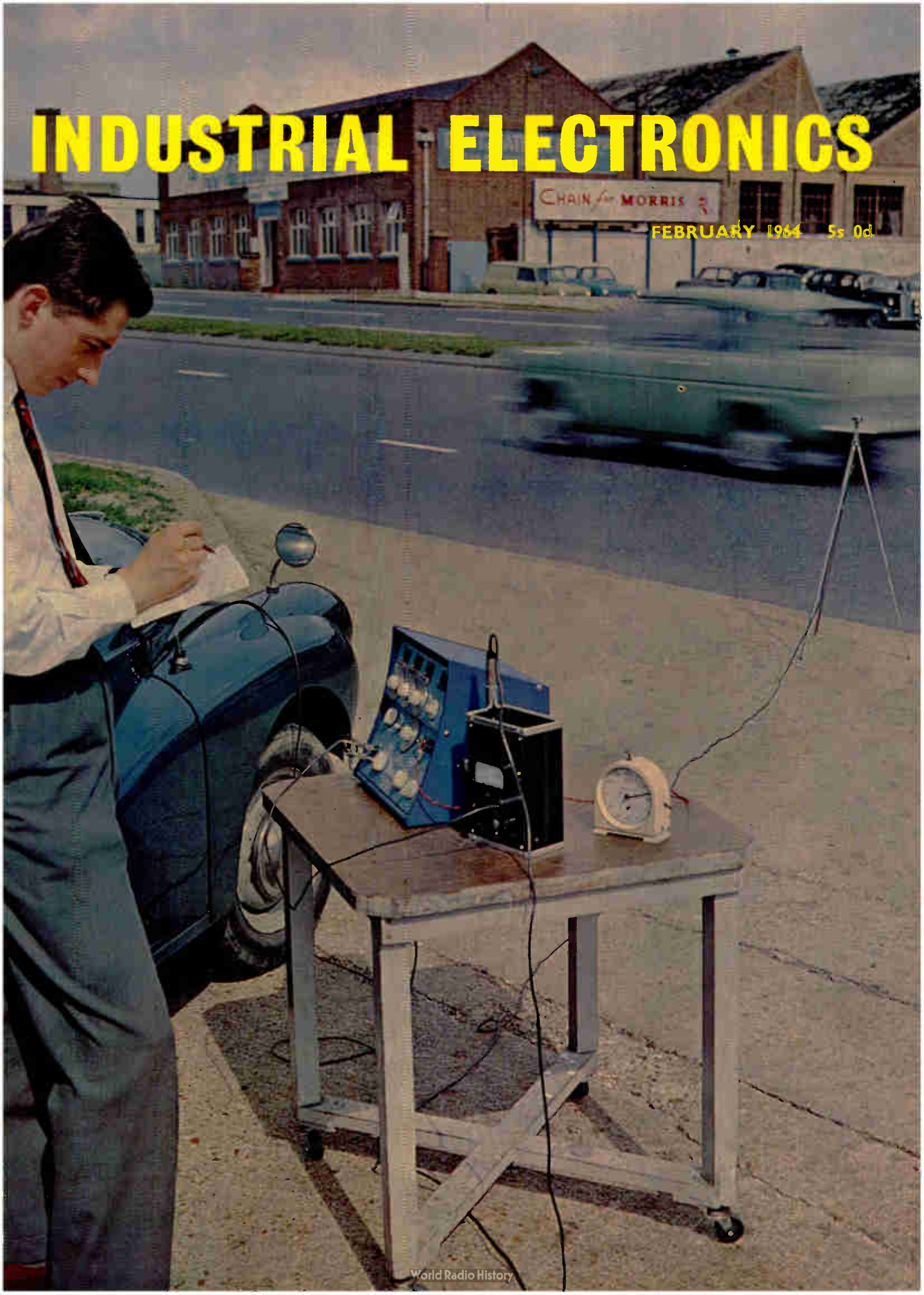
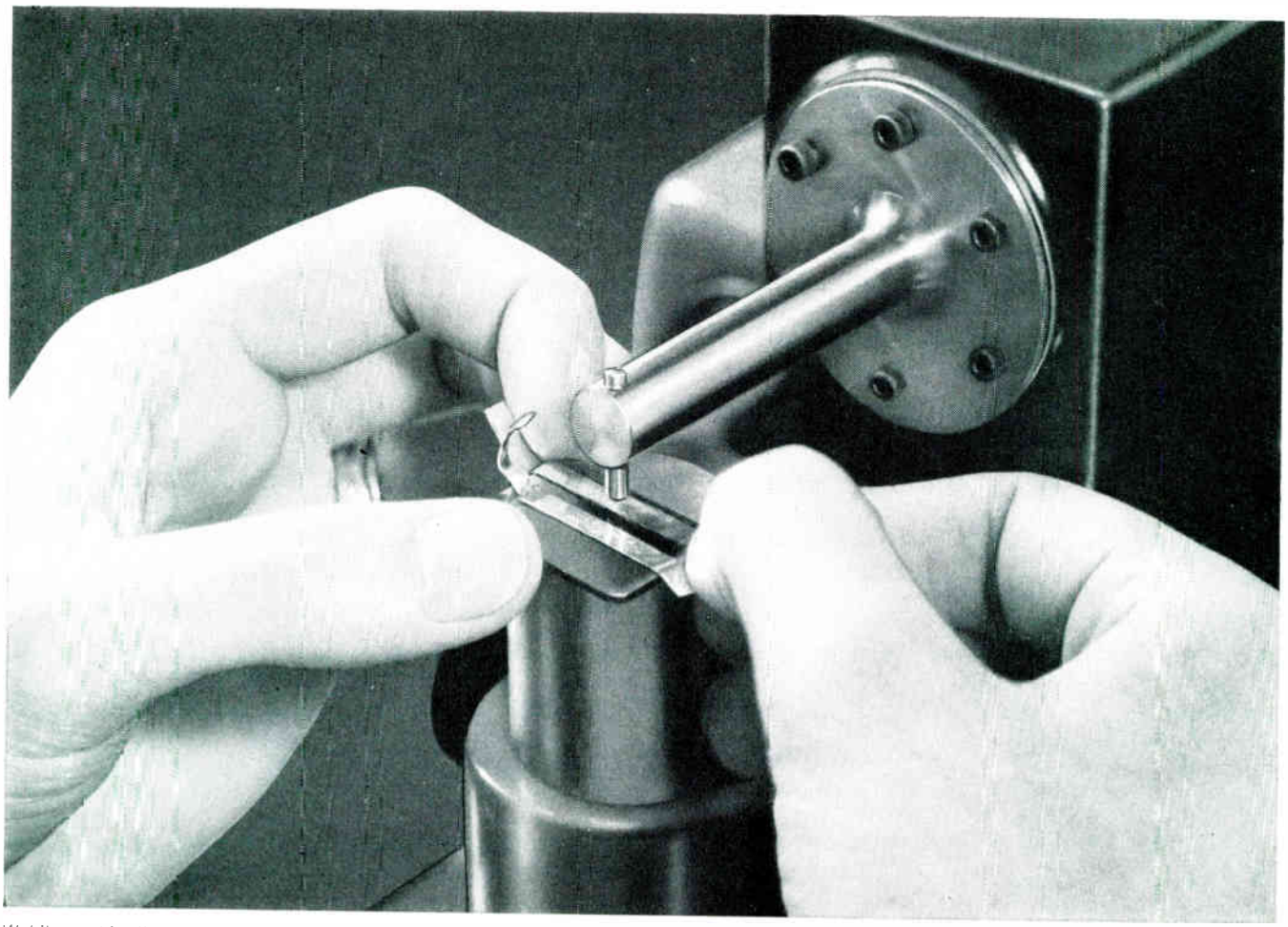
INDUSTRIAL ELECTRONICS

FEBRUARY 1964 5s 0d



Precision welding with M E L ultrasonics



Welding gold foil to glass. Foot-pedal control allows the operator use of both hands for delicate work.

For those delicate, tricky welding jobs—especially in microminiaturization—which you cannot handle by conventional spot-welding techniques, M.E.L. have developed the SL86 Ultrasonic Spot-Welder.
The SL86 offers the most practical method for joining together thin ductile sheets or fine wire. Welding similar or dissimilar metals, or metals to some non-metals is easily accomplished, without necessarily having to begin with clean surfaces. Because pressure is light and the process is unaccompanied by heat there is no significant deformation of the workpiece.

Write or telephone M.E.L. today for a copy of the leaflet "System SL86 Ultrasonic Spot-Welder"

M E L

MULLARD EQUIPMENT LIMITED

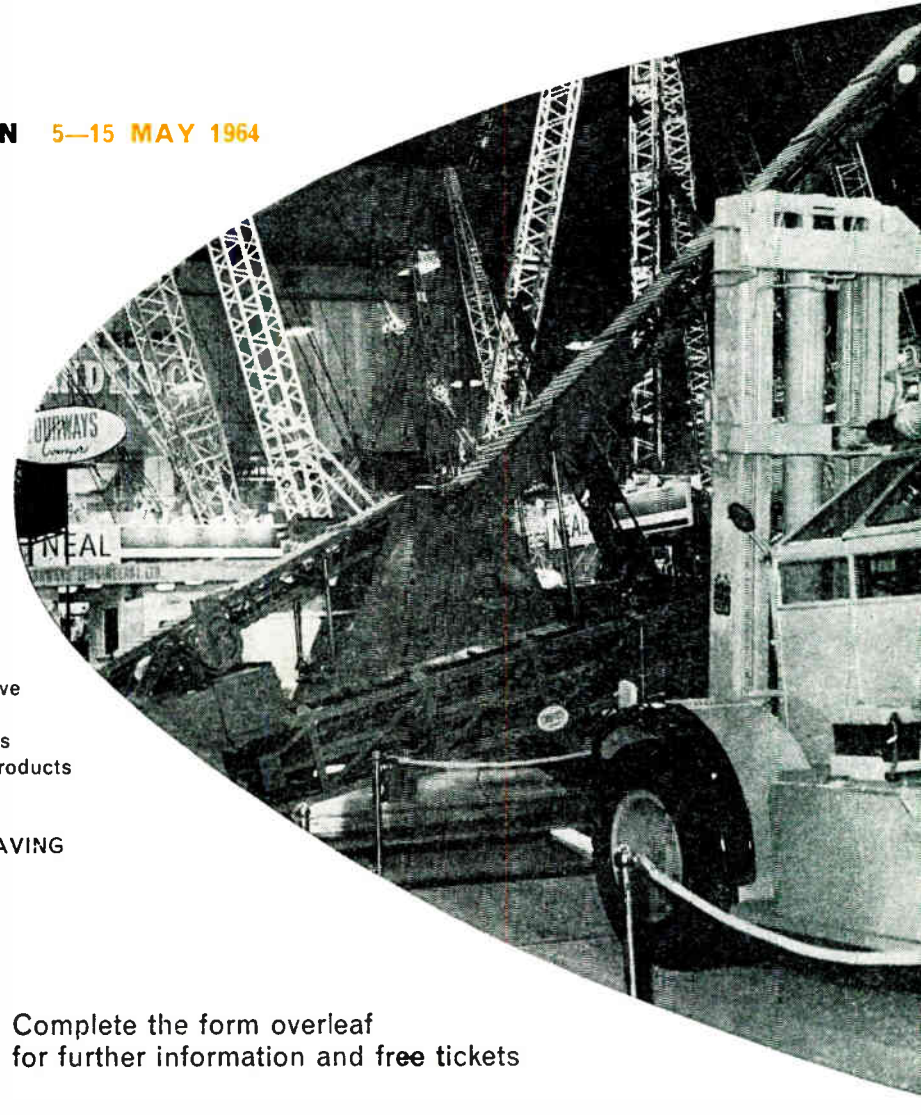
Manor Royal · Crawley · Sussex · Telephone: Crawley 28787

ME711

mechanical handling exhibition

Biggest-ever assembly of newest equipment for increasing industrial output and reducing costs

EARLS COURT LONDON 5—15 MAY 1964



WHOEVER YOU ARE
or whatever your industry
costs are the most important
single factor in your business

HOW COSTS CAN BE SAVED
in factories, warehouses, stores
and all places where goods
and materials must be moved
is demonstrated at the
Mechanical Handling Exhibition

This great exhibition
the largest and most comprehensive
of its kind in the world
houses the best of mechanical aids
to the handling of materials and products
It is an essential date
for all who are concerned with
PRODUCTIVITY AND COST SAVING

NOTE THE DATE NOW
May 5-15, 1964
Earls Court, London

Complete the form overleaf
for further information and free tickets

ORGANIZED BY THE ILIFFE JOURNAL MECHANICAL HANDLING

with the support of the leading British organizations: Mechanical Handling Engineers' Association; British Industrial Truck Association; The Association of Crane Makers; Aerial Ropeways Association; The Association of Lifting Tackle Makers.

mail this now for details of this important event

The Manager
Mechanical Handling Exhibition
Dorset House, Stamford Street
London, S.E.1.

Please send literature as published, also a complimentary season ticket to the Mechanical Handling Exhibition

INDUSTRIAL ELECTRONICS

incorporating *ELECTRONIC TECHNOLOGY*

Volume 2 Number 2 February 1964

contents

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

Assistant Editor **T. J. BURTON**

Advertisement Manager **G. H. GALLOWAY**

53 **Comment**

55 **Doppler in Aircraft, Pt. 1** *by G. Thomas, B.Sc.*
In this opening article the general principles of doppler navigation are discussed. The second part will describe a particular equipment in some detail.

58 **Automatic Statistical Analysis** *by W. E. Mason*
The instrument described in this article discriminates between different signal amplitudes and so sorts a signal, such as noise, into three channels. The number of samples in each channel are counted automatically.

62 **Applying Analogue Computers to Industrial Process Control** *by W. E. Willison*
The role of the analogue computer in on-line process control is discussed in this article with particular reference to its relationship with conventional instruments and small digital computers in integrated control hierarchies. The possible areas of application are considered and specific examples are given.

69 **Ultrasonic Cleaning** *by B. Brown, Ph.D., B.Sc.*
This second article on ultrasonic cleaning discusses the general kinds of equipment and their proper spheres of application.

85 **Multiple Pin-Hole Camera for Microelectronics** *by T. E. Price, Ph.D.*
Photographic methods are used in one stage of the manufacture of microelectronic devices and the microphotographs employed must contain an array of many identical images. This article describes the principles of a multi-pin-hole camera which automatically produces this multiplication of images.

89 **Industrial Applications of Radioactive Tracers** *by Denis Taylor, M.Sc., Ph.D.*
By including suitable radioactive isotopes in solid, liquid or gaseous material, it is possible to trace the movements of the bulk material. This article deals with the choice of isotope and its detection and describes a number of industrial applications.

continued overleaf

Published on the first Thursday after the 5th of each month by

ILIFFE ELECTRICAL PUBLICATIONS LTD.
Managing Director: W. F. Miller, M.A., M.Brit.I.R.E.
Dorset House, Stamford Street, London, S.E.1.
Telephone: Waterloo 3333.
Telegrams: Wirenger, London, Telex
Cables: Wirenger, London, S.E.1.

ANNUAL SUBSCRIPTION, HOME £3 0s. 0d.
OVERSEAS £3 10s. 0d.
CANADA and U.S.A. $10.00.

contents

continued

92 **The 1964 I.P.P.S. Exhibition**
The Annual Exhibition of The Institute of Physics and The Physical Society was held from 6th to 9th January 1964. This article reviews some of the exhibits having industrial interest.

FEATURES

60 **IBM Accounting System**

61 **New Sequence Control System**

67 **Weights and Measures Stamp Load Cell Weighbridge**

68 **Vibration Monitoring Equipment for Industrial Plant**

72 **Pozidrivs Supersede Phillips Screws**

73 **Road Lighting Measured from the Driver's Seat**

74 **Equipment Review**

88 **Measuring Oxygen in Hot Gases**

98 **Industrial News**

102 **New Books**

102 **Manufacturers' Literature**

31 *Classified Advertisements*

32 *Index to Advertisers*

OUR COVER

The cover picture shows electronic apparatus being used to establish the distribution of sound levels from traffic on an arterial road. The output from a Dawe type 1400E sound-level meter is fed into a type 1466A statistical analyser.

Next Month

The March issue will contain an article dealing with the use of control systems for Ward Leonard drives. Other articles will explain an electronic way of detecting 'pigs' in oil pipelines and treat some transistor biasing problems.

TO SAVE YOUR TIME

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

M-O V

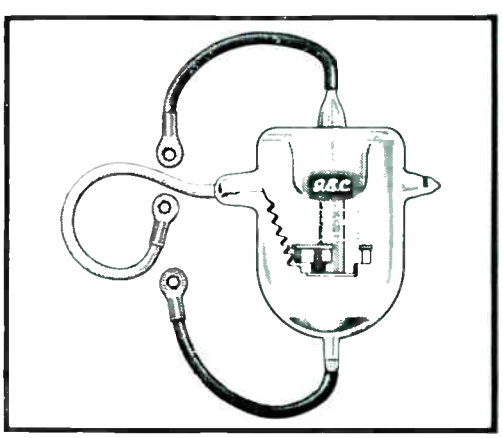
ARMED CIRCUIT PROTECTION THAT NEVER SLEEPS

Special M-O V agent E3020 is a triggered *cold cathode* gas discharge device to divert lawless surges. That means *no heater supply, no baffle supply, no bias supply,* and *no gas clean-up!* Compact, reliable E3020 doesn't cost much, and was designed to protect electronic equipment from flash arc damage and other voltage breakdown effects.

It dispenses with the need for expensive high speed fuses, and replaces hot-cathode thyratrons in circuits already using electronic protection – for instance in "crowbar" service in radio transmitters. The E3020 Surge Diverter features:

fast operation—less than 1 μs · high fault current—2000 A · wide voltage range—600-6000 V

E3020 is the first of a new M-O V range, and full circuit accessories are available.



G.E.C.

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

M-O VALVE CO LTD

BROOK GREEN WORKS · HAMMERSMITH · LONDON W6

Further developments in Mullard microwave valves

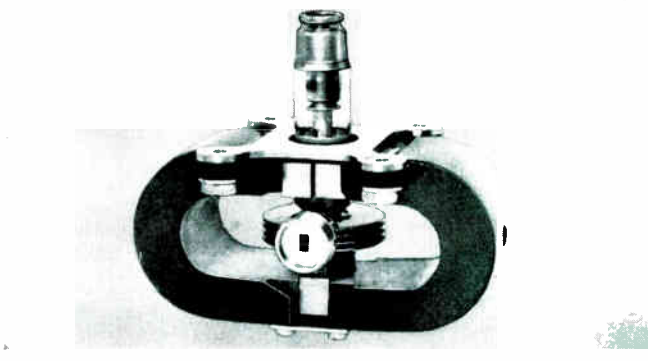
New types for radar and communications

Amongst the valves recently introduced into the Mullard range of microwave devices are the first magnetron for the new marine navigational radar band, two magnetrons for airborne radar, and a communications klystron.

First Magnetron for 33Gc/s Civil Marine Radar Band

The YJ1020 is the first magnetron available to fulfil the international frequency requirements of the 33Gc/s band for civil marine radar. The valve is a special version of the established JP35–30, a packaged magnetron intended for very short pulse operation, and incorporates many of the features of the earlier valve.

The frequency of the YJ1020 is fixed within the band 31·8 to 33·4Gc/s. The maximum pulse output power is 40kW at a duty factor of 0·0002, and typical operating characteristics are 30kW pulse output at 0·0001 duty factor.



Magnetron YJ1020 for 33Gc/s marine radar band

Lightweight X-band Magnetrons for Airborne Radar

Two recent additions to the Mullard range of lightweight magnetrons for airborne radar equipment are the YJ1090 and YJ1091. Each valve weighs only 200g, is rugged, and is mechanically tunable. A pulse output power of 50W can be obtained with an input pulse of 1·18kV at 0·9A, the pulse length being up to 2μs at a duty factor of 0·004.

A special feature of these two magnetrons is the frequency stability. The frequency temperature coefficient is less than 100kc/s per degC, and the frequency modulation under vibration with an acceleration of 12*g* at frequencies 50 to 2000c/s is 1Mc/s.

Magnetron YJ1091 is tunable over the range 8·5 to 9·0Gc/s, and the YJ1090 over the range 9·0 to 9·5Gc/s.

Lightweight X-band magnetron YJ1090 for airborne radar equipment

11Gc/s Communications Klystron

A mechanically tunable 11Gc/s klystron is now available for use as a pump for parametric amplifiers, and for use in doppler speed radar and in narrow-band point-to-point communications links. This klystron can be operated in two modes, enabling it to function as a local oscillator or a power valve. The klystron, type YK1091, is also available in a ruggedised version which has the type number YK1090.

The mechanical tuning range of both versions is from 10·5 to 12·2Gc/s and electronic tuning can also be used to produce a minimum frequency variation of 30Mc/s. A waveguide output is used for connection to WG16 waveguides. When operated as a local oscillator, the typical output power is 200mW (V.S.W.R. = 1·1) while the output when operating as a power valve is 370mW.

For further information on these microwave valves, please use the reader reply card of this journal (see reference number opposite).

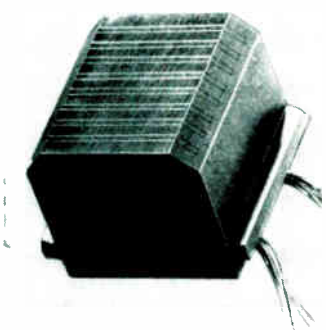
What's new from Mullard

Magnetic recording heads to individual specifications

High-density ferrite material improves head life

A design and manufacturing service for magnetic recording heads in professional equipment is offered by Mullard to users of these specialised devices. The service covers recording heads for tape, magnetic discs, and drums, and both single-track and multi-track types can be manufactured. These Mullard recording heads incorporate a range of ferrite materials which combine excellent magnetic properties with high durability.

