 16 channels. It is designed to operate at altitudes up to 70,000 ft and temperatures from 50°C to −50°C (52)*



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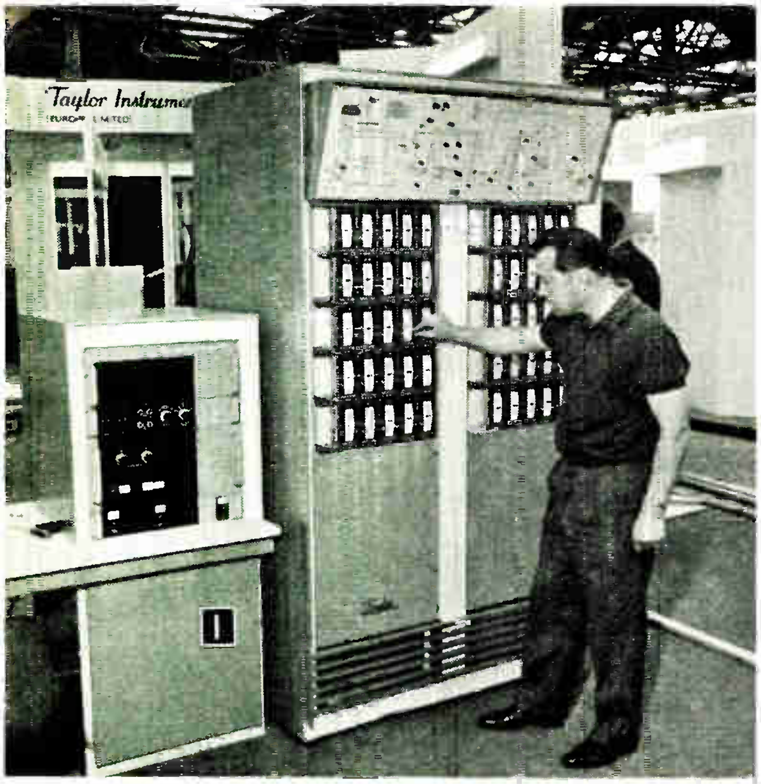

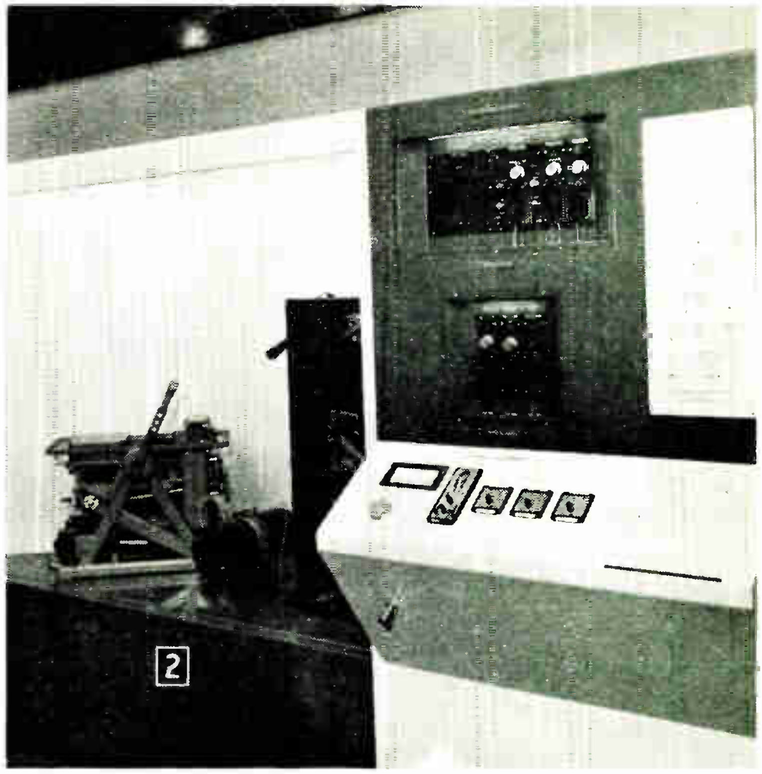

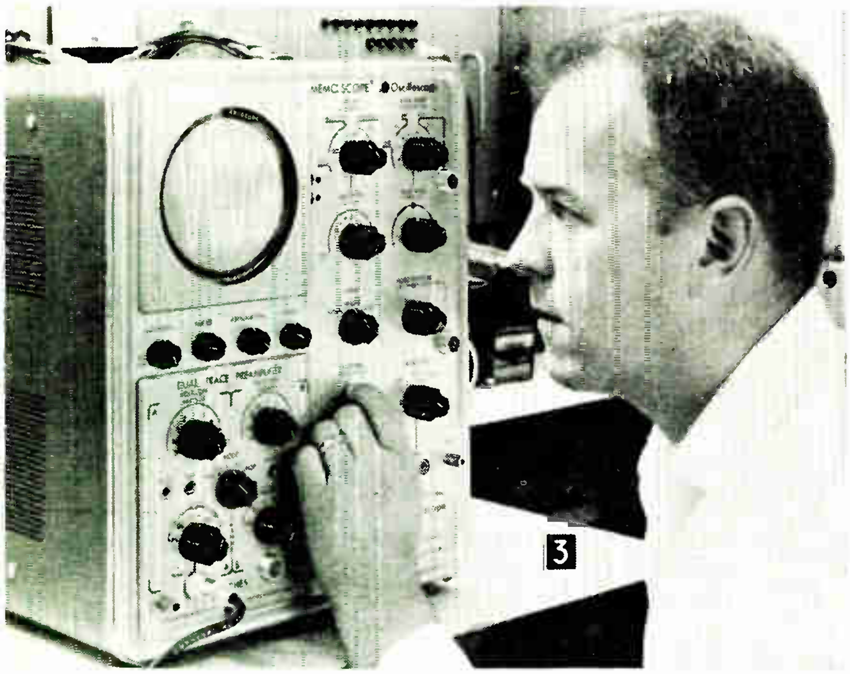

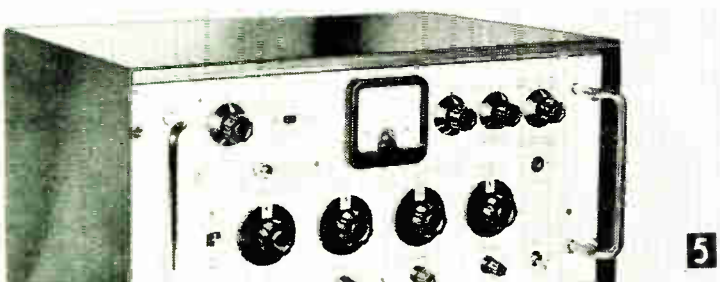

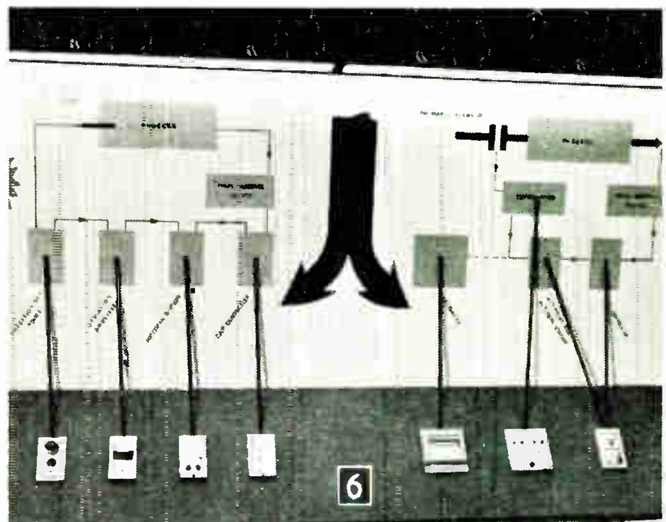

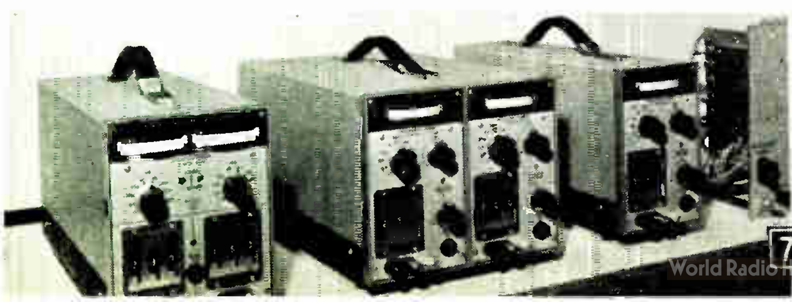

*1 Taylor Instruments' 'Quick-Scan' modular process control and recording system (57). 2 Bailey Meters & Controls' 'Bailctronic' modular control system simulating power station control (58). 3 Hughes' 'Memoscope' that can store a display and 'write' at a speed of a million inches per sec (59). 4 Veeco Instruments' RGLL-6 ionization gauge control (60). 5 G. & E. Bradley's type 125 a.c. calibrator (61). 6 Leeds & Northrup's 'M-Line' modular cascade control system (62). 7 Solartron's AS 1410 and 1416 stabilized power supplies with digital read-out (63)*

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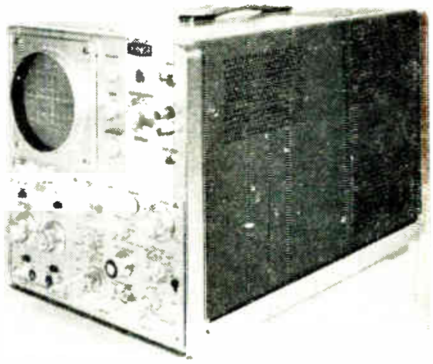
console. The accelerator contains an ion-source, extractor-focusing electrode, accelerating column, an ion pump, drift tube and a water-cooled target. The target can be reloaded with samples from the control console without opening up the accelerator. The ion source is designed to deliver a fixed-focus beam in excess of $600 \mu A$ to the target with only moderate gas consumption.

For analysis of the radiation dose received by workers, Pullin were showing an automatic densiometer (64). The instrument will be used in conjunction with a new type of film badge worn by each worker on his lapel. This badge has six separate screened areas to differentiate between the various types of radiation. Magazines containing 200 of these films are loaded into the instrument, which then picks them up singly; reads a code-number identifying the wearer; measures by optical means the amount of blackening produced by radiation on each area of the film; prints out the information; and records it on punched cards for long-term dose assessment by a computer. In addition, any film indicating excessive exposure is diverted for special investigation. The complete cycle takes about 14 sec per film.

Needless to say, all of the leading computer manufacturers were represented at the I.E.A. Exhibition. Each in their turn they were trying to demonstrate in an interesting and meaningful way how their machines could perform the complex and efficient processes that they have been designed to do. This is a very difficult problem, but most manufacturers were able to demonstrate the potentialities of their machines. Marconi were featuring on their stand a prototype ultra-high speed computer (65) which is to form the basis of their next range of machines. Derived from air traffic control and military requirements, it is claimed to be ten times faster than computers of comparable complexity currently available and, therefore, to have ten times the potential on-line capacity. It was demonstrated performing over 30 million orders per minute.

Elliott-Automation's display could only be described as a self-contained exhibition within the exhibition, with some of the products of nearly 50 associated companies and divisions being displayed. Computers were given pride of place. For industrial process control, the ARCH family of computing systems (66) was being demonstrated carrying out representative data-handling operations in real-time. Demonstrations were designed to show that the range extends from the simple 18-bit 4,000 operations-a-second ARCH 1000 to the versatile 20-bit 500,000 operations-a-second ARCH 6000.



*This CD100 modular oscilloscope was one of the many devices shown by Cossor. Using semiconductors throughout it is designed to accept a range of plug-in units. Conventional sweep and delayed-sweep facilities are provided along with Y-amplifier sensitivities of up to 500 $\mu V/cm$ and bandwidths up to 35 Mc/s (70)*

EXHIBITION

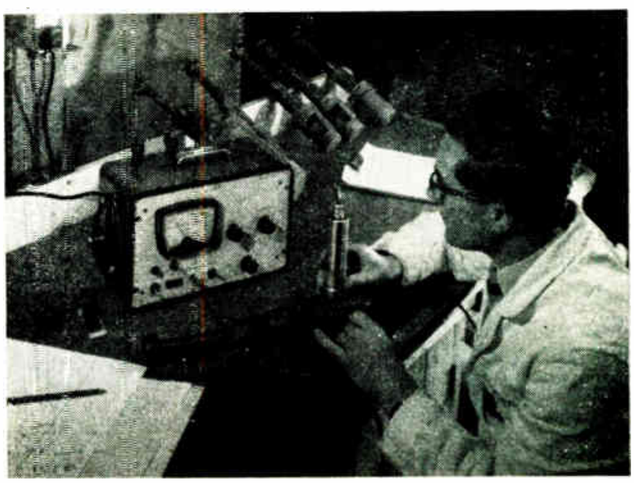
### Instrumentation for the Engineer

As was forecast in the 'Preview', the instruments at the I.E.A. Exhibition were indeed a very great attraction to hundreds. Wherever an instrument was shown there were people ranging from the what-happens-if-I-twiddle-this-knob type to those willing to discuss design philosophy and, of course, those who tell the manufacturers what is wrong with their latest developments before they have been released! Representative examples of all known electronic instruments were to be found at Olympia; some of the trend-setting devices are included here.

Southern Instruments were showing for the first time their M1800 series f.m. preamplifier unit (67) and G500 series transducers (68). Together these are intended to form the basis for the measurement of physical parameters. One of the standard transducers operates at temperatures of up to 2,000 °K and provides a voltage output proportional to pressure. The associated f.m. unit has an analogue output of ±3 V which is monitored on a meter and a digital output of 30 to 70 kc/s. The complete system may be physically or electrically calibrated in situ.

Magnetic recording equipment for instrumentation, data processing and communications was to be seen on many stands. Typically, Data Recording were displaying a number of recorders including their Data 540 unit (71). This provides, in a transportable form, facilities for recording up to 16 channels of information. Bandwidths of d.c. to 10 kc/s ($\frac{1}{2}$ dB) and 100 c/s to 100 kc/s (2 dB) are available on interchangeable f.m. and direct record/replay channels. Standard tape transports cover speed ranges from $1\frac{7}{8}$ to 60 in./sec.

In announcing the model 20150 XY/T plotting instrument (72) at the I.E.A., Bryans demonstrated in a practical way that increased production and sales can benefit the customer. While this model retains the performance of earlier instruments and offers certain additional facilities, the price has been reduced by nearly 19%. The 20150 has a graph area of 15 × 10 in. and a maximum writing speed of



*Displayed at the exhibition this radioactive thickness-measuring gauge has been developed by Panax Equipment. It is shown here being used by Audco Ltd. to check a very thin non-metallic coating applied to the plug of a chemical valve (69)*



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37 in./sec. A built-in time-sweep generator drives the pen along one axis at speeds from 0·1 to 10 in./sec. Automatic pen lift and flyback facilities are incorporated and the accuracy is 0·2% of full-scale deflection.

Developed to meet the demand for greater precision in electrochemical-potential measurements, the model 1019 research pH meter (73) was shown by Beckman Instruments. This is primarily intended for use in studies where minute changes in pH or millivolt potentials can have a significant meaning. It combines the inherent accuracy of null-type readout with the stability of its transistorized a.c. chopper-stabilized amplifier. Accuracy (relative to a buffer standard) of ±0·001 pH with repeatability of ±0·005 pH is attained. Other features include continuously variable sensitivity, output for recorder, and temperature compensation adjustable to the nearest 0·05 °C.

Comprehensive test instruments each providing different, but many, test facilities were demonstrated by Croydon Precision Instrument (Cropico) and Gresham Electronics. Cropico's AC/DC test set type TS1 (74) contains everything necessary for normal test-room measurements. It includes the equivalent of a d.c. potentiometer, volt ratio box, resistance standards, Kelvin bridge, Wheatstone bridge, and a.c. transfer standard. It is marketed at something less than half the total cost of separate instruments of comparable accuracy. Using a built-in galvanometer it provides for the measurement of resistance from 0·01 Ω to 10·99 MΩ; d.c. voltage from 1 μV to 650 V; direct current from 1 μA to 5·4 A; a.c. voltage from 2 V to 650 V; and alternating current from 5 mA to 5·4 A.

For television network testing Gresham Electronics were showing their type P.B.1 sine-squared pulse and bar waveform generator (76). This single line standard is available in three models for 405-, 525- or 625-line operation. It generates a waveform which can be used in the measurement of variation of gain with frequency, phase distortion, insertion gain, ringing and reflections. The P.B.1 can be supplied as a portable unit or for standard 19-in. rack mounting.

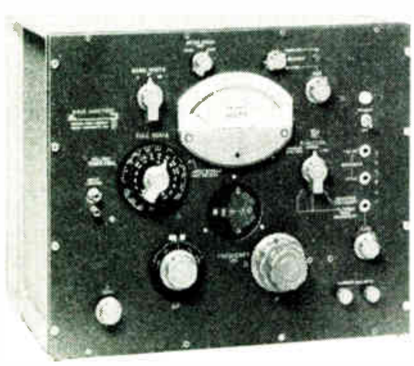
One of the entirely new oscilloscopes demonstrated by Tektronix typified three of the trends in this field. The first is the use of semiconductors throughout; the second is ruggedization of the oscilloscope; and third is the apparent realization that a bandwidth of 50 Mc/s is more than adequate for a great many applications. This type 647 oscilloscope (79) has been designed as a fully transistorized and ruggedized instrument with a bandwidth from d.c. to 50 Mc/s and a sensitivity of 10 mV/cm. It has calibrated sweep delay, dual-trace capability and a bright 6 × 10 cm no-parallax display. Dual-trace capability is provided by a plug-in amplifier and parallax is reduced to a minimum by the use of a tube with a parallel-ground glass face-plate. Amplitude accuracy is ±1% to 2% (depending on the range) from 0 °C to 40 °C and ±1·5% to 3% down to −30 °C and up to 65 °C. The environmental characteristics published by Tektronix cover in great detail temperature, vibration, altitude, shock, humidity and transit—suffice to say here that the figures really justify the ruggedized claim. One interesting point, the tube in the 647 is mounted in the central position of pre-Tektronix days.

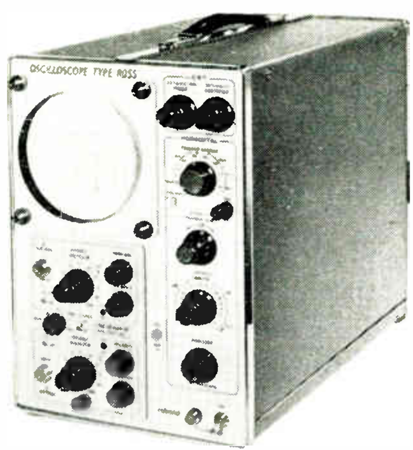
An oscilloscope camera is one of the products introduced by Avo at the show. It is a joint product of Avo and Beattie-Coleman Inc., of California. Avo-Beattie-Coleman oscilloscope cameras (80), although relatively inexpensive, use the latest Polaroid flat pack film, and have optional data-recording facilities. Adjustable ratio, multiple exposures and a choice of lenses up to $f/1{\cdot}2$ are other features. The 'A-B-C' camera can also be used for 'off-scope' photography.

In electronics, as in all industries, demand often dictates the development of a new class of machines. This is a possible explanation for the great number of digital voltmeters which are now being produced. In this group of devices International Electronics introduced their low-cost DSV.1 digital voltmeter (81). This is basically a 3-digit 0·1% instrument. It has four basic ranges of 1, 10, 100, and 1,000 V f.s.d., but the basic sensitivity is such that it will operate directly from most thermocouples to give a discrimination of 0·1 °C over 0–100 °C. The maximum conversion time is 10 msec and the instrument takes about 20 readings/sec.

*(Left) Illustrated here is the ratemeter type M5190 one of the new range of Ekco transistorized nucleonic equipment which also includes a scaler, timer, amplifier/pulse height analyser, and a high voltage unit (77)*

*(Below) On view at the I.E.A. was this General Radio type 1900-A wave analyser. It features switch selection of 3-, 10-, or 50-c/s bandwidth (75)*






*(Above) One of the four low-cost oscilloscopes introduced at the I.E.A. by Roband. Each unit uses a 5-in. c.r.t. The instruments are designated R050, R051, R055 (illustrated here) and R0501. They range from a wideband precision unit to a general-purpose servicing 'scope (78)*

## Components

Although forming the last section in this report, components are by no means the least important—nor should it be construed that they represented or captured a minority interest at this year's I.E.A. Exhibition. In fact, components in all shapes and sizes made up a relatively large proportion



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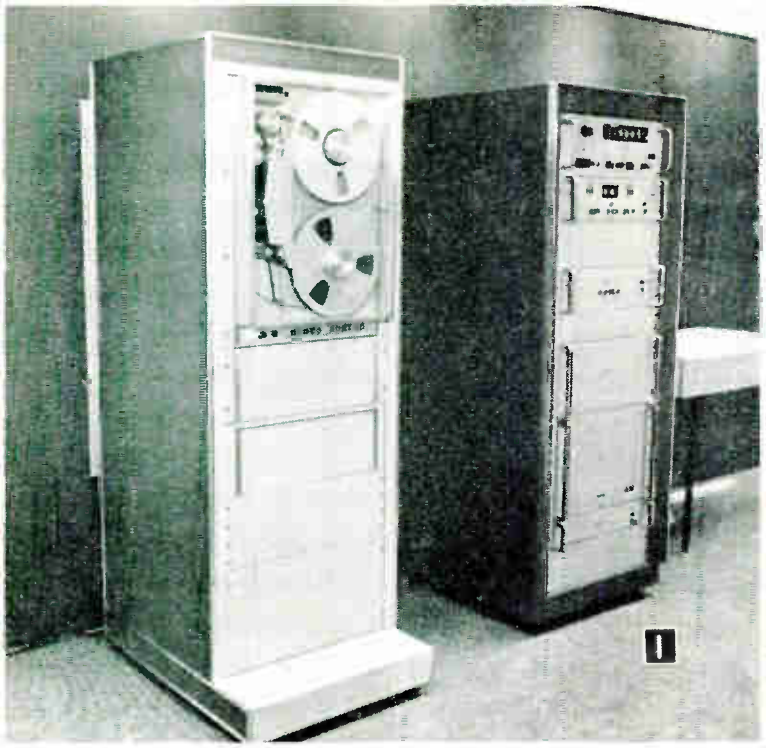