Recording heads with gap sizes down to 3μm can be manufactured, this size being the smallest required for most applications. For the smaller gap sizes, a special moulded-glass technique is used which enables a sharply defined gap to be obtained and eliminates erosion of the ferrite at the pole tips.



Life increased tenfold

The high-density ferrite materials used in the construction of the heads have considerable advantages over the laminated metals generally used. The low losses at high frequencies of the ferrites result in a low power loss in the head and a low head noise. The manufacture of the head is considerably easier using a ferrite rather than a laminated-metal core, and the life of the head is considerably extended. Tests have shown that ferrite heads using the moulded-glass gap technique have a life at least ten times that of the laminated-metal type.

Air-cooled ignitron can be fired by small thyratron

A small-sized ignitron capable of working in circuits handling peak demands of up to 200kVA has been added to the Mullard range. Special features of this ignitron are the use of forced-air cooling and the fact that it can be fired by a small thyratron.

This ignitron, type ZX1000, is designed for applications requiring precise control and is particularly suitable for resistance-welding equipment. A special ignitor enables a small thyratron to be used for firing, with a consequent reduction in cost in comparison with the firing circuits of conventional ignitrons. The capacitor firing system ensures ignition within 10μs, independent of variations in load impedance.

An alternative slip-on water-jacket can be supplied instead of the cooling fins for use in installations where cooling water is already available.

Reader Enquiry Service

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

New microwave valves 206

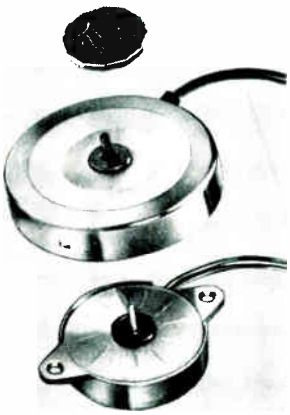
Recording heads 207

Chopper transistor BCY49 208

Ignitron ZX1000 209

Synchronous motors AU5009, AU5010 210

ZX 1000 with water-jacket (left) and air-cooling fins



Two series of synchronous motors extend range

Application in timing equipment

Two series of small synchronous motors have recently been added to the Mullard range for use in a wide variety of professional equipment. The new motors are intended for use mainly in timing equipment, and like the others in the range, combine high torque with a small physical size.

The AU5009 series will operate in an ambient temperature of 90°C. The working torque of all motors in this series at 1r.p.m. is 3750g.cm, and the free spindle speed is 250r.p.m. The motors operate from a 220V 50c/s supply, and types for clockwise and anti-clockwise rotation are available.

The AU5010 series is for use in timing applications where small size is of prime importance. Eight types are available, for clockwise and anti-clockwise rotation on supply voltages of 24, 48, and 110V at 50c/s, and of 117V at 60c/s. The working torque at 1r.p.m. of the 50c/s types is 1250g.cm, and the free spindle speed is 250r.p.m. For 60c/s motors, the working torque at 1r.p.m. is 1500g.cm, and the free spindle speed is 300r.p.m.

Both series of motors can be used with gearbox type AU5300, enabling over fifty reduction gear ratios to be obtained.

CHOPPER TRANSISTOR FOR LOW-LEVEL SWITCHING APPLICATIONS

A silicon p-n-p alloy-junction switching transistor has been recently introduced for use in low-signal-level chopper applications. Special features of this transistor, type BCY49, are the low 'on' resistance, the high 'off' resistance, and the low offset voltage.

The BCY49 can be used in any low-level switching application at frequencies up to 1kc/s. Typical applications include input choppers d.c. for amplifiers, and analogue switching.

AVEL INSTRUMENTATION for Every Electronic Need

✱ Fundamental Research.

Virtually all Electronic Measurement and Test Instrumentation for ANY INDUSTRY.

RF/UHF Transmission and Reception.

Electronic and Photographic Recording.

Educational aids.

✱ Our application engineers are competent to advise on any electronic measuring problems which you may have, and will suggest the correct instruments for the project in mind.

✱ After sales service is ensured by a well-equipped Technical Services Department, repairing and re-conditioning equipment and producing special modifications and accessories as required.

MICROWAVE HARMONIC GENERATOR.

The above illustrates the NARDA Type VE577 HARMONIC GENERATOR used for the generation of frequencies, where the fundamental frequency sources may not be available, through the use of lower frequency oscillators.

This item is but one of a comprehensive range of microwave components and instruments applicable to the frequency spectrum up to 90 Gc/s.

Aveley Electric Limited

Distributors in United Kingdom for:

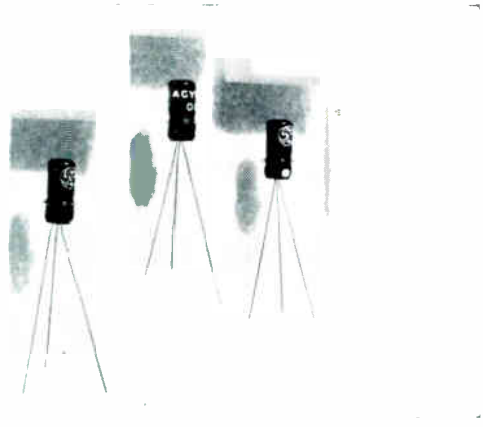
ROHDE & SCHWARZ
DUMONT
NARDA
BRUSH
STODDART

For Further Information Write or Phone

SOUTH OCKENDON ESSEX
Telephone. SOUTH OCKENDON 3444
Telex: 24120 AVEL OCKENDON

STC components review

FEBRUARY 1964



LF TRANSISTORS
ACY34 ACY35 ACY36

Another three devices have been added to the range of STC germanium low frequency transistors. These new p-n-p types are designed for use in driver and output stages, oscillators and low speed switching applications. All three have a collector dissipation of 200 mW and they conform to VASCA SO-2 outline □ These new transistors are competitively priced and are available with immediate delivery.

BRIEF CHARACTERISTICS

	ACY34 (Driver)	ACY35 (Driver)	ACY36 (Class B o/p, Switching)
h_{fe} at −2V, −0·5 mA	20-40	—	—
h_{fe} at −2V, −3·0 mA	—	30-75	—
h_{FE} at −7V, −80 mA	—	—	30-90
V_{CBM} (emitter open circuited)	−30V	−30V	−32V
V_{CEM} (base open circuited)	−10V	−10V	−16V
I_{CBO} at V_{CB} = −30V	−12μA	−12μA	−12μA

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

HIGH SLOPE UHF TETRODE

This forced-air-cooled high slope triode, which conforms to the USA JAN-7289 specification, is the latest STC addition to the 2C39A family. Its construction, which includes a ceramic/metal envelope, is more rugged than that of the 2C39A. Also, the distributed inductance and capacitance of the grid/cathode and grid/anode configurations are more tightly controlled. In most cases this valve can be used as a unilateral direct replacement for the 2C39A.

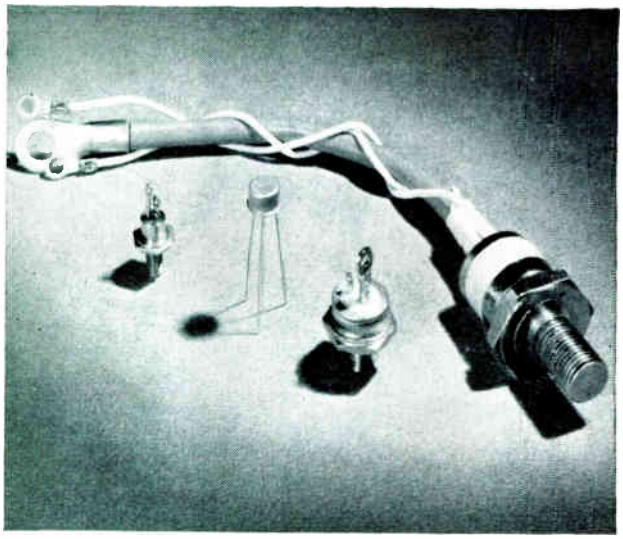
The 7298 is very suitable for use as a power amplifier, oscillator or frequency multiplier at frequencies up to 3 000 Mc/s.

ABRIDGED DATA

Cathode	Filament V	Filament A	μ	r_a kΩ	g_m mA/V	Max. P_a V	Max. V_a V	Class C Power Output W	Class C Frequency Mc/s
IH	6·0	1·0	100	4·0	25	100	1 000 3 500 (pulsed)	20 1 600pk	2 500 3 000

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

CONTINUED OVER



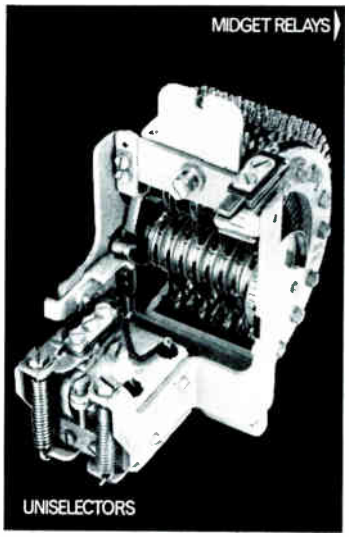
THYRISTORS FOR POWER SWITCHING AND CONTROL

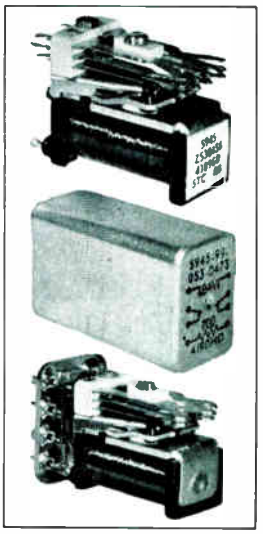
These new devices, the most recent addition to the range of Silicon rectifier devices made by STC, are backed by joint research and development programmes undertaken by the Semiconductor Division (Rectifiers) and Standard Telecommunication Laboratories. The range, now available, comprises 1, 3, 25 and 70 amperes units with ratings from 50 to 400 volts, all fabricated by a double diffusion process. The device construction is simple but robust, standard packages being used.

ABRIDGED DATA

Device Code	CRS 1/ ·· AF	CRS 3/ ·· AF	CRS 25/ ·· AF	CRS 70/ ·· AF
Mean forward Current (Full conduction Angle)	1·0A† 0·33A*	3A† 0·9A*	25A† 10A*	70A† 38A*
Peak Repetitive Forward Current	5·00A†	15·00A†	125A†	350A†
Crest Working Reverse Voltage	50 to 400V	50 to 400V	50 to 400V	50 to 400V
Peak Forward Blocking Voltage	60 to 480V	60 to 480V	60 to 480V	60 to 480V
Max. Case/Stud Temperature	125 C	125 C	110 C	125 C
	†at 65 C case *at 110 C case	†at 100 C stud *at 120 C stud	†at 75 C stud *at 95 C stud	†at 90 C stud *at 110 C stud
Forward on Voltage ..... max.	1·2V	1·3V	1·2V	1·2V
Holding Current (Minimum to hold ON)	20 mA	25 mA	50 mA	60 mA
Forward Blocking Current .....max.	1 mA	1 mA	5 mA	20 mA
Reverse Current at Rated CWV.....max.	1 mA	1 mA	10 mA	20 mA
Gate Trigger Current (Minimum value to trigger all devices)	10 mA	20 mA	50 mA	50 mA
Standard Outlines	VASCA SO-44A JEDEC TO-5	VASCA SO-35A	VASCA SO-28	VASCA SO-30C JEDEC TO-49

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





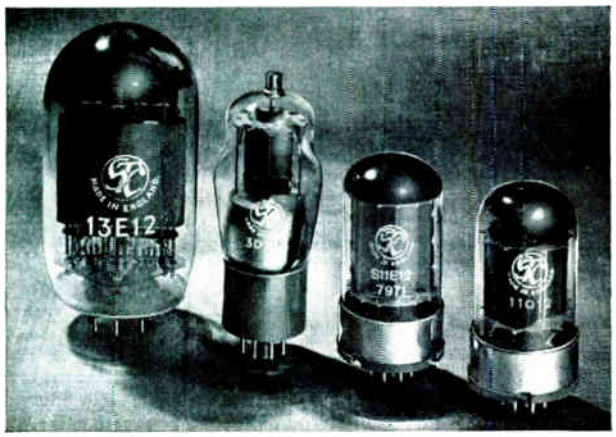
SWITCHING DEVICES FROM STOCK

MIDGET RELAYS. A wide range of Midget Relays, proved to be extremely reliable under the most exacting conditions of service, are available. Sealed or Open types for light, medium and heavy duty operation. Fully type approved. Hermetically sealed versions are fully tropicalized. Most of the 36 types in the STC standard range are now available from stock.

UNISELECTORS. Automatic switching devices for:— Control Circuits, Line Finding, Batch Counting, Registering, Time Switching, Special Systems and Telecommunications generally. STC Uniselectors are available with 3, 4, 5, 6, 8 or 10 levels for operation on 22V or 50V. All types except the 10 level can be supplied with wipers giving 2 appearances of 25 points, or 1 appearance of 50 points, per revolution. The 10 level gives 5 circuits of 50 points. Other coil voltages supplied with short delivery times.

Write, 'phone or Telex for literature and prices to STC Electro-mechanical Division, West Road, Harlow, Essex. Telephone Harlow 21341. Telex 81184.

STC components review

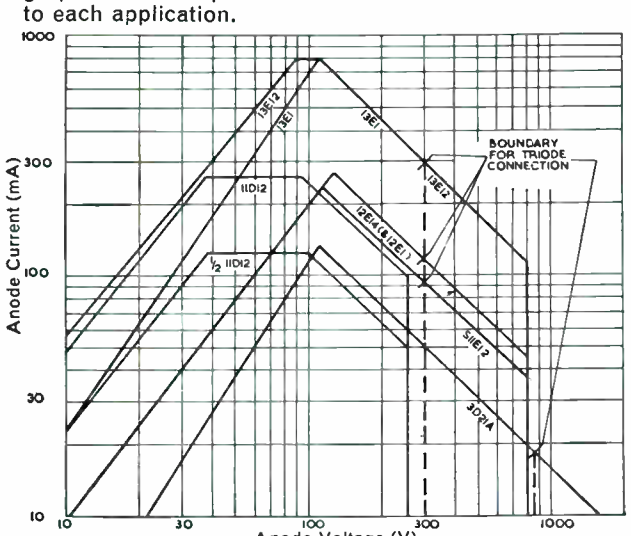


SERIES REGULATOR VALVES

STC manufacture a range of eight regulator valves, the latest being the type 11E14 beam tetrode which also has applications as a pulse modulator.

The limiting parameters of a regulator valve are normally: (a) characteristics at $V_{g1} = 0$, (b) average cathode current, (c) anode dissipation, and (d) maximum screen and anode voltages.

Comparative composite boundaries are shown on the graph below for quick selection of the valve best suited to each application.

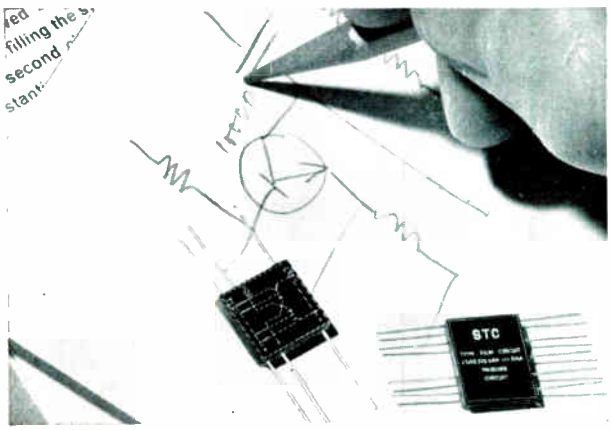


ABRIDGED DATA

Codes	Filament V	Filament A	Max. I_k mA	r_a Ω	g_m mA/V	Max. V_a V	Max. V_{g2} V	Max. P_a W	Max. V_{g1} V	Max. P_{g2} W
11D12 (6080)	6·3	2·5	2x125	280	7·0	250	—	2x13	—	—
11E14	6·3	1·2	200	—	16·5	800	400	10	—	4·0
3D21A	6·3	0·7	200	—	5·5	3 500	850	15	−500	3·0
S11E12*	6·3	1·6	300	400	14	800	300	28	−100	5·0
12E1	6·3	1·6	300	380	14	800	300	35	−100	5·0
12E14†	6·3	1·6	300	380	14	800	300	35	−100	5·0
13E1	26	1·3	800	130	35	800	300	90	−100	10
13E12	13	2·6	800	110	25	800	300	90	−100	10

* Special quality valve. † Single-ended, improved version of 12E1 and to be preferred for new equipment design.

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



THIN FILM CIRCUITS CUSTOM-BUILT OR READY MADE

Custom-built at short notice, or available ex-stock as ready-made circuits, STC Thin Film Circuits offer the circuit designer reliable micro-miniaturization and a wide selection of circuit configurations.

All STC Thin Film Circuits are manufactured under full Quality Control and are subjected to STC Quality Assurance Testing. Examples of standard circuits available immediately are:

☐ Amplifiers ☐ Logic Networks ☐ Trigger Circuits ☐ Multivibrators ☐ Attenuators ☐ Capacitors ☐ Resistors ☐ RC Networks

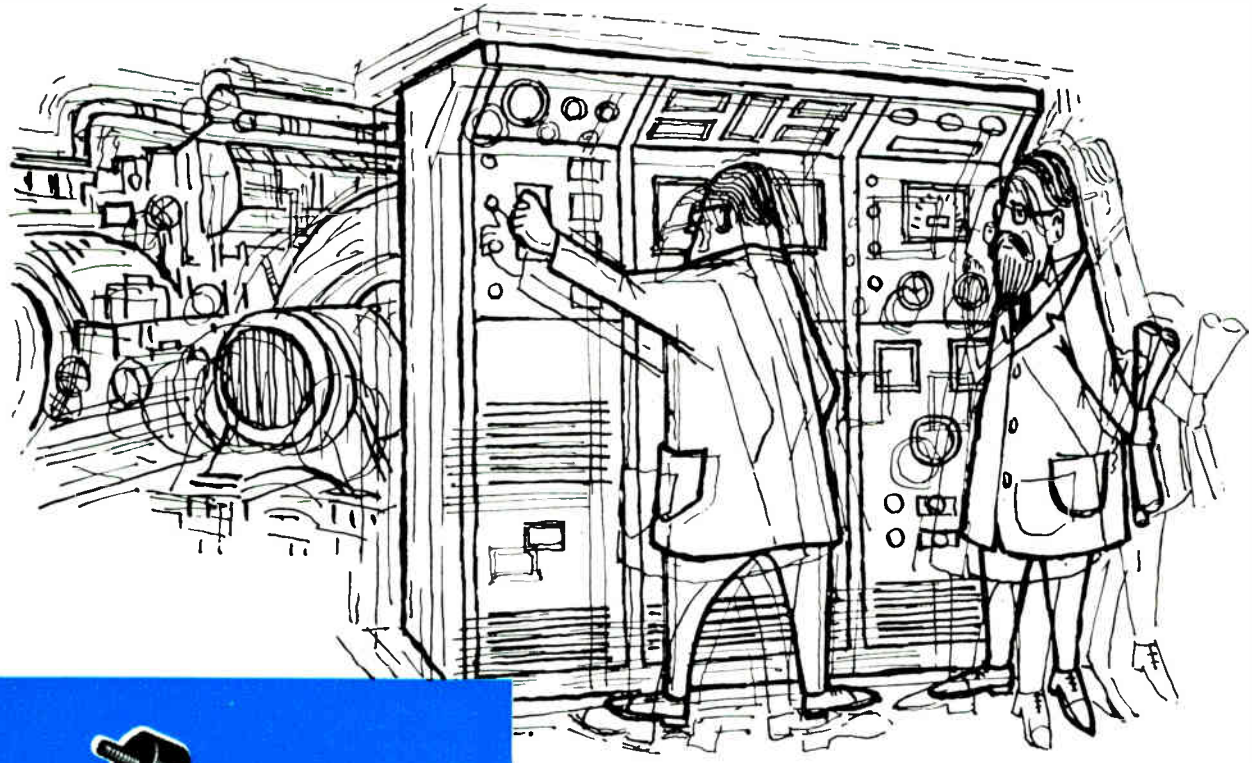
NEW DESIGN HAS ALL LEADS ON ONE EDGE

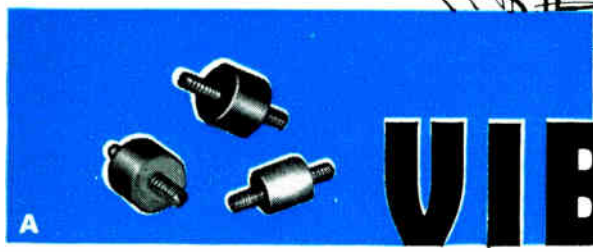
Transistor/Resistor Logic Circuit—actual size

The standard ranges of STC Thin Film Circuits are manufactured on ½ in. × ½ in. substrates. For applications that require the convenience of all leads emanating from one edge, such as insertion in printed or wiring boards, circuits can be supplied on 1½ in. × ½ in. substrates.

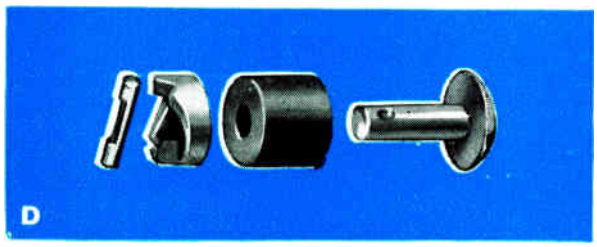
Write, 'phone or Telex for Data Sheets and prices to STC Capacitor Division, Brixham Road, Paignton, Devon or London Sales Office, Footscray, Kent. Telephone FOOtscray 3333. Telex 21836.

high-grade electronic components by **STC** COMPONENTS GROUP





VIBRATION?