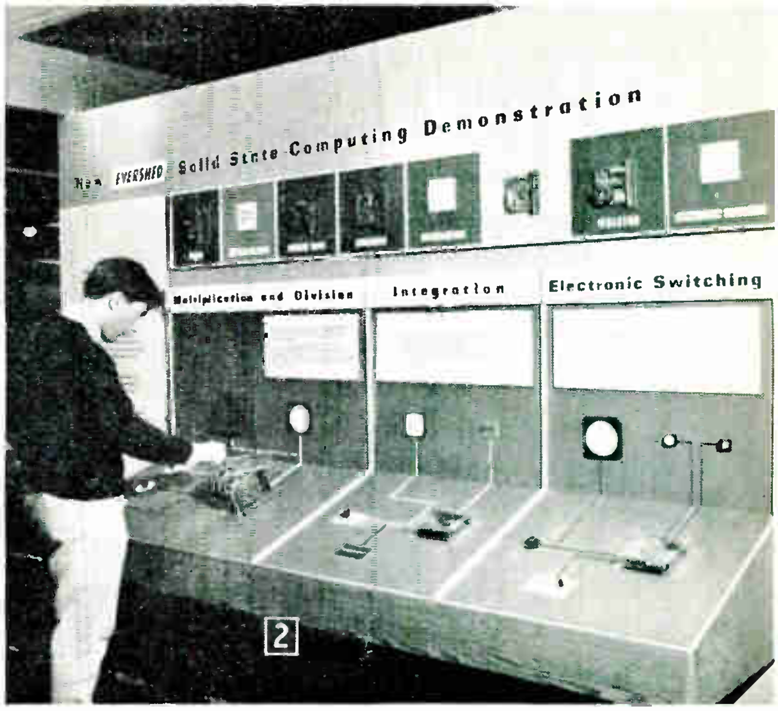


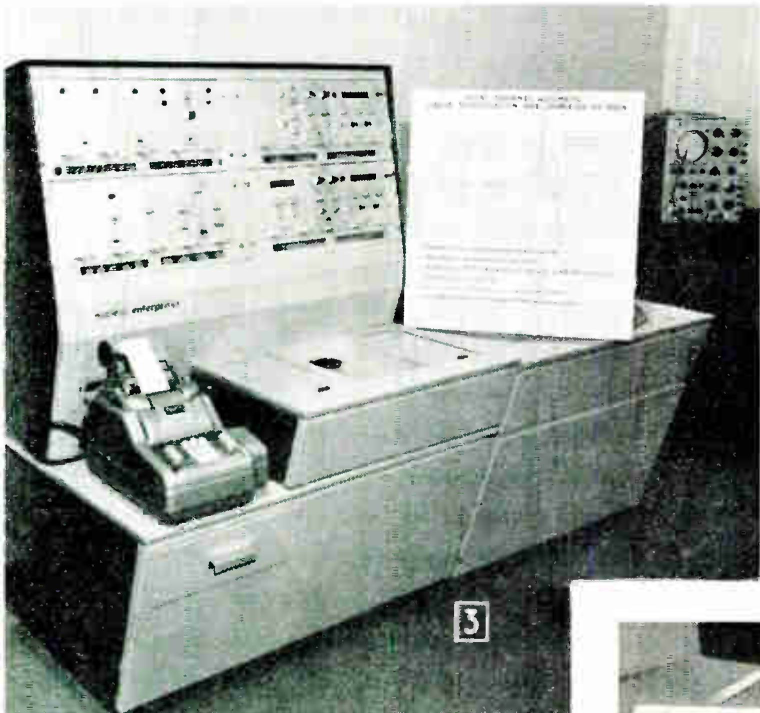


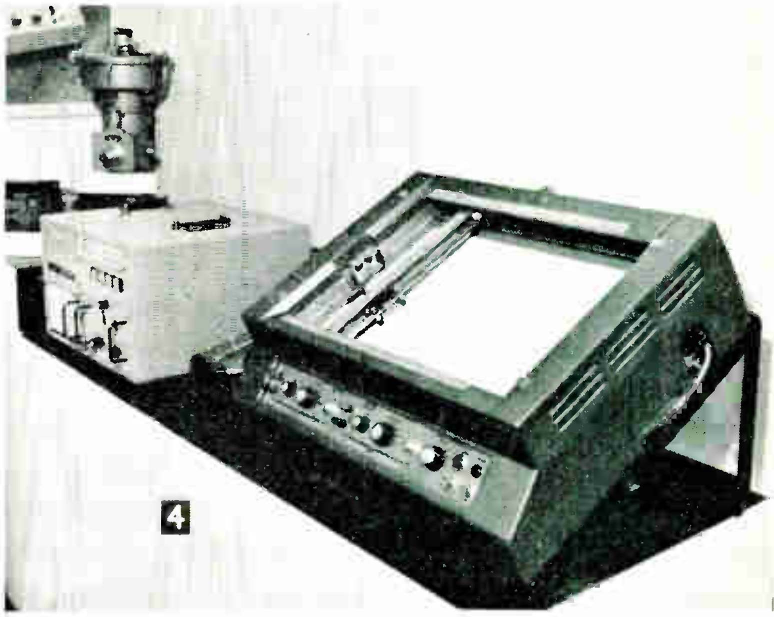


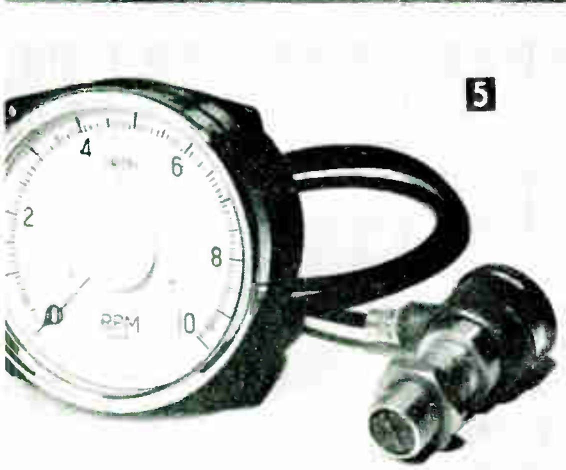


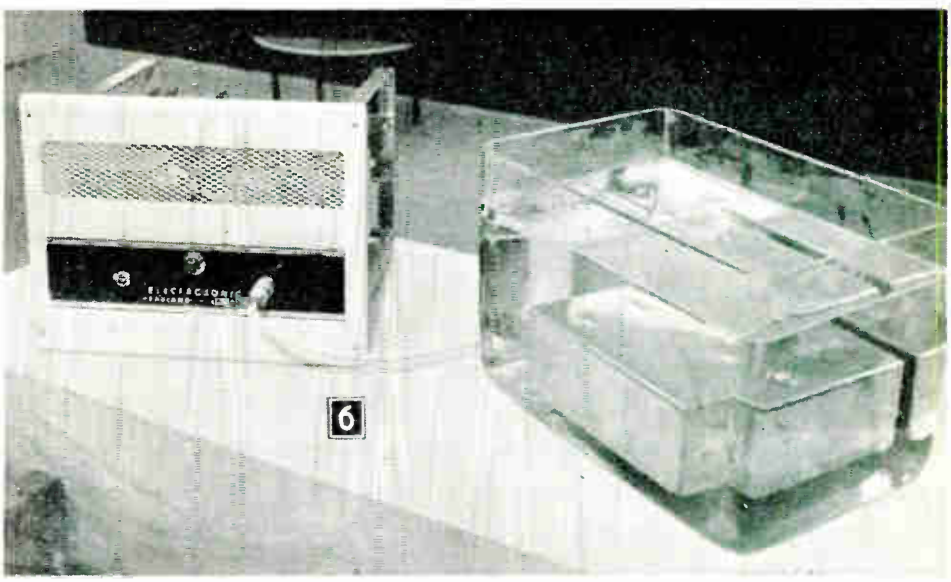


1 *Hewlett-Packard's industrial data acquisition and recording systems (82).* 2 *Evershed & Vignoles' series 300 solid-state module system for process control (83).* 3 *Nuclear Enterprises' liquid scintillation spectrometer (84).* 4 *Bryans Aeroquipment's XY/T plotter (85).* 5 *Smith's electronic tachometer (86).* 6 *Headland Engineering's ultrasonic generator H225 and submersible transducer (87)*



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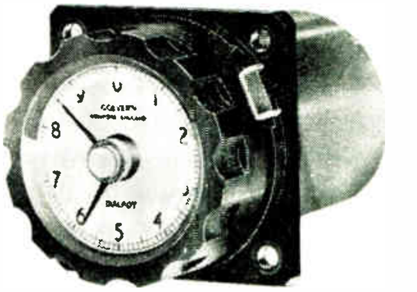
*A portable power-operated crimping tool which was demonstrated by Plessey-U.K. Compressed-air driven, this UNIcrimp is capable of one-hand or foot-pedal operation and makes square-form crimps on any size of wire or contact up to 12 a.w.g. (88)*



*(Above) This Colvern 'Dialpot' received much attention. It is a 10-turn helical potentiometer with an integral clock type dial. 100 divisions on the dial give 1,000 settings over the 10 ten turns. There are 3-W units available in the resistance range 100 Ω to 100 kΩ; standard linearity is ±0·25% (94)*

*(Left) This is one of the English Electric Valve Company's 75A vacuum variable capacitors. There are five types in the series (95)*

of the exhibits and received as much attention as any group of products.

In addition to the hundreds of conventional components on show there were many interesting new devices and radical developments. One such component is the Vacsyn slow-speed synchronous motor (89) which formed the subject of a working exhibit on the stand of Vactric Control. The Vacsyn motor is designed to produce high torque at low speeds to obviate the need for reduction gears. At 50 c/s, its synchronous speed is 60 r.p.m., giving a minimum synchronous torque of 150 ounce-inches corresponding to an output power of 5·5 W. This can also be used as a stepper motor.

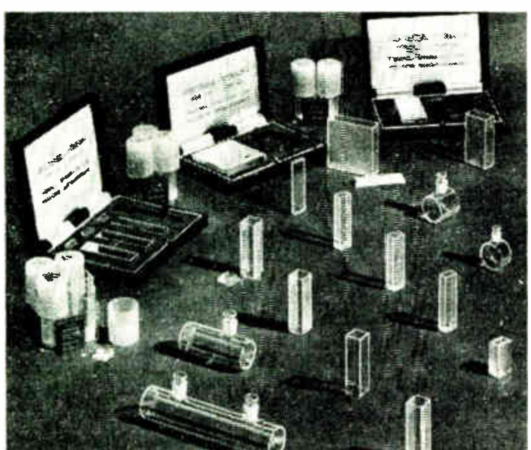
Components for thermal de-icing were featured by Technograph & Telegraph. Known as thermal de-icing elements (90), they are produced from resistive foil of the nickel-alloy type and are supplied on a flexible backing which can act either as a permanent or temporary support. These elements can dissipate 25 W/sq in.

Talk of components and Bulgin invariably springs to mind. Perhaps this is because, as at this show, they always seem to be introducing a mass of new products. One that caught the eye (no pun intended) was their D.920 legend neon signal lamp (91). Mains operated, the primary use of this is as a legend indicator where the legend falls into two areas, a permanently visible area and an area that is secret-until-lit. For example, when used for lift indication floors 1, 2, etc., could be permanently visible but an illuminated pointer-arrow could light up as each successive floor is reached. The legend measures $1\frac{15}{16} \times \frac{5}{8} \times \frac{7}{8}$ in. deep.

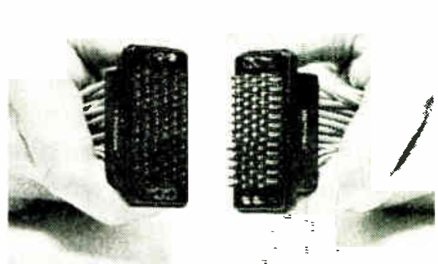
Universal throughout all industry is the need for first-class drawing paper. Ilford may have at last provided the answer to the draughtsman's plea by introducing a super-matted polyester drawing film called (Draflex (92). It was demonstrated that it has a surface capable of accepting all standard makes of quality pencil, all drawing inks, and typewriting; and is waterproof. Because of the film's coating multiple erasure is possible and no surface preparation of 'talcing' or 'pouncing' is necessary to ensure an even, blob-free ink 'take'.

To indicate the angular position of any shaft in binary code, Ferranti have developed and were showing a size 23 optical shaft encoder (96). The Gray code—a cyclic binary—is photographically reproduced on a glass disc mounted on the input shaft and consists of 10 annular tracks each with a pattern of opaque and transparent sections. The code reading system employs a filament lamp and a lens from which the light passes through the disc and a narrow radial slit to be detected by 10 photocells. Depending upon the position of the shaft,

*(Continued on page 283)*



*Thermal Syndicate featured large bore 'Vitreosil' fused quartz, a fused silica tubing, and 'Spectrosil' windows for use in the ultraviolet region. No variation is evident between cells. Additional advantages include increased transmittance towards the short u.v. and virtual freedom from fluorescence (93)*



*One of the BICC-Burndy MS-M Hyfen connectors exhibited at Olympia. These employ crimped, snap-locked removable contacts and allow subminiature coaxial and/or equipment wire interconnections to be readily made (97)*



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## *SATURABLE REACTORS

are chokes whose impedances may be varied by the flow of the direct current in the special winding. Fully tapped reactors are designed to vary the input voltage to any load between half and full rating of the reactor itself, from near zero to the full operating voltage, at mains voltages between 380/440v, 200/250v and 100/120v, A.C., 50 cycles, by the application of a small direct current on the control winding.

Correx reactors are available in standard ranges for powers up to 180 kVa per circuit on three phase operations. This refers to the 100% rating and not the possible uprating granted where reactors may be used on an intermittent rating i.e. furnace control where the rating utilization at control point may be as low as 60%. In addition to the well known Correactor and A.C.R. reactor this range includes Toroidal reactors and Auto-excited transductors.

**ABSENCE OF MOVING PARTS**
No brushes, contacts, etc. to wear out. No maintenance is required.

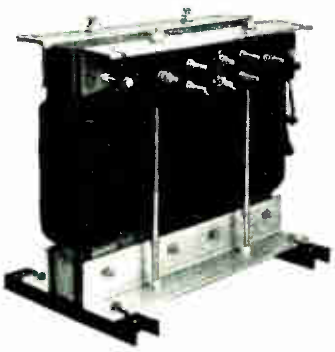
**CONSERVATIVE RATING**
For intermittent use particularly where current is drawn for a short period, these reactors will stand large overloads. They can therefore be considerably uprated for those applications where these intermittent requirements obtain.

**REMOTE CONTROL**
As a small potentiometer only is required for the D.C. control, the reactor need not be mounted on the control panel, and may be installed elsewhere.

**SMOOTH CONTROL ...**
Can be set to any predetermined voltage. There are no steps.

**HIGH EFFICIENCY**
Very low losses at all loadings.

# CORREX



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This range is readily available as individual units or as packaged systems designed to enable you to construct control schemes using the CORREX modular "add on" system.

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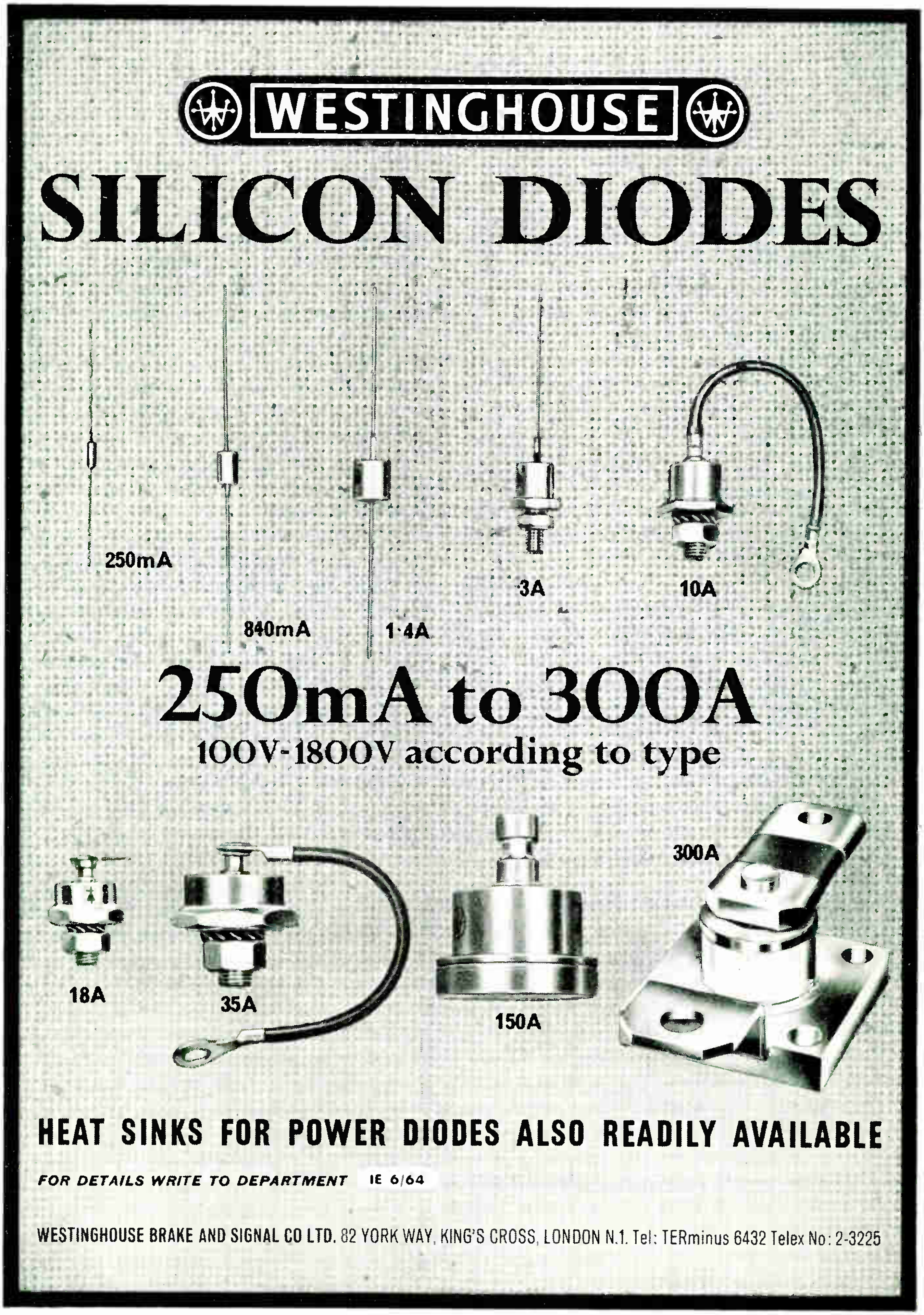




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certain cells will receive light through the transparent portions of the disc. The outputs from all 10 cells give the shaft position in coded form.

The first of a new generation of microwave components by The M-O Valve Co. had its debut at the I.E.A. This is a J-band packaged semiconductor microwave generator (98). Small, light, and exceptionally robust, this power source has an output signal frequency of 12 to 15 Gc/s, with a tuning range of ±140 Mc/s. The minimum power output is 15 mW. Spurious response is −30 dB up to +140 Mc/s from centre frequency, and the f.m. noise is 20 c/s in a 100-c/s bandwidth.

Monolithic construction, meaning an integrated whole, is being used for solid-state circuits and is now a technique being applied to capacitors. Typical of these are the capacitors shown by TCC and Electrosil. TCC monolithic ceramic capacitors (99) achieve a compactness almost comparable to electrolytics. They use multi-layer construction of thin ceramic dielectric films which are sintered with palladium electrodes into a solid block. Insulation resistance for these exceeds 10 k$\mathrm{M}\Omega$ or 10 k$\mathrm{M}\Omega\mu$F whichever is less; power factor $\tan\delta < 0{\cdot}03$ at 1 kc/s and 20 °C; operating temperature is 100 °C to −40 °C. A 2·2-$\mu$F, 25-V d.c. capacitor measures 0·5 × 0·415 × 0·25 in.

Electrosil 'Lo-Cap' capacitors (100) consist of two flat ribbons of metal (serving as plates and leads), a layer of dielectric glass, and two pieces of cover glass. All are fused into a solid, monolithic unit. The capacitance range of the Lo-Cap is 0·1 to 10 pF with tolerances of ±5, 10 and 20%. The capacitor is available in one case size of 0·38 × 0·2 × 0·09 in.

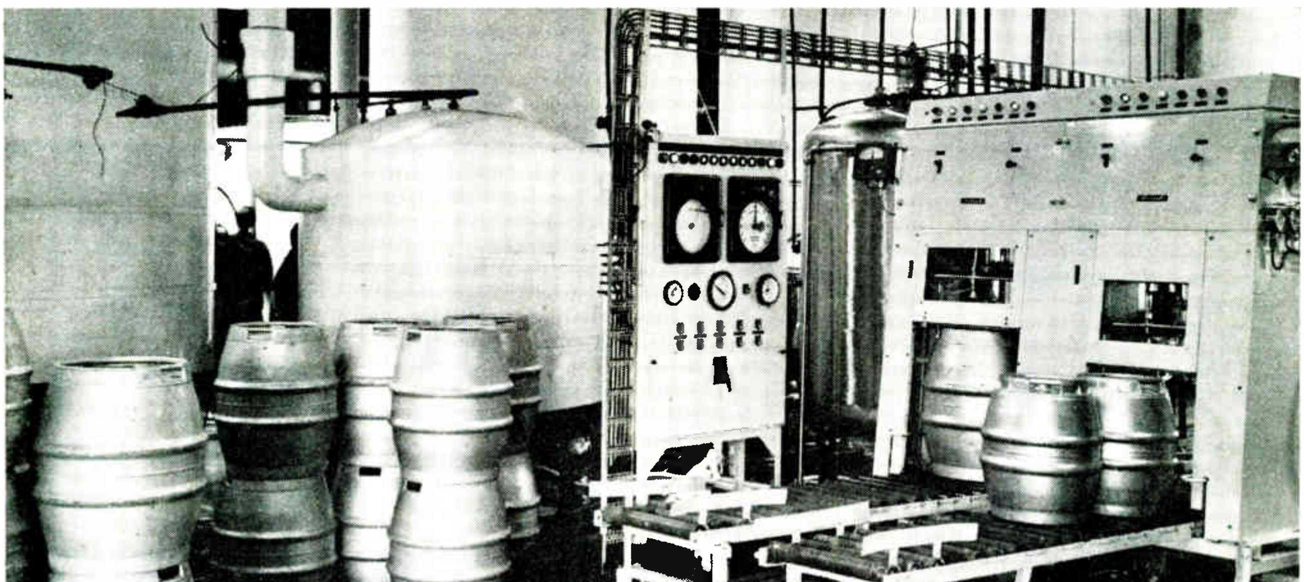
This necessarily brief report on the 1964 International Instruments, Electronics & Automation Exhibition is limited only by space and time and certainly not enthusiasm. With some 400 stands and thousands of products there was available a wealth of information—sufficient, in fact, to keep even the biggest computer on show busy for many weeks processing and storing it. Unquestionably, most people enjoyed their visit and benefited from it. Visitors and exhibitors alike agreed it was a first-class effort which had been considerably enhanced by the two-year break since the last I.E.A.

# Controllers for Beer Plant

An automatic controller which integrates the operation of continuous and batch processes has been developed by Londex. The first production units are being used on 'Paraflow' beer pasteurizing and keg filling plants made by A.P.V Ltd. of Crawley. In this application the controller has to cope with the opposing requirements of the pasteurizer, which operates most efficiently under continually stable conditions, and the intermittent demands of the keg filling machine .

Using timers and liquid-level controls the system adjusts the flow rate of the plant to suit the operating rate of the keg filling plant, while predetermined conditions of temperature and pressure are maintained. This allows complete automatic running of the pasteurizer which may be left unattended for long periods.

**For further information circle 101 on Service Card**





World Radio History

This article is based on some of the many interesting papers read at a recent symposium. The symposium, entitled 'Cold Cathode Tubes and their Applications', was held at Cambridge from 16th to 19th March by the Institution of Electronic and Radio Engineers.

# COLD-CATHODE TUBE APPLICATIONS

AT their first symposium since their change of name, from The British Institution of Radio Engineers to The Institution of Electronic and Radio Engineers, the I.E.R.E. brought together engineers from many countries to hear about and discuss the potentialities and present-day applications of cold-cathode tubes.

Some thirty papers were presented in the course of three whole-day sessions. The first session was 'Physics of Operation and Tube Development', the second 'Circuit Design and Reliability' and the final 'Applications of Cold-Cathode Tubes'. It is mainly the papers dealing with specific applications that are considered here.

Although semiconductors have held the limelight for the past decade, cold-cathode tubes have also progressed considerably and, when used properly, can do some jobs better than semiconductors. As is often the case in engineering each is superior to the other for certain applications only and in others they are complementary.

Cold-cathode tubes, also known as trigger tubes, form a large family of devices ranging from neon bulbs to numerical display or counting tubes. This very large family of devices has been developed to cope with a wide variety of applications. Typically, tubes are available for voltage regulation over the range 55 V to 27 kV and currents from 1 μA to 100 MA. Others make counting possible at frequencies up to 1 Mc/s, while a further group, known as relay tubes, have current gains from $10^6$ to $10^{12}$ and can be used to provide continuous control of loads up to 2 kW or switch peak loads of 10 MW. Yet another group has made the photographer's lot an easier one—high intensity light flashes from 1 μsec to 1 msec with colour approximating to daylight are available from electronic flash tubes.

One of the simplest forms of c.c.t. is a cold-cathode diode. This comprises two electrodes within an envelope containing a gas. With a low voltage across the electrodes the device is said to be in an 'off' state, meaning it presents a high impedance at its terminals. However, as the potential across the tube is raised, at a particular voltage level the tube will 'strike' (ionization takes place) and it will be 'on'—in its low impedance state.

For breakdown to occur not only must the voltage be sufficient, but also an ion or an electron is required to be in the inter-electrode gap. Priming agents required for the striking of a simple diode come from sources external to the tube, such as a light source that induces the liberation of photo-electrons from the cathode. In cases where a diode

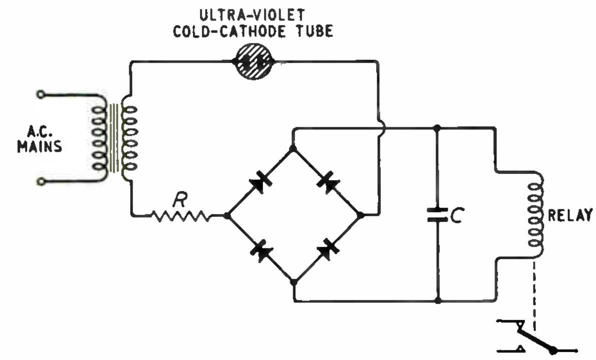



*Fig. 1. In this circuit the tube is used as an interruptor to provide an indication of the state of the burners. However this is not a fail-safe method*

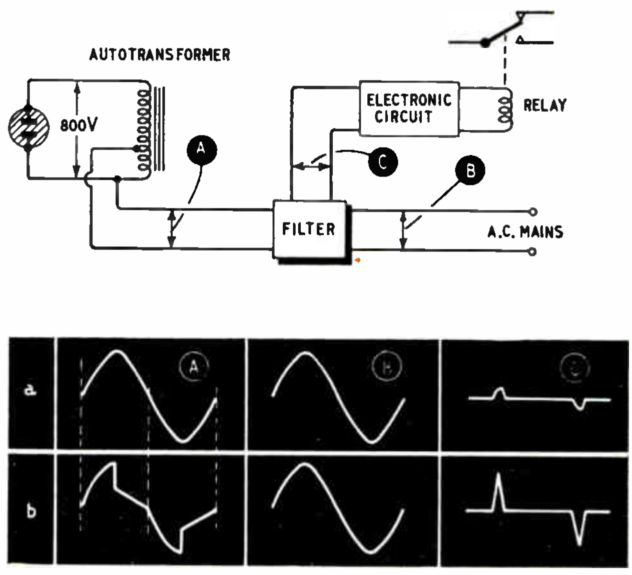



*Fig. 2. (Right) A fail-safe circuit with the c.c.t. used as a pulse generator. The diagrams show the waveforms at various points of the circuit (A, B, and C) for flame out (a) and flame on (b) conditions*



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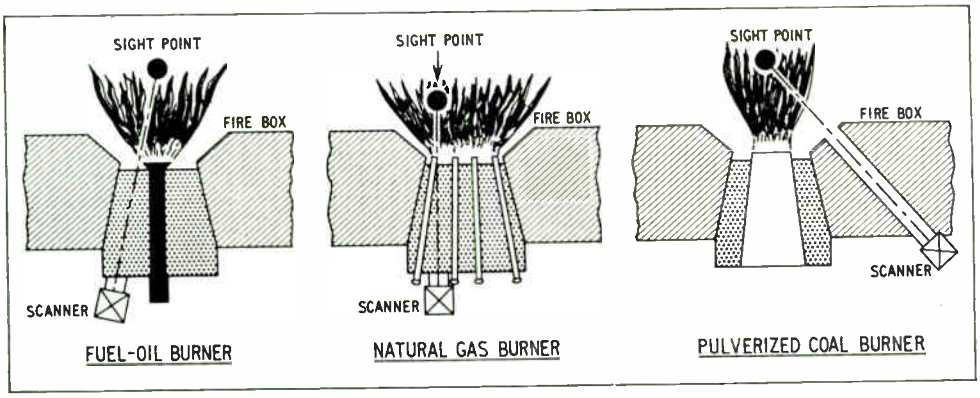


*Fig. 3. These artist's impressions show the positioning of the scanner (c.c.t.) for various fuels*

is required to operate in a dark enclosure cosmic-ray particles can produce ions and provide a supply of priming agents—albeit an erratic one.

It is because of erratic priming that diodes are not suitable for many applications and so development through the years brought about a third electrode within the tube, called the priming, trigger or firing electrode. This trigger is usually in close proximity to the cathode. A positive pulse applied to the trigger will cause local ionization but will not cause the tube to strike until the anode voltage is at a specific level. Taking a simple case, the anode voltage of a particular tube could be sufficient to strike the tube if primary ionization were to take place. Primary ionization will only take place when a sufficiently large pulse is applied to the trigger and then the tube will strike and glow.

**Burner Supervision**

At the symposium many applications of c.c.ts were described, but as usual it was the simple and unique which attracted most interest. One such paper was presented by J. M. Megnoux, of Electricité de France, and described an experimental system for detecting the presence or absence of flame on each burner of large steam generating boilers.

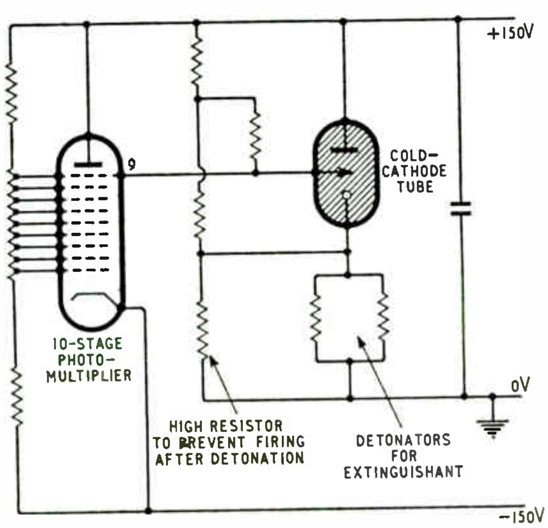


*Fig. 4. The basic circuit diagram of the circuit for explosion detection and suppression*

To add to the difficulties of design the system used had to be suitable for use in boilers using fuel oil, natural gas or pulverized coal.

Monsieur Megnoux and his colleagues investigated various photo-sensitive, heat-sensitive and other devices, but all proved to have undesirable industrial or practical characteristics.

Flames from the various fuels do not provide constant radiation over the electromagnetic spectrum. For all three fuels, the radiation level at the nose of the burner is lowest at the ultra-violet end of the spectrum and highest at the red and infra-red end. However, fire-box walls emit intense infra-red radiation, as do ashes and clinkers. It was therefore decided that the detection of u.v. radiation from each burner would be the most reliable indication of the state of the burners.

A cold-cathode tube requiring an external ultra-violet source to cause it to strike was used and, to date, has proved successful. The tube consists of two pure metal electrodes within an ultra-violet transmitting envelope filled with rarefied gases.

In operation, about 1 kV peak a.c. is applied to the electrodes and in the absence of the flame, and therefore absence of ultra-violet radiation, no current passes between the electrodes. When u.v. radiation is present the tube strikes, current flows and a relay is energized. Switch contacts are arranged to operate various indication and alarm devices.

The first circuit used, shown in Fig. 1, operated satisfactorily. However, the 'electronics' are sometimes located far from the burners and a short-circuit on the line joining the c.c.t. to the electronics would indicate the presence of a flame although there was no flame on the burner. This is therefore not a fail-safe system.

The circuit being used at present is truly fail-safe; this is shown in Fig. 2.

The operation of Fig. 1 is relatively simple. With u.v. falling on the c.c.t. and a voltage applied to it the tube presents a low impedance across its terminals. Although the applied potential is alternating, in effect ionization is continuous and current, controlled by a series resistor *R*, is fed to the rectifying bridge. The d.c. output from the bridge energizes the relay only while the flame is present.

The circuit of Fig. 2 is somewhat different in operation from that of Fig. 1. The tube is fed with a.c. from an autotransformer. With no flame, the c.c.t. will not strike and the current through the mains feed line will be sinusoidal a.c. at the mains frequency. A mains-frequency filter prevents the signal voltage resulting from this current from being fed to the electronic circuit. With a flame present



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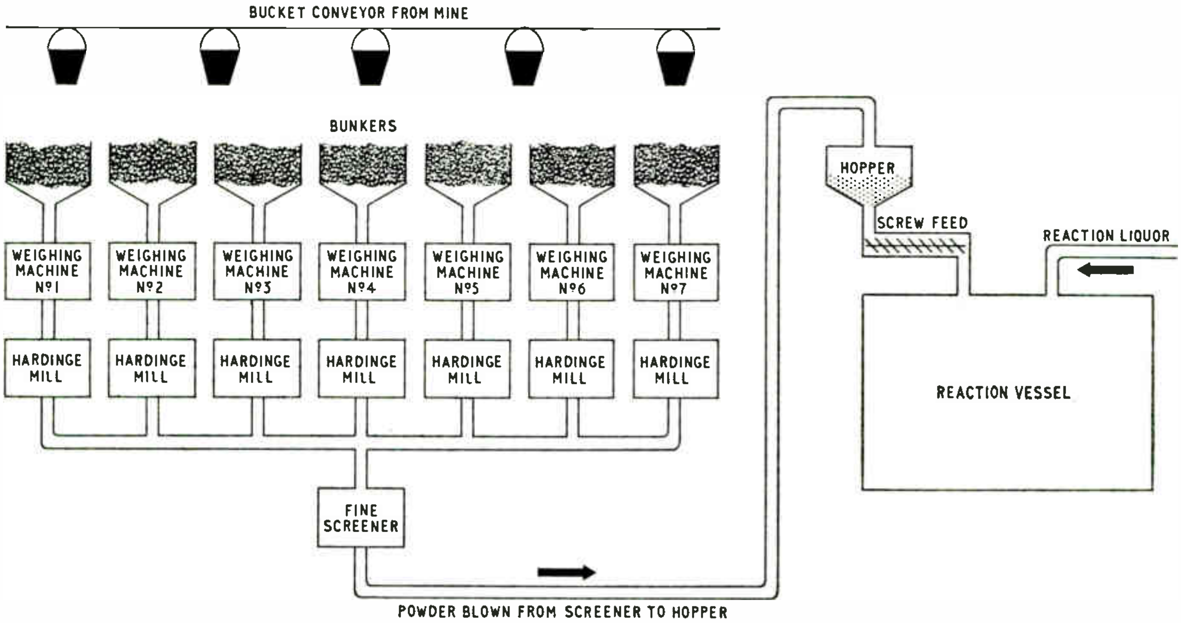


*Fig. 5. A schematic diagram of the plant fitted with a batch weight ratemeter*

it is arranged that the tube will strike, and therefore conduct, before the alternating supply potential reaches its peak value. This results in a non-sinusoidal current flow; this is illustrated by Fig. 2. The non-sinusoidal current produces a voltage of similar form at the input of the filter. The fundamental mains-frequency component is removed by the filter but the higher frequency is not. Therefore steep pulses are fed into the electronic unit. These trigger a pulse generator and produce an output which is later rectified and used to energize a relay.

A short-circuit in the cable connecting the tube to the electronics will only produce sinusoidal current flow. Thus no pulses will pass through the filter and energize the relay —this is therefore a fail-safe system.

### Installation Problems

There were two main installation problems: the first was how to keep the cold-cathode tube relatively cool and the second, how to prevent dust settling on the tube and reducing its pick-up sensitivity. Both were solved by blowing air past the tube.

One further problem was that of siting the c.c.ts in the three different types of burner. Depending on the fuel, and therefore the burner design, the u.v. region of the flame varies. Fig. 3 shows how the c.c.t. is mounted in different burners.

### Explosion Detection and Suppression

The phenomenon of explosion is somewhat a mystery to most. Therefore J. B. Collins' paper, 'Use of Cold-Cathode Trigger Tube in Explosion Detection and Suppression Circuits', was bound to provoke curiosity in some and perhaps scepticism in others. Within five minutes of the opening all were fascinated by this topic.

The object of the development was to produce a system capable of suppressing an explosion in an aircraft fuel tank. Successful suppression of an explosion demands detection and extinguishing action within a few milliseconds of its initiation.

In the system described by Mr. Collins, detection of the initiation of explosion is by means of a photomultiplier tube. The p.m. tube is fitted in the bottom of the tank viewing upwards through the fuel to the vapour space above the fuel. In the event of an initiation of explosion the tube detects the light and produces a signal that fires a cold-cathode tube. The tube is arranged to discharge a large capacitor through detonators which when set off propagate extinguishant from special containers within the fuel tank.

The basic circuit used in this system is shown in Fig. 4.

### A Batch Weight Ratemeter

Another industrial problem and its solution was discussed by W. W. Wood in his paper 'A Batch Weight Ratemeter Using Cold Cathode Triode Memories'. The basic problem was to monitor the output rate of each of seven batch-weighing machines.

Each machine is fed with crushed and screened rock. These machines independently weigh out $2\frac{1}{2}$-cwt loads of rock into separate Hardinge mills, where the rock is ground to a fine powder. Later the total output from the seven mills is mixed with a liquor in a reaction vessel. Maximum efficiency is attained when the solids-to-liquor ratio is held constant. Fig. 5 shows a schematic diagram of the plant installed at an I.C.I. division.

The flow of the liquor is easily controlled, but the rate of milling of rock and, therefore, the flow of solids is variable. Choking or malfunction in a machine or crusher can cause one or more weighing machines to stop temporarily until it has received a full $2\frac{1}{2}$-cwt load.

The problem is therefore to measure over a known period of time, typically 10 or 20 min, the total number of $2\frac{1}{2}$-cwt loads of material available for the reaction vessel. Seven separate cold-cathode memory units are used to store and display a record of the number of completed $2\frac{1}{2}$-cwt load weighings over a pre-set period of time.

Initially the equipment was built with 20-min memories to give a signal representing at any time the total solid weight weighed in the previous 20 minutes. Later it was found that better control was obtained with a 10-min delay in the instrument to simulate the plant lag. This was easily



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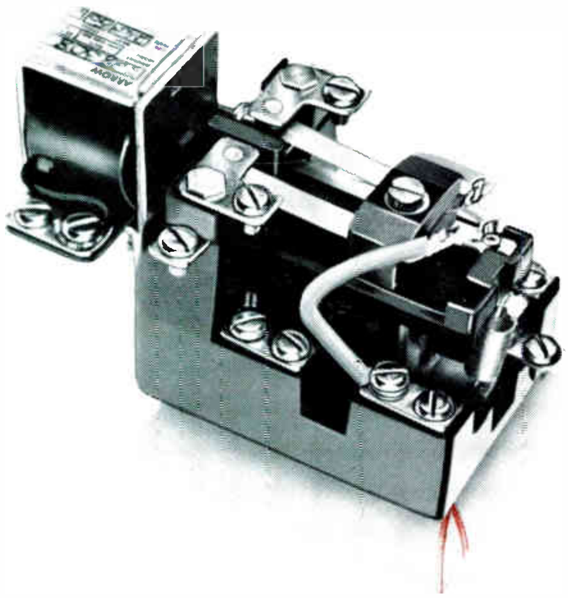

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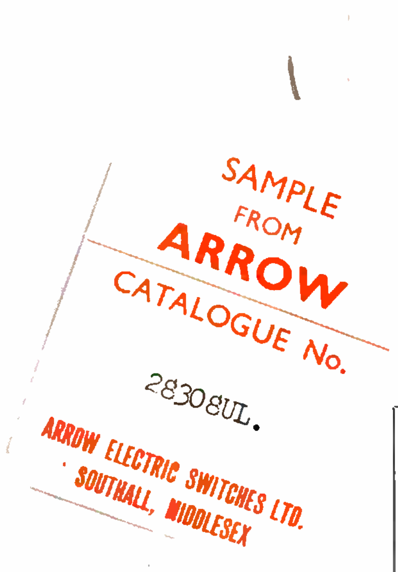


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|---|---|---|
| 0.1 | 0.1 | 0.033 |
| 0.15 | 0.15 | 0.047 |
| 0.22 | 0.22 | 0.068 |
| 0.33 | 0.33 | 0.1 |
| 0.47 | 0.47 | 0.15 |
| 0.68 | 0.68 | 0.22 |
| 1.0 | 1.0 | 0.33 |
| 1.5 | 1.5 | 0.47 |
| 2.2 | 2.2 | 0.68 |
| 3.3 | 3.3 | 1.0 |
| 4.7 | 4.7 | 1.5 |
| 6.8 | 6.8 | 2.2 |
| 10 | 10 | 3.3 |

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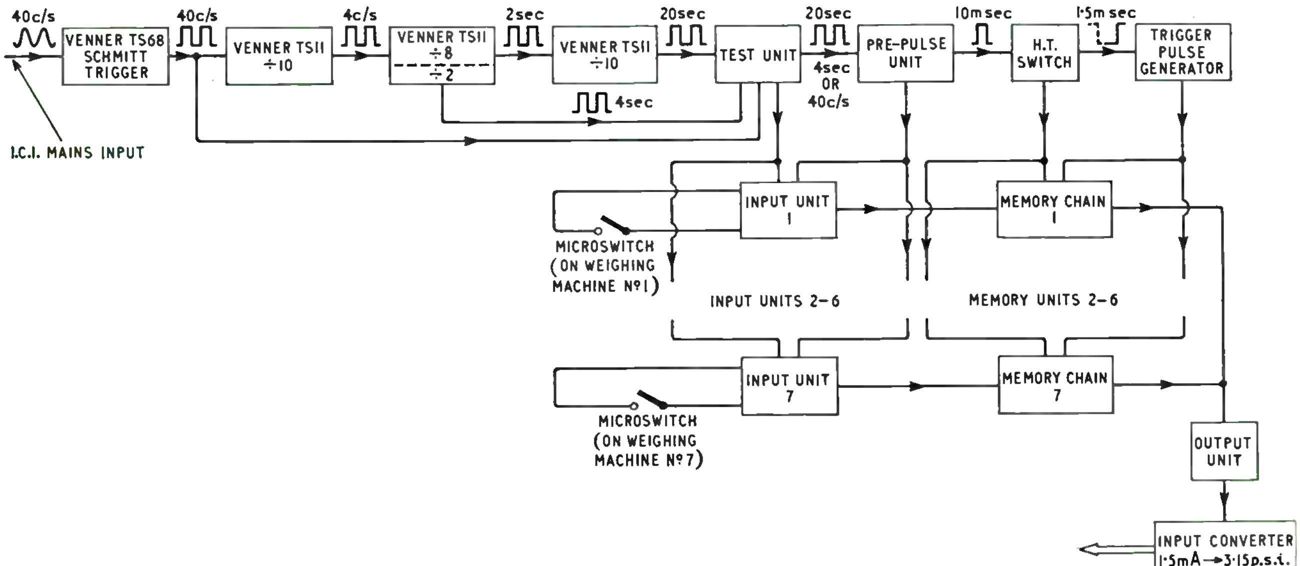


*Fig. 6. The block diagram of the batch weight ratemeter*

obtained by splitting each 20-min memory in the equipment into two 10-min memories.

Fig. 6 shows a schematic diagram of the complete system. This comprises one common timing channel and seven memory channels. The only inputs are a 230-V 40-c/s single phase supply (from I.C.I's own power station) and seven pairs of leads going to microswitches on the weighing machines.

The 40-c/s sinusoidal input results in a 40-c/s square wave being generated by the input Schmitt trigger. The 40-c/s square wave is divided successively by a number of standard units so that 4-sec and 20-sec square waves are available. The 4-sec wave is used for test purposes and the 20-sec waveform is used to produce a pulse which operates the h.t. switch. This h.t. switch reduces the h.t. supply to the anodes of the c.c.ts for 1·5 msec. The trailing edge of the 1·5-msec pulse operates the trigger-pulse generator which applies a pulse to the trigger rail in the memory channels.

The result of this is that every 20 seconds the pattern in the memory chain moves on one place and the state of the input store, which is determined by the weighing machine microswitch, is transferred to the first memory tube. There are 60 tubes in each memory chain so the memory time will be 60 × 20 sec ; i.e., 20 min as required.

In a perfect sequence of events a weighing machine could weigh a 2½-cwt load every minute. This means that at the end of each minute the associated microswitch will close and feed a signal to the input store of the appropriate memory unit. Every 20 sec the input store is fed into the main memory so that after 20 min the memory will have 20 tubes alight and 40 off. This clearly indicates that in the 20-min timing period twenty 2½-cwt loads have been made available to the reaction vessel. Should one of the machines in the plant fail to operate at the maximum speed, less than 20 tubes will glow and indicate the exact weight of material processed in the preceding 20-min period.

This necessarily brief report gives an insight into some of the topics discussed at the symposium. Throughout the three days delegates were treated to a feast of cold-cathode tubes, their capabilities and application. Although the pace was rapid and lively there was no sign of physical or mental indigestion. To coin a phrase, a good time was had by all—in no small measure this was due to the I.E.R.E. and, of course, the contributors.

Complete sets of symposium papers are available from The Secretary, The Institution of Electronic and Radio Engineers, 8-9 Bedford Square, London, W.C.1.

# COMPUTER RENTAL SERVICES EXPANDED

THE Hydac 2000, a hybrid computer which combines analogue and digital facilities in one integrated system, is now included in the rental services offered by Electronic Associates Limited, Burgess Hill, Sussex. EAL are manufacturers of Pace computers, Hydac being the latest addition to their range.

The new computer has been added to the systems installed at the company's U.K. Computation Centre, where the complete range of Pace scientific computers may be hired on an hourly basis. Rates range from £5 to £25 per hour, depending upon the facilities required.

The hybrid computer may be used in iteration and optimization studies. Such operations must be carried out in problems involving model building, process simulation, parameter studies and end-point boundary-value programmes. Another application would be the solution of linear and non-linear partial differential equations based on difference techniques and using function storage and playback. Serial solution and time-multiplexing techniques can be successfully employed for boundary-value partial differential equations. In an adaptive control system the dynamic behaviour of the system is represented by normal analogue elements, while the logic of the control system itself is represented by the digital logic elements.

There are five computers in the Computation Centre. Also available are two Pace data-plotters, having plotting speeds up to 80 points per second, and offering two-pen operation with symbol printing.

The Centre is staffed by mathematicians and application engineers whose services are included in the rental terms.



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# TRANSISTOR OPERATING CONDITIONS-4

**In this final article, the effects of resistor tolerances and supply voltage and transistor variations on the operating point are discussed. It is shown that their effect is likely to be much greater than that of temperature.**

***By W. TUSTING***

WE shall now consider the applications of the discussion of the preceding articles to a practical design problem.

Let us suppose that the requirement is to produce a signal current $i_L$ of 1 mA peak in a load resistance $R_L$ of 1 kΩ, using a power supply $E_{cc}$ of 12 V and an OC71 transistor. Let the upper temperature limit be 45 °C and the circuit that of Fig. 1.

From the maker's data for the OC71 we have $\alpha' = 47$, $I_{co} = 4{\cdot}5$ μA at 25 °C, $V_{ce\ min} = 0{\cdot}25$ V, $I_{c\ max} = 10$ mA, $T_{j\ max} = 75$ °C, $\theta = 0{\cdot}4$ °C/mW, $V_{ce\ max} = 30$ V for $R_b < 0{\cdot}5$ kΩ, 10 V for $R_b > 50$ kΩ. For $V_{ce} = 12$ V, $R_b$ must not exceed 20 kΩ. Since $R_b (= R_1R_2/(R_1 + R_2))$ is very unlikely to exceed 20 kΩ the limitation on $V_{ce\ max}$ is unlikely to affect our design.

We now start to produce the diagram of Fig. 2, choosing suitable scales for $V_{ce}$ and $I_c$, and marking in the line $V_{ce\ max} = 0{\cdot}25$ V and the point $E_{cc} = 12$ V. In this particular case, collector dissipation is unlikely to be a limiting factor, but we ought to draw in a dissipation curve as a matter of routine for in some designs it will set a definite limit.

From equation (1), Part 1,

$$P_{tot} = 75 - 45/0{\cdot}4 = 75 \text{ mW}$$

At 15 V, the dissipation is 75 mW when $I_c = 5$ mA, so the only point on the dissipation curve which falls on our diagram is at the extreme top right-hand corner. We thus cannot plot the curve in this instance because it falls outside our piece of paper. As long as we confine ourselves to the bounds of this piece of paper we are in no danger of exceeding the dissipation limit. The same thing happens over the peak current rating of 10 mA.

Using equations (4) and (5) of Part 1, we determine the minimum permissible values for $R_c + R_e$. From (4) we have $144/300 = 0{\cdot}48$ kΩ and from (5) $12/10 = 1{\cdot}2$ kΩ. So $R_c + R_e$ must not be less than 1·2 kΩ.

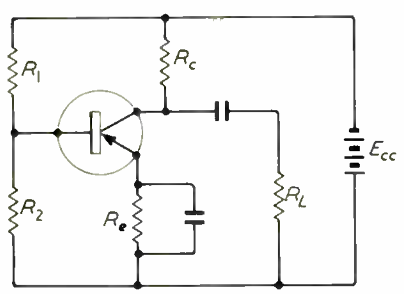


*Fig. 1. Circuit of the transistor stage considered*

From the signal point of view $R_L$ and $R_c$ are in parallel, so the a.c. load is $R_LR_c/(R_L + R_c)$. The voltage $v_L$ across the load is $i_LR_L = 1$ V. The current to be supplied by the transistor is

$$i_c = i_L(1 + R_L/R_c)$$

We have to make an arbitrary initial choice for $R_c$. To reduce the peak current output of the transistor it should be large compared with $R_L$. However, too large a value will cause an excessive voltage drop across it. Generally, $R_c$ should be from 2 to 4 times $R_L$, so let us try about 3 times and make $R_c = 3{\cdot}3$ kΩ, a standard value. Then

$$i_c = 1(1 + 1/3{\cdot}3) = 1{\cdot}3 \text{ mA peak}$$

We now have to decide on a value for $R_e$. Again the choice is rather arbitrary. For a given degree of stabilization $R_b$ increases with $R_e$. Now from the signal point of view $R_b$ is in shunt with the input impedance of the transistor of, perhaps, 1·5 kΩ and robs it of signal current. We should like to have $R_b$ large compared with 1·5 kΩ.

On the other hand, a large value of $R_b$ reduces $V_{ce\ max}$, but that does not worry us in this instance. However, it also means a larger value for $R_e$ and, hence, an increased voltage drop across it. It usually works out best if $R_e$ is about a third of $R_c$; $R_b$ is then roughly six times $R_e$ and about three times the input impedance. No effects are negligible, but none is overwhelming.

We thus decide $R_e = 1$ kΩ. The d.c. load $R_c + R_e = 4{\cdot}3$ kΩ and we can draw in the d.c. load line from $E_{cc} = 12$ V to $I_c = 12/4{\cdot}3 = 2{\cdot}79$ mA.

At 25 °C, $I_{co} = 4{\cdot}5$ μA, so at 45° C $I_{co} = 18$ μA. We must choose $S$ arbitrarily and as in this case we seem to have plenty of latitude we will make $S = 10$, rather a high value. Thus $SI_{co} = 0{\cdot}18$ mA and we draw in the limit line.

The limits of operation now come at $V_{ce} = 0{\cdot}25$ V and $I_c = 0{\cdot}18$ mA. Since the peak signal current is 1·3 mA, the mean current must not be set less than $1{\cdot}3 + 0{\cdot}18 = 1{\cdot}48$ mA. Since the peak signal voltage is 1 V, the mean collector voltage must not be set less than $1 + 0{\cdot}25 = 1{\cdot}25$ V, for which the current is 2·5 mA. These limits are marked in as $Q_1$ and $Q_2$. A reasonable operating point to choose would be $Q_0$ at 2 mA for which $V_{ce} = 3{\cdot}43$ V.

The a.c. load is $1 \times 3{\cdot}3/4{\cdot}3 = 0{\cdot}767$ kΩ and we draw a line of this slope through $Q_0$ to represent it. The limits of current excursion are $2 \pm 1{\cdot}3 = 3{\cdot}3$ to $0{\cdot}7$ mA and these are well within any limiting values.



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From equation (6) of Part 3

$$R_b = 1\frac{10-1}{1-10/48} = \frac{9}{0{\cdot}791} = 11{\cdot}35\ \text{k}\Omega$$

and from (7)

$$E_{bb} = \left(\frac{2}{10} - 0{\cdot}018\right)(1 + 11{\cdot}35) + 0{\cdot}15$$

$$= 0{\cdot}182 \times 12{\cdot}35 + 0{\cdot}15$$

$$= 2{\cdot}4\ \text{V}$$

then from (2)

$$R_1 = 11{\cdot}35\,\frac{12}{2{\cdot}4} = 56{\cdot}75\ \text{k}\Omega$$

$$R_2 = 11{\cdot}35\,\frac{12}{9{\cdot}6} = 14{\cdot}2\ \text{k}\Omega$$

Standard values of 56 kΩ and 15 kΩ will suffice. This nominally completes the design and it looks a satisfactory one. The required output is well within the capacity. It would be better to move $Q_0$ and the a.c. load line to the left until equal excursions of current about $Q_0$ bring the current down to $SI_{co}$ on the one hand and the voltage to $V_{ce\ min}$ on the other. This is to the point $Q_0'$ at $I_c = 2{\cdot}33$ mA, for which the limiting peak signal current is 2·15 mA, so that a peak current output approaching 2 mA would be reasonable. This change requires only an alteration to $R_1$ and $R_2$.

Although the design is superficially satisfactory, it may well be disappointing in practice, for no account has been taken of component tolerances. Supply voltage, resistance values and transistor parameters all vary and, taken together, may add up to result in a surprisingly large variation in the position of the operating point.