The wide use of electronic equipment in industry, often in close proximity to machinery, presents new vibration problems. Every effort should be made to eliminate the trouble at its source by the use of Silentbloc machinery mountings, bearings and couplings; but local precautions in the electronic apparatus itself are also desirable, and there is an extensive Silentbloc range of devices for this purpose. A few are described here.

A. *Bonded rubber/metal stud mountings for supporting apparatus of light weight. There is a range of sizes of various degrees of stiffness.*

B. *Ring-type resilient mountings giving extra flexibility for shock insulation of sensitive equipment. Available in sizes to suit a great variety of applications.*

C. *Instrument mountings for general service offering good insulation with a useful degree of mechanical stability. Sizes and characteristics for every conceivable purpose.*

D. *'Vibrex" panel fasteners—quick one-hand action, with or without electrical and mechanical insulation between panel and base. Easier to fit than any other panel fastener: simple drilling of panel and base; no screwing, tapping, sweating or brazing.*

MOUNTINGS • BEARINGS • "VIBREX" PANEL FASTENERS

ANTI-VIBRATION DEVICES BY

SILENTBLOC

SILENTBLOC LTD • MANOR ROYAL • CRAWLEY • SUSSEX

Telephone: Crawley 27733 Telegrams: Silentbloc Crawley

Andre Rubber Co. Ltd. is another Silentbloc Company

Silentbloc products are also manufactured by Silentbloc (Australia) Pty. Ltd., Melbourne

Broadway/S304

FERRANTI FIRST AGAIN

ONE MILLION MILLION OHMS

REVERSE IMPEDANCE

Silicon Planar Epitaxial Miniature Diodes

ZS150	ZS151	ZS152	ZS153

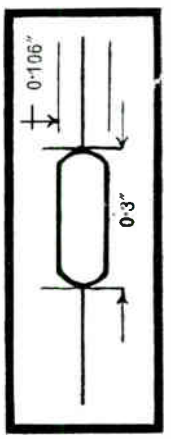
IMMEDIATELY AVAILABLE

SPECIAL FEATURES

- Surface Passivated Structure
- Exceptionally Stable Forward & Reverse Characteristics
- Small Size
- Negligible Leakage Current
- High Conductance

APPLICATIONS

- Magnetic Amplifiers for use at High Temperatures
- Modulators and Demodulators



MAXIMUM DIMENSIONS

MAXIMUM RATINGS AT 25°C		ZS150	ZS151	ZS152	ZS153
Peak Inverse Voltage	Volts	50	100	50	100
Max. Reverse Leakage Current	25°C μA	0·001*	0·001*	0·005	0·005
Max. Reverse Leakage Current	150°C μA	1·0†	1·0†	5·0	5·0
Max. Mean Rectified Current	mA	250	250	250	250
Max. Forward Voltage Drop	I_F = 200mA Volts	1·2	1·2	1·2	1·2
Operating Temperature Range	°C		—65°C to 200°C		

Typically * 0·0001 μA † 0·1 μA

FERRANTI *First into the Future*

FERRANTI LTD · GEM MILL · CHADDERTON · OLDHAM · LANCS
London Office Telephone: TEMple Bar 6666 Telephone: MAIn 6661

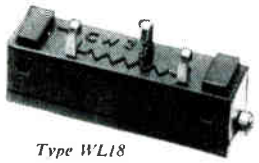
FE 249/2

Reliance

RECTILINEAR POTENTIOMETERS

Type WL18

Printed circuit version



Type WL18

Standard version

Type WL35

Standard version

Type WL35

Printed circuit version

Reliance Type WL35 Potentiometer is a 35 turn, wire wound, rectilinear potentiometer with a fully visible wiper. It is available in both standard and printed circuit versions, the latter having tags on the 0.1″ grid. The unit is stackable, has fully recessed terminals and slipping clutch action at both ends of travel.

SPECIFICATION:

Resistance Range: 10 ohms to 10,000 ohms nominal.
Tolerance: over 100 ohms ± 5%, below 100 ohms ± 10%.
Operational Temperature Range: −40°C to +100°C.
Maximum Working Voltage: 500 volts D.C.
Resolution: 10 ohms = 0.5% 1000 ohms = 0.17%
50 ohms = 0.4% 5000 ohms = 0.16%
500 ohms = 0.25% 10000 ohms = 0.12%

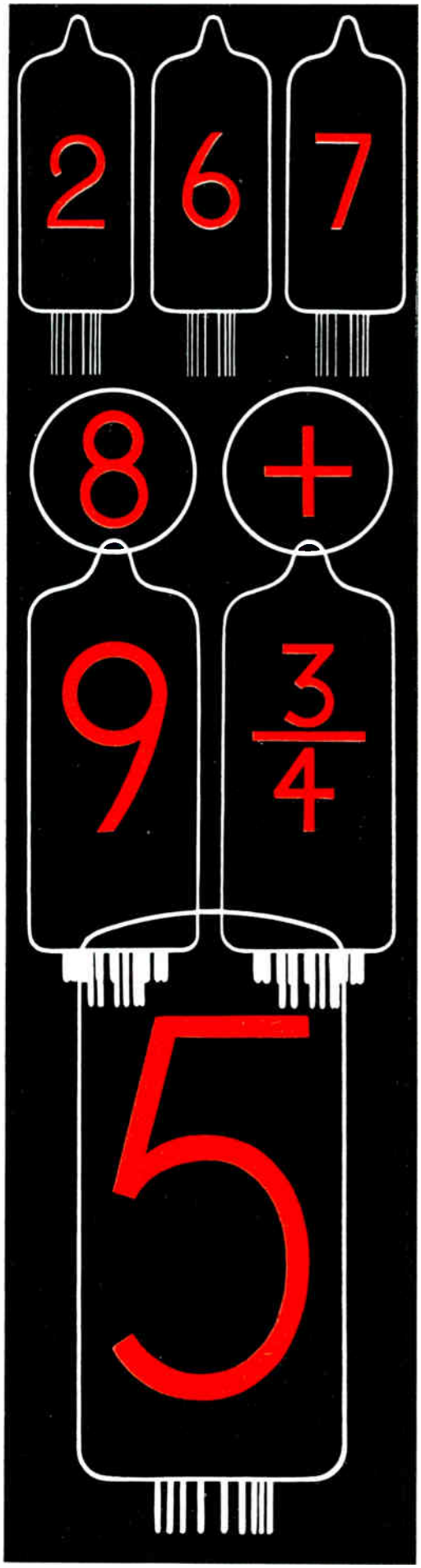
Reliance Type WL18 Potentiometer is an 18 turn, wire wound, rectilinear potentiometer which has been designed for use where an economically priced, high quality component is required but where sealing is not of paramount importance. Both standard and printed circuit versions, 0.1″ grid tags, are available.

SPECIFICATION:

Resistance Range: 1 ohm to 40,000 ohms
Tolerance: over 100 ohms ± 5%, below 100 ohms ± 10%.
Operational Temperature Range: −40°C to +105°C.
Maximum Working Voltage: 500 volts D.C.
Resolution: 50 ohms = 0.3% 2000 ohms = 0.62%
100 ohms = 0.66% 10000 ohms = 0.33%
500 ohms = 0.8% 40000 ohms = 0.19%

Full details are available from:-

RELIANCE CONTROLS LIMITED
RELCON WORKS SUTHERLAND ROAD WALTHAMSTOW E.17
Telephone: LARkswood 8404-7 · Telegrams: Reltrol London E17



*DIGITRON DISPLAY

FOR INSTANTANEOUS READOUT

Digitron type cold cathode readout is now universally accepted as the most economical and versatile method of presenting numerical and character display.

Their vivid presentation and wide angle viewing facility enable these robust tubes to be viewed quite easily over long distances even in areas of high ambient light. A wide variety of well proportioned character sizes are available in side viewing and end viewing types with wire ended or "pin-base" terminations.

Methods of initiating the readout can be from virtually any switching source ranging from simple mechanical or electro-mechanical devices to cold-cathode counting tube or transistor circuits.

If you are looking for a low-cost, reliable, long life and brilliant method of displaying numerical or character information Digitron tubes are worthy of your consideration.

For data and application information about Digitron Display tubes please write to the address below.

TYPE	Characters	Character Height		Nominal current	Viewing	Base	Equivalents
GR2J	+ and —	18 mm	.709"	1.5 mA	SIDE	B26A	
GR4J	¼ ½ ¾ 1	30 mm	1.181"	3.5 mA	SIDE	B26A	
GR10J	0 — 9	30 mm	1.181"	4.5 mA	SIDE	B26A	Z522M*
GR10K	0 — 9	19 mm	.748"	2 mA	END	B17A	
GR10M	0 — 9	15.5 mm	.610"	2 mA	END	B13B	Z520M B5031*
GR10N	0 — 9	60 mm	2.362"	10 mA	SIDE	B17A	
GR10X	0 — 9	15 mm	.591"	2 mA	SIDE	FLYING LEAD	ZM1080*

*Near Equivalents

*Digitron is an Ericsson Registered Trade Mark.

TUBE DIVISION · TECHNICAL SERVICE DEPT.

ERICSSON TELEPHONES LIMITED
ETELCO LIMITED

A Principal Operating Company of the Plessey Group

ERICSSON TELEPHONES LIMITED · TUBE DIVISION · BEESTON · NOTTINGHAM TEL: 254831
ER67

. . . AIMING AT THE ULTIMATE IN RESISTOR TECHNOLOGY

. . . And Now nearest to the ultimate for MOULDED HIGH STABILITY CARBON RESISTORS

TYPE, STYLE, RATING, OHMIC RANGE AND TOLERANCE

WELWYN TYPE	R.C.S.C. STYLE	WATTS RATING @ 70°C	MAX. VOLTAGE	N.A.T.O. STYLE	WATTS RATING @ 70 C	MAX. VOLTAGE	MIL. R. REF.	WATTS RATING @ 70 C	MAX. VOLTAGE	OHMIC RANGE @ 1"., 2"., & 5".
C85	DEF 5115 (Draft) RG4	1 8	200	NRN 21	1 10	200	RN 55D	1 8	200	10Ω-300K
C80	RC4-L	1 8	200	NRN 06	1/8	250	RN 60D	1 4	250	10Ω-1M
C81	RC4-M	1 4	250	NRN 07	1 4	300	RN 65D	1 2	300	10Ω-1M
C82	RC4-N	1 2	350	NRN 08	1 2	350	RN 70D	1	350	10Ω-5M
C83	RC4-P	1	500	NRN 09	1	500	RN 75B	1	500	10Ω-10M
C84		2	1,600	NRN 10	2	750	RN 80B	2	750	10Ω-10M

STORAGE: After 12 months storage, the maximum change in resistance will not exceed 0·7%.

STABILITY: For 2,000 hours full load operation at 70°C, the typical change of Welwyn Moulded Insulated High Stability Carbon Resistors is :—

LOW VALUES	0.2%	Limits in DEF 5115 (Draft) 1½% to 3%
MEDIUM VALUES	0·5%	
HIGH VALUES	1.0%	

For 10,000 hours full-load operation at 70°C, the typical change of Welwyn Moulded Insulated High Stability Carbon Resistors is:—

LOW VALUES	0.5%
MEDIUM VALUES	1.0%
HIGH VALUES	2.0%

TEMPERATURE COEFFICIENT:
In the general range of—0·025% per °C

WRITE NOW FOR FULL DETAILS

WELWYN ELECTRIC LIMITED

BEDLINGTON - NORTHUMBERLAND - ENGLAND

Telephone : Bedlington 2181-9 - Telegrams : Resistor' Bedlington.

FACTORIES IN AUSTRALIA AND CANADA

Comment

Since the union of The Physical Society and The Institute of Physics, the name of the annual exhibition of scientific instruments and apparatus has been somewhat awkward. It used to be called The Physical Society's Exhibition and was commonly referred to as the 'Physoc'! The present title is too cumbersome for convenience, for it is no less than the Annual Exhibition of The Institute of Physics and The Physical Society. It is good news, therefore, to learn that in future it will be called quite simply The Physics Exhibition.

Next year the exhibition is expected to be held rather later in the year, probably early April, and in Manchester. This change of venue is surprising and in the nature of things we think it unlikely that the attendance can be so good.

Elsewhere in this issue we give a brief report of some of the exhibits at this year's exhibition. The organizers have applied even more strictly the rules introduced last year which limit exhibits in both number and kind. They undoubtedly have had a big effect in changing the character of the show. Electronics still forms a major part of it, but other branches of physics are now much better represented, especially the nuclear side of things.

From the nature of the exhibition it is not to be expected that the engineer should find in it much of direct industrial application. Its value is more indirect in bringing to his notice happenings in related fields of physics and the visitor with imagination may well gain an insight into future commercial possibilities.

Radio Astronomy

This month has brought a variety of news about matters related to radio astronomy. Jodrell Bank Research Station is carrying out interferometry experiments with a long baseline using the radio telescope at Jodrell Bank in conjunction with a portable 25-ft diameter aerial on the moors near Leeds. Both aerials feed Ferranti 408-Mc/s parametric amplifiers and the results are equivalent to using a 175-ft aerial, the noise temperature being only 100 °K. The experiments are connected with the detection of flare stars.

The 210-ft radio telescope at Parkes, Australia, is one of three stations which have located nine objects near the fringe of the observable universe, over 3,000 million light years away. The telescope has an A.E.I. control system which provides it with an accuracy of pointing better than 15 seconds of arc.

The use of electronics in ordinary astronomy is exemplified by the English Electric image intensifier used at the Kitt Peak National Observatory, Arizona. It has enabled photographic exposures of two minutes to yield as much information as one and a half hours without it.

Thus in many different ways electronics is contributing to our knowledge of the universe.

Valve and Semiconductor Exports

There are some people who think that the valve has been largely superseded by the transistor and other semiconducting devices. The export figures tell a different story, however.

For the quarter to 30th September 1963 the valves exported had a value of almost £1,660,000 whereas semiconductors amounted to £441,350. The term valves includes thyratrons, hot-cathode mercury vapour and gas-filled rectifiers, and piezoelectric crystals, as well as the more ordinary types. Exports of cathode-ray tubes, which are not included under valves, amounted to £418,708.

Thus cathode-ray tubes alone almost equal the total of all semiconductors and the value of the valves exported is roughly four times that of semiconductors. The total of all devices for the quarter is £2,519,965, which shows that the valve and semiconductor industry is contributing quite a respectable amount to British exports.

Ultrasonics v. Supersonics

In the January *Wireless World* Free Grid wonders why ultrasonics are so-called and are not denoted by supersonics. The answer is that they once were but another industry took over the word and gave it another meaning. To avoid confusion, therefore, our industry was forced to adopt ultrasonics in its place.

At the present time usage of the word 'supersonics' is confined to *velocities* greater than that of sound, while 'ultrasonics' is used for *frequencies* which lie above the audible range. In fact, 'ultrasonics' is actually employed for frequencies down to about 10 kc/s, which are within the audible range.

The difficulties and confusion with these words arises out of the prevalent habit of turning adjectives into nouns. Strictly, 'ultrasonic' means 'beyond sound' while 'supersonic' means 'over sound' or 'above sound'. There is thus little or no difference between the meaning of these adjectives. The Concise Oxford Dictionary, in fact, gives 'supersonic' as 'relating to sound waves of such a high frequency as to be inaudible, (of speed) greater than that of sound.' For 'ultrasonic' it gives '= supersonic.'

Historically, supersonic came first in our field and applied to frequency. It still survives in the word superheterodyne which is nothing but an abbreviation for supersonic heterodyne, the original name of this type of receiver. What we now term ultrasonics were originally called supersonics. It so happened, however, that in the pre-war days there was no great application for supersonics and the word was not much used. When the aircraft people wanted a word to describe velocities greater than that of sound waves they picked on supersonic.

No great harm would have resulted if the word had continued to be used adjectivally. Supersonic frequencies and supersonic velocities could have existed side by side without difficulty and with a gain in clarity. But no, the expressions had to be abbreviated by adding an 's' to supersonic to make it a noun. Thus 'supersonics' was born and became a word with no natural meaning such as it had as an adjective. It had only a defined meaning and this was 'a velocity greater than that of sound'.

'Supersonics' then became a useless word for 'frequencies above audibility' and 'ultrasonics' had to be adopted in its place.

Radar Warnings

Radar methods of checking the speed of motor cars are well known. From time to time we see references to devices for warning motorists of their approach to such checking points. They usually take the form of a receiver in the car which picks-up the radar signal and operates an alarm.

It now appears that such devices are illegal. They are wireless receivers and as such can be legally used only under licence from the Postmaster General. The ordinary wireless broadcast receiving licence, however, does not cover such apparatus, for it only authorizes the reception of broadcast programmes and transmissions from amateur stations.

A special licence for a radar warning device is necessary but will not be issued because the international radio regulations make it necessary for there to be no unauthorized interception of radio communications not intended for general use by the public. Police signals are not intended for public reception.

The user of a radar warning device is thus liable to prosecution under the Wireless Telegraphy Act 1949.

C.C.T.V. in Schools

We have been reading an interim report on an experiment in the use of closed-circuit television which is being conducted at the Warblington County Secondary School at Havant, Hampshire. It is published by the Supervisory Committee of the Warblington Experiment at the Office of the County Education Officer for Hampshire, The Castle, Winchester. As might be expected, c.c.t.v. has been most useful as a form of magnifier, enabling dissection in biology and fine stitches in needlework to be clearly shown to each member of the class.

Because its usefulness in this role is so clear, most of the experiment has been conducted in other fields, notably mathematics. One thing struck us in particular. There is two-way sound communication between teacher and class so that pupils can ask questions. Should not there also be two-way television so that the teacher can see his class?

DOPPLER IN AIRCRAFT

By G. THOMAS, B.Sc., Graduate I.E.E.*

Part 1. General Principles of Doppler Navigators

In this opening article the general principles of doppler navigation are discussed. The second part will describe a particular equipment in some detail.

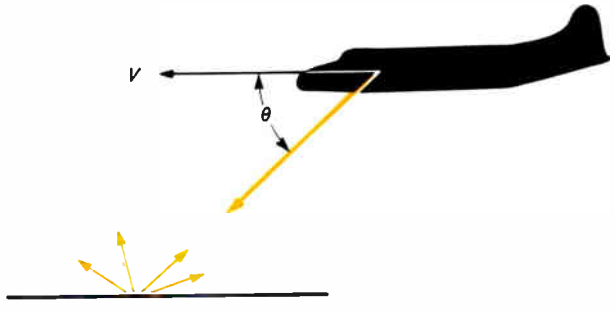
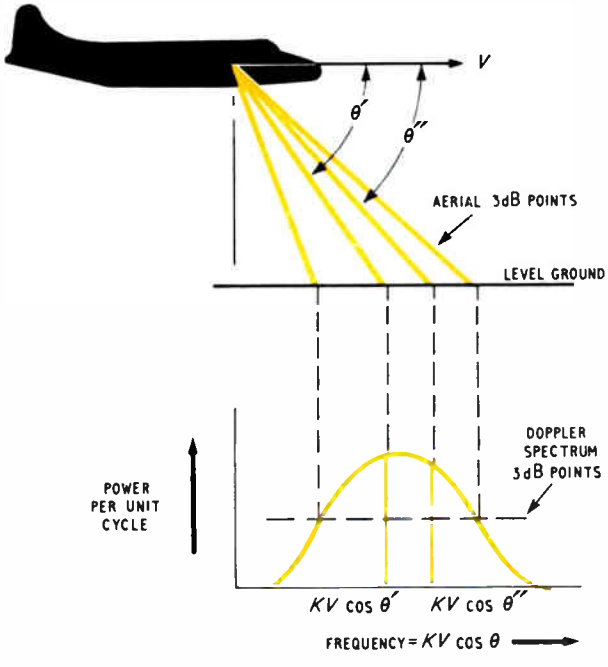


Fig. 1. An aircraft flies with velocity V and transmits a signal to the ground along a path at an angle θ to its line of flight

Fig. 2. The signal has a finite beam width and so the signal returned to the aircraft has many components of unrelated amplitude and phase



DOPPLER navigation systems depend on the effect, noted by C. J. Döppler about a century ago, that when there is relative radial motion between a wave source and an observer, there is a difference between the received and transmitted frequencies. The effect is normally associated with sound waves but is equally applicable to electromagnetic waves.

It was realized for many years that this effect might be used in determining the speed of an aircraft by transmitting radio waves from the aircraft towards the ground and measuring the frequency difference (the doppler shift) contained in the resultant echo received back at the aircraft. By 1940 quite a number of patents had been taken out covering various schemes. It was not until 1954 however that the first production doppler navigation equipment[1] went into service with the Royal Air Force. It was designed by the Marconi Company in collaboration with the Royal Radar Establishment and is still in service.

Further military equipments have since been developed, and when, in 1957, the subject was removed from the classified list the application to civil aviation was started. Today many firms produce civil doppler navigators, and the doppler system of self-contained navigation is well established in both military and civil aviation.

The Doppler Signal

Before examining design details of various possible doppler systems consideration of the characteristics of a typical doppler signal is worth while.

An aircraft flying with velocity V transmits a single ray of frequency f at an angle θ to the line of flight (Fig. 1). Upon striking a stationary target the signal is returned and received at the aircraft. The received frequency differs from that transmitted by the doppler shift frequency which is given[2] by the equation $f_d = (2Vf/c)\cos\theta$.

In practice a doppler beam will have finite width and a substantial area of the ground will be illuminated. This area of ground can be considered as a large number of small reflecting elements each one scattering the particular rays directed at it. Thus the returned signal is made up of a large number of separate components the amplitude and phase of which are unrelated. The result is very similar to electrical noise covering a narrow band or spectrum of frequencies. The bandwidth is determined by the range of variation of θ in the beam or in other words the beamwidth (see Fig. 2). The range does not come into the doppler equation; we get the same doppler shift for each particular part of the beam whatever the altitude, ruggedness or slope of the ground below. However,

* The Marconi Co. Ltd.

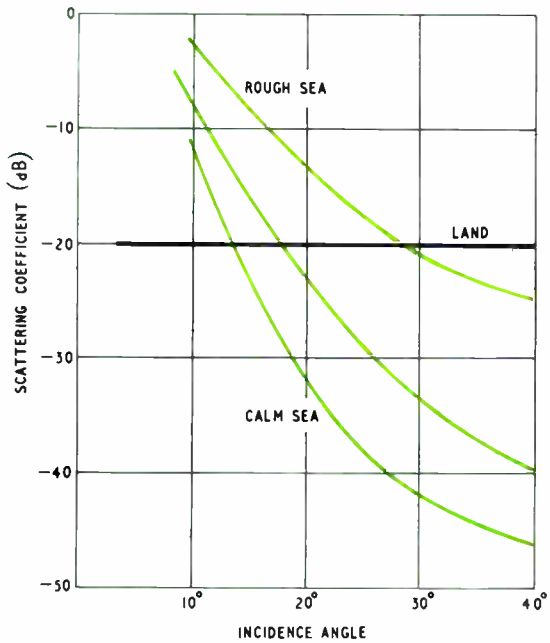
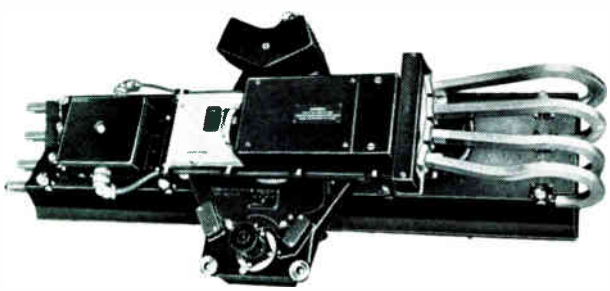
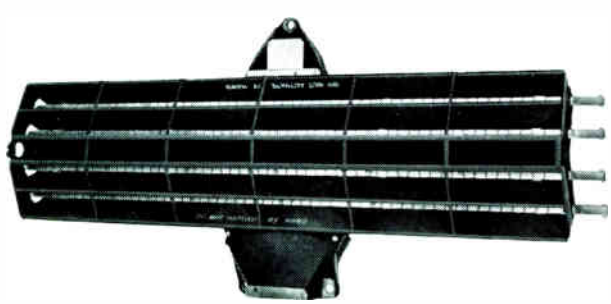


Fig. 3. Signal backscatter depends on the nature of the terrain and the angle of incidence



The top and bottom pictures show the top and bottom of the aerial unit of the AD2000 equipment which was the first doppler apparatus in the world to go into quantity production



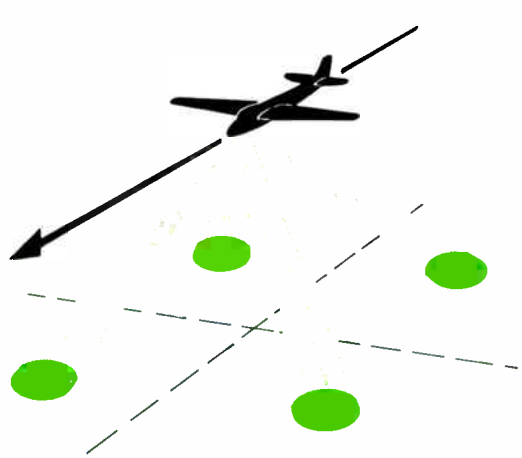


Fig. 4. Typical disposition of four beams relative to an aircraft

random variations of reflectivity in the surface illuminated can cause instantaneous changes in the power distribution of the doppler spectrum. Over land this effect is averaged out but over water with a consistent variation of reflectivity over the range of angles of incidence in the beam (see Fig. 3) there is a small but permanent shift of the centre of power towards the lower frequencies. This is termed the water bias or terrain effect.

Basic Equipment Design Factors

Transmitter Frequency

Considerations of the size of aerial aperture required to produce suitable narrow beams indicate the use of high transmitter frequencies, while considerations of atmospheric attenuation and scatter indicate frequencies less than 16–20 kMc/s. In fact only a relatively narrow band around 8·8 kMc/s to 13·5 kMc/s is considered suitable for normal doppler transmissions in aircraft.

Aerial Systems

A minimum of three non-coplanar beams is required for complete information on the aircraft velocity vector, each beam giving the component of the aircraft velocity in its own direction. In practical equipments two, three or four beams are used in order to give the particular components of the velocity vector which are required (see Fig. 4).

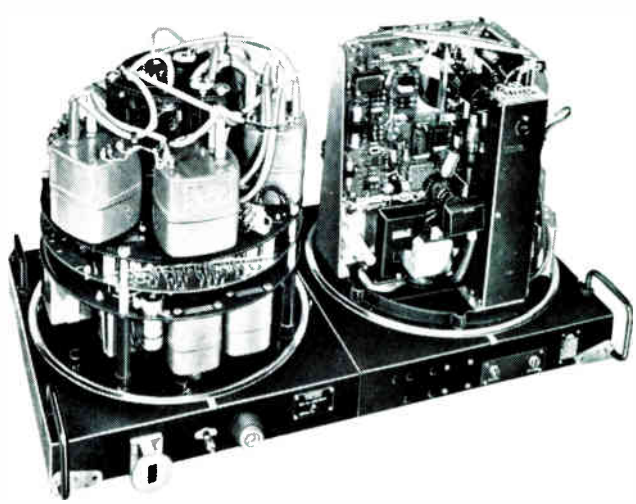
With a fixed multi-beam system it is possible to measure the doppler frequency corresponding to each beam and compute the corresponding drift and pitch angles and ground speed.

An alternative is a moving aerial which is automatically aligned so that the doppler signals from all four beams are equal in frequency. In this condition the aerial will line up with the aircraft velocity vector. Drift and pitch angles can then be measured directly relative to the fore and aft line of the aircraft. There will also be a constant relationship between ground speed and doppler frequency as θ will be a constant for a correctly aligned aerial. Such a 'null' method gives the highest accuracy and best overall simplification for the system.

Transmit-Receive Systems

The simplest form of transmission is a pure continuous wave and equipments of this type are used by mixing a little of the transmitter signal with the received signal

Transmitter and receiver assemblies of the AD2000 with their covers removed



whereupon the doppler frequency appears as the difference. There is a considerable problem, however, associated with the breakthrough of transmitter power to the receiver by local direct paths. Any spurious modulation on this breakthrough due to valve noise or aerial vibration is interpreted by the equipment as a false doppler signal. A rigid aerial structure and good isolation between transmitting and receiving apertures are required for operation of a c.w. system. Another approach is to use some form of modulation on the transmitter. This may be either pulse (amplitude) or frequency modulation.

The use of a pulse transmitter overcomes breakthrough completely since the receiver signal occurs when the transmitter is off. A reference signal is then needed in order to produce the doppler signal. In the coherent-pulse system this is obtained by locking the transmission to a continuously-running oscillator. The alternative self-coherent pulse system obtains doppler information by mixing the returns from two beams.

If a sine-wave frequency modulation is applied to a continuous-wave transmission (f.m.c.w.), and the received signal is mixed with a sample of the transmitter power, the amplitude of the various sidebands after mixing is a function of the time delay imposed by the round trip to the ground, as well as the modulation index[3]. The power in a particular sideband can be zero for no delay (corresponding to unwanted breakthrough) while it is a useful proportion of the transmitted power at the wanted range. All parts of the transmitted spectrum will be doppler shifted so information can be recovered from any sideband chosen.

Tracking Systems

That part of the equipment that 'converts' the doppler signal spectrum to a single frequency is called the tracker. The tracker usually includes circuits for automatic gain control and 'memory' operation during periods of insufficient signal strength.

It is possible to measure the signal frequency directly with an axis-crossing counter but for this a high signal/noise ratio is required to avoid errors.

An alternative is a frequency comparator in which the signal is compared with a reference tone. The output of the comparator is used to re-tune the reference tone so that it maintains the correct relationship to the centre of distribution signal spectrum.

An auxiliary 'search' system is normally required in order to bring the signal and reference tone close enough together for the system to lock on.

Navigation Computers

In order to use the information provided by the doppler sensor (consisting of the aerial, transmitter/receiver and tracker) a further unit is normally provided. This is a small computer which accepts ground speed and drift angle from the sensor together with a heading reference from some such source as a compass and then continuously integrates the information to find the true aircraft track and present position (see Fig. 5).

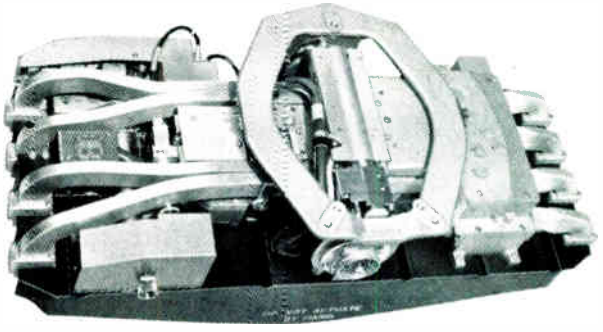
In Part 2 of this article, Doppler Navigation in Practice, details will be given of a modern doppler navigator and its display of information to the pilot.

References

[1] G. E. Beck and T. G. Thorne, 'An Airborne Doppler Navigation Equipment', Vol. 105, Part B, *Proc. I.E.E.*

[2] Quantum, *Electronic and Radio Engineer*, Oct. 1957, pp. 319–372.

[3] K. C. M. Glegg, 'A Low Noise C. W. Doppler Technique', *Proc. Nat. Conf. on Aeronautical Electronics*, Dayton, Ohio, May 12–14, 1958, pp. 133–144.



Top view of the AD2300 aerial unit

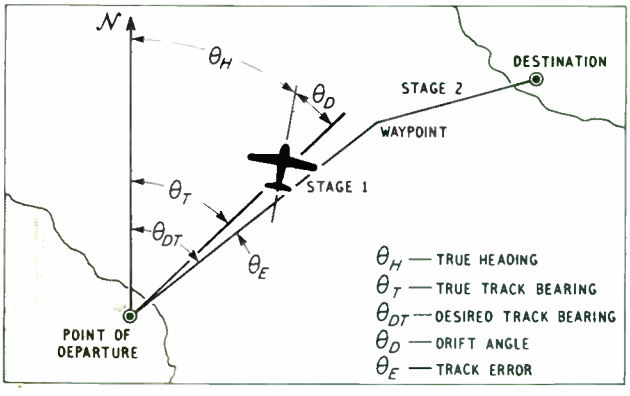


Fig. 5. Defining the various angles which occur in aerial navigation

AD2300 equipment installed in a Viking aircraft for a demonstration tour in 1958

By W. E. MASON*

The instrument described in this article discriminates between different signal amplitudes and so sorts a signal, such as noise, into three channels. The number of samples in each channel are counted automatically.

AUTOMATIC STATISTICAL ANALYSIS

THE quantitative definition of fluctuating phenomena always presents some difficulty. Any one value is bound to be misleading and even the statement of a range of values is dangerous, since the two limiting values may be extremes between which there may be a wide variety of distributions. The only satisfactory way of defining such phenomena is by means of a statistical analysis of a representative number of individual readings.

This consideration has led to the development of the Type 1466A Statistical Analyser by Dawe Instruments Ltd., in co-operation with Professor Gino G. Sacerdote of the Istituto Elettrotecnico Nazionale of Turin in Italy, a leading authority on the subject of noise measurement. Various requirements had to be satisfied by the design of the instrument. It had to be capable of discriminating at least three ranges, whose limits had to be adjustable. The ranges could be called 'too low', 'correct' and 'too high' or, for noise measurement, 'innocuous', 'fatiguing' and 'injurious'. An example might be the monitoring of broadcasts, where amplitudes must be kept within given limits to avoid distortion.

The rate of change of a fluctuating phenomenon also affects the method of sampling. The duration of each sample, the rate of sampling and the period over which samples are taken must be adjustable. An analysis of amplitudes in telephony, for instance, demands shorter

Dawe Instruments Ltd.

Danger to hearing from noise is a function of both noise level and duration of exposure. Where noise level fluctuates, as in many workshops, statistical analysis of levels is essential

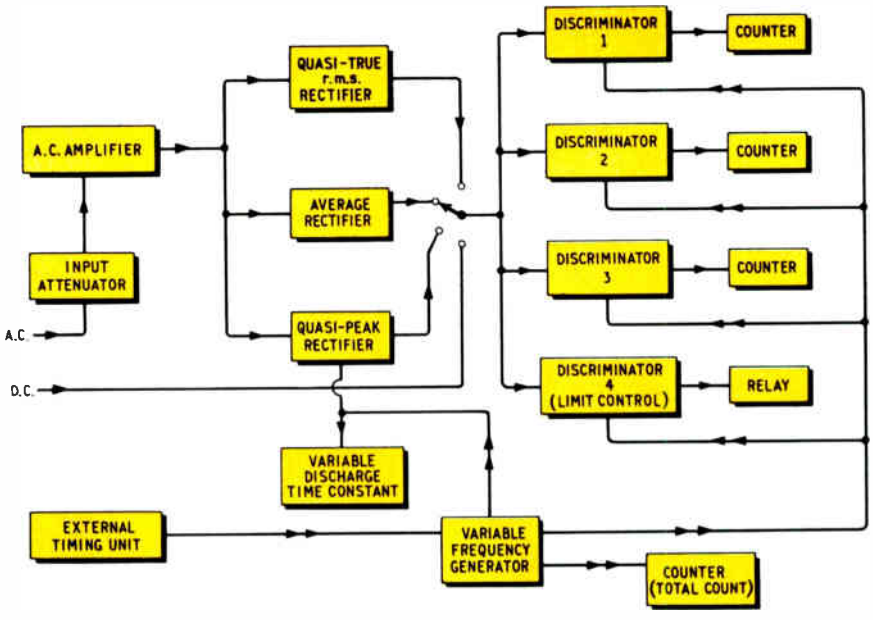


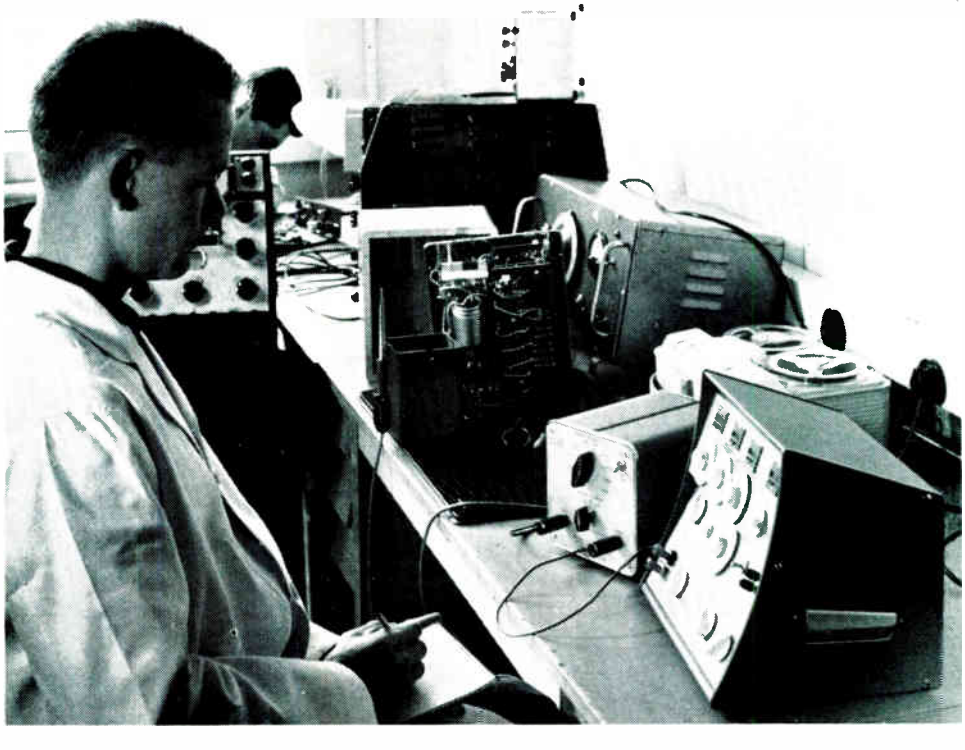
Fig. 1. Block schematic circuit of the new Dawe Type 1466A Statistical Analyser

samples at greater density than an analysis of traffic noise, but a shorter sampling period. On the other hand, different settings can give different information about the same subject. A statistical analysis of traffic noise extending over ten minutes will give a picture of noise distribution under prevailing traffic conditions, while an analysis covering 24 hours will show variations in traffic noise with changing conditions.

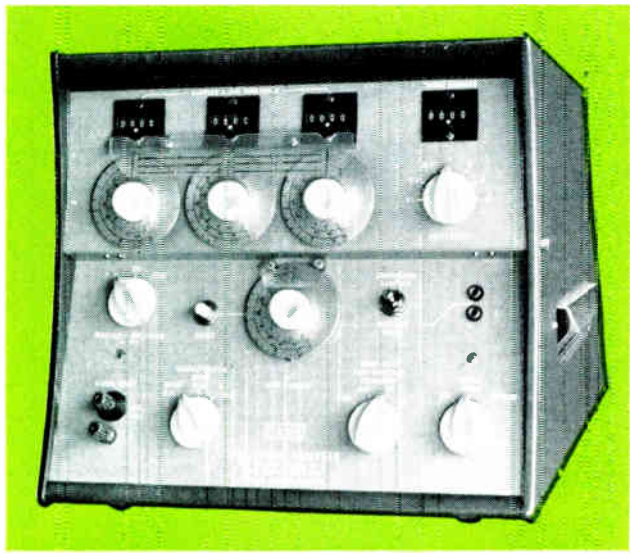
The analyser should also be capable of accepting as wide a range of signals as possible, to render it suitable for different applications. The original purpose, of course, was to use the analyser in conjunction with the Dawe Type 1400E Sound Level Meter; this application is shown on the front cover, which illustrates the equipment set up for the analysis of noise levels on an arterial road, while a photograph shows the same set-up used in a workshop. The object in both cases is merely to establish the distribution of overall noise levels in relation to time.

In some cases, however, the noise varies not only in amplitude but also in frequency, and if both factors are important a different approach is called for. The noise under investigation is recorded and played back repeatedly through a Dawe Type 1464 Octave Band Filter. The figures obtained for each setting of the filter can then be compared.

The new statistical analyser itself is shown in a photograph, while Fig. 1 is a block schematic diagram of its circuits.



If both amplitude and frequency of a noise vary with time, the noise can be recorded and played back to the statistical analyser through an octave band filter



The new Dawe Type 1466A Statistical Analyser. Originally conceived for analysing the statistical distribution of sound levels, it can be used to analyse any randomly fluctuating signal

The input signal may be either a.c. (10 c/s–20 kc/s) or d.c. An a.c. signal to be analysed is fed through a three-position attenuator having an input resistance of 300 kΩ with an overall voltage range of 0·1 to 100 V r.m.s. or peak. Overload protection up to 300 V r.m.s. is provided. The signal is then fed into a high input impedance amplifier having local and overall negative feedback. The output, after full-wave rectification, is applied to circuits responding to the average value of the quasi-true r.m.s. value or the quasi-peak value of the input signal. The quasi-true r.m.s. circuit has a response time of 0·2 sec as specified for sound-level meters (B.S. 3489 and I.E.C. publication 123). The quasi-peak circuit has a discharge time constant which may be selected from 1, 10, 100 millisec or 1 sec. The rectifier circuits are d.c.-coupled into a circuit having an input impedance of 1 MΩ. For 2 to 11 V d.c. operation the input is switched directly to this circuit, which also has overload protection. The high input impedance circuit presents the d.c. signal to four discriminator circuits which sample the information at a predetermined rate. The period for which the signal is inspected is approximately 10% of the total period of the sampling-rate generator. For example, in a sampling rate of 2 per sec the period would be 0·5 sec and the sample size will therefore be 0·05 sec. At a sampling rate of 0·5 sample per sec, the sample size will be 0·2 sec, which is the speed of response required in the I.E.C. specification for sound-level meters.

The total number of samples taken is displayed on an electromagnetic digital counter. Three of the discriminator circuits each have an electromagnetic digital counter, which will record the number of times the amplitude of the sample is greater than a preset level. The sampling rate may be selected from 0·1, 0·2, 0·5, 1, 2, 5 and 10 samples per sec to suit the conditions. The higher the sampling rate the better will be the statistical analysis, but this limits the period in which the analysis can take place, the maximum count being 9999. Since the period in which samples are taken is important, the instrument is provided with external contacts which may be operated by a manual switch or a clock mechanism or by the subject under examination to determine the total sampling time.

The 'threshold level' at which each discriminator will record a count may be set to within ± 5% of each voltage range. It is sometimes desirable that, if the amplitude exceeds a certain limit, the investigation be terminated; for example, if a body experiences a displacement in excess of 0·2 in. it may be destroyed. The fourth discriminator has therefore been included to operate a limit relay which can control external equipment once this selected level has been exceeded. Two sets of contacts are available on the rear panel for use with the limit control, one set normally open, and the other normally closed.

For most practical applications sampling at three discrete levels is adequate but for more detailed analysis the data may be recorded on a suitable magnetic tape. The data may then be reproduced and the threshold levels reset. If suitable frequency filter networks are included in the system, a statistical analysis in discrete frequency bands can be performed. To reduce any variations within the instrument due to supply fluctuations, a stabilized power unit is incorporated. The instrument may be operated from 100–125 V, 200–250 V, 50–60 c/s, or from an external 18-V battery. It is a completely self-contained accessory to a sound-level meter.