If the power supply is from dry batteries, the voltage is likely to change from 1·6 V to 1·3 V per cell during the life of the battery. A nominally 12-V supply will vary from 12·8 V to 10·4 V about a mean value of 11·6 V, a change of ± 1·2 V, or ± 13·5%.

If $R_1$ and $R_2$ are at opposite extremes of their tolerance, $E_{bb}$ can vary relative to $E_{cc}$ by almost twice the resistor tolerance. With the usual 20% tolerance resistors and taking into account supply voltage changes, $I_c$ may vary by ± 53·5% from these causes alone! The other resistors and the transistor have tolerances also and to obtain a satisfactory design it is essential to take them all into account.

We must, therefore, start the design all over again taking tolerances into account and this is where the real merit of the graphical construction shows up. For the OC71, although the average $I_{co}$ is 4·5 µA, it may be as high as 13 µA. Also $\alpha'$ may be anything from 30 to 75!

We shall take $E_{cc}$ to be 11·6 V nominal with maximum and minimum figures of 12·8 V and 10·4 V. We shall initially assume a 10% tolerance on $R_c$ and $R_e$, but no tolerance on $R_L$. As before we start the diagram, Fig. 3, by drawing in the $V_{ce\ min}$ line at 0·25 V and marking off the three $E_{cc}$ values. Taking $R_c = 3{\cdot}3$ kΩ, as before, and $R_e = 1$ kΩ, we draw a load line for 4·3 kΩ from 11·6 V to 11·6/4·3 = 2·7 mA. Now with 10% tolerance on the resistors the d.c. load may vary by ± 0·43 kΩ, from 3·87 kΩ to 4·73 kΩ. The current will be its lowest when high tolerance resistors are associated with low supply voltage and vice versa. We thus draw load lines from 10·4 V to 10·4/4·73 = 2·2 mA and from 12·8 V to 12·8/3·87 = 3·31 mA.

The two outer load lines in Fig. 3 represent limiting lines for the operating point set by resistor and battery variations. The middle line is the nominal load line for zero tolerance.

At 45 °C $I_{co}$ can now be a maximum of 52 µA, so if $S = 10$, $SI_{co} = 0{\cdot}52$ mA. This is rather large and it is advisable to try making $S$ smaller, say $S = 6$. Then $SI_{co} = 0{\cdot}312$ mA. $S$ will vary with the tolerances, but for the moment we will

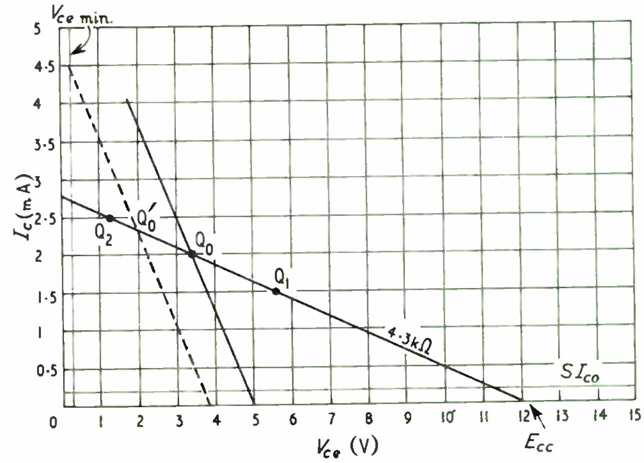


*Fig. 2. Load line for $R_c = 3{\cdot}3$ kΩ and $R_e = 1$ kΩ. For a load $R_L$ of 1 kΩ the a.c. load becomes $R_c$ and $R_L$ in parallel and is represented by the line drawn through an operating point $Q_0$ at 2 mA. The other point $Q_0'$ is more suitable since it permits equal current swings in both directions before the limits are reached*

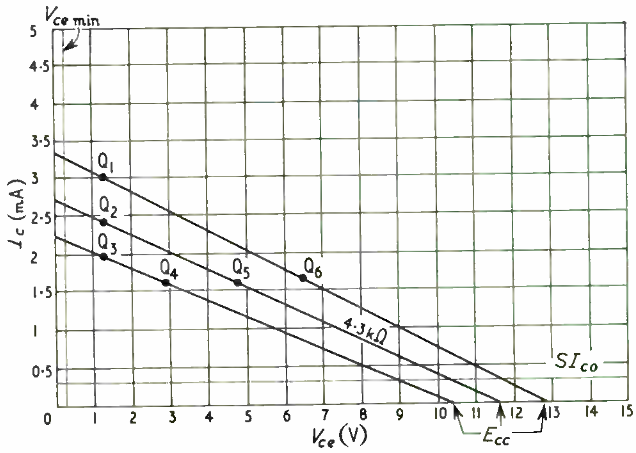


*Fig. 3. Load lines for 4·3 kΩ and 4·3 kΩ ± 10% are plotted here for supply voltages of 10·4, 11·6 and 12·8 volts. The points $Q_1$ to $Q_6$ bound a quadrilateral within which the operating point must lie if the required output is to be obtained*

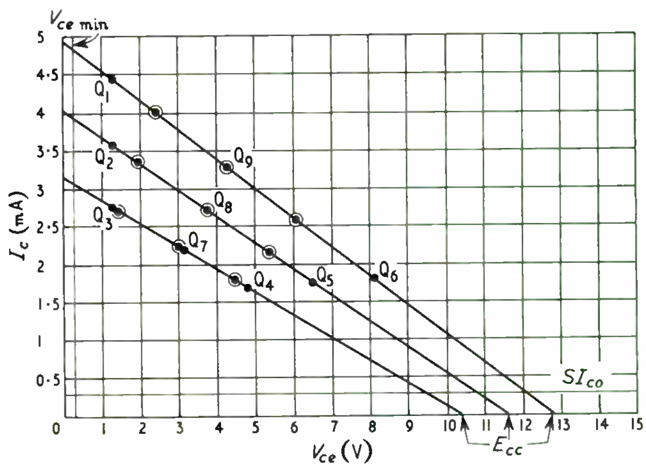


*Fig. 4. Load lines for $R_c = 2{\cdot}2$ kΩ, $R_e = 680$ Ω and for values 10% high and low. The limits of operation are set by $Q_1$ to $Q_6$. The ringed points near there indicate the actual limits of the operating point. $Q_8$ is the operating point with all values correct, $Q_7$ and $Q_9$ are the points with only $E_{cc}$, $R_c + R_e$ off their proper values*



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TABLE 1

| Q | $E_{cc}$ (V) | $R_1$ (kΩ) | $R_2$ (kΩ) | $\frac{R_2}{R_1+R_2}$ | $E_{bb}$ (V) | $E_{bb}-0{\cdot}15$ (V) | $R_b$ (kΩ) | $R_e$ (kΩ) | $\alpha'$ | $\frac{R_b}{1+\alpha'}$ (kΩ) |
|---|---|---|---|---|---|---|---|---|---|---|
| $Q_1$ | 12·8 | 24·3 | 6·16 | 0·2025 | 2·59 | 2·44 | 4·92 | 0·612 | 75 | 0·0646 |
| $Q_2$ | 11·6 | 24·3 | 6·16 | 0·2025 | 2·35 | 2·2 | 4·92 | 0·68 | 75 | 0·0646 |
| $Q_3$ | 10·4 | 24·3 | 6·16 | 0·2025 | 2·105 | 1·955 | 4·92 | 0·748 | 75 | 0·0646 |
| $Q_4$ | 10·4 | 29·7 | 5·04 | 0·145 | 1·51 | 1·36 | 4·3 | 0·748 | 30 | 0·1385 |
| $Q_5$ | 11·6 | 29·7 | 5·04 | 0·145 | 1·68 | 1·53 | 4·3 | 0·68 | 30 | 0·1385 |
| $Q_6$ | 12·8 | 29·7 | 5·04 | 0·145 | 1·85 | 1·7 | 4·3 | 0·612 | 30 | 0·1385 |
| $Q_7$ | 10·4 | 27 | 5·6 | 0·172 | 1·79 | 1·64 | 4·64 | 0·748 | 47 | 0·0965 |
| $Q_8$ | 11·6 | 27 | 5·6 | 0·172 | 1·99 | 1·84 | 4·64 | 0·68 | 47 | 0·0965 |
| $Q_9$ | 12·8 | 27 | 5·6 | 0·172 | 2·2 | 2·05 | 4·64 | 0·612 | 47 | 0·0965 |

| Q | $R_e$ (kΩ) | $R_e+R_b$ (kΩ) | $I_{co}(R_e+R_b)$ (V) | $E_{bb}-0{\cdot}15-I_{co}(R_e+R_b)$ (V) | $R_e+\frac{R_b}{1+\alpha'}$ (kΩ) | $I_c$ (mA) |
|---|---|---|---|---|---|---|
| $Q_1$ | 0·612 | 5·532 | 0·2875 | 2·7275 | 0·6766 | 4·02 |
| $Q_2$ | 0·68 | 5·602 | 0·292 | 2·492 | 0·7446 | 3·35 |
| $Q_3$ | 0·748 | 5·668 | 0·295 | 2·25 | 0·8126 | 2·775 |
| $Q_4$ | 0·748 | 5·048 | 0·262 | 1·622 | 0·8865 | 1·83 |
| $Q_5$ | 0·68 | 4·98 | 0·259 | 1·789 | 0·8185 | 2·185 |
| $Q_6$ | 0·612 | 4·912 | 0·256 | 1·956 | 0·7505 | 2·6 |
| $Q_7$ | 0·748 | 5·388 | 0·28 | 1·92 | 0·8445 | 2·28 |
| $Q_8$ | 0·68 | 5·32 | 0·2765 | 2·1165 | 0·7765 | 2·72 |
| $Q_9$ | 0·612 | 5·252 | 0·274 | 2·324 | 0·7085 | 3·28 |

assume it to be constant and draw in the $SI_{co}$ line at 0·312 mA.

We can now mark off limits to the operating point set by signal conditions. The peak signal voltage is unchanged at 1 V, so the mean collector voltage must never be less than 1·25 V and we mark in the points $Q_1$, $Q_2$ and $Q_3$.

When $R_c$ is high on tolerance it is 3·63 kΩ. Consequently, for 1 mA peak in $R_L$, $i_c = 1 + 1/3{\cdot}63 = 1{\cdot}276$ mA. The mean current must never be less than this plus $SI_{co}$, or 1·588 mA, and we can mark in $Q_4$. When $R_c$ is 3·3 kΩ, $i_c = 1 + 1/3{\cdot}6 = 1{\cdot}3$ mA, and $Q_5$ is at 1·612 mA. When $R_c$ is low at 2·97 kΩ, $i_c = 1 + 1/2{\cdot}97 = 1{\cdot}337$ mA, so $Q_6$ is at 1·649 mA.

These points $Q_1$–$Q_6$ mark off an area within which the operating point must lie if the stage is to be capable of delivering 1 mA to the load $R_L$.

Now the two points nearest together are $Q_3$ and $Q_4$ on the high resistance load line, at 1·95 mA and 1·59 mA. If with nominal values for $R_1$ and $R_2$, we set the quiescent point half-way between at 1·77 mA, the permissible variation of collector current with resistor tolerances on $R_1$ and $R_2$ is $\pm$ 0·18 mA, or $\pm$ 10·15%. The total effect of the tolerances on $R_1$ and $R_2$ is twice that of the individual tolerances. Therefore, $R_1$ and $R_2$ must be a little better than 5% tolerance components and we have still not taken into account the effect of $\alpha'$.

It thus looks as if we shall have to use something like 2% tolerance components for $R_1$ and $R_2$. This is undesirable on the grounds of cost. Is there anything which we can do to ease matters? In fact, there is. If we adopt a lower value of $R_c + R_e$ the d.c. load lines will be steeper and the currents larger. The $Q_4$ current, however, will increase very little and the net result will be a gain.

We will thus reduce $R_c$ to 2·2 kΩ and make $R_e$ = 680 Ω. With a $\pm$ 10% tolerance $R_c$ has limits of 2·42 kΩ and 1·98 kΩ, while $R_e$ has limits of 0·748 kΩ and 0·612 kΩ. The range of $R_c + R_e$ is thus 3·168 kΩ to 2·592 kΩ. The load lines are thus drawn from 10·4 V, 11·6 V and 12·8 V to 10·4/3·168 = 3·28 mA, 11·6/2·88 = 4·03 mA and 12·8/2·592 = 4·95 mA as shown in Fig. 4.

As before, the limiting operating points $Q_1$–$Q_3$ can be marked in at 1 V above the $V_{ce\,min}$ line, to allow for the 1 V peak signal across the load. As before, we take $S$ as 6 and $SI_{co}$ = 0·312 mA, so we can draw in the $SI_{co}$ line.

We now have to calculate the signal current again. With $R_c$ = 2·42 kΩ it is $1 + 1/2{\cdot}42 = 1{\cdot}413$ mA, so $Q_4$ comes at 1·413 + 0·312 = 1·725 mA. With $R_c$ = 2·2 kΩ, the current is $1 + 1/2{\cdot}2 = 1{\cdot}455$ mA, making $Q_5$ at 1·767 mA. Finally with $R_c$ = 1·98 kΩ, the current is $1 + 1/1{\cdot}98 = 1{\cdot}505$ mA and $Q_6$ comes at 1·817 mA. Now, $Q_3$ and $Q_4$ correspond to 2·775 mA and 1·725 mA. The mean is 2·25 mA and a change about this of 0·525 mA is permissible; that is, a change of $\pm$ 23·3%. Thus, changing $R_c$ from 3·3 kΩ to 2·2 kΩ has resulted in more than doubling the permissible tolerance on collector current and it is now possible that we can use $\pm$ 10% tolerance resistors for $R_1$ and $R_2$.

Now we want the mean operating point with low $E_{cc}$ and high $R_c$ and $R_e$ to be midway between $Q_3$ and $Q_4$ at 2·25 mA, that is, at $Q_7$. This is for correct values for $R_1$ and $R_2$ and $\alpha'$. Going back to equations (6) and (7) of Part 3

$$R_b = 0{\cdot}748\,\frac{5}{1-6/48} = 4{\cdot}27\text{ k}\Omega$$

$$E_{bb} = (2{\cdot}25/6 - 0{\cdot}052)(4{\cdot}27 + 0{\cdot}748) + 0{\cdot}15 = 1{\cdot}77\text{ V}$$

Then from (2) of Part 3

$$R_1 = 4{\cdot}27\,\frac{10{\cdot}4}{1{\cdot}77} = 25{\cdot}1\text{ k}\Omega$$

$$R_2 = 4{\cdot}27\,\frac{10{\cdot}4}{8{\cdot}63} = 5{\cdot}15\text{ k}\Omega$$

One may reasonably expect that these values will give the required results, but it is necessary to check that they do. Also, we shall want to adopt the nearest standard values. In choosing these we must change them both in the same direction to minimize errors. We might choose 27 kΩ and 5·6 kΩ or 22 kΩ and 4·7 kΩ. The first makes the divider ratio 5·6/32·6 = 0·172, the second makes it 4·7/26·7 = 0·176; these compare with the proper figure of 5·15/30·65 = 0·167.

We therefore choose $R_1$ = 27 kΩ, $R_2$ = 5·6 kΩ as being slightly the nearer to the proper value.



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We now work out $I_c$ for these values to make sure that the change to standard values for $R_1$ and $R_2$ has not shifted the operating point too much. We have

$$E_{bb} = 10{\cdot}4 \frac{5{\cdot}6}{32{\cdot}6} = 1{\cdot}785 \text{ V}$$

$$R_b = 27 \times 5{\cdot}6/32{\cdot}6 = 4{\cdot}64 \text{ k}\Omega$$

and from (3) of Part 3

$$I_c = \frac{E_{bb} - V_o + I_{co}(R_b + R_e)}{R_e + R_b/(1 + \alpha')}$$

$$= \frac{1{\cdot}785 - 0{\cdot}15 + 0{\cdot}052(4{\cdot}64 + 0{\cdot}748)}{0{\cdot}748 + 4{\cdot}64/48} = 2{\cdot}265 \text{ mA}$$

This is so close to the design current of 2·25 mA that it is almost indistinguishable from it in Fig. 4.

We now want to determine the remaining eight values of $I_c$ for the various combinations of resistance. It is best to carry out the calculations in a systematic tabular fashion for it is all too easy to get the wrong combination of tolerances. Table 1 shows the calculations and the points are plotted in Fig. 4 and ringed to distinguish them from the limiting points.

Things are tightest with low supply voltage and high tolerance resistors for $R_c$ and $R_e$ but the extreme operating points just come inside the $Q_3$ $Q_4$ limits. Elsewhere the extreme operating points are well within the Q limits. The design is thus a satisfactory one. The required output of 1 mA peak can be obtained with 10% tolerance resistors throughout and with any transistor within its tolerances and with any supply from 10·4 V to 12·8 V. The collector current will vary widely. It should be 2·72 mA, but it may be anywhere from 1·83 mA to 4·02 mA. This is at constant high temperature. If the temperature drops to a low level a further change of 0·295 mA occurs, making the lower current drop to 1·535 mA. For simplicity the effect of temperature on $V_o$ has not been considered. It will, of course, introduce further changes of the operating point. The effect, however, is usually important only at low temperatures.

Because of the stabilizing circuit the effect of temperature is quite small, resistor and supply voltage tolerances have a much bigger effect. Although the design worked out meets the initial requirements, in one sense it is a poor one. Of the transistor characteristic by far the greater part is reserved for the wandering of the operating point, and the signal swing is small in comparison. This wandering of the operating point is only tolerable when the signal level is small. With any largish signal it becomes essential to have very small tolerances on the resistors, especially $R_1$ and $R_2$ and the power-supply voltage.

This sort of trouble is not evident with valve circuits using cathode-bias and the transistor circuit is superficially similar. The essential difference, however, is that the grid of the valve is returned to a fixed point, earth, not to a potential divider across the h.t. supply. It is evident from the equations that if $E_{bb}$ were constant the variations of current would largely disappear. As an example suppose $E_{bb}$ is fixed at 1·99 V $Q_8$ is unchanged, whereas $Q_1$ and $Q_4$ become

$$I_{c_1} = \frac{1{\cdot}84 + 0{\cdot}2875}{0{\cdot}6766} = \frac{2{\cdot}1275}{0{\cdot}6766} = 3{\cdot}14 \text{ mA}$$

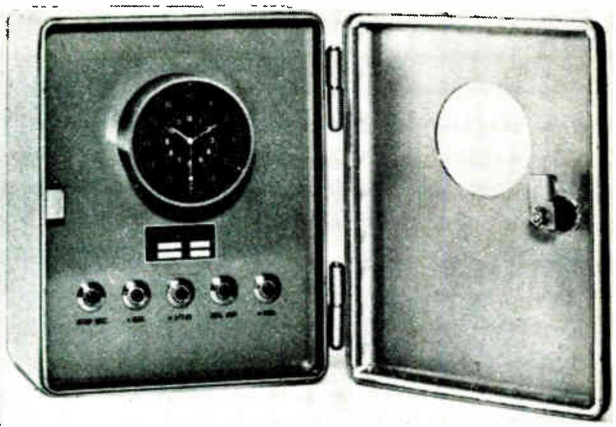
$$I_{c_4} = \frac{1{\cdot}84 + 0{\cdot}262}{0{\cdot}8865} = \frac{2{\cdot}102}{0{\cdot}8865} = 2{\cdot}38 \text{ mA}$$

The change is 0·76 mA instead of 2·19 mA. With battery operation, therefore, it would probably pay to use a separate battery of voltage $E_{bb}$ for bias rather than to derive it from $E_{cc}$. The current drain on $E_{bb}$ would be relatively small and its voltage would be much more constant than that of $E_{cc}$. In addition, no potential divider would be needed, and $R_b$ would be a single resistor only. At the outside it should then be possible to keep $E_{bb}$ within $\pm$ 5%. The same battery could, of course, then serve for more than one transistor.

Design would have to follow a somewhat different course for $E_{bb}$ would be variable only in 1·5-V steps, and $R_b$ would probably come out at some unsuitable value for temperature stability. Consequently, there would be less freedom in design.

There seems to be no escape from the fact that the operating point of a transistor varies widely with changes of supply voltage and resistance values, somewhat less widely with variations of transistor characteristics, and relatively little with temperature changes if proper stabilization is used. With transistors, therefore, a stabilized power supply and small tolerance resistances are essential if the operating point is to remain near its proper value.

# SWISS WATCH FAIR 1964



*The Patek Philippe electronic master clock*

This year's Swiss Watch Fair at Basle featured a representative selection from the output of the Swiss watch industry, which now stands at more than 47 million watches and movements annually. Of particular interest are the advances being made in the fields of electronics and styling.

Included in a display of over 20,000 clocks and watches was the Patek Philippe electronic master clock, model ECK 24. Fully transistorized with no mechanical contacts, this mains-operated instrument has a 10-hr power reserve for the master and up to 100 slave clocks. Setting is carried out by means of pushbuttons and the working stability is better than 0·1 sec per 24 hr. The clock is resistant to shock and vibration, operates in any position, and is unaffected by magnetic fields and variations in gravity, humidity and atmospheric pressure. Overall dimensions are approximately 8 × 10 × 6 in.

**For further information circle 102 on Service Card**



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# EQUIPMENT REVIEW

## 1. Strain Simulator

Industrial Electronetics Corporation have announced a portable strain simulator intended primarily for calibrating resistive strain-gauge systems. The simulator enables the user to vary the strain-gauge output by step-selecting resistance values connected in parallel with the input. The circuit design enables the switching in and out of the resistance values at six different rates: system frequency response determinations can be made at 10, 30, 100, 300, 1,000, and 3,000 c/s for each value of 40, 60, 120, 240 and 480 kΩ.

The simulator may be used with wired or radio strain monitoring systems. The provision of a screened input cable allows the instrument to be used in systems that employ f.m. telemetry transmitting stations as well as directly modulated r.f. carrier systems. The Electronetics strain simulator operates from a long-life self-contained power pack consisting of two 4·2-V cells.—*Industrial Electronetics Corporation, Post Office Box 862, Melbourne, Florida, U.S.A.*

**For further information circle 1 on Service Card**

## 2. Solid-State Switch

Many industrial applications of photoelectric control involve a fast repetition and demand instantaneous solenoid action. To meet this requirement M.O.M. are offering a solid-state transistor switch which has no relay, a low d.c. voltage being applied to the load instantly upon the interruption of the beam. Alternatively, if preferred, the device can be controlled mechanically by a micro-current low-voltage switch to control an inductive load to a maximum of 140 W at 24 V. Any standard M.O.M. receiver can be connected.

The d.c. switching method obviates any variable time-constants in the solenoid operation, and no wear and tear is incurred by continuous use at high striking rates. Two compact models are available, rated at 3 and 6 A maximum output. Supplies required are 10 or 20 V a.c. and standard M.O.M. transformers give 3 A at 11 V, 1½ A at 20 V, or 6 A at 20 V to power the transistor switch and projector lamp. — *Photoelectronics (M.O.M.) Holdings Ltd., Oldfields Trading Estate, Oldfields Road, Sutton, Surrey.*

**For further information circle 2 on Service Card**

## 3. Contact Programmer

An Actan programmer featuring sliding, programmable contact activators is now available from Sealectro. The design makes it possible for the equipment designer or operator to select the contacts to be activated at each programme position simply by sliding the contact activators to the appropriate positions.

These programmers are multiple-position programming devices available with up to 50 positions and 50 contact stations for each position. The following contact configurations are available: s.p.s.t., n/o; s.p.s.t., n/c; d.p.d.t., make before break; and d.p.d.t., break before make. Contacts may be stacked at each station and may be of various configurations. Ratings are 2 A at 24 V d.c. and 115 V a.c., and a mechanical life in excess of 100 million operations. — *Sealectro Ltd., Hersham Trading Estate, Walton-on-Thames, Surrey.*

**For further information circle 3 on Service Card**

## 4. Electronic Time Delays

The Electrical Remote Control Co. have recently introduced a range of variable electronic time delays designated the ER series. The units use printed circuitry and a miniature cold-cathode tube with a minimum operating life expectancy of 30,000 hr. Since the tube operates only during the actual time delay period the effective life of

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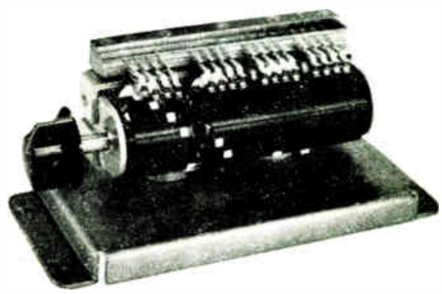

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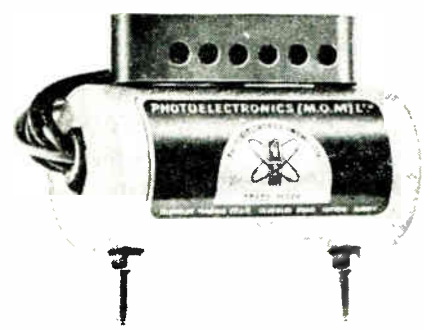


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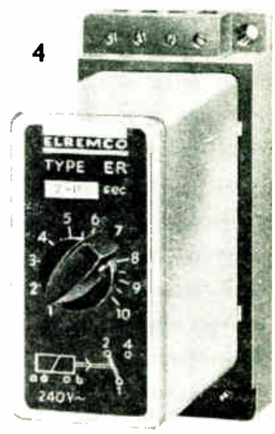


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the device is infinite for all practical purposes. Mechanical life expectancy of the units is claimed to be 20 million operations.