The statistical analyser is, in effect, an impulse counter with provision for grading impulses into three classes according to amplitude. The instrument is therefore suitable for the analysis of any phenomenon which can be expressed in terms of an electrical signal. Since there is already a wide variety of transducers to convert almost any physical quantity into electric signals, the potential field of application of the new instruments is virtually unlimited.

IBM Accounting System

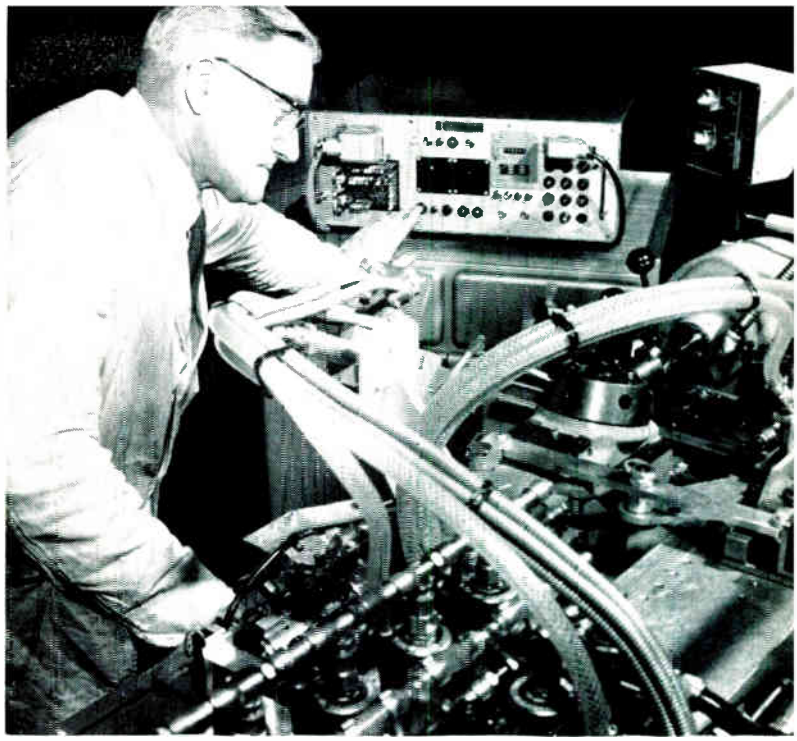
IBM United Kingdom have announced a low-cost keyboard accounting system—the IBM 6400. Based on a novel magnetic ledger card, this system offers to the smaller company integrated invoicing, sales ledger, stock control, and many other applications for a purchase price of £14,000. The version to be sold in the United Kingdom is capable of working with both sterling and decimal currencies.

The core of the new system is an electronic calculator, with a large and flexible programme controlled by a wired instruction panel. This calculator is capable of performing the four basic arithmetic operations at speeds considerably faster than those of most keyboard machines; it also has the ability to vary its programme by taking simple logical decisions. Addition and subtraction take 5 msec, multiplication and division 296 msec.

The automatically-positioned ledger card is made of standard punched card stock; it can vary from 8½ to 14 in. wide and is 11 in. deep. The reverse side carries a stripe of computer-quality magnetic tape which will carry up to 252 alphabetic or numeric characters of information. The magnetic 'memory' stripe materially increases the speed and accuracy of operation by reducing the amount of data which has to be fed in via the keyboard.

Two printers are available with this system, both based on the IBM 72 'golf ball' typewriter, and each with a printing speed of 15 characters/sec; one has a 220-character printing line, the other a 130-character line. Punched card input and output are available on the system as optional features.

For further information circle 49 on Service Card



Shown here is the sequence control system fitted to a Hardinge capstan lathe

New Sequence Control System

A FLEXIBLE method of automatically controlling machine tools and co-ordinating a wide range of industrial batch processing equipment has recently been demonstrated by Elliott-Automation. This system can be applied retrospectively to almost any type of machine tool in current use.

The complete system comprises four basic elements: an electronic control unit, a number of sensing devices, actuators and a programme chart. The sensing system can consist of microswitches, photoelectric cells or other types of transducer, or any combination of these, providing that they are capable of giving a suitable electrical signal to indicate that a mechanical action has taken place. Actuating systems can be built up from existing standard components which can be electric, electro-pneumatic, or electro-hydraulic, to suit the requirements of a particular application.

The sensing elements are used to detect that the process under control is ready to receive the first actuating impulse. This is fed into the control unit in the form of an electrical signal. The control unit then feeds an electrical signal to the appropriate actuator to perform a movement. When this movement is completed a further sensor sends a data signal back to the control unit and this process is repeated for the full cycle of operation.

Operation

To illustrate this system in a simple way consider its application to a standard capstan lathe which is to be used to produce, say, short, round rods with a reduced diameter at one end. The complete cycle of events comprises a number of input signals from sensors to the programmed sequence control unit and corresponding output command signals to actuators. The cycle of events could be as follows:

Event	Data Signals from Sensors	Event	Command Signals from Control Unit to Actuators
1	Lathe chuck open	2	Feed through material
3	Required material through	4	Close chuck
5	Chuck closed	6	Switch-on drive motor
7	Drive motor running	8	Select cutting tool
9	Cutting tool selected	10	Engage tool traverse and commence cutting
11	Appropriate length of rod reduced	12	Disengage tool traverse
13	Tool traverse disengaged	14	Move tool capstan clear of work
15	Capstan clear of work	16	Select parting tool
17	Parting tool selected	18	Move parting tool the appropriate length along workpiece
19	Parting tool in correct position	20	Stop parting tool traverse
21	Capstan stationary	22	Pare-off component part
23	Component completed	24	Return capstan to starting point
25	Capstan at starting point	26	Switch-off drive motor
27	Drive motor off	28	Open lathe chuck

In this hypothetical case some of the possible automatic checks, such as tool breakage, have not been included and many of the commands could be linked together to make greater use of the control unit. If during any part of the cycle the appropriate action has not taken place the data signal clearly indicates this and prevents the cycle of events from continuing.

The Control Unit

This is basically a transistorized switching unit and a power pack which provides electrical output signals to control actuators in a predetermined sequence. Control is by a programme set up on a plug-in patchboard. The sequence of events continues as long as data signals are received by the control unit to indicate that an action has taken place, for only then will the unit initiate the subsequent action.

A very useful feature of the system is the facility to control independently each step or operation in sequence by a push button on the facia of the main unit. This greatly aids the setting up of actuators and sensors and the testing of the system in the event of a breakdown.

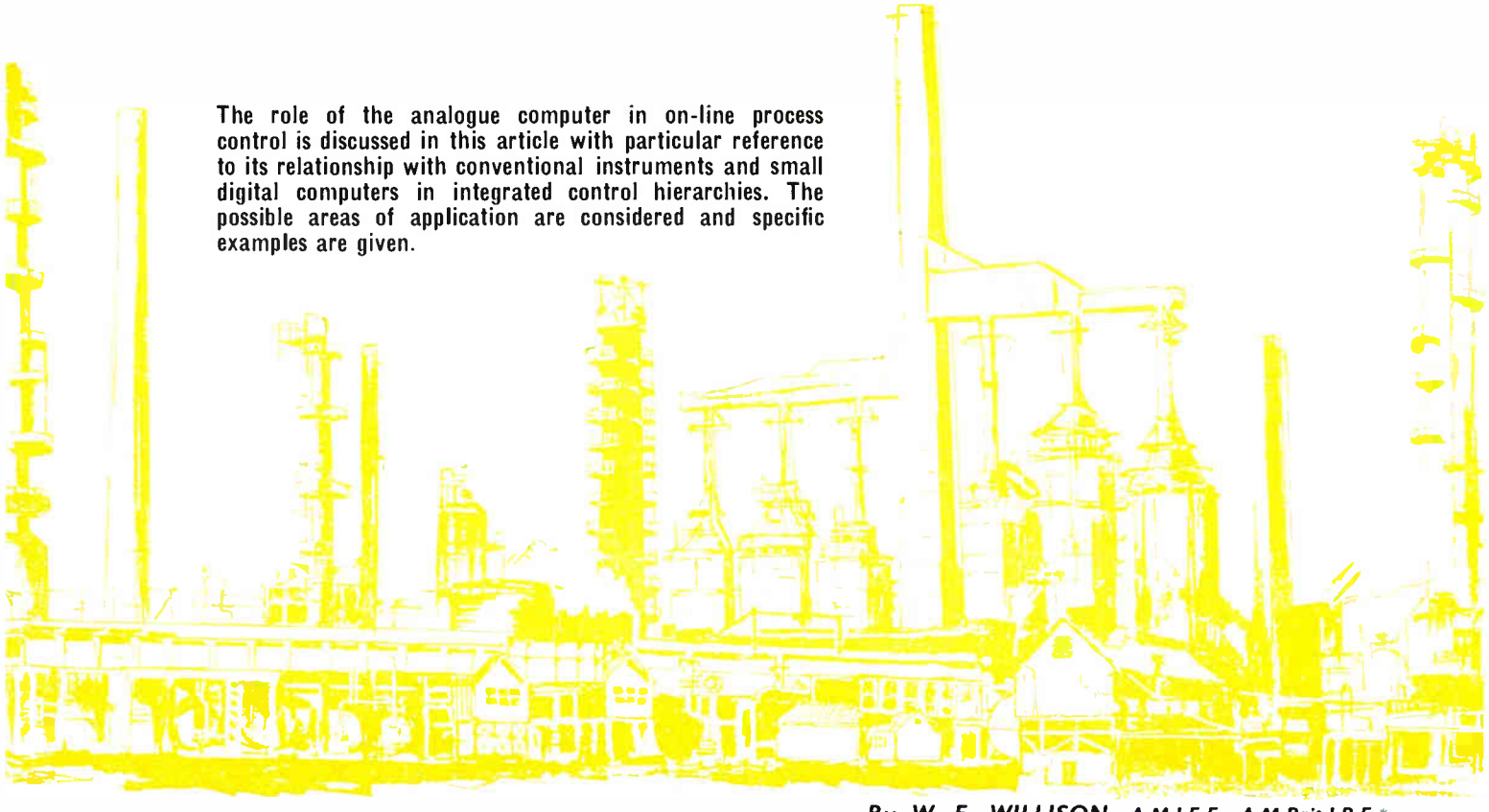
Cost and Advantages

The basic unit, which provides up to 9 command actions and 25 data channels, costs £640. This does not include sensors and actuators, which could be fitted to machines and systems by the customer.

The major advantage of this system is that one or more units can be fitted to almost any machine, capable of performing a number of operations, and thereby convert it at a modest cost into a versatile automatic machine.

For further information circle 50 on Service Card

The role of the analogue computer in on-line process control is discussed in this article with particular reference to its relationship with conventional instruments and small digital computers in integrated control hierarchies. The possible areas of application are considered and specific examples are given.



By W. E. WILLISON, A.M.I.E.E., A.M.Brit.I.R.E.*

APPLYING ANALOGUE COMPUTERS TO INDUSTRIAL

IN recent years attention has been focused upon the use of digital computers for the on-line supervision and control of industrial processes and many papers and articles have been published, including the recent series in *Industrial Electronics*.[1] The object of this article is to stimulate interest and encourage the more extensive use of the 'other' type of computer for the solution of the many relatively simple problems which arise in process control.

Contrary to popular belief the analogue computer is not a recent invention and, in fact, has been established for many years as a versatile mathematical and scientific tool. The modern computer has evolved from the basic principles formulated in the year 1876 by Lord Kelvin in a paper which described a ball-and-disc integrator and showed how these could be used to solve differential equations.

The present-day general-purpose analogue computer owes much to the aircraft industry where its potential was first exploited. In particular, the Royal Aircraft Establishment made very significant contributions to the development of accurate and reliable general-purpose electronic computers. The success of many projects in the field of high-speed flight and guided missiles can be partly attributed to machines such as Tridac[2], a very large analogue computer installed at the R.A.E. Farnborough in 1954.

Later, when smaller computers became generally available, other industries soon realized that they too could benefit by the use of analogue machines. The direct analogy with the physical system, the ease with which changes can be made, the high speed of operation and the graphical form of output are characteristics which have great appeal to the engineer and the analogue computer soon proved its worth in many diverse fields of application. The process industries were slower in adopting the techniques, largely due to the complex nature of the processes and the difficulties involved in the formulation of the necessary equations and transfer functions. The development of simulation techniques enabled 'cut-and-try' methods to be used and today analogue computers are widely used for the investigation of process plant behaviour and for control system design studies. The contribution of the analogue computer to the better understanding of process dynamics cannot be overvalued. This, however, is only the beginning—the analogue computer, in a variety of special-purpose configurations, will surely play an important part in on-line control and in automation in the widest sense of the word.

* Elliott Bros. (London) Ltd.

The Control Hierarchy

The concept of the control hierarchy and the ARCH system of process control has been described in considerable detail elsewhere[3]. This section will therefore give only such facts as are necessary to place the analogue computer in perspective.

The ARCH system is based upon the computer hierarchy concept and allows an evolutionary approach to the solution of control problems. A comprehensive range of analogue and digital computing modules, supported by analogue-to-digital and digital-to-analogue converters provides the means for the construction of a wide variety of unique computer control systems analogue, digital or hybrid.

The hierarchy concept is illustrated in simple block-diagram form in Fig. 1. The plant is divided into a number of process units each of which can usually be further sub-divided into a number of stages or areas. Each stage or area is provided with a number of automatic control loops,

PROCESS CONTROL

one for each controlled variable. Above the conventional controllers a small computer operates on multi-variable input data to determine the values of the controlled variables necessary to satisfy the process requirements. The computer automatically adjusts the set-points of the controllers thus co-ordinating several control loops. The computer communicates with the controllers via 'link' units which make small incremental adjustments of the set-points. At the next higher level a further small computer supervises and co-ordinates a number of lower level computers; this principle is repeated as necessary up to the highest level.

The number of levels will be determined by the size and complexity of the plant, and the techniques adopted at the different stages and levels will depend upon the nature of the processes and associated control functions. At the higher levels the control problems will usually be of a managerial nature involving logical decisions and sequencing operations. Such operations are best performed by digital methods and analogue computers will seldom, if ever, be found at the higher levels of the hierarchy. It is at the lower levels of the hierarchy that analogue computers can make a significant contribution to improved process control. Close to the process plant the control actions must generally be continuous, non-linear functions are often involved and the input data is invariably available only in analogue form. These circumstances are ideally suited to the analogue computer and it is with the lower levels of a hierarchy that this article is concerned. The on-line analogue computer takes over where conventional instruments and controllers reach their limit of application, either because of practical, technical or economic considerations. The computer may be an entirely autonomous system or part of a hierarchy under the supervision of a digital computer. The ARCH analogue modules are compatible with the digital modules thus simplifying the interface problems in an integrated system.

On-line Computer Requirements

Apart from sharing common fundamental principles of operation the on-line analogue computer bears little resemblance to a conventional general-purpose machine. On-line process control has special requirements and demands equipment having the highest possible order of reliability, often under very poor environmental conditions.

The essential requirements are:

(a) The equipment must be capable of continuous fault-free operation over very long periods of time without attention.
(b) The equipment must be robust and be unaffected by extremes of temperature, humidity and dirty atmospheres.
(c) Functional modules must be available for scaling, summation, multiplication, division, integration, linearization, function generation, etc.
(d) The accuracy of the modules must be such that the overall accuracy of a computation is consistent with the accuracy of measurement transducers.
(e) The computer must accept input signals from standard instruments and transducers and provide output signals compatible with controllers.

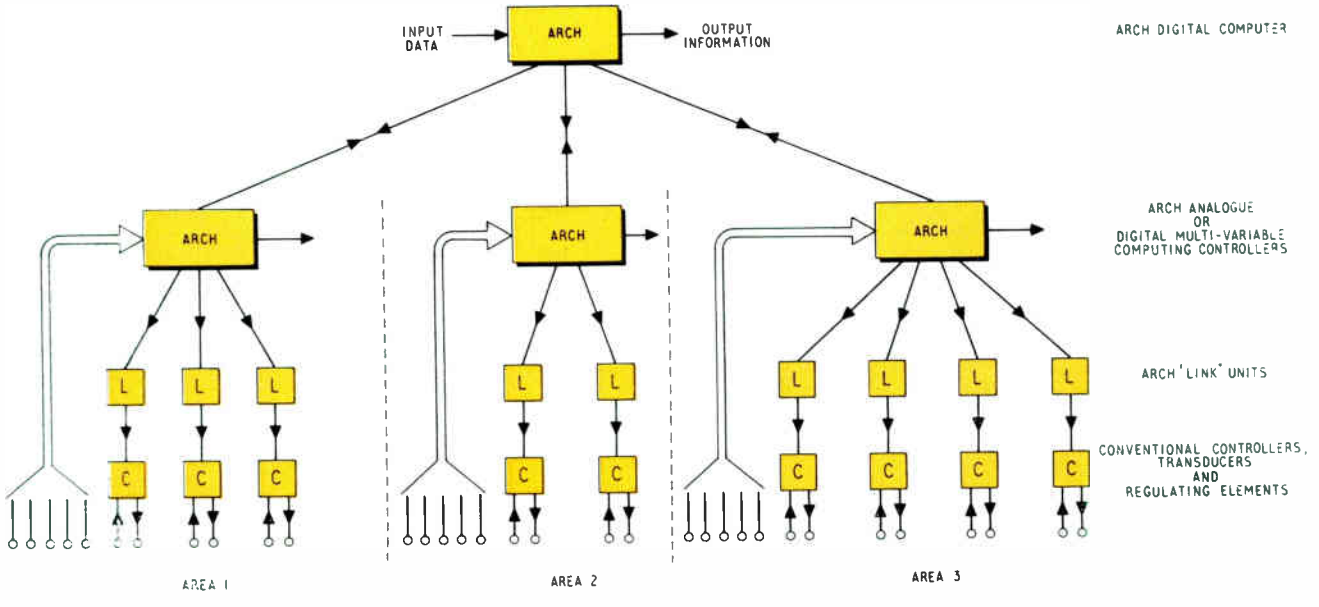
The ARCH range of analogue modules has been designed to satisfy these requirements. The majority of the modules are based upon a fully transistorized d.c. operational amplifier which is illustrated in Fig. 2. The operational amplifier is used with a variety of different networks to perform the essential mathematical operations. Fig. 3 shows a typical assembly.

Applications

The possible applications of analogue computers in process control are legion and cannot be adequately covered in one short article. However, by discussing some of the areas of application and considering one or two specific examples it is hoped to encourage the more active consideration of the analogue computer in process control.

In general there are two main classes of application for any computer, be it analogue or digital: these are off-line

Fig. 1. Typical ARCH control hierarchy



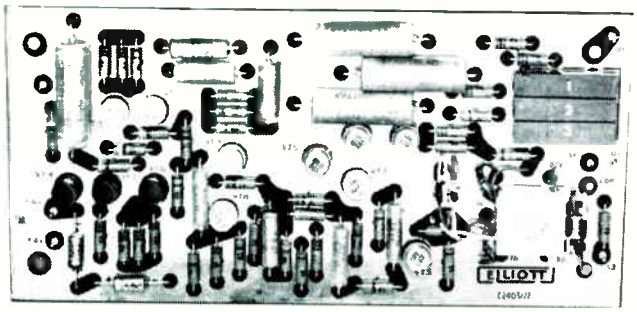


Fig. 2. Transistorized d.c. operational amplifier

and on-line. An off-line computer has no direct connection with the process plant and functions quite independently and in fact could be a general-purpose computer situated well away from the plant area. On the other hand, an on-line computer receives input data from measurement transducers installed in the process plant and will usually be sited in the plant area. By definition, a system is on-line as soon as a single input signal is obtained from a direct connection to a plant transducer. Off-line applications will not be considered in this article.

On-line computers can be further classified into open-loop and closed-loop applications. An open-loop computer operates upon the input data but does not exercise any control functions; the outputs may merely provide operational information that cannot be obtained by direct measurement or, more usefully, may give instructions to the process operators regarding the best settings of the conventional controllers. This so-called advisory mode of operation is a sensible preliminary to closed-loop control by the computer and allows the system to be thoroughly tested under human operators before the plant is entrusted to the full care of the computer.

A closed-loop system is achieved as soon as a single control signal is connected to the plant controllers or actuators so that the process responds in some manner to a command from the computer. In the majority of closed-loop systems the computer output signals are used to adjust the set-points of conventional controllers which look after the control valves and actuators. This method ensures a high degree of safety, because should the computer fail the plant will remain under control and will function safely, although perhaps not at optimum efficiency, until computer control can be restored. In due course on-line computers will doubtless take over the functions of the controllers and operate actuators and modulate control valves without intermediate regulators, but most control engineers agree that analogue controllers should be retained for the immediate future.

There are many relatively simple computing problems that are ideally suited to solution by analogue techniques but are too complex for conventional process control instruments and yet, in themselves, do not justify the use of a digital computer. Again, in cases where a digital computer installation is planned it may be possible to use a smaller or slower machine by delegating certain tasks to an on-line analogue computer, thus effecting an overall economy.

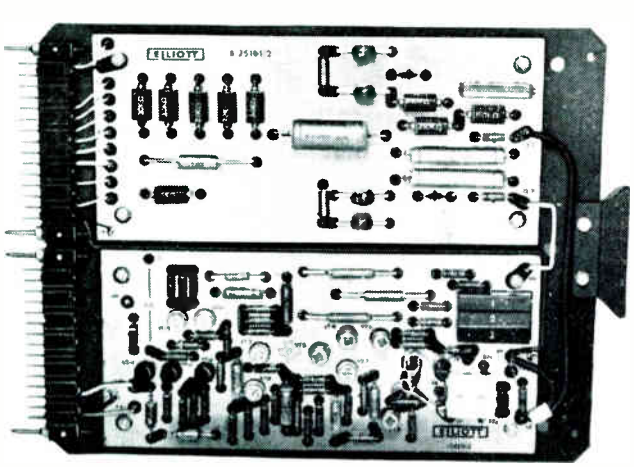


Fig. 3. Assembly of a pair of units of an analogue computer

Open-loop Applications

One area of application is in data logging systems where the usefulness of the logger can be considerably increased by the adoption of analogue computing techniques, either by incorporating analogue modules in the data logger or by using a separate computer which conditions the input data prior to connection to the data logger. The scope ranges from a very simple operation such as the linearization of a transducer characteristic to quite complex calculations such as plant efficiency indexes. In digital-computer control systems, data acquisition and logging are usually involved so the analogue techniques to be described are applicable.

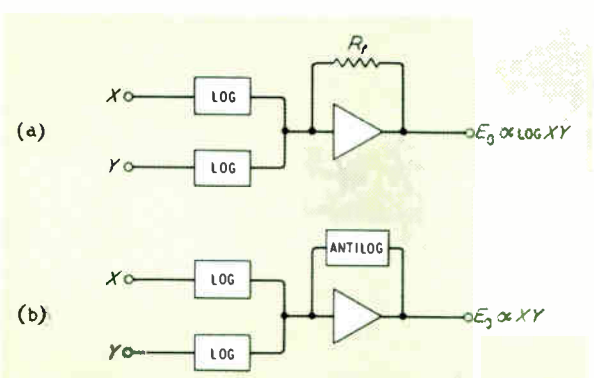


Fig. 4. Form of circuit for producing an output proportional to log XY (a) and to XY (b)

Linearization and Correction of Transducer Characteristics

Many primary measurements can only be made with transducers which have non-linear characteristics or which are not independent of other physical quantities. For example, the determination of flow rate by measurement of the differential pressure across an orifice plate results in a relationship of the form:

$$\text{Flow rate } F \propto \sqrt{\text{Differential Pressure } \Delta P}$$

The signal obtained from the transducer must be converted to flow rate by means of a square-root function generator. To complicate matters further, the differential pressure is also a function of temperature and pressure, the expression for flow rate becoming:

$$F \propto \sqrt{\frac{\Delta P \cdot P}{T}}$$

where P is the absolute pressure and T is the absolute temperature. The analogue computation can be performed by electro-mechanical methods using conventional process-control instruments such as self-balancing recorders[1]. This

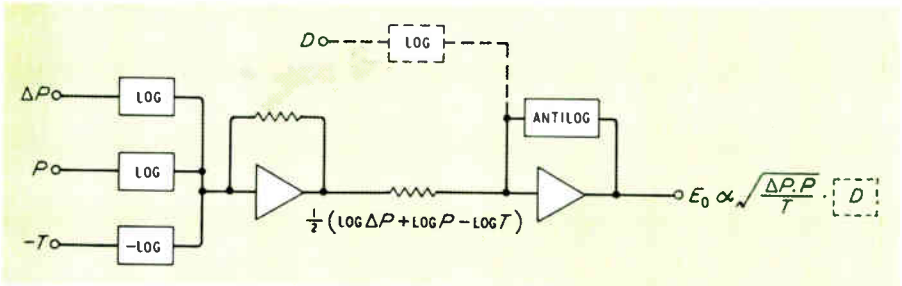


Fig. 5. Arrangement for determining flow rate

approach is reasonable where only one or two such computations are involved, but for more complex problems the entirely electronic computer is preferable.

The methods used in ARCH for flow-rate determination are worthy of detailed consideration since they have a much wider field of application. The main requirement is for multiplication and division of the variables ΔP, P and T. Multiplication and division are effected by means of logarithmic modules based upon the identity:

$$\log_a XY = \log_a X + \log_a Y$$

This identity can be simply established by means of two logarithmic function generators and a summing amplifier connected as shown in Fig. 4(a). If the feedback resistor is replaced by a function generator which provides a current proportional to the logarithm of the amplifier output voltage, then this voltage will be proportional to the product XY. For convenience, this network is called an anti-logarithmic network since this is the function it performs. This is shown in Fig. 4(b). The technique is extremely flexible; multiple products such as XYZ can be easily obtained by the addition of another logarithmic network, division requires only a change of sign of the appropriate input signal and roots or powers are obtained by simple scaling. The arrangement used for flow-rate determination is shown in Fig. 5. This illustrates the power of the logarithmic technique and the reader will appreciate that a wide variety of operations can be performed by different arrangements of a small number of standard modules. The simplicity of the method is shown by the dotted lines in Fig. 5, which modify the arrangement to produce the mass-flow rate by multiplying by the density D; this requires only one more logarithmic generator.

There are numerous other operations of a simple nature which can be performed by less complex function generators, one example being the linearization of a thermocouple.

Integration of Process Variables

A frequent requirement is for the automatic logging of total flows over quite long periods of time, perhaps once per operating shift, once per day or once a week. Electronic operational integrators as used in general-purpose computers are restricted to relatively short integrating periods by the output drift of the amplifier. This can be overcome by a hybrid analogue-digital method as shown in Fig. 6. The integrator output voltage, E_0, is compared with a fixed reference voltage equivalent to the full-scale value of the integrator. When full-scale is reached the integrator is clamped and a digit inserted in the counting register. The integrator is then reset to zero and the cycle is repeated. The scaling of the integrator is arranged so that the time taken to reach full-scale with the input signal at its minimum value is within the permissible time to give the required accuracy. This technique allows totalization over very long periods of time with a good order of accuracy.

Process Operating Guides

In certain processes improved control can be achieved by computing quantities which cannot be obtained by direct measurement and displaying this information to the operators to assist them in running the plant at or near optimum. This is an advisory mode of operation—hence the term 'operating guides'.

By way of example, in the oil industry the operation of a catalytic cracker can be improved by computing a number of such guides[5]. These include the calculation of catalyst circulation rate from a heat-balance equation, the calculation of the carbon burning rate and the catalyst-to-oil ratio. These calculations are easily performed by analogue computing methods.

In many industries, steam raising is an essential part of the process operations and a continuous measure of boiler efficiency is extremely useful. This is yet another job for the on-line analogue computer—always provided that the necessary primary measurements can be made. In the case of an oil-fired boiler the direct computation of efficiency is usually possible since the fuel input can be measured to a reasonable order of accuracy.

In the case of a coal fired boiler the precise measurement of fuel input is virtually impossible so that the direct computation of efficiency must await improved methods of coal weighing, measurement of calorific value, etc. Indirect methods of computing efficiency have been suggested, based upon the measurement of losses. Such methods depend upon the measurement of stack losses by means of CO_2 or O_2 gas analysers and if the radiation losses and the combustibles in the ash are considered constant then a fairly simple computation will yield a reasonable approximation to the boiler efficiency. In fact, the radiation losses will vary with the boiler loading and a function generator could be incorporated to compensate for load variations. The carbon-in-ash is much less predictable and until such time as a suitable on-line instrument is available for measuring this loss it must be treated as a pre-set constant based upon laboratory analyses of ash samples.

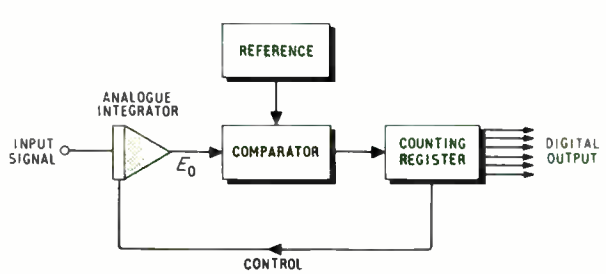


Fig. 6. Long-period integrator in which the analogue integrator is reset to zero every time its full output is reached and the number of times it is reset is recorded digitally

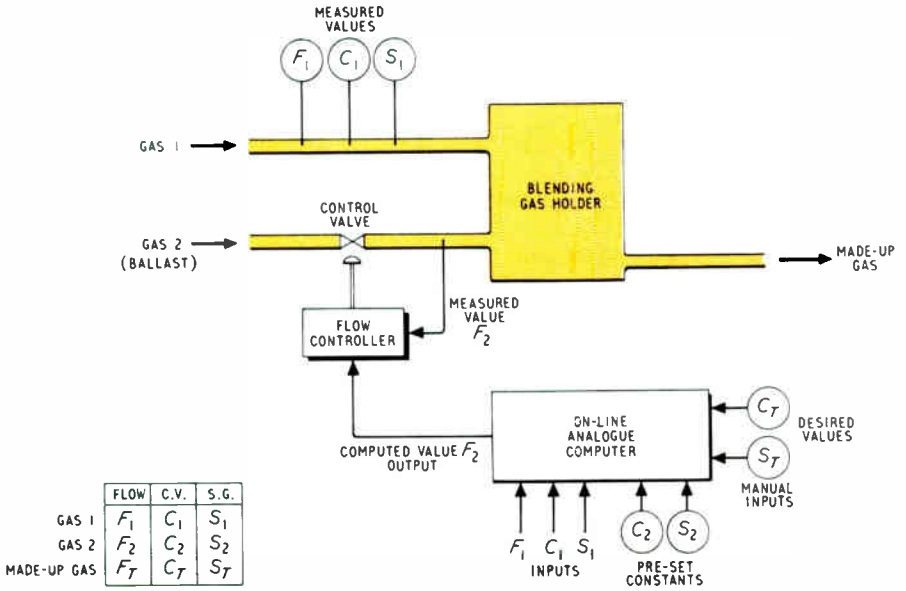


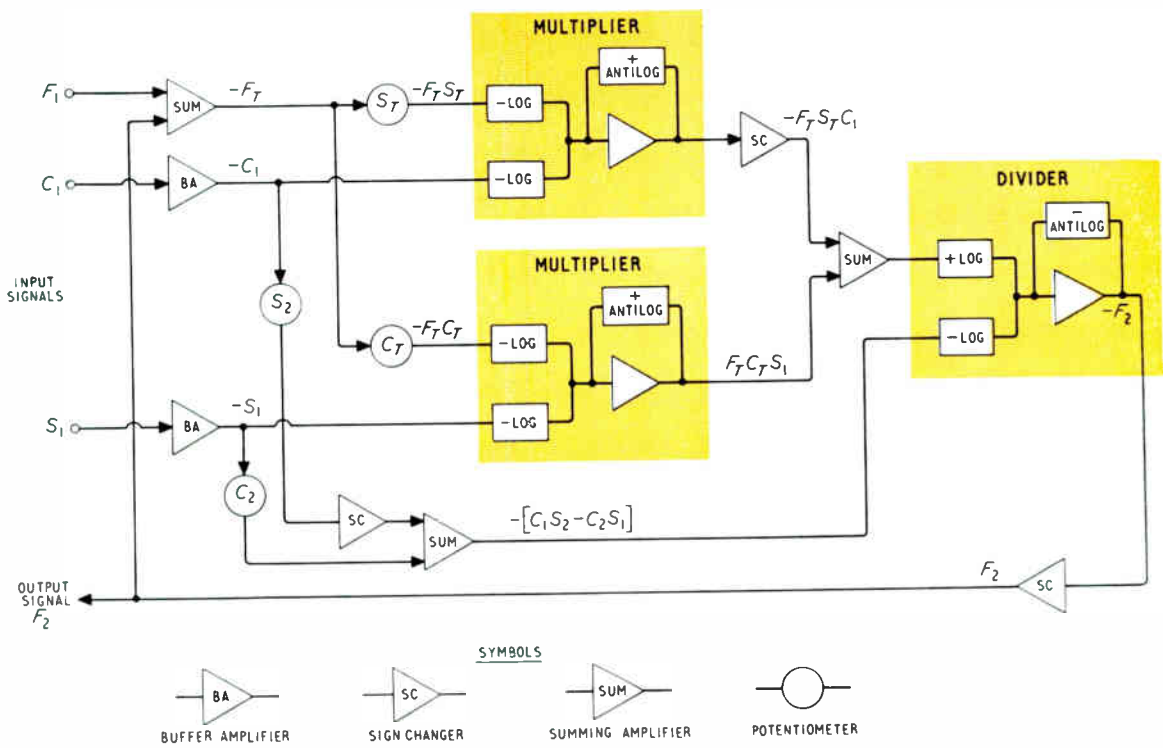
Fig. 7. General form of a gas blending problem

Closed-loop Applications

The problem of blending a number of products to yield a specified end product arises in many of the process industries, and if this blending is to be a continuous on-stream process then an on-line computer is a necessity. In some cases the calculations will be so complex that a digital system must be used, but for the simple blending problem with a small number of components the analogue computer is ideal.

A good example occurs in the gas industry where the requirement is to produce a gas which meets the statutory regulations in respect of the declared calorific value and specific gravity. Certain gas-manufacturing processes yield gases with calorific values which exceed the statutory value and must therefore be diluted by the addition of a ballast gas of low calorific value. The control problem is the determination of the necessary flows of the constituent gases to satisfy the desired values of calorific value and specific gravity of the made-up gas. The problem is shown in Fig. 7. Gas 1 is the basic gas of high calorific value and Gas 2 is a low calorific value ballast gas, usually nitrogen. In practice the calorific value and specific gravity of the nitrogen would be considered as constants and would not be continuously measured. The computer must be arranged to solve three

Fig. 8. Block diagram of apparatus for solving the gas blending problem of Fig. 7



simultaneous equations to yield the desired value of the flow of Gas 2 and use this to adjust automatically the set-point of the flow controller. The equations to be solved are:

$$\begin{aligned} &\text{Total Flow} && F_T = F_1 + F_2 \\ &\text{Heat Balance} && F_T C_T = F_1 C_1 + F_2 C_2 \\ &\text{Mass Balance} && F_T S_T = F_1 S_1 + F_2 S_2 \end{aligned}$$

Solving these equations for F_2 yields:

$$F_2 = \frac{F_T S_T C_1 - S_1 F_T C_T}{C_1 S_2 - C_2 S_1}$$

The computing arrangement for this equation is shown in Fig. 8.

There are many other closed-loop control problems which may perhaps be solved by on-line analogue computers but space does not permit the consideration of further examples.

Conclusion

The analogue computer can be a valuable aid to improved control in a wide variety of industrial processes and deserves much more consideration than it is at present receiving. The ARCH system is important because the value of analogue techniques is recognized, but kept in true perspective—the key phrase is 'use the best technique for each job'; there is clearly a place in process control for analogue and digital computers—ARCH provides both.

References

[1] 'Collection of Plant Data for On-line Computer Processing' and others, J. F. Roth, *Industrial Electronics*, Vol. 1, January, March, July, November 1963.

[2] 'TRIDAC, A Large Analogue Computing Machine', F. R. J. Spearman, *et al.* *Proc. I.E.E.*, Vol. 103, Part B, 1956.

[3] 'The Development of ARCH—A Hybrid Analogue-Digital System of Computers for Industrial Control', G. B. Cole and S. L. H. Clarke, *The Radio and Electronic Engineer*, Vol. 26, No. 1, July 1963.

[4] 'Electronic Systems for Industrial Measurement and Control', M. V. Needham, *Control*, Vol. 1, July, August and September 1958.

[5] 'Automatic Computing for Process-Unit Operating Guides', H. F. Moore, A.S.M.E. Paper No. 57-ASME-EIC-1.

Weights and Measures Stamp Load Cell Weighbridge

After many years of development of electric instrumentation for weighing machines, W. & T. Avery Ltd. have achieved a degree of accuracy with their load cell installations usually associated only with the more orthodox mechanical lever systems.

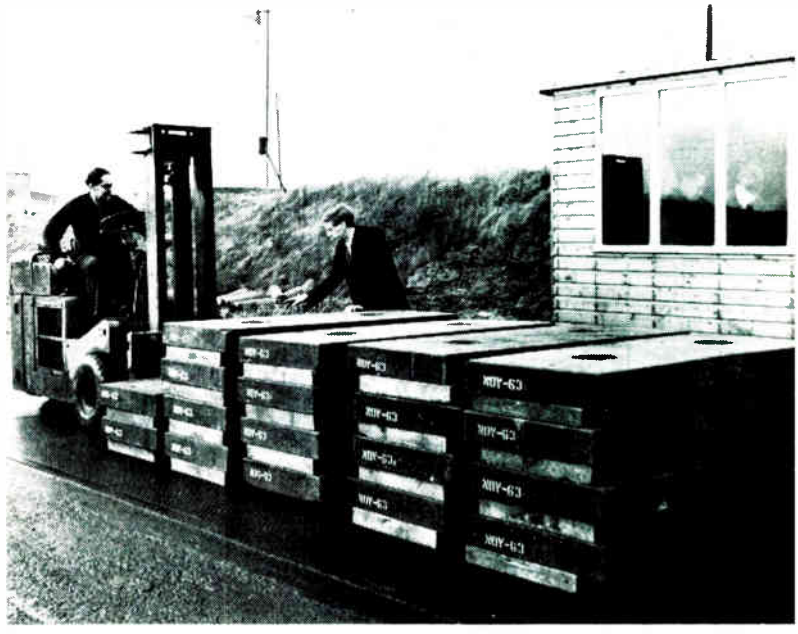
As a result of this they have obtained the approval of the Standard Weights and Measures Department of the Board of Trade for their load cell weighbridge. Accordingly a road weighbridge of 30 ton capacity, installed at their new factory site at Tame Bridge, Staffs., was recently stamped for unrestricted trade use.

This significant development now allows electronic load cell weighbridges to be used as the basis for calculations of wages, invoicing or other trade purposes. Stampability is the criterion of accuracy of weighing equipment and unless the stringent requirements of the Weights and Measures Regulations are met, the Inspector of Weights and Measures' stamp is withheld.

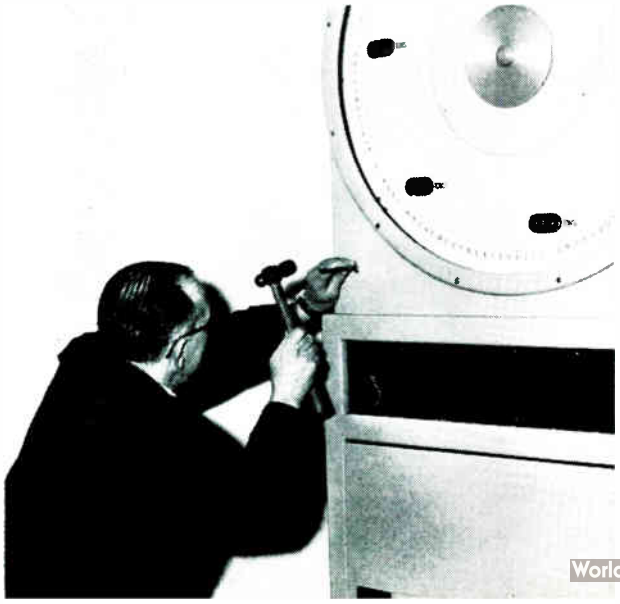
The weighbridge dial, which is electronically operated from the electric load cells, is graduated up to 30 tons by 28-lb divisions. This is made possible by an electric ranging device by means of which the pointer travels round the dial five times giving a total of 2,400 divisions. The Weights and Measures Regulations require that the scale shall be accurate to better than half of one of these divisions, that is, to an accuracy of 0·02% of the total capacity or one part in 5,000.

For further information circle 51 on Service Card

(Right) Placing 1 ton test weights on the weighbridge at the Tame Bridge works of W. & T. Avery Ltd., during the verification test. The wooden separator blocks were of course previously balanced off before verification began



(Below) The Inspector placing his stamp on the weighbridge indicator headwork



VIBRATION MONITORING EQUIPMENT FOR INDUSTRIAL PLANT

AN indicating amplifier and an alarm relay unit have recently been added to the Philips range of vibration monitoring equipment that is available in Britain from Research & Control Instruments Ltd. Both units are designed to be permanently installed with turbines, compressors and similar plant where excessive vibration can be an indication of faulty operation or incipient breakdown. Both are used in conjunction with electrodynamic pick-ups.

The vibration-indicating amplifier PR7411 provides a continual check on the vibration level of industrial machinery. It complements the existing Philips PR7410 equipment which has additional facilities that are not required for continuous monitoring. The new unit, although simpler and more economically priced, is well engineered and includes all the necessary features for day-to-day monitoring of vibration displacement and velocity.

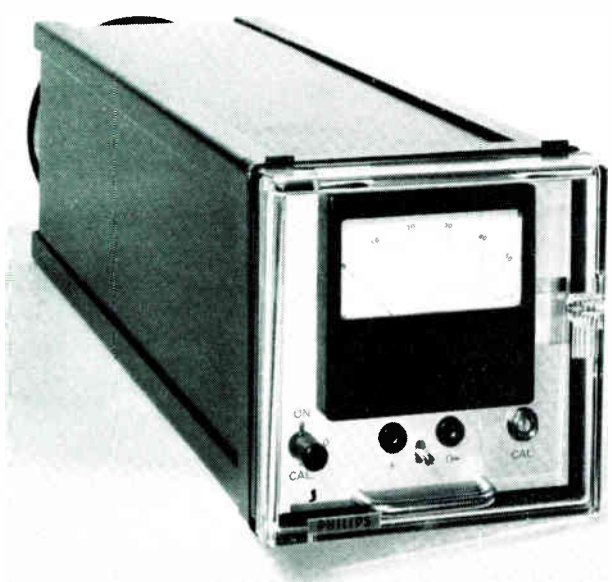
Internal connections enable the unit to be set to measure one of three vibration displacement ranges: 0 to 50, 150 or 500 μ; or one of three vibration velocity ranges: 0 to 10, 30 or 100 mm/sec. The measured value is indicated on a meter at the front of the unit where there are also sockets for an oscilloscope. At the rear of the unit there is a terminal box for alarm relay and recorder connections. Either a potentiometric or moving-coil recorder may be employed. A socket is also provided inside the unit for an optional 'Sensitact' relay which can be pre-set at a specified vibration level to operate an alarm. The unit is designed for panel mounting and occupies a panel area of less than 6 × 6 in.