Time ranges available are 0·5–5, 2–15, 5–30 and 10–60 sec; reset time is 15 msec. The units are insensitive to temperature variations of −30 °C to +65 °C, mains voltage transients and mechanical shocks up to 15 *g*, and will operate in any mounting position. Maximum continuous contact current is 15 A resistive or 5 A inductive (power factor 0·4) a.c. The overall size is $4\frac{5}{16} \times 1\frac{27}{32} \times 4\frac{21}{32}$ in. high.—*Electrical Remote Control Co. Ltd., Bush Fair, Harlow, Essex.*

**For further information circle 4 on Service Card**

## 5. Plug-in Units

Following the introduction of the TD.1 and TD.2 plug-in decade assemblies, Panax have considerably extended the range with the addition of further complementary units. At prices ranging from £17 10s. for an electromechanical register unit to 10s. 6d. for a printed-circuit board connector, it is possible to build inexpensive electronic counting and timing equipment for any purpose.

The additional items available are: a 12-V stabilized power supply unit; plug-in auxiliary supply unit, pulse-shaping unit, coincidence unit and double-sided decade unit; a register unit, and single- and double-edge p.c. board connectors.—*Panax Equipment Ltd., Holmethorpe Industrial Estate, Redhill Surrey.*

**For further information circle 5 on Service Card**

## 6. Improved Transducers

The Coutant Electronics CP12 range of resistostrictive transducers has been redesigned to meet wider environmental conditions and to simplify incorporation into rigs and prototype equipments. As a result of internal improvements and the provision of a PTFE cable connection, the working temperature range has been extended to cover from −20 °C to +105 °C.

The range comprises transducers for use both in normal fluid/gas pressure measurement, and for applications where contact is made with corrosive or conductive media. Maximum working pressure is 12,000 p.s.i., or 0 to ±5,000 p.s.i. for differential types using a small sample volume of the measured media. Electrical output is up to 1·5 V d.c. at maximum pressure with a 40-V input to the 4-arm precision measurement bridge. — *Coutant Electronics Ltd., 3 Trafford Road, Richfield Estate, Reading, Berks.*

**For further information circle 6 on Service Card**

## 7. Miniature Reed Switch

The Hamlin MRG-DT, now available from Flight Refuelling, is a miniature single-pole changeover reed switch, with a glass envelope 0·625 in. long and 0·13 in. in diameter. Biasing magnets are not required. Overall length, including the leads, is 2·125 in. The short glass length permits the leads to be cut to a maximum length of 0·75 in. where necessary.

The switch has an average life expectancy of 10 million operations at its maximum ratings of 3 W d.c. resistive, 28 V and 0·25 A. The gold-alloy contacts offer an initial resistance of 150 mΩ and an insulation resistance of 100 MΩ. The switch is available in a sensitivity range from 30 to 80 A-turns, the tolerance being $\pm 7\frac{1}{2}$ A-turns.—*Flight Refuelling Ltd., Industrial Electronics Division, Wimborne, Dorset.*

**For further information circle 7 on Service Card**

## 8. R.F. Milliwatt Meter

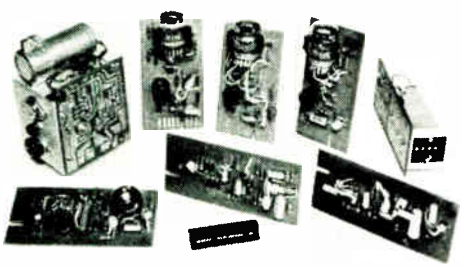
An r.f. power meter by Electro Apparatus requires no power supply and is equally suitable for laboratory and field use. Two versions are available, one having dual ranges of 3 and 10 mW f.s.d., the other a single-range instrument with an f.s.d. of 25 mW. No setting-up is necessary before taking a reading and immediate indication of power is given. There is a 50-Ω terminating load and the v.s.w.r. is better than 1·1 up to 1 Gc/s.

Each instrument is individually calibrated and the overall accuracy of 10% is maintained over the range from 10 Mc/s to 1 Gc/s. 10-dB attenuators are available to extend the range to 250 mW and 2·5 W. Other attenuators for higher powers will be available in the near future. The input connector (EID $\frac{3}{4}$ in., 'N', G.R., C, B.N.C. or Dezifix) can be mounted on either the back or front panel. Nothing projects beyond the outline of the case except the plastic feet, thus giving good protection to the instrument. — *Electro Apparatus (London) Ltd., Stansted, Essex.*

**For further information circle 8 on Service Card**

## 9. Portable Radiation Monitor

The BN.132 portable radiation monitor introduced by Burndept Electronics forms part of a complete system and can be obtained with all or part of a



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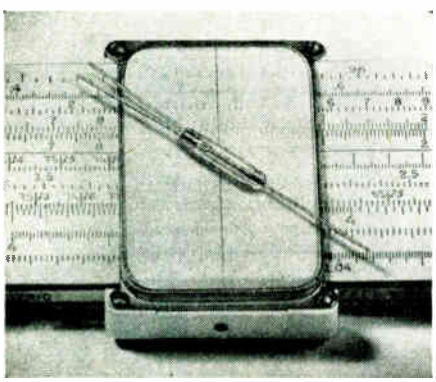

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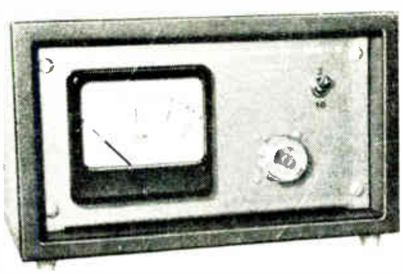

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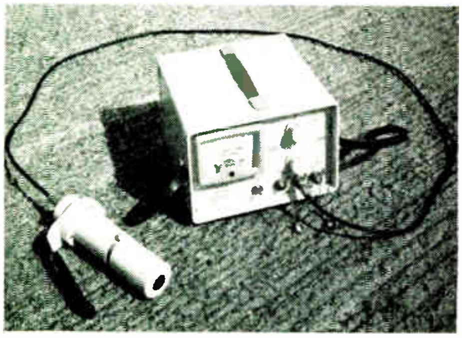

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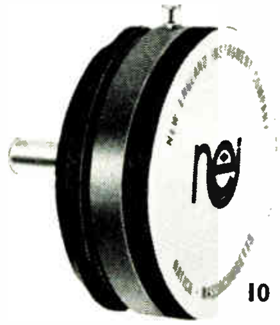

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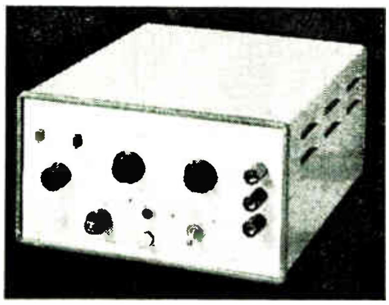

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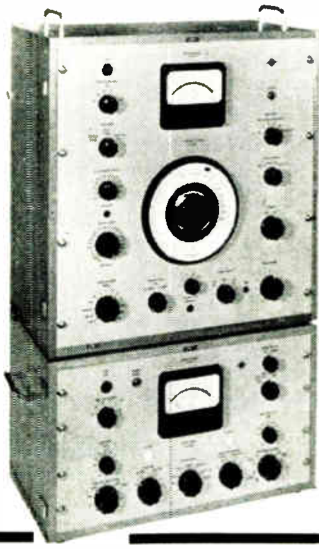

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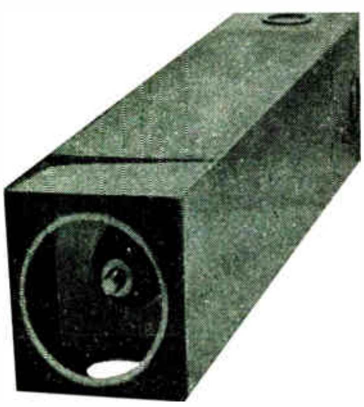

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number of accessories as required. The price of the basic instrument is £100 and a typical selection of accessories costs £50, including a shoulder-strap harness and such items as a mains battery charger, an expendable battery compartment, an internal gamma probe, and an illuminated meter scale.

The basic ratemeter weighs approximately $6\frac{1}{4}$ lb. A battery having a life of 60 hr on standard nickel-cadmium rechargeable cells weighs 2 lb with its compartment; an expendable battery, also with its compartment, weighs $1\frac{1}{4}$ lb. Because of its light weight and convenient size ($8\frac{1}{2}$ in. by $5\frac{3}{4}$ in. by 8 in. deep) the monitor is particularly suitable for checking the contamination level of work surfaces, clothing and equipment.

Most standard probes can be employed with the three inputs provided and the count rate is displayed on a $2\frac{1}{2}$-in. scale meter, linearly calibrated. Any one of four ranges (5, 50, 500 and 5,000 counts per sec f.s.d.) can be selected, and a switch can be turned on to give an audible count in clicks per sec. The ratemeter is governed by two controls only, for range selection and probe selection; it will stand up to hard treatment and will operate at temperatures from 0 to 55 °C.—*Burndept Electronics Ltd., Riversite Building, Erith, Kent.*

For further information circle 9 on Service Card

## 10. Slim Plastic Potentiometers

New England Instrument Co. have announced the 'Waferpot' range of conductive-plastic potentiometers. The basic single-cup unit is 0·5 in. deep. Each additional cup adds 0·180 in. in depth. Resistance values from 1 to 20 kΩ are available and the line includes standard diameters of $1\frac{1}{16}$, $1\frac{7}{16}$ and 2 in.

The Waferpot meets the 100-Ω noise specification now written for wire-wound potentiometers. It withstands 10-day MIL-R-12934 humidity cycling tests with a resistance change of less than 2%. Temperature coefficient is ±200 parts/million/°C for most resistance values. Resolution is essentially infinite, and operating life is 10 million revolutions.—*New England Instrument Company, Kendall Lane, Natick, Massachusetts, U.S.A.*

For further information circle 10 on Service Card

## 11. Constant-Current Pulse Amplifier

Argonaut Associates Inc. have announced the LRA 046 constant-current pulse amplifier which provides an isolated and floating source of rectangular current pulses with duration determined by an external control



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signal. Amplifier current output may be varied from 20 μA to 50 mA in steps of 1, 2, 5 sequence, with variable control provided between steps. An output function switch allows choice of positive or negative going, floating or grounded output pulse generation.

Typical applications include: a pulse amplifier for high current stimulation from a floating source, constant-current pulse generation, and an isolated current pulse that may have as its reference a d.c. voltage reference level offset from earth. The LRA 046 will also function as an isolated constant-current supply of ±200 V when operated continuously. Isolation of the output pulse is greater than 1,000 MΩ at d.c.—*Argonaut Associates Inc., P.O. Box K, Beaverton, Oregon, U.S.A.*

For further information circle 11 on Service Card

## 12. Vibration Test Equipment

Bruel & Kjaer have announced the sine-random generator type 1040 which can supply sine-wave signals, narrow-band noise signals or wide-band noise in the frequency range 5 c/s to 10 kc/s, and the vibration meter type 2501 which can be used to monitor vibration level and feed the regulator circuit of the generator with the desired control signal.

This equipment is not only suitable for controlling common sinusoidal vibration tests and wideband random vibration tests, but also includes the necessary prerequisites to conduct a new type of vibration test—the 'sweep-random' test—which simulates random vibration environment to a much greater degree than does the sweep-sine test, while producing the same number of stresses and accelerations at each level as the wideband test. It operates on the principle of replacing the wideband, low acceleration density excitation with an intense narrow-band random excitation sweeping slowly over the frequency range of the test.

For complex systems, when the equipment is operated in the sweep random or sweep sine condition, up to four generators and vibration meters can be connected together in a 'master-slave' arrangement.—*B & K Laboratories Ltd., 4 Tilney Street, Park Lane, London, W.1.*

For further information circle 12 on Service Card

## 13. Internal Telephone System

Caribonum Office Machines have announced the introduction of the 'COMtalk' internal telephone system. These telephones are fully intercommunicating and are available in both 16-way and 11-way versions. The basic design of the instrument is exactly the same as the G.P.O. '706' telephone and the push-button selectors are arranged in the space normally occupied by the dial.

Features of the system include conference facility and automatic line clearance. Each instrument is fitted with a non-kink flex and supplied with its own terminal box. Wiring is kept to a minimum as no central control box is required.

The systems are powered either by mains or by one set of batteries and the operating distance is up to 300 yards between any two instruments.—*Caribonum Office Machines Ltd., Leyton, London, E.10.*

For further information circle 13 on Service Card

## 14. Low Voltage Power Unit

Pioneer Designs have introduced a low voltage power unit which provides centre-tapped a.c. and d.c. supplies of 50 V and 25 V at a maximum current of 0·75 A. Separate mains transformers and rectifiers are employed on each side of the centre-tap and output voltage is selected by means of a single two-position switch. The unit is housed in a heavy welded-steel case and all components are mounted on the front panel which is easily removable. Excluding handle, the unit measures 9¼ × 6¼ × 5 in. and weighs 10½ lb.

For servo systems where potentiometers are employed the low voltage supply can be applied directly to the potentiometer and an electrical signal proportional in magnitude and direction to angle of shaft rotation obtained easily between the slider of the potentiometer and the centre-tap of the supply in use. Synchro control transmitters and similar 50-c/s synchros may be powered directly from the unit.—*Pioneer Designs Ltd., Crown House, Walton-on-Thames, Surrey.*

For further information circle 14 on Service Card

## 15. Screen Room Filters

F. C. Robinson & Partners have introduced to this country a range of Aerovox metal-cased screened-room filters, which with their simple mounting arrangements and high attenuation, ensure that mains supplies taken into screened rooms are free from interfering signals—and also that locally-generated signals are not fed into the mains.

Several different current and voltage ratings are available and the frequency band attenuated is from 14 kc/s to 1 Gc/s (with variations at the low-frequency end). Two special types extend this range up to 10 Gc/s.

In the lower current ratings (30 and 50 A), single, two, or three circuit units are standard. The maximum size for a single-circuit version is 4⅜-in. square by 22-in. long, and all types are hermetically sealed with shielded terminals.—*F. C. Robinson & Partners Ltd., Davies House, 2nd Floor, 181 Arthur Road, Wimbledon, London, S.W.19.*

For further information circle 15 on Service Card

## 16. High-Power Waveguide Loads

A range of waveguide loads recently introduced by Marconi have been designed to have extremely high electrical and mechanical stability, and are capable of operation up to a surface temperature of 300 °C. These loads are available in waveguide sizes 10, 12 and 16, covering frequency ranges from 2·6 to 3·95 Gc/s, 3·94 to 5·99 Gc/s, and from 8·2 to 12·5 Gc/s. Over 3 kW can be dissipated without any external cooling for the waveguide No. 10 loads, and with forced draught this power can be increased safely to 5 kW.

The waveguide section containing the load is reinforced to allow maximum waveguide pressures up to 60 lb/sq in., and the method of construction is sufficiently rugged to allow a blower motor to be mounted directly on the fins to provide forced air cooling. The v.s.w.r. is uniformly low throughout the operating frequency band. Any mounting position may be used, although a horizontal position gives the best heat dissipation.—*The Marconi Company Ltd., Specialized Components Division, Chelmsford, Essex.*

For further information circle 16 on Service Card

## 17. Universal Counter/Timer

A 1·2-Mc/s universal counter/timer embodying an easily-read 6-digit display, is the latest addition to the range of digital counters and frequency meters from Racal Instruments. Priced at £195, the SA.535 is a compact, solid-state instrument weighing 9 lb.

Direct frequency measurement from d.c. to 1·2 Mc/s can be made with signal levels as low as 70 mV. An accuracy of ±1 count ±1 part in $10^6$, over a temperature range from 0 to 45 °C is achieved by the use of a 1 Mc/s oven-controlled crystal. Additionally, facilities for time measurement from 1 μsec to 2·8 hr and multiple period average measurement are included.

For more accurate measurements, an external standard at 1 Mc/s may be used as a reference. Standard frequencies in decade steps from 100 c/s to 1 Mc/s and print-out facilities are included in the standard model. Opera-



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tion is from 115/230 V 45/60 c/s, 115 V 400 c/s or external batteries.—*Racal Instruments Ltd., Western Road, Bracknell, Berks.*

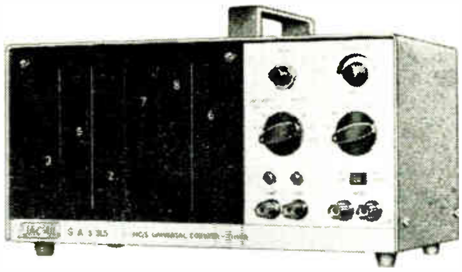
**For further information circle 17 on Service Card**

## 18. Meter-Style Timer

Industrial Timer Corporation have introduced the series MTD 'time delay timer' which features a meter-type dial, enclosed in a clear plastic face which protects both the progress and setting indicators from damage or tampering. The MTD is an automatic reset timer which operates an isolated load switch at the completion of a predetermined time delay. During the timing function, a red pointer moves to zero while the black setting pointer remains at the pre-set figure.

The series MTD is available for 115- and 220-V, 50/60-c/s supplies. Load circuit is s.p.d.t., snap action. Contacts are rated at 10 A, non-inductive at 115 V. Maximum time cycles available range from 6 sec to 5 min; minimum cycles are 0·1 sec to 3 sec.—*Industrial Timer Corporation, U.S. Highway No. 287, Parsippany, N.J., U.S.A.*

**For further information circle 18 on Service Card**



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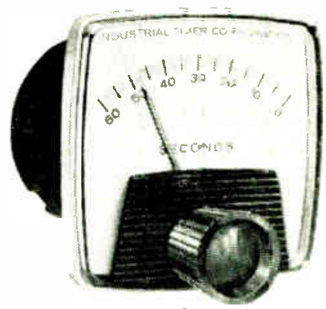

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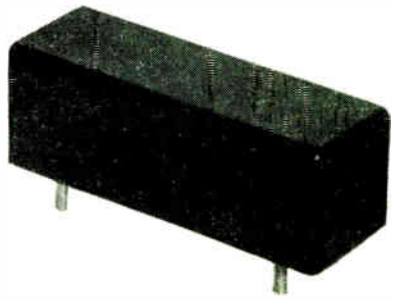

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## 19. Telephone Dial Lock

A.E.I. telephones fitted with 'dial locks' to prevent unauthorized use are now available for overseas markets only. Fitted to telephones in the A.E.I. 800 and 900 series, the device has been designed to prevent telephones from being used for outgoing calls, but leave them capable of receiving incoming calls. Coded switch 217A, the lock is also available as a separate item for use in any other device requiring similar facilities.

A Yale lock is set in the side of the telephone case. When the key is removed, an electrical springset device operates and in turn short-circuits the dial impulse contacts, making the dial inoperative. The telephone can be supplied with a special dial so that the numbers zero or nine, which might be used for emergency calls, remain operative when the key has been removed.—*Telephone Apparatus Department, A.E.I. Telecommunications Division, Woolwich, London, S.E.18.*

**For further information circle 19 on Service Card**

## 20. 5-μsec Delay Line

A lumped-constant delay line providing a 5-μsec delay with a 30-to-1 delay-to-rise time ratio is now available from Hi-G Inc. This unit has 500-Ω input and output impedance and features an insertion loss of 1 dB.

Environmental specifications include an operating temperature range from −55 °C to 125 °C, the ability to withstand vibration from 5 c/s to 2 kc/s at 20 *g* and shock to 50 *g* for 11 msec. The maximum temperature coefficient of delay is 100 p.p.m./°C. Overall dimensions are 1·70 in. square × 3¼ in. excluding mounting studs and wiring terminals.—*Hi-G Inc., Spring Street and Route 75, Windsor Locks, Connecticut, U.S.A.*

**For further information circle 20 on Service Card**

## 21. Analogue Programmer

Perkin-Elmer has introduced a self-contained programmer that provides adjustable function generation. The equipment is suitable for providing complex temperature or pressure programmes as well as function generation in an analogue computer.

Operating from 115 V ±10%, 60 c/s, the programmer allows the setting of empirical functions or multiple slope reversals from a 34-pole, 100-position switch. The programme output is plotted against a timebase with accuracies of ±0·5% of full scale. The device features a flexible fixed-programme display as well as allowing change of programme under dynamic loading conditions.

The standard model can be used to establish the reference set point for a Brown, L & N, or Bristol strip chart recorder. Optional features include adjustable speeds for the timebase, a manual mode, and an auxiliary soak timer for temperature control applications.—*Lectropon Ltd., Kinbex House, Wellington Street, Slough, Bucks.*

**For further information circle 21 on Service Card**

## 22. Kilovolter

Measurements of high voltage in the range 3 to 30 kV are easily and quickly carried out with the Kilovolter Mark II manufactured by Waveforms. This is an inexpensive, pocket-sized, calibrated spark gap of sturdy construction and having a substantially linear 2½-in. scale.

The Kilovolter is read after withdrawal from the high-voltage source, rather like a clinical thermometer. It does not retain a charge and is therefore entirely safe in use.

This instrument is designed for measurement of e.h.t. in television and radar equipment and can be used in testing nuclear and electro-medical instruments, electric fences, pipeline 'holiday' detectors, and car ignition systems.—*Waveforms Ltd., 72 Vauxhall Bridge Road, London, S.W.1.*

**For further information circle 22 on Service Card**

## 23. Sealectoboard Channel Pins

A multiple pin is now available for use with ¼-in. grid 'Sealectoboard' programming boards. Two, three or more individual shorting pins are mounted



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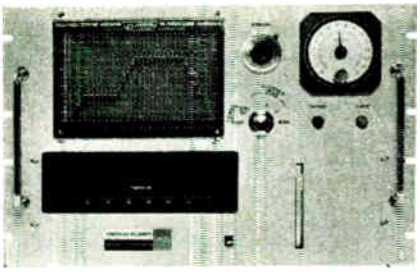

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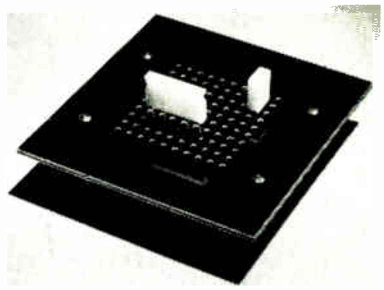

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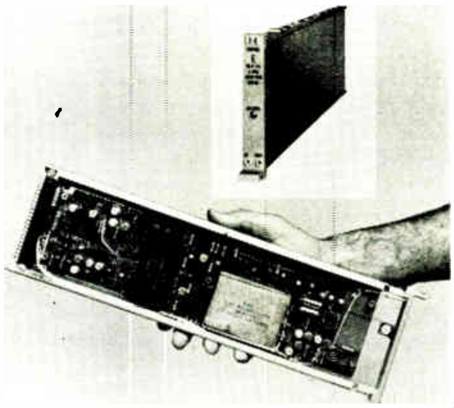

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in a common body, which enables multi-circuit switching with one pin insertion.

A typical application is the channelling of three-wire instruments to recorders. The channel pins can be isolated or commoned, and can be pitched to suit the ¼-in. grid or alternatively the diagonal.—*Sealectro Ltd., Hersham Trading Estate, Walton-on-Thames, Surrey.*

**For further information circle 23 on Service Card**

## 24. Pre-Set Batch Counters

Photronic Controls announced two pre-selection batch counters for industrial processing applications. The units comprise a low-voltage light-beam projector unit and a photo-transistor receiver which can be mounted up to 10 ft away.

As the articles pass through the beam, an impulse is passed to the control unit containing the power supplies and electromagnetic pre-selection counter. Any number up to 999,999 can be pre-selected on the control and when this number is reached the process can stop until manually re-set (unit type BCM) or provide an output pulse for further control operation while continuing counting for the next batch (unit type BCA).

Maximum counting speed for both types is 1,500/min and minimum impulse time, 5 msec. Power consumption is 15 W. Prices: £35 and £45 for the BCM and BCA respectively.—*Photronic Controls Ltd., Randalls Road, Leatherhead, Surrey.*

**For further information circle 24 on Service Card**

## 25. Miniature Discriminator

A low-priced, pulse-averaging sub-carrier discriminator designed for use in frequency multiplex telemetering systems is available from the Sarasota Division of Electro-Mechanical Research, Inc. Designated the model 267A, this solid-state unit features linearity within 0·1% and output noise less than 0·1% of full bandwidth. Centre frequencies between 300 c/s and 300 kc/s, with deviations of ±5% to ±40%, are available.

Panel size is one 'modular width' ($\frac{13}{16}$ in.) by 5¼ in. high, permitting 18 units to occupy a single 19-in. rack width. All components of the model 267A are mounted on a single circuit card.—*Solartron Electronic Group Ltd., Victoria Road, Farnborough, Hants.*

**For further information circle 25 on Service Card**

## 26. Sweep Generator/Marker Adder

The Paco G.32 sweep generator and marker adder, now available from KLB Electric, is an f.m. signal generator with a centre frequency range of 3–213 Mc/s in five overlapping bands. The sweep width is adjustable from 0–30 Mc/s on the high range.

This instrument is useful for aligning wideband amplifiers of all types, a desirable feature being that markers are added after the signal has been through the component under test, thus avoiding the possibility of spurious results.

The G.32 is priced at £55 12s. 0d. complete with connecting leads, or may be purchased in kit form at £52 9s. 0d.—*KLB Electric Ltd., 335 Whitehorse Road, Croydon, Surrey.*

**For further information circle 26 on Service Card**

## 27. Automatic Transformer Tester

Rapid production testing of transformers, ballasts, reactors and similar electrical equipment can be accomplished with a tape-programmed, automatic transformer tester available from the IGE Export Division of U.S. General Electric.

The unit automatically performs high potential, induced voltage, polarity, voltage ratio, exciting current and exciting watt tests. Test requirements are entered into the system either manually by pushbuttons or automatically through the use of standard eight-channel punched tape.

Test results for any parameter appear as cells numbered 0 to 29. Rejects above and below the 30-cell range are indicated by lights marked 'HI' and 'LO'. When the test is tape-



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programmed, a failure automatically removes the power, and there is a visual indication of the parameter that failed, with a reject reading from the classifier. — *International General Electric Co. of New York Ltd., 296 High Holborn, London, W.C.1.*

**or further information circle 27 on Service Card**

## 28. Miniature Motors

B.V.C. Electronic Developments have introduced a series of miniature high-frequency motors of the squirrel-cage type, which can be supplied fully encapsulated to operate under arduous environmental conditions. In addition to driving small cooling-fan units, these motors can also be designed as servo motors.

The ED.33 (illustrated) is a motor designed specifically for miniature fan application. The output at 22,000 r.p.m. is 1·5 W and the supply required is 200 V, 3-phase, 400 c/s. — *B.V.C. Electronic Developments Ltd., Goblin Works, Leatherhead, Surrey.*

**For further information circle 28 on Service Card**

## 29. Precision A.C. Divider

The DM2101 precision a.c. divider, developed by Digital Measurements, can be used for the measurement and production of a.c. voltage ratios or for the comparison of standards of resistance, inductance, capacitance or ratio. Voltage division with an accuracy and reproducibility of 1 part in $10^7$ can be attained, which is claimed to be an order of magnitude greater than anything previously possible.

The instrument consists of a series of auto-transformers, in which each transformer is divided into 10 equal divisions and any selected division may be further sub-divided by the succeeding transformer. Settings are indicated on instrument dials, or remotely on automatic typewriters or tape punches. Key to the accuracy of this equipment is an alloy, of exceptionally high and reliable magnetic permeability, from which the transformer cores are wound.—*Digital Measurements Ltd., 25 Salisbury Grove, Mytchett, Aldershot, Hants.*

**For further information circle 29 on Service Card**

## 30. 150-Amp Epitaxial Thyristor

International Rectifier has extended its epitaxial thyristor range to include a 150-A thyristor. The new type, 150RE series, is available with p.i.v. from 800 V to 1·3 kV.

Bulk avalanche characteristics are a feature of these devices and the 1·3-kV version has a minimum reverse avalanche voltage of 1·5 kV. Current capacity is up to 235 A r.m.s. with a surge current capacity up to 3,000 A.—*International Rectifier Company (Great Britain), Hurst Green, Oxted, Surrey.*

**For further information circle 30 on Service Card**

## 31. Wide-Range Gaussmeter

The model 120 gaussmeter manufactured by F. W. Bell, Inc., a direct-reading instrument for measuring the direction and magnitude of magnetic flux density, is now available from Livingston Laboratories. The unit, which employs an indium arsenide sensing element using the Hall Effect, measures d.c. and a.c. fields up to 50 c/s.

There are twelve ranges from 100 milligauss to 30,000 gauss f.s.d. and fields as low as 10 milligauss can be detected. The accuracy is $\pm 1\%$ of full scale up to 10,000 gauss, a calibration curve being available for higher readings. Accessories include a wide variety of transverse and axial probes, reference magnets and zero gauss chambers. —*Livingston Laboratories Ltd., 31 Camden Road, London, N.W.1.*

**For further information circle 31 on Service Card**

## 32. Solder Bubble Pack

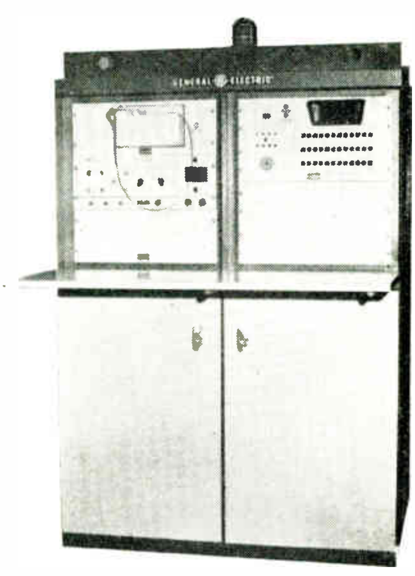
Multicore Solders are to make for the North American market a 50-cent bubble pack of 5-core Ersin Multicore solder in a dispenser. The pack is specially designed for display on peg-board units which are used extensively in North America.

It has been designed in conjunction with Multicore Sales Corporation of Long Island, U.S.A., to complete a range of packaged Ersin Multicore solder specifications which are made at Multicore's Hemel Hempstead factory for U.S.A. and Canadian wholesalers, radio parts distributors and hi-fi dealers.—*Multicore Solders Ltd., Maylands Avenue, Hemel Hempstead, Herts.*

**For further information circle 32 on Service Card**

## 33. Laboratory Power Supply

Advance Electronics announce the introduction of the model PP7 stabilized laboratory power supply. It is fully transistorized and provides a d.c. floating output between 0 and 30 V with a ripple of less than 1 mV peak-to-peak. Voltage adjustment is



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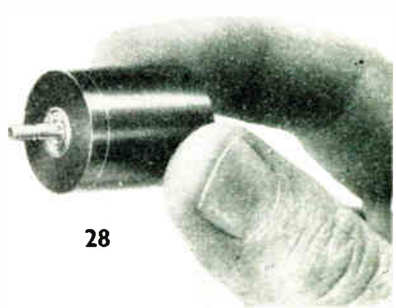
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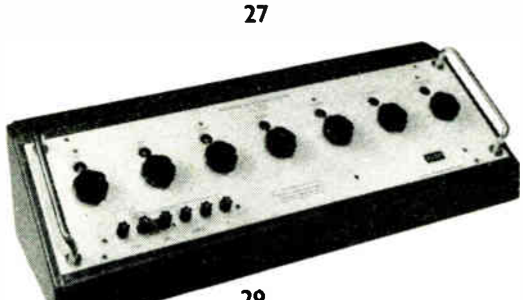
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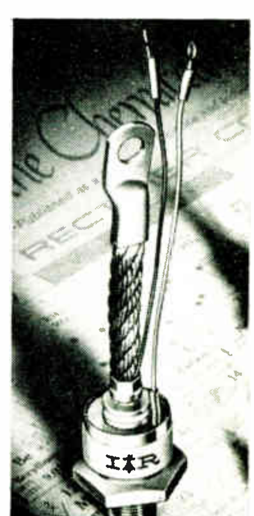
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made in decade steps of 0·1 V and the maximum current available is 3 A.

A constant-voltage transformer is used in combination with a temperature-compensated Zener diode control circuit to ensure stable output with large variations of supply voltage, load and temperature. A four-terminal output provides compensation for the resistance of connecting leads.

Full protection against progressive overload and short-circuit current is provided by an electronic cut-out that can be continuously adjusted between 33 mA and 3·2 A. An overload indicator is fitted on the front panel, together with a four-range ammeter that can also be used for voltage check measurements. — *Advance Electronics Ltd., Roebuck Road, Hainault, Ilford, Essex.*

**For further information circle 33 on Service Card**

## 34. Digital Output Printers

Data Products Corporation have announced a series of high-speed buffered line printers. The new range, designated dp/p-4000, is currently available in 600 line-per-min speeds. Later in the year, 1,000 line-per-min models will be available.

A key operating feature is the elimination of all adjustment devices. The design of the hammer mechanism eliminates friction points, pivot mechanisms and mechanical linkages so that adjustment is not necessary. The paper feed system will accept all standard form weights and numbers of copies without special adjustments. The cabinet completely encloses the printing mechanism and paper storage baskets so that operating noise is held to a minimum and paper dust remains within the cabinet.—*Data Products Corporation, 8535 Warner Drive, Culver City, California, U.S.A.*

**For further information circle 34 on Service Card**

## 35. Precision A.C. Potentiometer

A single-turn Vernistat a.c. potentiometer for use in high-performance servos, analogue computers, and navigation systems has been developed by the Electronic Products Division of the Perkin-Elmer Corporation.

Designated model 6R1, the unit is suitable for applications where mechanical rotation is limited to 360°. It features a quadrature of 0·1 mV/V, an input impedance of 10 kΩ at 30 V and an output impedance of 100 Ω. This provides an input/output impedance ratio of 100.

Absolute linearity is ±0·1%. The combination of low output impedance and high linearity results in a high loaded linearity: worst case loaded linearity for a 40-kΩ load is ±0·18%. Resolution is 0·05%. The model 6R1 is 1¼ in. in length.—*Elliott Brothers (London) Ltd., Century Works, London, S.E.13.*

**For further information circle 35 on Service Card**

## 36. Industrial Inspection Kit

Ellis Optical Co. have introduced the 'Ellisminor' handy-sized industrial inspection kit.

The kit contains the following inspection aids: one 11-in. illuminated probe and an illuminated magnifier, both of which fit into the battery handle and are powered by two U.10-type batteries; one 11-in. probe with 18-mm adjustable mirror; one 11-in. malleable probe with 26-mm magnify-

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ing mirror at one end and, at the other, a magnet for removing metal filings, etc., from inaccessible spots.

The lid of the fitted case is detachable and can be used as a work tray. Price of the kit is £10 10s. complete.—*Ellis Optical Company, Mayday Road, Thornton Heath, Surrey.*

**For further information circle 36 on Service Card**

## 37. Microammeters

The Greibach Instruments Corporation has announced a series of ultra-sensitive, wide-range d.c. current meters. The model 700US series offers full deflection across a 6-in. slide-rule scale for currents as low as 200 nA without the aid of amplifiers or other electronic circuitry.

As many as 23 ranges can be included in a single meter to permit complete coverage of the microampere, milliampere and low ampere current bands. These meters are available with full-scale accuracies of ±0·25% and ±0·5%. A light-beam pointer eliminates parallax errors, and full overload protection is included as standard. Models are available for portable service and panel installation. —*Greibach Instruments Corporation, 315 North Avenue, New Rochelle, N.Y., U.S.A.*

**For further information circle 37 on Service Card**


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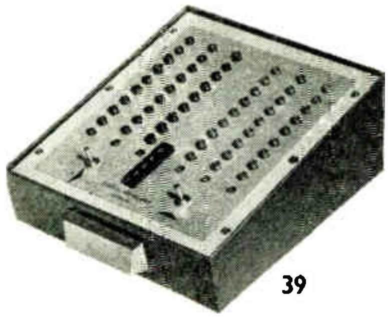

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## 38. Stabilized Power Units

Newton Brothers (Derby) have introduced the type KB range of transistorized power-supply units.

Six types are available, covering the range from 15 V at 200 mA to 40 V at 1 A, with low output impedance. All models are fitted with current limit control and short-circuit protection. Output voltage is continuously adjustable by means of a high resolution potentiometer, with the alternative on some models of a 3- or 10-turn Helipot. High voltage stability up to ±0·01% is obtained with low noise and ripple. —*Newton Brothers (Derby) Ltd., Alfreton Road, Derby.*

**For further information circle 38 on Service Card**

## 39. Low-Cost Digital Keyboard

Scientific Furnishings have announced the low-cost model K1 digital keyboard which is used in conjunction with the model XY-1P X-Y Autoplotter (or similar X-Y recorders) to speed up precision graph plotting of tabulated digital data.

The data are simply converted to points on a curve by entering the X and Y co-ordinate values on a twin three-digit decade keyboard and pressing the 'Plot' bar. The keyboard supplies d.c voltages to the X and Y axes of the recorder, the magnitudes of which are proportional to the co-ordinates set up on the X and Y key decades with an accuracy of ±0·25%. Suppressed zero and scale expansion permits optimum scaling of the graph, for both positive and negative values.

In the past the wide use of keyboard conversion of tabulated data to curves has been limited by high cost. This equipment, costing only about one-third of previous units, brings keyboard plotting within reach of the average laboratory. The price of the model K1 keyboard is £93.—*Scientific Furnishings Ltd., Electronics Division, Poynton, Cheshire.*

**For further informatioa circle 39 on Service Card**

## 40. Throat Microphone

Amplivox have developed a miniature magnetic throat microphone under a M.o.A. development contract in collaboration with the R.A.E.

The microphone has very good speech intelligibility in wideband noise levels of about 126 dB above threshold. The two small magnetic capsules are contained in a one-piece moulded neoprene connector assembly with two press studs for easy attachment of the elastic neckband and quick removal in the event of an emergency. The assembly is small enough to avoid discomfort by undue pressure on the throat and tests have shown that intelligibility is maintained with minimum contact pressure.

This fully tropicalized throat microphone, type X.13761, will be available with alternative rubber connectors to provide for series or parallel wiring to give a choice of 300- or 75-Ω impedance. — *Industrial Division, Amplivox Ltd, Beresford Avenue, Wembley, Middlesex.*

**For further information circle 40 on Service Card**

## 41. Waveguide Attenuators

The first two of a line of waveguide attenuators have been announced by The Singer Company, Metrics Division. The line will ultimately cover full waveguide bandwidths for each of the EIA standard series of waveguides.

Model AW-751 fixed attenuator covers 10–15 Gc/s, with attenuation values of 3, 6, 10, 20, 30, 40 dB and other values from 1 to 40 dB available. Maximum v.s.w.r. is 1·15, with bilateral matching.

Model AW-755, with maximum v.s.w.r. of 1·20 and bilateral matching, also covers 10–15 Gc/s. This is a step attenuator for 0, 20, 40, 60, maximum dB. Both attenuators dissipate at least 1 W and fit WR-75 waveguide.—*The Singer Company, Metrics Division, 915 Pembroke Street, Bridgeport, Connecticut, U.S.A.*

**For further information circle 41 on Service Card**



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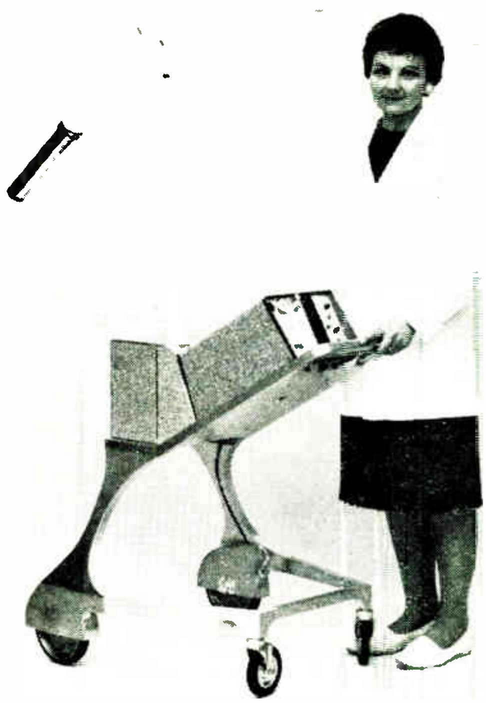

*Hospital cart mount of Fexitron portable X-ray machine. The cart also contains tube boom capable of movement in three planes and containing tube head and light locator. This X-ray machine produces 105 and 150 kV X-rays capable of penetrating all parts of human anatomy*

# ELECTRONICS IN THE SERVICE OF MEDICINE

## Exhibition at the U.S. Trade Center

WHOEVER called the heart a pump or a computer an electronic brain did not realize how much and how soon medical science will adapt for its own use developments which have taken place in other industries. Visiting the Exhibition of Electronics for Medical Diagnosis and Monitoring held at the U.S. Trade Center, London, during the last ten days of April, one could see the way in which industrial development can be adapted for medical use and in turn emerge from this transformation endowed with new possibilities for industry.

Twenty-five exhibitors, almost all with British representation, were showing items of medical electronic equipment and in most cases these had been adapted from well-known industrial apparatus. The basic point of difference between the industrial prototype and the medical refinement which follows appears to be in the greater accuracy and sensitivity of the latter.

One example is the Sperry ultrasonic diagnostic equipment. This uses the same type of oscillating circuits as any ultrasonic unit. It is used for detecting soft tissue in the brain, yet it could equally be used for many industrial applications where, say, a pocket of plastic which has not set might be suspected in an otherwise hardened product. The industrial Sonoray flaw detector was seen on the stand among sonar atomizers and mixing equipment suitable for laboratory use. Radiation Instrument Development Laboratory of Illinois showed a transistorized 400-channel analyser on the stand of Continental Distributors Ltd. This instrument is described as being able to determine the relative number of pulses having an amplitude falling between the values $E$ and $E + \Delta E$ and it covers the 400 channels by scanning. It has a ferrite-core memory, count capacity of 100,000 per channel, works from 75–130 V or 150–250 V, 60 (or 50) c/s. It weighs 80 lb and its size is $19\frac{1}{2} \times 19\frac{1}{2} \times 21$ in. It has a display unit or a type-out unit or could record its results on a tape.

Of interest in the industrial field is the new 50-lb portable X-ray unit shown by Livingston Laboratories on behalf of Field Emission Corp. of Oregon. Its miniature X-ray tubes were developed in 1955 and since that time have been used in industrial and medical X-ray equipment. The machine uses pulsed power and a cold-cathode X-ray tube at 150 kV. A 3-mm lead shield is placed around it, reducing radiation at 1 m distance to $10^{-6}$ roentgen per pulse. In a paper read last October to a joint meeting of various radiological societies Mr. P. W. Dyke, of Field Emission Corp., described the X-ray tube as having enormous power (140 MW) combined with a very short exposure time. The power is provided by a voltage multiplication circuit and it lasts for $\frac{1}{20}$ of a microsecond. It is therefore useful to have it linked to a cine recording unit and/or to provide ordinary X-ray pictures by repeated exposure. As an example of the former use in terms of human bodies, the short exposure is sufficient for X-raying a child, animal or a limb. An alternative procedure provides for up to 99 'shots' (according to a pre-set directive on a dial) for more dense objects. A human hip for instance requires about 30 'shots' at 33 in. though a knee requires only one. The very small tube head (12in. by $1\frac{1}{2}$–2 in. dia.) can be fixed in a mobile boom or at the end of a flexible lead. The tube itself is only 8 in. long. These tubes have a life of 40,000 pulses.

*Type 1805 Sonoray 30 transistor battery operated ultrasonic flaw detector/thickness gauge*



World Radio History

# INDUSTRIAL NEWS

## Personal and Company News

The formation is announced of **Seltronic Group Ltd.** with an authorized capital of £400,000 to purchase controlling interests, by cash or share exchange, of companies specializing in the fields of industrial measurement, controls and business data processing. Fifty per cent of the Seltronic Group equity is held by Scientific and Electronic Industries Trust Ltd., a public company. The remainder has been placed privately. The group headquarters is at 24 St. Mary Axe, London, E.C.3.

**The M-O Valve Co. Ltd.** announce the appointments of R. G. Robertshaw as technical manager and E. Kettlewell as development manager.

**Thorn Electrical Industries Ltd.** announce the appointment of M. J. Squire, M.I.E.E., as Government liaison sales engineer for the Special Products Division at Enfield.

The formation has been announced of **General Radio Company (U.K.) Ltd.,** a wholly owned subsidiary of the U.S. company with offices at Marlow Road, Bourne End, Bucks. The new organization will support and supplement the existing sales and service activities of Claude Lyons Ltd. Directors of the company are I. Sichel (managing), M. H. Evans and D. E. Schonhut.

**Auto-Electronics Ltd.** announce that they have been appointed sole U.K. distributors by Solitron Devices Inc. of Norwood, N.J., for their range of silicon semiconductor products.

Kemet Division, Union Carbide Ltd., have appointed **SASCO** (Stewart Aeronautical Supply Co. Ltd.) to act as their U.K. distributors of the J-series solid tantalum capacitors.

**Vice Admiral Sir Frank Mason, K.C.B.,** has been elected President of The Institution of Mechanical Engineers in succession to Mr. R. C. Bond.

**Bendix Electronics Ltd.** have acquired the sole agency in the U.K. for equipment manufactured by the General Data Corp. of Orange, California, U.S.A. This includes analogue-to-digital converters, data amplifiers, a.c./d.c. converters and a range of equipment for data logging and industrial control.

R. A. G. Dunkley, previously manager of the **G.E.C. (Electronics) Ltd.** applied electronics laboratories at Stanmore, Portsmouth and Salisbury (Southern Australia), has been appointed technical director of the company.

P. E. Leventhall, B.Sc.(Hons.), M.I.E.R.E., has been oppointed chief engineer of the **Cossor Communications Co. Ltd.**

**Industrial Instruments Ltd.** have combined with Transipack Electronic Engineers and have taken premises in Stanley Road, Bromley, Kent (Tel: Ravensbourne 9212/3). The company name is retained and all correspondence should be addressed to the new headquarters.

*Brookhirst Igranic BI-Stat static-switching controls at Burnley gasworks are in use with a converted conventional plant that was previously making gas from coke and oil, but is now making gas from oil alone. Plant modification cost only £35,000 or one-third of the cost of new plant of the same capacity (between $2\frac{1}{2}$ and $3\frac{1}{2}$ million cu ft of gas per day). Fully automatic, the new plant is served by one man per shift instead of two and the carbon-monoxide content has been substantially lowered. The change-over has been so successful that a further six sets of BI-Stat controls have been ordered.*

**For further information circle 103 on Service Card**



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K. K. Schwarz. M.A., A.M.I.E.E., has been appointed a local director of **Laurence, Scott & Electromotors Ltd.**

Brush Crystal Co. Ltd. has been renamed **Brush Clevite Co. Ltd.** No change in the structure or operations of the company is involved.

**Rank Cintel** have signed a contract for the marketing of the full range of electronic instruments manufactured by Princeton Applied Research Corporation of New Jersey, U.S.A. Initially, marketing in the U.K. will be concentrated on lock-in amplifiers and precision voltage/current reference sources, but will later be extended to include complete systems.

**Fix Equipment Ltd.** announce the following changes to their board of directors: J. U. K. Kimbell has been appointed chairman, and P. B. N. Davies, managing director.

The B.B.C. announces the retirement on 31st July of **W. Proctor Wilson,** C.B.E., B.Sc.(Eng.), F.C.G.I., M.I.E.E., head of Research Department, Engineering Division, and the appointment of **G. G. Gouriet,** M.I.E.E., to succeed him.

N. G. Watkinson has been appointed works manager of **Expert Industrial Controls Ltd.**

**Livingston Holdings Ltd.,** parent company of the Livingston Group, have acquired the whole of the issued capital of the newly-formed company, Circetch Ltd., of Bognor Regis, which will manufacture printed-circuit boards.

**W. Mackie and Co. Ltd.** have appointed as sole agents in Denmark, Firma Erik Jenk, Hausergade 3, Copenhagen.

**Amphenol-Borg (Electronics) Ltd.** announce the appointment of Norman Robshaw, A.M.I.Mech.E., as chief engineer.

The Aircraft Equipment Department of **Ferranti Ltd.** has concluded an agreement with the Autonetics Division of North American Aviation Inc., Anaheim, California, whereby Ferranti will manufacture under licence Autonetics stability augmentation components for helicopters and market them in the U.K., parts of Western Europe and certain Commonwealth countries.

**Elliott-Automation** announces the acquisition of 80% of the share capital of A. E. Dean & Co. (X-ray Apparatus) Ltd.

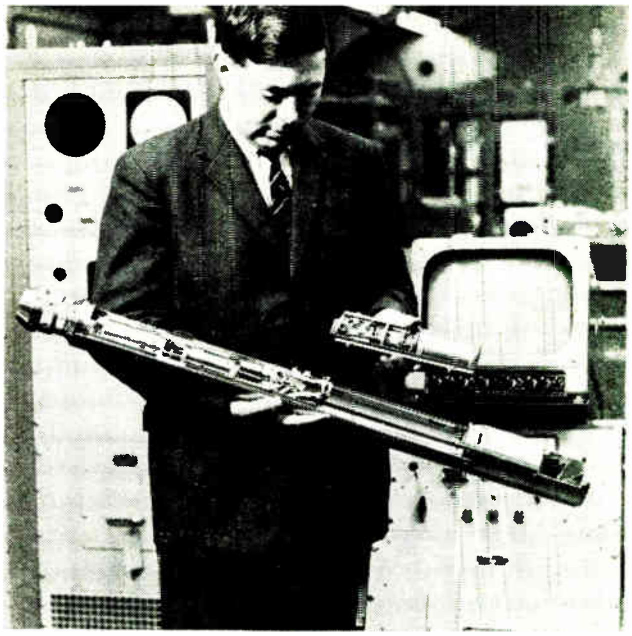
Sir Harold Bishop, C.B.E., has joined the board of **International Research & Development Co. Ltd.**

K. E. Owens has joined the board of **Livingston Laboratories Ltd.** and has been appointed general manager of their Camden Road operations.

Field Marshal Lord Harding has been appointed deputy chairman of **The Plessey Company Ltd.**

**B.I.C.C. Ltd.** announce that they have acquired the share capital, which was all privately owned, of William Geipel Ltd., electric cable manufacturers.

Kenneth Brookhouse Hogg has recently been appointed a director of **Electronic Instruments Ltd.**



*A plug-in camera unit (in left hand), using a 1-in. vidicon tube and claimed to be the smallest of its kind on the market, is a feature of this miniature television camera which is used in gas-cooled reactors. The cameras, which have been installed by Pye in all operational nuclear power stations in the U.K., are designed for use under shut-down conditions and can work in temperatures in excess of 200 °C. They are made of stainless steel, have self-contained lighting and are equipped with a range of motor-driven interchangeable attachments for viewing and grabbing operations*

**For further information circle 104 on Service Card**

On behalf of the **N.E.D.C.,** Sir Robert Shone, director general, has announced three more appointments to the Economic Development Committee for the Electronics Industry. The new members are: T. A. Breakell, member of the Executive Council, Electrical Trades Union; Dr. G. G. Macfarlane, director of the Royal Radar Establishment, Ministry of Aviation; Professor J. R. N. Stone, C.B.E., Leake Professor of Finance and Accounting, Cambridge University.

The appointment of **Van Der Heem, N.V.,** of The Hague, Holland, as distributor for Fairchild's Du Mont Laboratories has been announced.

**The Derritron Electronics Group** announce the appointment of W. T. Macqueen as area supervisor for Scotland, the North of England, and Northern Ireland.

The B.B.C. announces the appointment of **L. G. Dive,** A.M.I.E.E., A.M.I.E.R.E., as senior engineer, United States office (New York), in succession to D. A. V. Williams, B.A., A.M.I.E.E.

New premises for the Glasgow Sales and Service Centre of the **Cambridge Instrument Co. Ltd.,** have been opened at 52 Waddell Street. R. Watkins, the present resident engineer, has been appointed to the new position of resident engineer, London area. His successor at Glasgow is F. Baillie.