The vibration relay unit PR7412 provides the simplest means of giving an alarm or switching off a machine when vibration velocity exceeds a preset value. This may be at any point between 5 and 30 mm/sec, and in the frequency range 15 to 1,000 c/s. There is no continuous indication of vibration level, the unit being basically a transistorized trigger which operates a change-over switch when safe conditions are exceeded. The switch contacts are rated at 250 V a.c., 2 A with a non-inductive load.

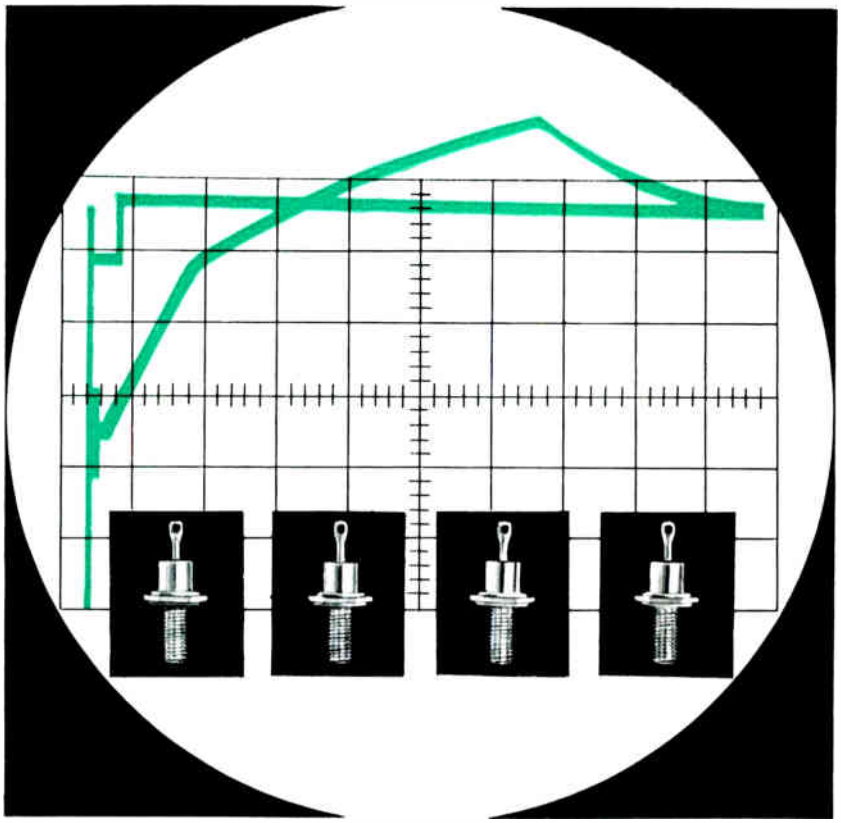
The vibration relay unit

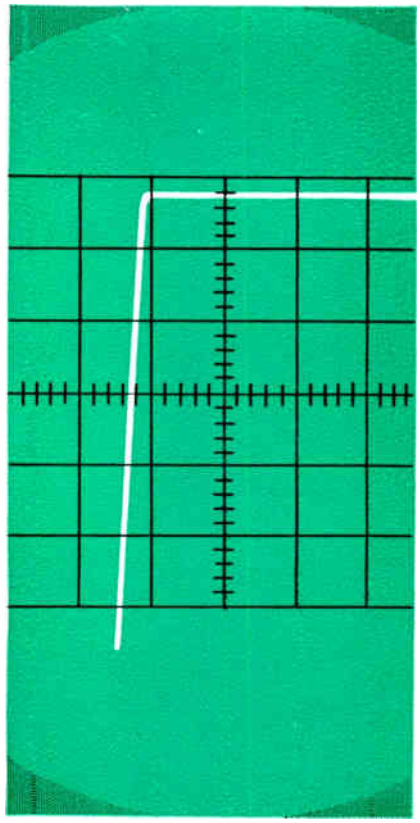
The unit is 'self-latching' and even after a momentary excursion beyond the pre-set value will remain in the alarm condition until the re-set button has been pressed. The initiating accuracy at a nominal sinusoidal 50-c/s voltage is ±6% of the pre-set value, which, to facilitate resetting, must be at least 40% above the normal operating level. The unit is mains operated and is contained in a cast-iron housing measuring 6 × 6 × 8½ in.

For further information circle 52 on Service Card



The vibration indicating amplifier





ANOTHER SILICON AVALANCHE RECTIFIER has been added to the STC range. This is the RAS508AF, a diffused junction stud mounted device with a 4 kW reverse power surge rating. Avalanche rectifiers are self-protecting against voltage transients and the avalanche property of the RAS508AF has a voltage limiting characteristic that permits surges fifty times greater than the conventional silicon rectifier can withstand. High voltage stack construction is simplified, the rectifier can be series-connected without voltage equalizing resistors and, in many applications, equalizing capacitors are unnecessary. Write, 'phone or Telex for Data Sheet MF/132Z to STC, Semiconductor Division (Rectifiers), Edinburgh Way, Harlow, Essex. Telephone Harlow 26811. Telex 81146.

RAS508AF	
Rated Forward Current	5 A
Rated Crest Working Voltage	800 V
Min. Reverse Avalanche Voltage	1000 V
Rated Max. Surge Power	4 kW
Rated Max. Temperature	125 C
Standard Outline	VASCA SO-10 JEDEC DO-4 IEC 1-103

high grade electronic components by **STC**
COMPONENTS GROUP

64/1MF

ULTRASONIC CLEANING

This second article on ultrasonic cleaning discusses the general kinds of equipment and their proper spheres of application.

By B. BROWN, Ph.D., B.Sc., A.Inst.P.*

THE cleaning effect of ultrasonic waves on materials immersed in liquids is now well known and this technique is employed in a large variety of industries. Several designs of ultrasonic cleaning equipment are available and the production engineer who wishes to install an ultrasonic-cleaning plant finds a wide variation not only in design but also in cost. In this article the particular merits of the various equipment designs available are discussed and the field of application of ultrasonic cleaning is briefly surveyed.

Two factors strongly affect the efficiency of any industrial-cleaning process, the solvent used and the method of application of the solvent. Much industrial cleaning is done by soaking the article in a suitable solvent together with some mechanical agitation. Another method in common use is spray machine washing and in difficult cases it is not uncommon to find hand scrubbing used. These methods may be quite capable of producing the degree of cleanliness required but they are often expensive, in terms of the cost of solvents used, labour involved, and time taken. In certain industries moreover normal cleaning methods are just not capable of producing the degree of cleanliness required. For instance, the delicate and intricate parts used in rockets and satellites must be cleaned to a very high standard, much more so than can be obtained using normal cleaning methods. The application of ultrasonics to industrial-cleaning processes readily enables such intricate parts to be cleaned without difficulty and in addition its application to established cleaning processes often results in a reduction in the time, labour and cost involved.

Ultrasonic cleaning basically consists of immersing the article to be cleaned in a suitable solvent which is then ultrasonically irradiated, as follows. High-frequency elec-

*Royal College of Advanced Technology, Salford.

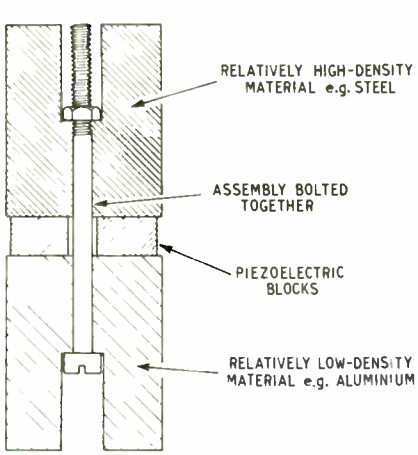


Fig. 1. General form of sandwich type of transducer

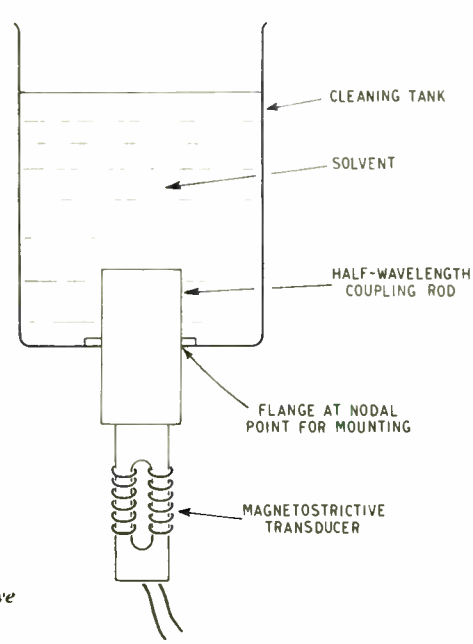


Fig. 2. Method of coupling a magnetostrictive transducer to a cleaning tank

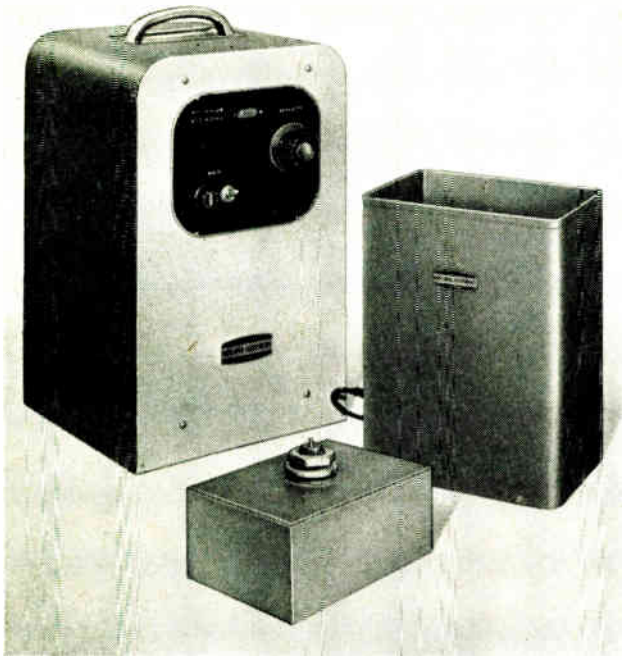


Fig. 3. Six litre, 500-W ultrasonic cleaning unit
Courtesy Mullard Equipment Ltd.

trical oscillations produced by an electronic generator are fed to a transducer which converts them to mechanical vibrations. By suitably coupling the transducer to the cleaning solvent the ultrasonic vibrations thus produced are propagated in the solvent. Provided the energy and frequency of the ultrasonic waves are sufficient, their propagation through the liquid initiates cavitation; i.e., the rapid formation and subsequent collapse of innumerable minute bubbles or cavities due to successive rarefactions and compressions in the liquid. The shock waves produced during cavitation impinge on any solid surfaces present in the liquid and very effectively scour the surface. The effect is similar to mechanical scrubbing but acts much more efficiently, rapidly penetrating to every hole and corner of an assembly immersed in the liquid.

The range of useful frequencies is from about 13 kc/s to about 1 Mc/s and the type of transducer used varies with the frequency. At high frequencies, say more than 100 kc/s, piezoelectric transducers made of quartz or barium titanate are used and in the low-frequency range, say from 13 kc/s to 40 kc/s, both magnetostrictive and piezoelectric transducers are used. It has been established that the intensity of cavitation increases as the ultrasonic frequency decreases and consequently most ultrasonic cleaning equipment works at fairly low frequencies, about 20 kc/s. Ultrasonic cleaning equipment utilizing frequencies greater than 100 kc/s has largely been discontinued. However, higher frequencies do have one important application, and this is where deep blind recesses are to be cleaned. Their use in this particular case is due to the fact that at high frequencies the ultrasonic wave can be beamed to penetrate the deep crevices. Low-frequency waves cannot be beamed in this manner and hence do not penetrate and clean deep recesses very effectively.

The production of low-frequency ultrasonic waves for cleaning purposes is accomplished by the use of various types of magnetostrictive and piezoelectric transducers. The power outputs available range from a few watts to several kilowatts thus enabling a wide range of liquid volumes to be efficiently irradiated. A previous article discussed in more detail the various types of transducers used and only the factors affecting their suitability for cleaning will be considered here. Magnetostrictive transducers have the advantage of being robust and for cleaning heavy machinery, etc., which may be dropped into the cleaning tank, they are preferable to piezoelectric transducers such as barium titanate, which will not withstand severe knocks. Their high Curie point permits their use at high temperatures which is often desirable in certain cleaning processes. On the other hand barium titanate is limited to use at a maximum temperature of about 160 °F and if higher temperatures than this are required the ultrasonic energy must be transmitted to the hot cleaning solution through a water bath fitted with cooling coils. The development of lead zirconate as a piezoelectric transducer material, however, has largely overcome this disadvantage of a low Curie point and in addition the use of sandwich type transducers has largely overcome the non-robustness of piezoelectric materials. These sandwich transducers consist of a thin piece of piezoelectric material sandwiched between two metal blocks as shown in Fig. 1. The assembly is firmly bolted together and the system vibrates as a whole. These transducers have a low mechanical Q which is an advantage in so far as it overcomes the necessity for exact tuning to resonance required with other types of transducer. However, if robustness and temperature considerations are not applicable then the factors which will decide a user to buy a particular piece of equipment are reliable and efficient cleaning at the lowest cost. In this respect all ultrasonic-cleaning equipment will obviously clean to some extent and it may well be that for a particular process several types of equipment will carry out the task successfully. Under these circumstances, therefore, the most suitable unit will be the cheapest, provided its quality of finish, etc., is of no importance. In many cases, however, it is found that low-power cleaning units are unable to clean sufficiently or in doing so take too long. In these circumstances a more powerful unit is necessary, preferably at a lower fre-

Fig. 4. Rapiclean 32/1000 for hospital use, marketed by Manlove Alliott & Co. Ltd. of Nottingham
Courtesy Ultrasonics Ltd.

quency. It is common practice among manufacturers of ultrasonic cleaning equipment to refer to power output in terms of watts/cm². This is not always a good criterion of cleaning ability, however, as other factors such as frequency of vibration, loading of the transducer, etc., considerably affect the results which can be achieved.

The design of ultrasonic-cleaning equipment depends very much on the use which is to be made of it. Generally the transducers are connected to a cleaning tank containing a solvent in which the articles to be cleaned are immersed. The coupling of the transducer to the tank depends on the type of transducer used. Magnetostriction transducers are normally attached to resonant coupling stubs which are bolted to the tank at their nodal points (Fig. 2). Piezoelectric transducers are either cemented to the outside of the tank or constructed in a form such that they can be directly immersed in the solvent. Fig. 3 shows a 500-watt Mullard ultrasonic-cleaning unit. Here the electronic generator can either drive the transducers mounted in the bottom of the tank or the immersible transducer shown in the front of the photograph. While a certain amount of scattering of the ultrasonic waves takes place, by and large the region of activity in a cleaning tank (i.e., where cavitation takes place) lies only above the transducer face and consequently in cleaning baths it is important to have the entire base of the tank covered with transducers. Some equipment has a small gap between transducers and in this case it is important to realize that certain parts of the liquid volume may be less active than others. Ultrasonic-cleaning tanks are normally made of stainless steel and are basically simple in design. When necessary, of course, they can be fitted with a drain, piping, and suitable pump to pass the solvent through a filtering unit. If the solvent is more effective at higher temperatures then heating units are also readily available. Ultrasonic degreasing units using trichloroethylene and similar solvents are more complicated since it is necessary to prevent the vapour escaping and cooling coils near the top of the tank must be incorporated.

The cleaning solvent used depends on the soil to be removed. Alkaline, acidic, and aqueous solutions have all been successfully used in ultrasonic-cleaning baths. It is worth noting that in many cases the use of ultrasonics has enabled expensive solvents to be replaced by much cheaper solutions. Generally speaking it is often possible to clean ultrasonically with weaker solutions than normally used. This is an important point since if the cleaning is usually done with, say, a fairly strong acidic solution, then under the action of cavitation the acid would rapidly attack the tank walls, particularly the wall to which the transducers were attached or, in appropriate cases, the transducer face itself; i.e., in the case of a magnetostrictive transducer nodally mounted.

The applications of ultrasonic cleaning are extremely widespread and range from the cleaning of fine watch parts, jewellery, etc., to the cleaning of heavy steel strip. Naturally the particular application determines the modifications which are made to the basic cleaning equipment. For many cleaning jobs, however, a simple tank transducer driven by an electronic generator will suffice. The generator is usually fairly simple in design supplying electrical oscillations at a fixed frequency and power output. In many cases, to keep the apparatus even simpler, no rectification is incorporated, with a resulting pulsed or half-wave output. Controls on the generator are few to make operation as simple as possible. There is an on/off switch, of course, and in many generators, by the use of a suitable mechanism, the one switch suffices to switch on both l.t. and h.t. supplies. Besides this there is also incorporated a crude tuning control to enable the generator output to be tuned to the mechanical resonance frequency of the transducer or transducers being used. This mechanical resonance frequency may vary from one transducer to another and in addition it is affected by temperature. Hence, each time a cleaning unit is used, the generator output must be adjusted to match the transducer frequency. This adjustment is very slight in the case of magnetostrictive transducers and also in the case of multipower transducers, which, as mentioned earlier, have a low mechanical Q obviating the necessity of precise tuning, but it may be

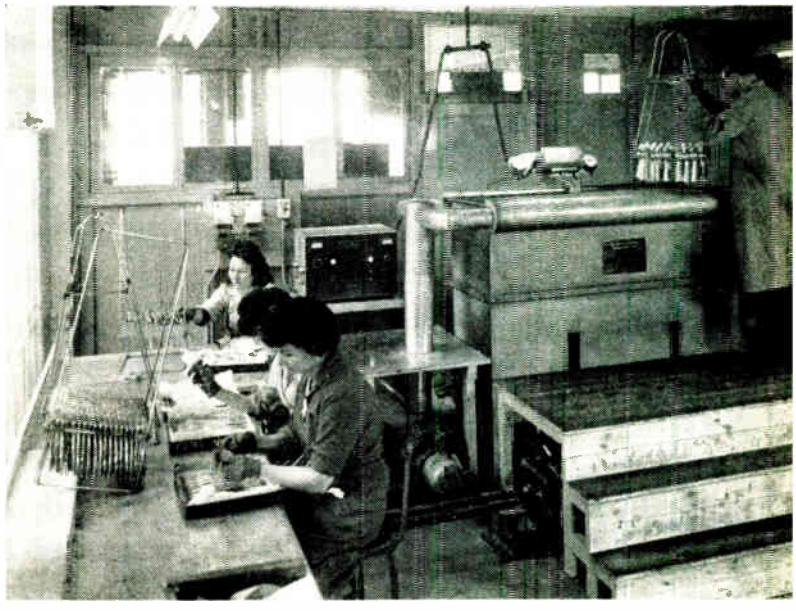
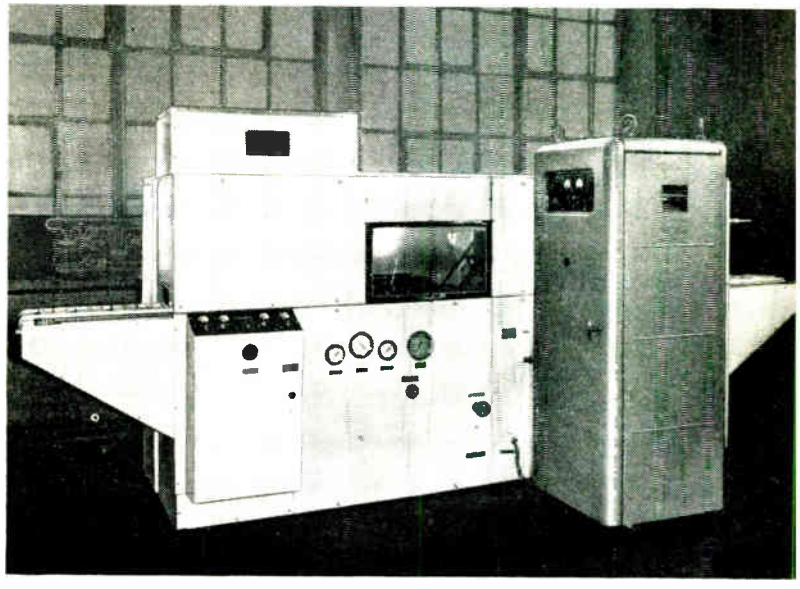


Fig. 5. I.C.I. ultrasonic cleaning plant type ULV6 installed at Viners Ltd., Sheffield 1, for the perfect cleaning of silver and stainless steel cutlery before plating and in between stamping operations. The plant has six transdducers connected to a Dawe 4 kW Soniclean generator producing electrical impulses at a frequency of 40 kc/s

Fig. 6. Cleaning plant with conveyor belt for handling the articles to be cleaned

Courtesy Kerry's (Ultrasonics) Ltd.



more pronounced with barium titanate transducers. The power outputs available from standard cleaning units range from about 50 W to 4 kW and the cleaning tanks vary in size from a capacity of about 200 cc to 100 litres. Larger units are also available of course but are normally constructed to meet individual requirements. Filtering units are more or less standard equipment in these larger units and provided that bulk soil has been removed by normal dip cleaning, say, then the filters will not need changing too frequently. Articles to be cleaned can either be placed directly into the solvent or, if it is more convenient, held in suitable containers. Wire baskets of small mesh are not particularly suitable containers since certain sizes of mesh can interfere with the propagation of the ultrasonic waves. In general, therefore, containers used have a thin solid metal base through which the waves can easily pass.