**Unicam Instruments Ltd.** announce an agreement with Ernst Leitz, G.M.B.H., for the marketing of Unicam spectrophotometers in West Germany. Future joint manufacture by Leitz is also envisaged.

SASCO (Stewart Aeronautical Supply Co. Ltd.) have been appointed official distributors by **Electrosil Ltd.** to market their 'triple-rated' range of size TR4, TR5 and TR6 glass tin oxide resistors.



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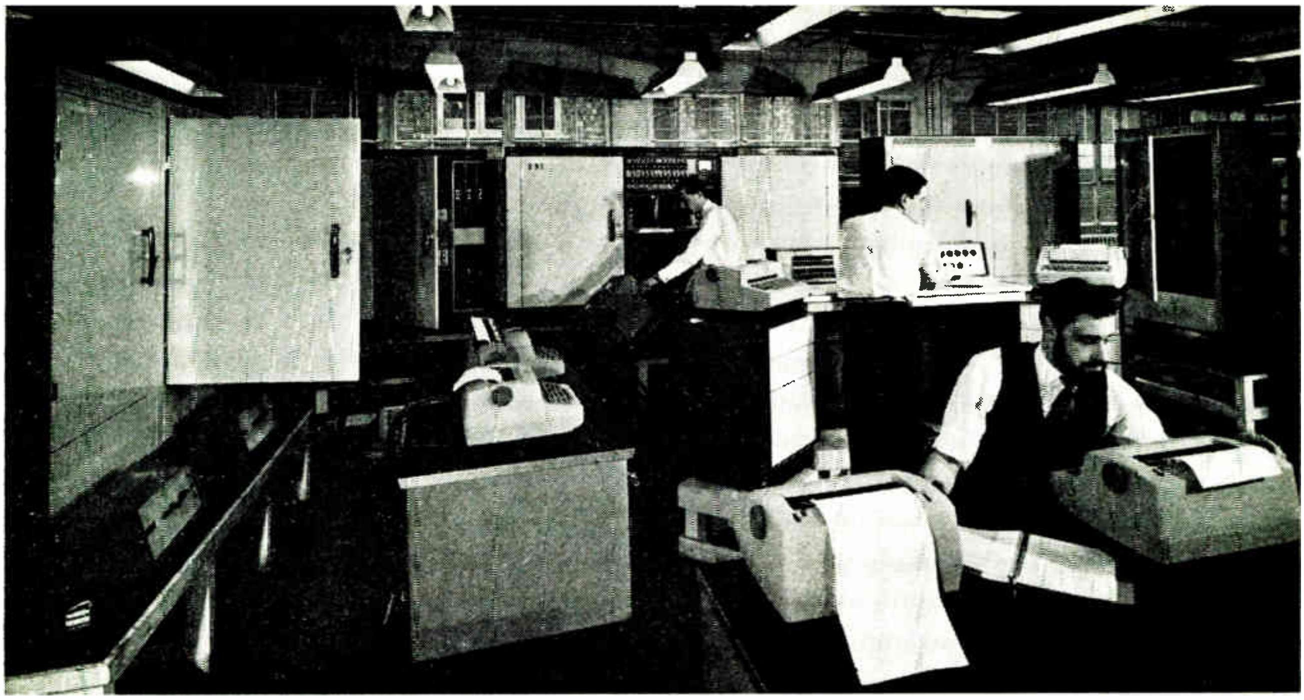


*An ARCH 8000 industrial process control system on final test at Elliott-Automation's Borehamwood factory. The complete system will monitor over 500 points of measurement, and provide alarm scanning facilities as well as on-line computer control of a new petrochemical plant at Bratislava in Czechoslovakia. This is the largest and most sophisticated single computer control system so far made by Elliott-Automation.* **For further information circle 105 on Service Card**

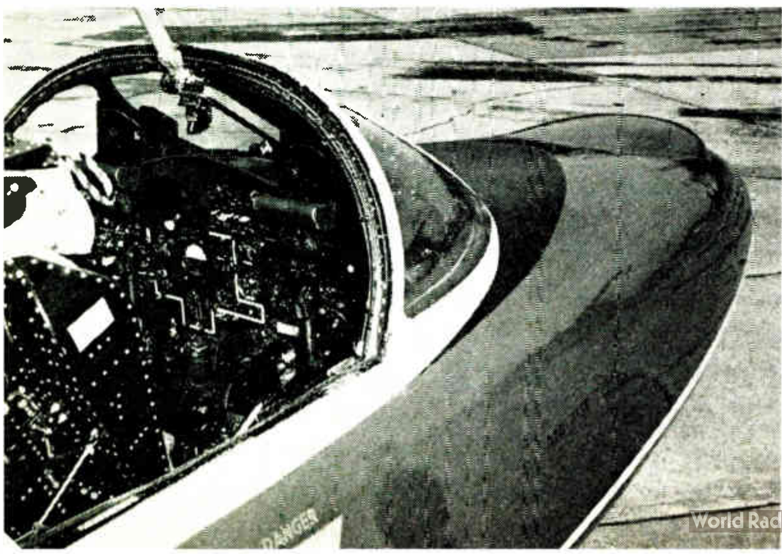
## A.E.I. Computer Centre

The A.E.I. 1010 data processing system is being offered to customers of the new A.E.I. Computer Centre at 33 Grosvenor Place, London. This system, controlling 29 peripheral units including 18 high-speed magnetic tape equipments, is the one ordered by the Air Ministry to deal with the stock control of R.A.F. establishments and has passed H.M. Treasury acceptance tests at better than 95%.

The new A.E.I. service, known as 'Dataline', has a staff of over 60 who can discuss problems at short notice with individual customers on applications ranging from pension schemes and payrolls to operational research. The 1010 can process either punched paper tape or punched cards. It can handle half-a-million characters, and calculate 70,000 times a second.

*Specto Avionics twin head-up display equipment installed in the Hunter Mark 12, which has completed an extensive flying trials programme at the R.A.E., Farnborough, to evaluate and optimize the form of display that is most readily understood and correlated to the outside world by the pilot. A further programme is currently evaluating the system in conjunction with various aircraft and ground control systems. Flying trials of this head-up display system are also being carried out by the Boeing Aircraft Transport Division and the U.S. Bureau of Naval Weapons*

**For further information circle 106 on Service Card**



## Radar Link Assists Thames Navigation

The Port of London Authority's Thames Navigation Service Centre at Gravesend can now supervise shipping in the Thames Estuary as far down river as Southend by means of a remote control radar system developed by Decca Radar and Elliott-Automation.

The very high quality of the radar information presented to the controllers in the centre has been made possible by transmitting a radar picture of navigation in the estuary over a very broad-band microwave link from a point on the river bank five miles away, together with data transmission signals which convey the exact bearing of the radar scanning aerial.

The system also incorporates a u.h.f. narrow-channel radio link to transmit the control and monitoring signals which enable the radar equipment to be operated remotely and to provide a speech channel for maintenance and other purposes.

**For further information circle 107 on Service Card**

## Quality Control

Quality control is the means of obtaining a reliable product. Most firms today check the final product but many of them do not adjust their inspection methods to take advantage of new techniques and equipment. A new booklet, 'Quality Control and Inspection,' published by D.S.I.R., describes the basic principles of these important industrial processes.

Many firms, even now, are not familiar with the techniques involved or aware of the possibilities offered by quality control for raising the standard of their products. Some smaller firms ignore what they consider to be an expensive luxury.

The booklet outlines the tools available and indicates what the testing equipment costs. Everything from X-rays to calipers gets a brief mention and ways are suggested by which quality control might be improved with the right equipment.

This booklet is sixth and last in the series, 'Automation at Low Cost,' obtainable free of charge from The Library, D.S.I.R., State House, High Holborn, London, W.C.1.



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# NEW BOOKS

**British Instruments Directory and Buyers' Guide: 4th Edition**

Pp. 700. Published by the Scientific Instrument Manufacturers' Association and available from United Science Press Ltd., 9 Gough Square, London, E.C.4. Price £3 10s. 0d. (post free).

This standard reference work on the British instrument industry is produced in co-operation with the trade association of the industry, the Scientific Instrument Manufacturers' Association, and is published every other year. In 9 separate sections, this provides a comprehensive guide to sources of supply of British scientific and industrial instruments and their component parts. This edition includes 150 new headings for instruments and components bringing the list of classified headings to over 2,500. In the address section there is a 15% increase in the number of firms listed.

The directory also includes for the first time an Italian-English glossary. With the existing Spanish-English, German-English, French-English, and Russian-English glossaries, the major instrument using countries of the world are now covered.

In addition to listing the wide range of instruments and components available in this country and their manufacturers and agents, the directory also gives valuable information on organizations concerned with the instrument industry, specialist services and glossaries of terms in five languages.

**Microphones 2nd Edition**

By A. E. ROBERTSON, B.Sc.(Eng.), A.M.I.E.E. Pp. 357 + xii. Published for *Wireless World* by Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1. Price 75s.

Written by the Deputy Head of the B.B.C. Engineering Training Department, this book is intended primarily as a training manual for B.B.C. technicians. In this, the elementary principles of microphones are explained and some of the features which distinguish one type of microphone from another are discussed.

Any book which devotes much space to the description of microphones in current use in a broadcasting organization is soon out of date. It is for this reason that this second edition concentrates mainly on principles of operation and only describes actual microphones if they illustrate an important development or if they have some historic significance. Therefore this manual is likely to be used as a reference book rather than a text book.

**Semiconductor Fundamentals, Devices and Circuits**

By A. H. SEIDMAN and S. L. MARSHALL. Pp. 278 + ix. John Wiley & Sons Ltd., Glen House, Stag Place, London, S.W.1. Price 50s.

There are 14 chapters and two appendixes in this book. The first four deal mainly with the physics of diodes and transistors, while the next two are concerned with construction and manufacture. The treatment is fairly simple and involves little mathematics.

Chapter 7 deals with equivalent circuits and chapter 8 with the use of transistor characteristic curves. Biasing and stabilizing are then treated. Succeeding chapters cover amplifiers, including negative feedback, oscillators, circuits for digital computers, the tunnel diode, and electrical measurements of diode and transistor characteristics.

The appendixes give some physical units and the answers to some of the problems which are posed in the book.

**Vacuum and Solid State Electronics: An Introductory Course**

By D. J. HARRIS, B.Sc.(Eng.), Ph.D., A.M.I.E.E., and P. N. ROBSON, B.A., A.M.I.E.E. Pp. 254 + ix. Pergamon Press Ltd., Headington Hill Hall, Oxford. Price 20s.

The emphasis in this book is on electron devices themselves and the physical processes responsible for their operation, rather than on details of the circuits in which they may be used. However, one chapter is included which describes the use of these devices as rectifiers, amplifiers and oscillators. The authors have written this book with the needs of 1st and 2nd-year engineering students in mind, although it could be read with profit by students prior to entry to an engineering course.

**Graphical Symbols for Components of Servo-Mechanisms: Part 2 General Servo Mechanisms**

B.S. 3238 : Part 2. Pp. 32. British Standards Institution, 2 Park Street, London, W.1. Price 12s. 6d.

B.S. 3238 is intended to serve as a companion standard to B.S. 1523, Section 5, which defines terms for general servo-mechanism components—although it is recognized that not all these terms need graphical symbols. The first part of B.S. 3238 has already been issued and deals with graphical symbols for transductors and magnetic amplifiers.

The aim of the standard is to develop standard symbols which allow the functioning and interconnections of general servo-mechanisms to be indicated on a single diagram—even if the mechanisms are combinations of electrical, mechanical and hydraulic or pneumatic devices. It is this type of diagram which is required by the servo-mechanism manufacturer and user.

**Analog Computer Techniques 2nd Edition**

By CLARENCE L. JOHNSON (Lieutenant-Colonel, U.S. Air Force). Pp. 315 + xii. McGraw-Hill Publishing Co. Ltd., McGraw-Hill House, Shoppenhangers Road, Maidenhead, Berks. Price 69s. 6d.

This book describes for practising engineers, of graduate level, the uses of analogue computers. To fully benefit from this, the reader needs an understanding of electrical and mathematical principles including d.c. and a.c. circuits and differential equations. An understanding of servo-mechanism theory and Laplace transform theory will also be helpful for a full appreciation of certain sections.

This second edition is expanded and re-arranged in a more logical order and much of the outdated material has been eliminated. Recent improvements in equipment and techniques are included in this edition. One of these is the simulation of electronic systems to which a new chapter is devoted. In addition, the author has placed heavier stress on fundamentals of problem preparation. In particular, the treatment of problem scaling has been expanded and simplified by the development of additional rules which aid the engineer in estimating the magnitude of problem variables. Other material expanded or added to the original text includes: the simulation of servomechanism systems, the true time lag or transport delay phenomenon, the quarter-square multiplier, circuits for performing trigonometric resolutions and inverted trig. functions without mechanical resolvers, a brief introduction to random noise generation and material on amplifiers and amplifier design criteria.



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**Fundamentals of Microwave Electronics**

By V. N. SHEVCHIK. Translated from Russian by L. A. THOMPSON and edited by W. A. GAMBLING. Pp. 253 + xxxi. Pergamon Press Ltd., Headington Hill Hall, Oxford. Price 70s.

There are three parts to this book. The first is the shortest and covers oscillatory circuits for microwaves. The second deals with electronic phenomena such as velocity modulation, bunching and the energy exchange between an electron beam and an a.c. field. The third discusses electron devices, klystrons, travelling-wave tubes, magnetrons, etc. The treatment is fairly mathematical.

The book is based on a course of lectures given by the author at Saratov State University.

**Electronic Information Display Systems**

Edited by JAMES H. HOWARD. Pp. 309 + vii. Cleaver-Hume Press Ltd., 10-15 St. Martin's Lane, London, W.C.2. Price 78s.

The material in this book is in the main adapted from lectures at the Institute on Electronic Information Display Systems at the Center for Technology and Administration of the American University in May 1962. There are four parts covering fundamentals, requirements, techniques and applications.

**Addition to B.S. 448 Electronic-Valve Bases, Caps and Holders**

Pp. 7. British Standards Institution, 2 Park Street, London, W.1. Price 3s.

This addition to B.S. 448 includes specifications for B9A/D base, B9A/D pin and tabulation position gauge and B9A/D pin straightening tool.

## Manufacturers' Literature

**STC Radio Interference Suppressors for Aircraft.** This 8-page booklet describes a range of high temperature, lightweight capacitors developed for aviation use, and wound from metallized polyester film. These capacitors have been designed specifically for the suppression of radio interference aboard aircraft. They range in value from 0·2 to 2 μF.
*STC Capacitor Division, Footscray, Sidcup, Kent.*
**For further information circle 108 on Service Card**

**Component-Type 'Variacs'.** This single-page leaflet describes, with prices and ratings, a new range of component-type 'Variacs', intended for permanent installation. Simplified terminal arrangements are a feature of these units.
*Claude Lyons Ltd., Valley Works, Hoddesdon, Herts.*
**For further information circle 109 on Service Card**

**Low Cost Electronic Devices.** A four-page leaflet describing the full range of low-cost electronic devices made by Richard Allan Radio. Among the items illustrated are photo-electric counters and a batch counter with a 90-day memory.
*Electronics Division, Richard Allan Radio Ltd., Taylor Street, Batley, Yorkshire.*
**For further information circle 110 on Service Card**

**Semiconductors.** A 20-page short-form catalogue of Siemens & Halske semiconductors includes details of transistors, Hall-effect devices, diodes, tunnel and zener diodes, photo-electric devices and thermistors. Photographs and outline drawings are provided.
*R. H. Cole Electronics Ltd., 26-32 Caxton Street, Westminster, London, S.W.1.*
**For further information circle 111 on Service Card**

**Belling-Lee Hygrometric Tables.** One of the standard procedures of a manufactured product involves exposing it in an atmosphere of 95% relative humidity at temperatures between 30 and 60 °C. The relative humidity may be measured by the standard wet-and-dry bulb thermometer method, but the intervals in standard published hygrometric tables covering this temperature range are too wide to permit close enough assessment and control of the conditions of test.

To enable the equipment to be accurately adjusted in their own laboratories, Belling-Lee programmed a digital computer to accept basic climatic data and calculate the values of relative humidity at intervals of $\frac{1}{10}$ °C depression of the wet bulb thermometer over the temperature range involved, and covering a range of atmospheric pressures between 800 and 1,120 millibars. The results have been compiled in a set of tables, copies of which are available free of charge to all laboratories genuinely engaged in this type of work.
*Belling & Lee Ltd., Great Cambridge Road, Enfield, Middlesex.*
**For further information circle 112 on Service Card**

**Cold Cathode Indicator Tubes.** Publication MS/126, a 24-page booklet in the STC Application Notes series, is devoted to alphabetical and numerical indicator tubes. Information given for the control of indicator tubes and their application includes a number of circuit diagrams.
*STC Valve Division, Footscray, Sidcup, Kent.*
**For further information circle 113 on Service Card**

**Mufax Weather Chart Facsimile Transmission.** Details of the facsimile method of transmitting and recording weather charts are given in this 12-page illustrated brochure, which outlines the advantages of facsimile as opposed to coded transmission. The current range of Mufax equipment is fully described.
*Muirhead & Co. Ltd., Beckenham, Kent.*
**For further information circle 114 on Service Card**

**Westool Coils.** An 8-page publication on industrial electric coils produced by Westool includes information on layer-wound coils, including self-supporting coils, fabricated bobbin coils and moulded bobbin coils.
*Westool Ltd., St. Helen's Auckland, Bishop Auckland, Co. Durham.*
**For further information circle 115 on Service Card**

**Potentiometric Pressure Transducers Terminology and Definitions.** This 6-page booklet provides recommended terminology and definitions pertaining to potentiometer-type pressure transducers. Its purpose is to assist the engineer in selecting the correct transducer for a particular application, and also to avoid misunderstandings between manufacturer and user.
*Tectron Electronic Corporation, 91 Rome Street, Farmingdale, New York, U.S.A.*
**For further information circle 116 on Service Card**

**D.C. Motors and Generators.** The current E.P.E. 20-page catalogue and price list contains a comprehensive guide to d.c. motors and generators. It includes rating details for screen-protected and totally-enclosed d.c. motors for use with electronic speed control equipment.
*The Electrical Power Engineering Co. (B'ham) Ltd., Bromford Lane, Ward End, Birmingham 8.*
**For further information circle 117 on Service Card**

**INFORMATION WANTED ?**

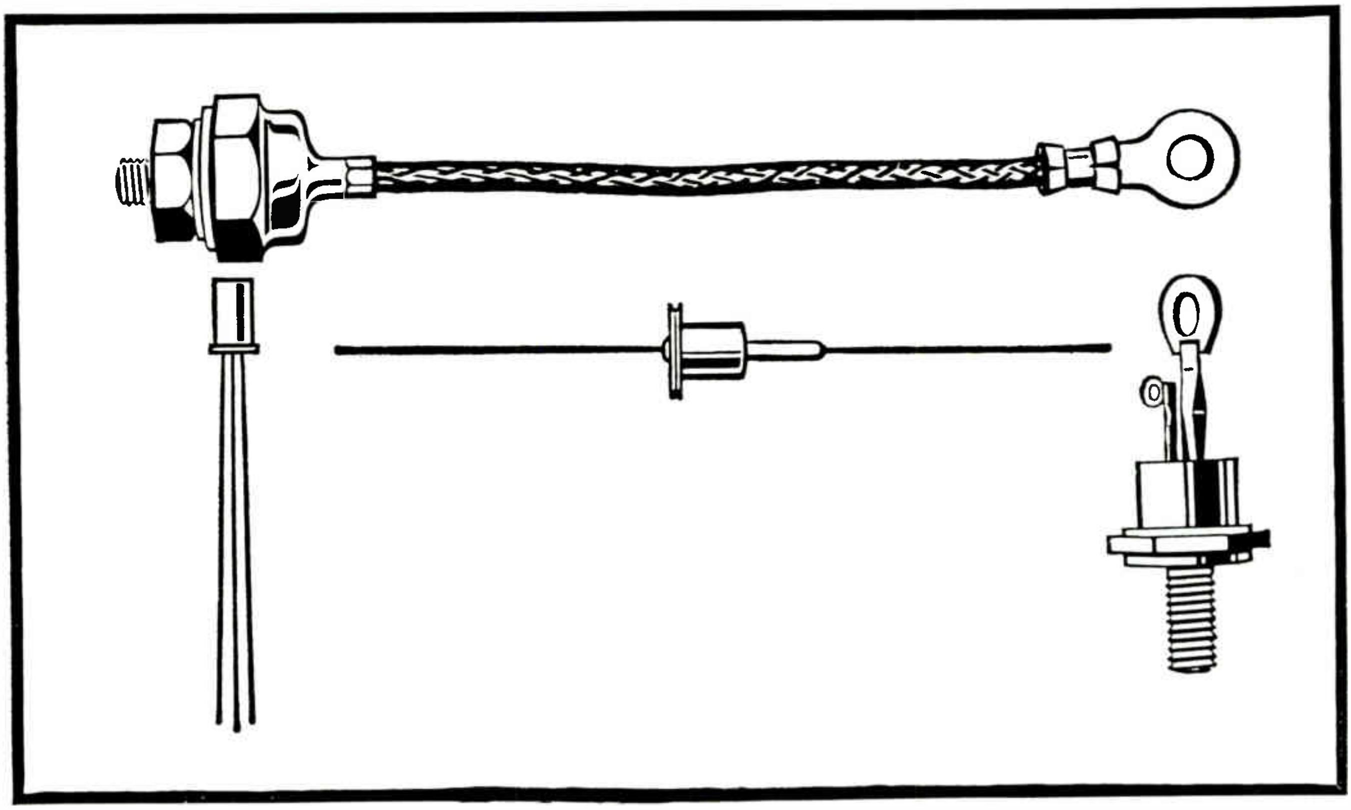
If you require further details of products or processes described or advertised in INDUSTRIAL ELECTRONICS you will find it convenient to use the enquiry cards which will be found in the back of the journal. The sheet of cards can be folded out to enable you to make entries while studying the editorial and advertisement pages.



World Radio History

# SEMICONDUCTORS

## IMMENSE RANGE—IMMEDIATE DELIVERY



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# YOU'LL NEED TO KNOW ABOUT DELANCO GLASS FIBRE LAMINATES

If you need a material with a working temperature of up to 250 C very high dielectric strength and low loss properties PLUS high mechanical strength and exceptional machining properties you need look no further than the DELANCO range of glass fibre laminates, in sheet, tube, rod or in parts accurately machined to your drawings.

In fine and medium weave glass cloth base, with a bonding agent of silicone, Epoxy, melamine or phenolic, each grade having characteristics suitable for specialised applications. These applications are mainly in the electro-mechanical fields, but more recent technological advances in other fields are bringing regular enquiries for many new trades.

Class C Transformers, for example, Aircraft construction, and plating jigs, give some idea of the versatility of this material.

For machined parts only, we have one of the most modern tool departments in the country, and all tools and fixtures are made by operators with first-hand knowledge of the materials on which these tools will be used.

Parts can be blanked, routed, milled, drilled and counterbored, and metal tags and terminals can be fitted. Engraving on the finished parts is also done in our own works.

For further Technical Details send for Delanco Catalogue.

**Delanco**

for Electrical Insulation

*Anglo-American Vulcanized Fibre Co. Ltd., Cayton Works, Bath Street, London, E.C.1. CLE 8484. Grams: Prompserv, Cent, London. Delanco Works, Leonard Street, London, E.C.2.*



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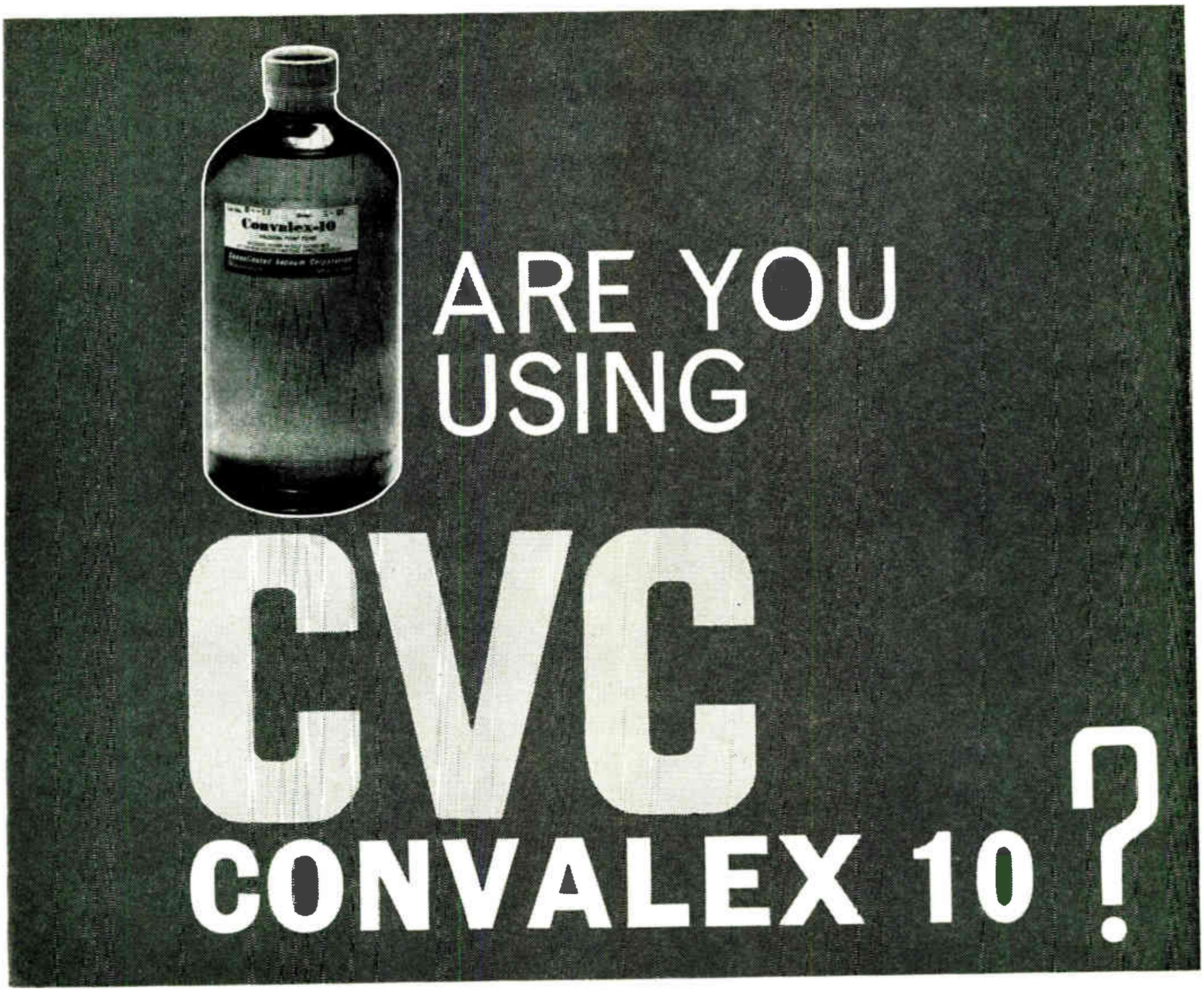


Convalex-10 is a highly-refined organic vapour pump fluid now available from CVC for use in vapour pump systems where the lowest ultimate pressures and lowest rates of backstreaming are essential.

Independent comparative tests (as reported at the 1963 Symposium of the American Vacuum Society) have shown that pressures as low as $2 \times 10^{-9}$ torr and backstreaming rates as low as $3 \times 10^{-9}$ mg/cm$^2$ min have been obtained using a simple water-cooled elbow type of trap.

Convalex-10 contains no silicon and is, therefore, recommended for applications where silicon contamination could be detrimental. This fluid will also withstand prolonged exposure to air at high temperatures with minimum oxidation and decomposition.

**CONVALEX-10 GIVES YOU LOWER BACKSTREAMING RATES WITH LOWER ULTIMATE PRESSURES THAN ANY OTHER DIFFUSION PUMP FLUID AVAILABLE TODAY...**

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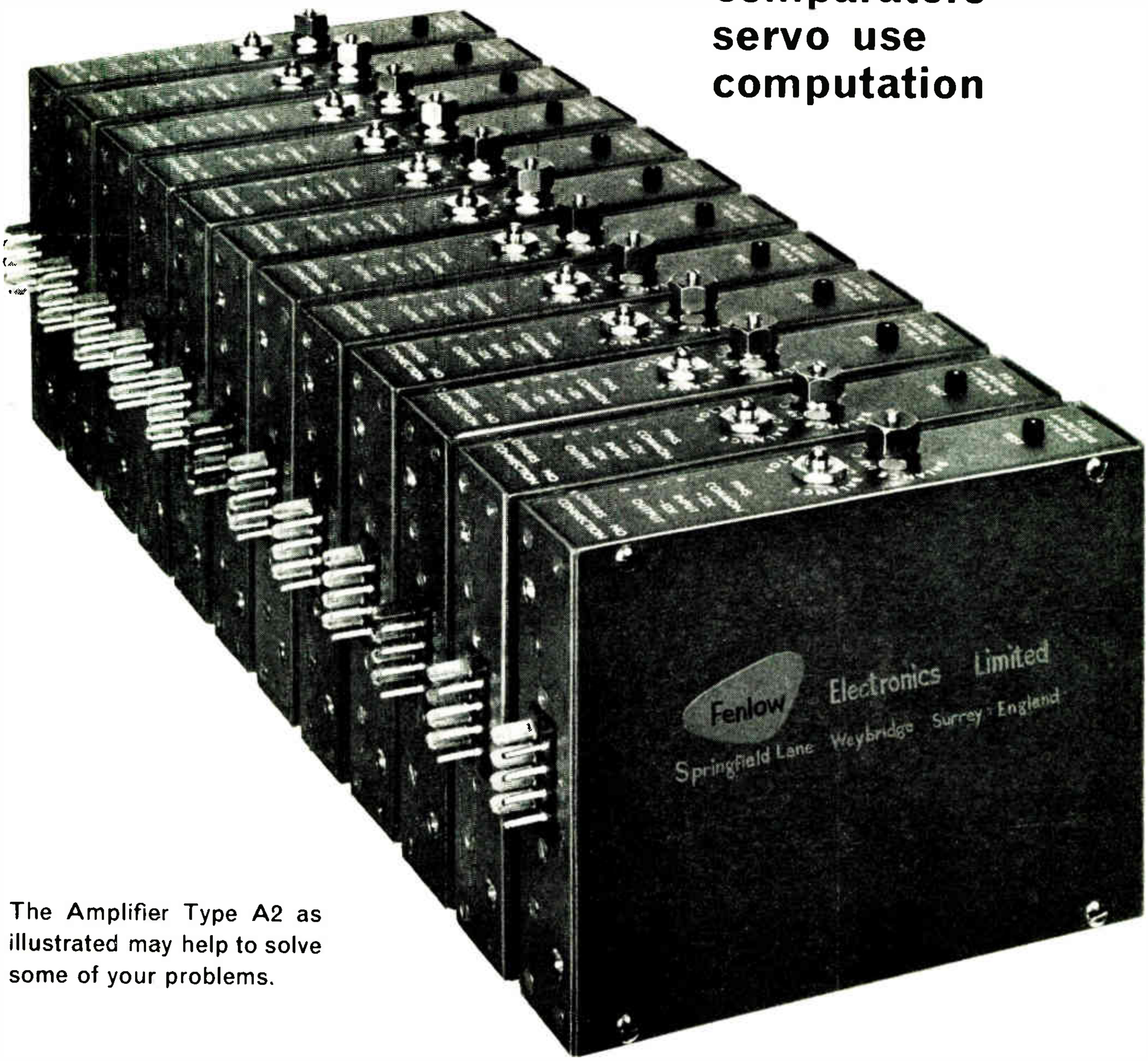
# AMPLIFIERS

## for signal amplification
## integration
## summation
## differentiation
## comparators
## servo use
## computation




The Amplifier Type A2 as illustrated may help to solve some of your problems.

**APPLICATION REPORTS AND LITERATURE SENT ON REQUEST**

**Fenlow Electronics Limited**

**SPRINGFIELD LANE, WEYBRIDGE, SURREY. WEYBRIDGE 43978**



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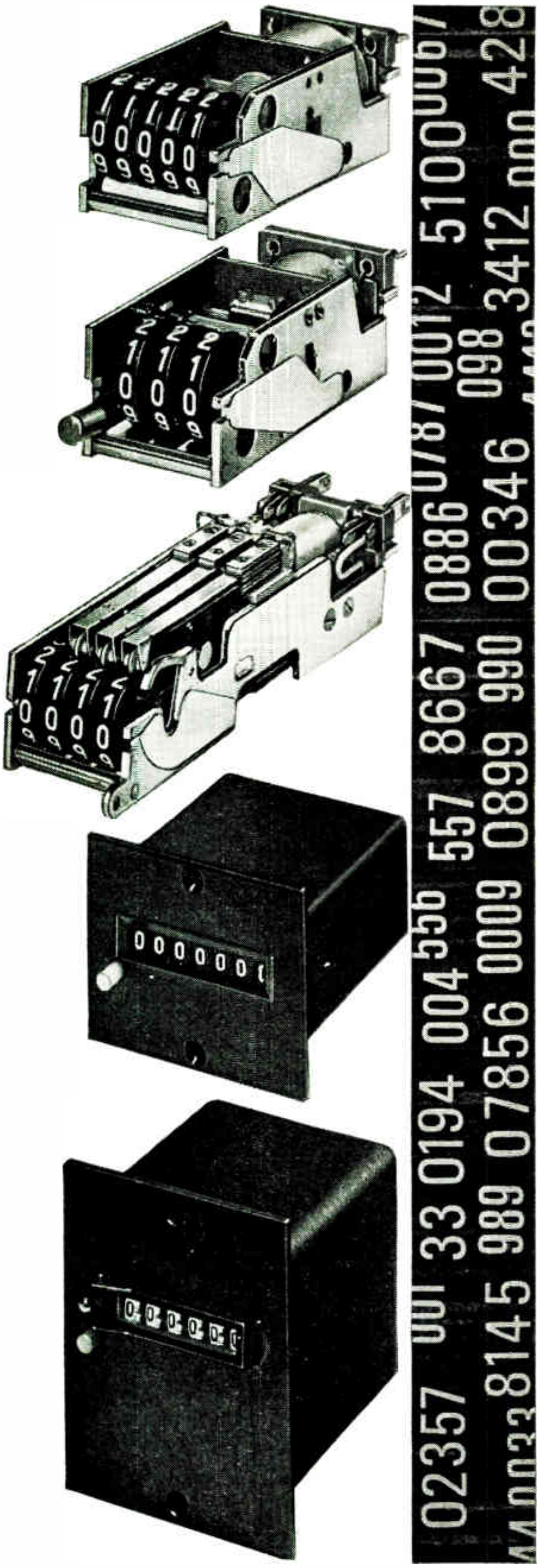

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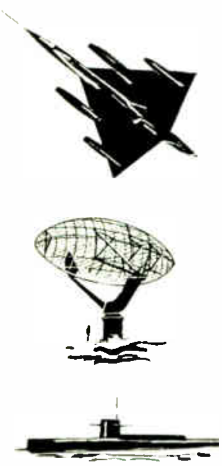

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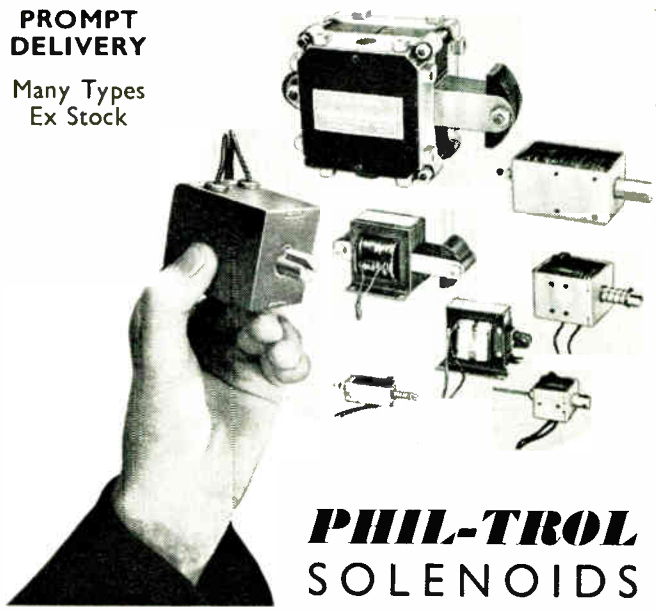

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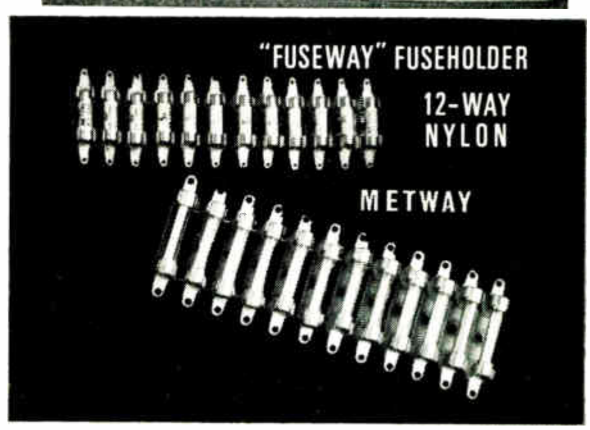


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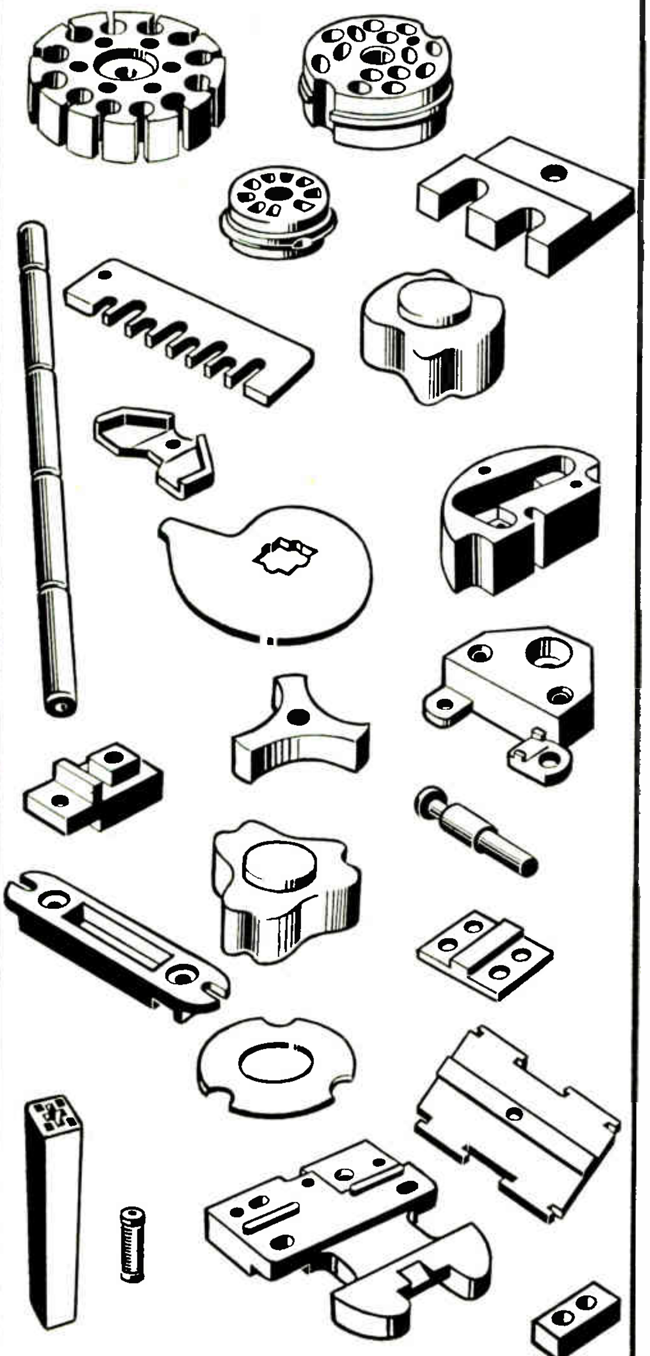

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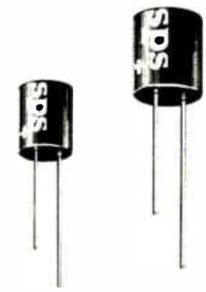


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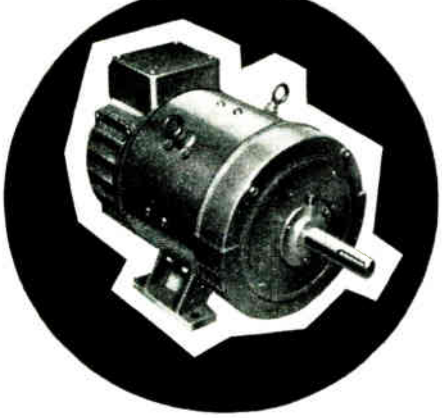

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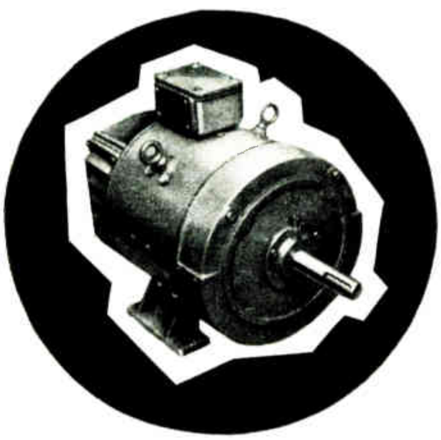

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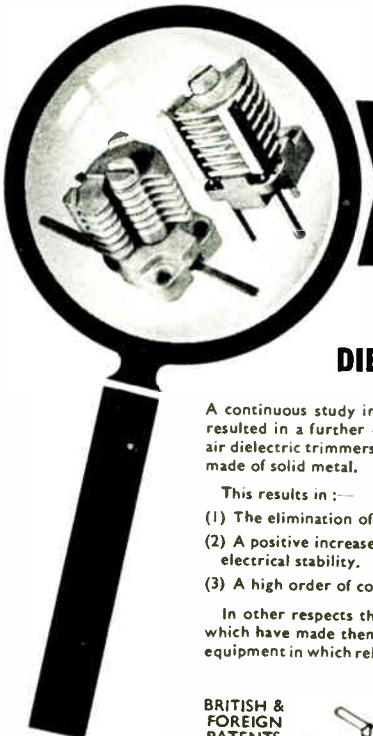

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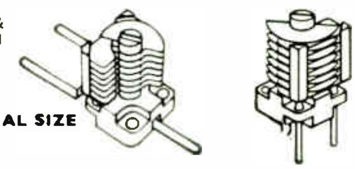

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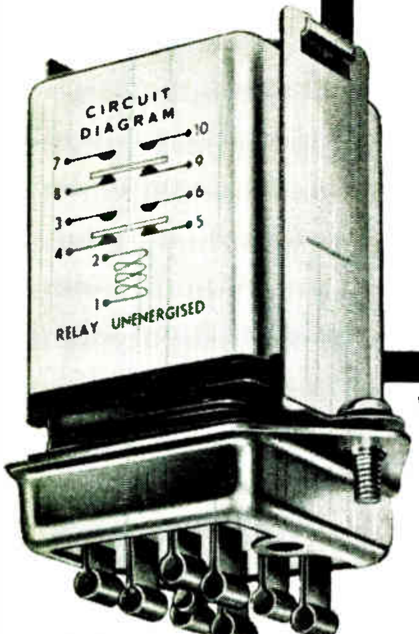


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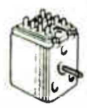

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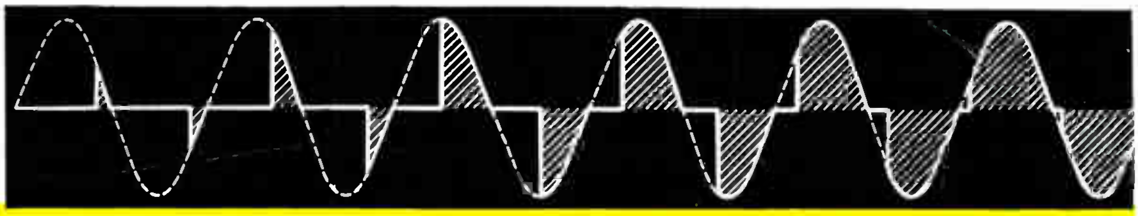

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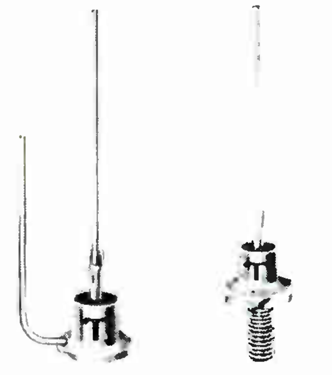


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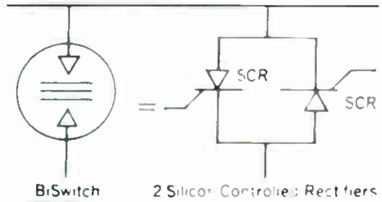
**Contrôle de puissance d'éclairage**
**Contrôle de chauffage**

Der "BiSwitch", eine von Transitron hergestellte Silizium-Schalterdiode, mit zwei stabilen Arbeitspunkten, wurde für die Anwendung in Wechselstromschaltungen mit Phasenanschnitt entwickelt. Mit einer Diode dieser Art ist der Ersatz von zwei gesteuerten Gleichrichtern möglich. Durch ihren niedrigen Preis, in Verbindung mit der für diese Diodenart charakteristisch einfachen Schaltungstechnik, ist die Diode für alle industriellen Anwendungen geeignet, wie zum Beispiel für die:

**Drehzahlregelung elektrischer Maschinen**
**Helligkeitsregelung in der Beleuchtungs**
**Belichtungstechnik und für Temperaturregelungseinrichtungen**

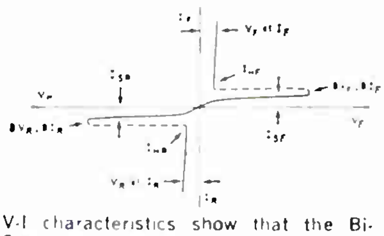
SIMPLER, MORE ECONOMICAL




Economical in itself, the BiSwitch permits further savings by replacing two silicon controlled rectifiers.

BiSwitch — 2 SCR's

SWITCHES RAPIDLY IN EITHER DIRECTION



V-I characteristics show that the BiSwitch blocks voltage in either direction and rapidly switches into conduction by exceeding the breakover voltage.

BLOCKING CAPABILITIES UP TO 200 VOLTS. LOAD CURRENTS UP TO 7 AMPS

ABSOLUTE MAXIMUM RATINGS

**Transitron Electronic Ltd.,**
Bilton House, Uxbridge Road,
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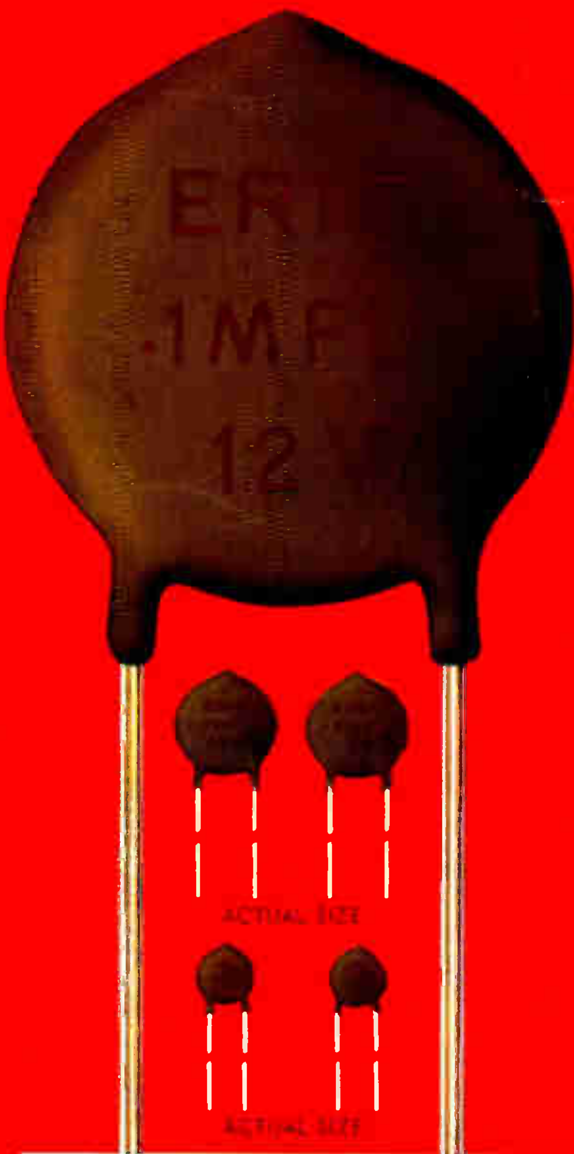
**Transitron Electronic,** 29 Avenue de l'Opéra, Paris 1er. OPE. 69-89.
**Echanges Techniques Internationaux,** 73 Avenue de Neuilly, Neuilly-sur-Seine. SAB. 70-40.

**Transitron Electronic G.m.b.H.,**
8000 München 5, Corneliusstrasse 12.
Telefon: 24 12 74.

For further information circle 202 on Service Card




# Transcaps* beat paper capacitors 4 ways ! ! ! !

1. Transcaps are much smaller than paper capacitors of identical capacitance.
2. Transcaps — thin discs — are more conveniently shaped to fit into confined spaces.
3. Transcaps — with their parallel leads — are more speedily mounted, particularly to printed circuit boards.
4. Transcaps are superior — in stability and in reliability.

***There's always room for a Transcap****

| [illegible] | Capacitance µF | Volts Wkg d.c. | [illegible] | [illegible] | | Capacitance µF | Volts Wkg d.c. | [illegible] | [illegible] |
|---|---|---|---|---|---|---|---|---|---|
| 831/T/12V | 0.010 | 12 | 1Mohm | | 831/T/3V | 0.068 | 3 | 100kohm | |
| 831/T/12V | 0.015 | 12 | 1Mohm | | 811/T/12V | 0.068 | 12 | 1Mohm | • |
| 831/T/12V | 0.020 | 12 | 1Mohm | | 831/T/3V | 0.100 | 3 | 100kohm | |
| 831/T/12V | 0.022 | 12 | 1Mohm | | 811/T/12V | 0.100 | 12 | 1Mohm | • |
| 831/T/12V | 0.030 | 12 | 1Mohm | | 811/T/25V | 0.100 | 25 | 50Mohm | • |
| 831/T/12V | 0.033 | 12 | 1Mohm | | 811/T/6V | 0.220 | 6 | 250kohm | |
| 831/T/3V | 0.047 | 3 | 100kohm | | 811/T/3V | 0.250 | 3 | 50kohm | |
| 811/T/25V | 0.047 | 25 | 100Mohm | • | 811/T/3V | 0.470 | 3 | 50kohm | |
| 831/T/3V | 0.050 | 3 | 100kohm | | 811/T/3V | 0.500 | 3 | 50kohm | |
| 811/T/25V | 0.050 | 25 | 100Mohm | • | | | | | |

Capacitance tolerance: −25% +50%
Max. Power Factor: 5% at 1kc/s and 0.5V
Working Temp. Range: −40°C to +85°C
Finish: 'EPITEX' insulating coating
Marking: Typographic, red, showing capacitance in µF and working voltage

ERIE* ELECTRONIC COMPONENTS

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