A more specialized type of ultrasonic cleaning lies in its application to hospital work. Ultrasonic equipment is being used more and more in hospitals for the cleaning of syringes, needles, and surgical instruments much more effectively than can be accomplished by other methods. Fig. 4 shows a hospital cleaning unit manufactured by Ultrasonics Ltd., of Otley. The standard of cleaning reached is far higher than that previously obtainable and is carried out in a much shorter time. The application of ultrasonics to metal degreasing is also now a well-established process. The purpose of metal degreasing is to remove oil and grease from metal surfaces before surface treatment, finishing processes, etc., and this is normally done by the use of a solvent such as trichloroethylene. Where a high standard of cleanliness is required then ultrasonics is also incorporated in the process. Normally ultrasonic degreasing is a three-stage process; a boiling liquor stage, to remove bulk soil, an ultrasonically irradiated cool liquor stage, to achieve complete removal of fine solid matter, and finally a vapour stage, from which the treated parts emerge in a dry neutral condition ready for any subsequent processing. Since organic solvents are used the equipment is designed to ensure that no vapour escapes from the cleaning unit. A typical ultrasonic degreasing plant is shown in Fig. 5. This particular unit is manufactured by I.C.I. Ltd. and Dawe Instruments Ltd.

All the equipment discussed so far has been concerned with batch cleaning but in fact, where necessary, cleaning equipment can be designed to enable continuous cleaning to be carried out. Fig. 6 shows a conveyorized ultrasonic-cleaning system marketed by Kerry's Ltd. in which gear assemblies are cleaned in one minute. Due to the lack of demand in this country, however, continuous cleaning units are not offered as standard equipment. Several companies are, of course, quite willing to design and supply such equipment when required.

While it is seen that there are several standard types of ultrasonic cleaning equipment on the market it is most important to make sure that the equipment used is the best for the particular purpose. From this point of view it is desirable initially to consider the factors which are likely to affect the type of equipment required. Such factors include, size of the article to be cleaned, material of which the article is made, quantity to be handled (i.e., rate of cleaning required), purpose of cleaning (speeding up an existing process, accomplishing at present impossible cleaning, etc.), present cleaning method, solvent desired, necessity for heating, filtering, etc. A consideration of these and other factors will undoubtedly assist any potential user of ultrasonic cleaning equipment.

Pozidrivs Supersede Phillips Screws

A new type of recessed-head screw and screwdriver designed to cut time and costs on industrial assembly lines has been announced jointly by G.K.N. Screws & Fasteners Ltd. and Stanley Works (Great Britain) Ltd.

Under the name 'Pozidriv', it will entirely supersede the Phillips patent recess-head screws and screwdrivers which have hitherto been standard for most industrial assembly operations. It is claimed that the Phillips Pozidriv will mean an immediate and direct cost saving to industry.

Sample Pozidriv screws

The advantages of the new recess and driver are stated to be: that they will virtually eliminate the tendency of the driver to 'cam-out' (come out under torque), give faster driving and increased driver life, and considerably reduce operator fatigue; in short, more screws can be driven in less time, with such increased productivity as this implies.

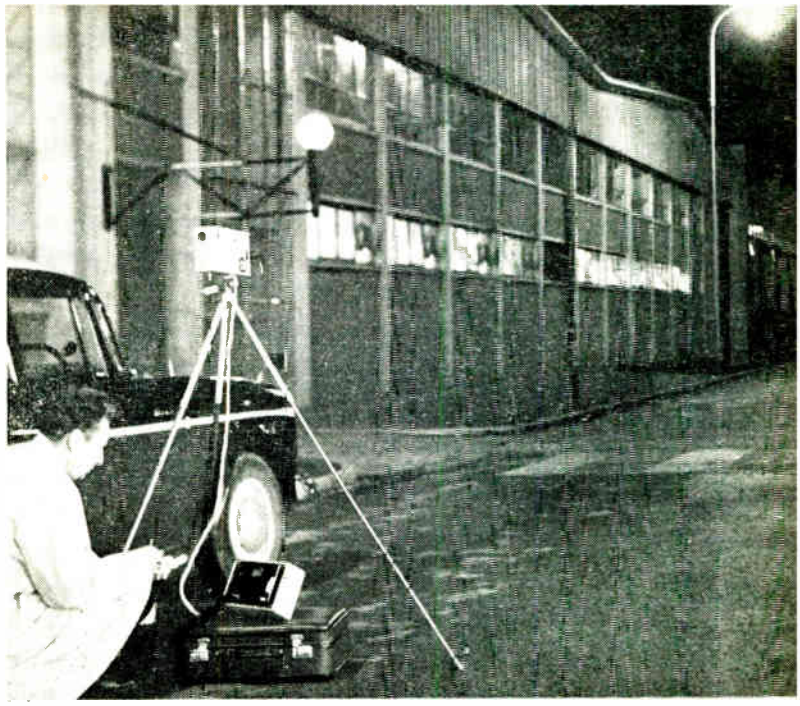
This has been achieved by designing a recess which gives vertical driving faces, while at the same time being more speedily located by the driver without danger of misalignment.

Pozidriv recess screws will be marketed at the same price as the present Phillips recess, and will become the standard recess on all G.K.N. screws.

In order to ensure that there will be no dislocation during the changeover period, the Pozidriv recess has been designed to accept the old Phillips driver. The full benefits will not be realized until the combination of Pozidriv driver and Pozidriv recess becomes generally available.

The screws will be manufactured by G.K.N. in Birmingham and the screwdriver and screwdriver bits by Stanley Works in Sheffield.

For further information circle 53 on Service Card



Illustrated here is the equipment being used to measure road lighting intensity

Measuring Road Lighting from the Motorist's Viewpoint

MOST motorists have positive views about the rather haphazard road lighting in Britain. While motoring in some areas it is possible to pass from complete darkness through dimly gas-lit streets to brilliantly illuminated roads and in the process take in conventional electric, mercury and sodium lighting of varying intensities.

The reasons for this are complex. Highway illumination is the responsibility of various bodies, the cost may be met by local, county or national authorities and although codes of practice do exist there is a lack of nationally-accepted standards.

Now the effectiveness of road lighting as seen from the driving seat of a car can be measured with a new 'luminance meter'. It has been developed by Philips, and is available commercially in Britain through Research & Control Instruments.

The compactness of the equipment can be seen from this picture which shows the instrument and accessories packed in one case

The viewing head, similar in appearance to a small ciné camera, is sighted to cover the stretch of road that is considered to be of greatest importance to a driver. This, naturally, varies from road to road, but on a straight level road the section most usually chosen lies between about 200 and 500 ft from the point of observation.

The average luminance of the whole stretch of road seen in the viewing head is indicated directly in candelas per square metre on an associated unit. When the viewing head is correctly sighted, the operator closes a cable-operated switch which 'freezes' the meter reading. This enables him to sight the viewing head and to note the luminance reading without the assistance of another person

The distinguishing feature of the instrument is that the average luminance of a whole section of road can be measured directly in a few seconds. The time required for the local measurement of a number of small areas is avoided, and traffic is not interrupted. Also, there are no problems of calculating the average luminance from several measurements. This can be especially difficult when allowing for the effects of perspective.

The light-sensitive element in the viewing head is a photo multiplier tube, and, as the indication is given direct in candelas per square metre, no photometric experience is required of the operator. There are seven measuring ranges, from 0·1 to 100 candelas per square metre f.s.d. Accuracy is ensured by an internal light source with which the instrument may be calibrated immediately before use.

Provision is also made for making local measurements of small areas, such as may be required when assessing the uniformity of lighting. For this purpose the viewing head is placed on its side on the road surface. Its position is then adjusted with the aid of a beam projected from an internal alignment lamp on to a small screen which is placed a few feet away.

The instrument is battery operated and is equipped with an internal charger. A carrying case is supplied together with viewing slides for different road widths, a tripod and all necessary accessories.

For further information circle 54 on Service Card

EQUIPMENT REVIEW

1. Automatic Frequency Response Tracer

The C.R.B. automatic response tracer is an audio-frequency spectrum analyser for experimental work on, and testing of, amplifiers, filters, recorders, microphones, pickups, loudspeakers and transducers, and circuit elements generally.

The instrument essentially comprises a low-distortion beat-frequency oscillator, covering the range 0 to 20 kc/s, which is swept repetitively by a motor drive. The variable-frequency constant-level output of the b.f.o. is applied, via a power amplifier with calibrated attenuators, to the device under test, and the output of the latter is returned to the tracer where it is applied to a logarithmic amplifier feeding the vertical-deflection system of a long-persistence cathode-ray tube. The horizontal sweep for the c.r.t. is derived from a very robust 180-step potentiometer mounted on the b.f.o. sweep drive shaft, thus producing a direct amplitude/frequency graph.

Manufactured by Construzione Elettriche di D. Borsini of Ancona, Italy, the TAR/61 automatic frequency response tracer is available in the United Kingdom through the *Instruments Division of Claude Lyons Ltd., Hoddesdon, Herts.*

For further information circle 1 on Service Card

2. Inexpensive Digital Voltmeter

Digital Measurements Ltd. have announced an addition to their range of digital voltmeters. The DM2004 is designed for d.c. measurements from 1 mV to 1 kV, in four switched ranges, to an accuracy of 0·1% of reading ±1 digit. It has a scale of 1999 in two manually selected stages: 0 to 999 and 1000 to 1999.

The instrument has a fully-floating input and provides unambiguous indication of reverse polarity and overload. The measurement is displayed on numerical indicator tubes and the position of the decimal point is automatically shown. No warm-up period is required. The DM2004 utilizes printed-wiring boards and semiconductors for all active circuits. Its dimensions are $10\frac{5}{8}$ in. wide by $3\frac{3}{4}$ in. high by $11\frac{1}{8}$ in. deep. Price: £150.—*Digital Measurements Ltd., 25 Salisbury Grove, Mytchett, Aldershot, Hants.*

For further information circle 2 on Service Card

3. Miniature Collet Knobs

A range of miniature collet knobs has been developed by Plessey to meet the requirements of DEF 5221. A feature of the design is that the same basic phenolic moulding can be fitted to shafts of both $\frac{1}{8}$-in. and $\frac{3}{16}$-in. diameter, using alternative collets.

The knob assemblies require a circumferential groove in the shaft and a slot across its end. Tightening the locking screw contracts the collet so that it locates in the radial groove; this prevents the knob from being pulled off the spindle. The drive, however, is transmitted by a key which engages in the slotted end of the spindle.—*The Plessey Company (U.K.) Ltd., Titchfield, Hants.*

For further information circle 3 on Service Card

4. Dosimeter Charging Unit

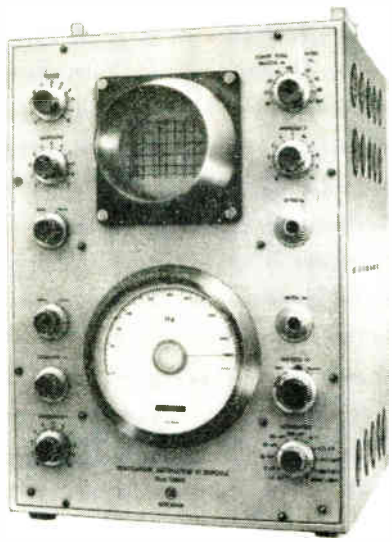
Dynatron Electronics are producing a dosimeter charging unit, designed for use with quartz-fibre dosimeters of British, American, and many Continental types. This unit, known as the N.124, derives its power from an ordinary U2 (or similar type) battery cell, which also supplies the current for the illumination of the scale. Dimensions are $4\frac{7}{8} \times 3\frac{7}{8} \times 3\frac{1}{2}$ in.

It is simple to use, as the action of inserting the dosimeter into the charging socket and applying slight pressure switches on the light which enables the scale to be clearly read. Further pressure brings the charging potential into action, and this, in conjunction with the operation of the control knob, charges the dosimeter to zero in a matter of seconds.—*Dynatron Electronics, St. Peter's Road, Furze Platt, Maidenhead, Berks.*

For further information circle 4 on Service Card

5. Educational Digital Computer

The 'Lan-Dec' educational digital computer has been designed to provide an inexpensive instrument capable of a wide range of computer-circuit demonstrations. It is basically a large patch board, 19 × $10\frac{1}{2}$ × $2\frac{1}{2}$ in., with standard computer logic symbols representing each of the fifteen NOR gate transistor-resistor logic circuits, which



1

2

3

are wired directly to the underside in five vertical columns of three gates each. Connections to each of the NOR gate inputs and outputs are made via silver-plated miniature sockets which are duplicated at each point.

Each computer is supplied complete with all necessary cords for patching, etc., and a comprehensive manual. A relay control unit is available to provide control facilities for external mechanisms. Normally supplied for bench use the 'Lan-Dec' may also be fitted flush in a standard 19-in. rack simply by removing the side pieces.—*Lan-Electronics Ltd., 97 Farnham Road, Slough, Bucks.*

For further information circle 5 on Service Card

6. Data Logging System

Accommodated in two units, a transportable data-logging system, designed by Deakin Phillips Electronics under contract to the D.S.I.R., provides facilities for strain and temperature measurement in prestressed concrete structures. Up to fifty channels of each parameter can be measured, and the output is presented digitally both as a printed record and on punched tape.

Strain is measured on a vibrating-wire strain gauge embedded in the concrete structure. The period of 100 cycles of wire vibration is recorded and the simple square-law relationship between strain and period thus measured facilitates direct calculations of the internal strain in the structure.

Temperature measurements are derived from resistance thermometer elements and the results are displayed as direct readings in the absolute scale of temperature. The equipment is designed for unattended site operation and can be programmed to run automatically at pre-determined intervals of up to 2 hr.—*Deakin Phillips Electronics Ltd., Tilly's Lane, High Street, Staines, Middlesex.*

For further information circle 6 on Service Card

7. Television Camera Controller

Pye Switches have recently developed to the requirements of the B.B.C. a slim-line controller for the remote adjustment of iris and lift of television cameras. This unit, known as type 793, is sealed against dust and has an overall width of only 3 in.

The need for this development has arisen because of the increasing numbers of picture sources now being controlled by a single vision control supervisor. In addition to controlling up to six cameras, the function of the supervisor has been extended to control caption and telecine sources.—*Pye Switches Ltd., Otehall Works, Burgess Hill, Sussex.*

For further information circle 7 on Service Card

8. Instrument C.R.T.

A 5-in. cathode-ray tube has been developed by English Electric Valve Co. for use in wide-band high-speed oscilloscopes. The special features of this tube are: deflection sensitivities in the Y and X directions of 3 and 9 V/cm respectively; excellent brightness enabling high writing speeds to be employed; good resolution (typical line width 0·4 mm).

These features are achieved by the use of a post-deflection accelerator mesh positioned a few millimetres from the phosphor screen, and an improved gun design. Since the region between the mesh and the screen in which the beam is accelerated is short, raster distortion is kept to a minimum while an improved X-deflection sensitivity is achieved by having a large X-plate-to-mesh spacing.

A further advantage of this position of the mesh is the improved stability in X- and Y-deflection sensitivities with changes of temperature, making the tube particularly suitable for use with deflection circuits employing transistors. The tube is available with two phosphors: T948H blue-green afterglow (phosphor equivalent to P31) and T948N yellowish-green afterglow (phosphor equivalent to P2). Both versions have medium-short persistence.—*English Electric Valve Co. Ltd., Chelmsford, Essex.*

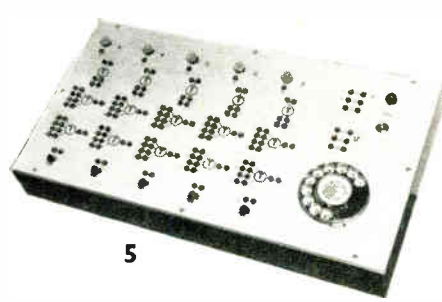
For further information circle 8 on Service Card

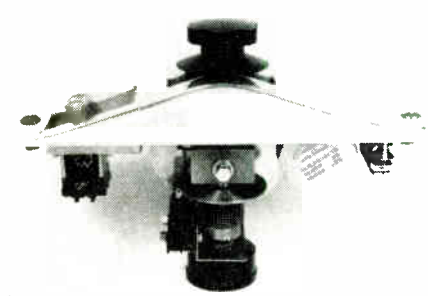
9. Carrier Modulation Amplifier

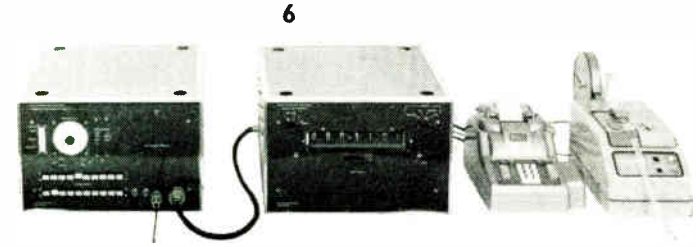
The Derritron dual-phase carrier modulation amplifier is designed for use with very-low-frequency vibration techniques. It produces two modulated carrier outputs with a crystal-controlled carrier frequency of 10 kc/s, the phase relation of the two modulations being 180°. The system is capable of modulating the carrier with frequencies between 1 and 130 c/s to depths as high as 90% with less than 4% second-harmonic, 2% third-harmonic distortion.

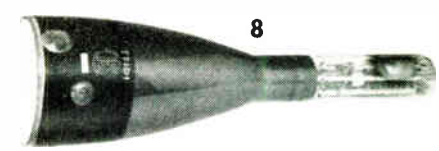
The frequency response of the

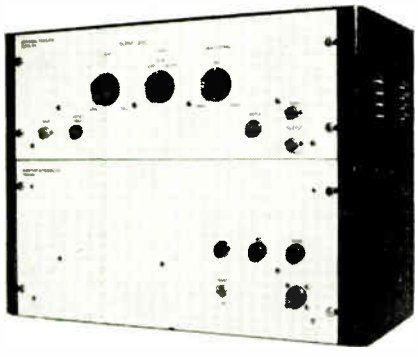

4


5

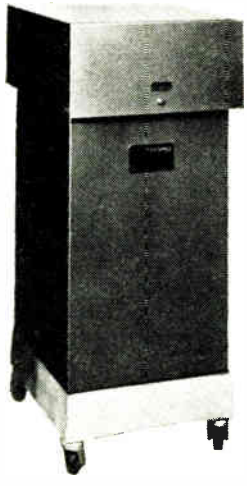

7


6


8

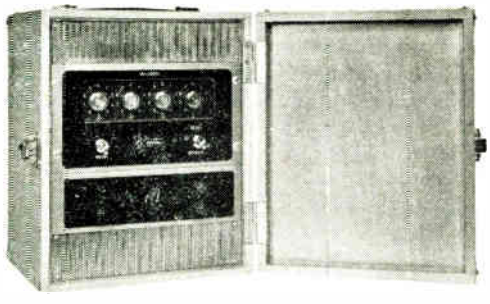


9

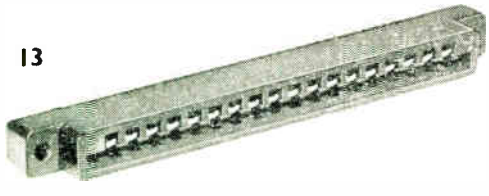


10

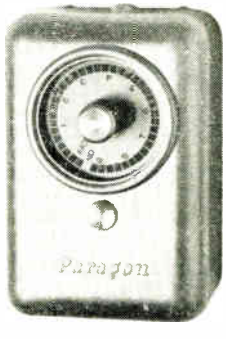
11



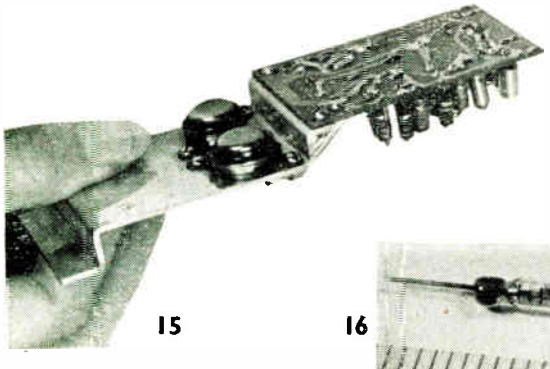
12



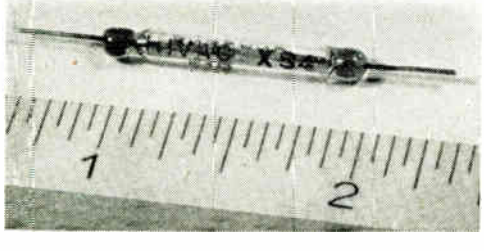
13



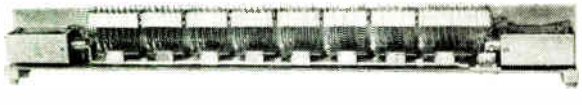
14



15



16



17

modulator is within ±2% between 5 and 120 c/s. Built-in low-pass filters attenuate frequency beyond this range by at least 6 dB per octave. Modulation above 90% is limited by a clipper stage and an indicator lamp indicates over-modulation. The input signal for 90% modulation is less than 2 V r.m.s. and the input impedance is 50 kΩ; the two outputs are suitable for a 600-Ω load, output being continuously variable up to 500 mV with this load.

A relative amplitude control is incorporated. The hum and noise level is approximately 80 dB below full modulation. A stabilized power supply operating from 200/250 V is incorporated in the equipment which measures approximately 21 × 19 × 16 in.—*Derritron Ultrasonics Ltd., 24 Upper Brook Street, Mayfair, London, W.1.*

For further information circle 9 on Service Card

10. Robust Voltage Stabilizer

Servomex Controls have announced the type 126 a.c. voltage stabilizer designed for use in industrial environments. Totally enclosed in a case of heavy-gauge mild-steel sheet without any orifices such as ventilating slots, the instrument can be used in dusty or damp atmospheres and can be washed or hosed down if necessary.

Operating on a nominal input supply of 200/250 V a.c., its correction range is −20% to +10% or −15% to +15% with an output of 7 kVA, and −10% to +5% or −7½% to +7½% with an output of 14 kVA. Temperature variations of 40 °C are unlikely to change the output by more than 0·1%. Harmonic distortion is negligible.

A feature of its design is the ease with which it can be installed and serviced. It is mounted on castors, will withstand shocks of up to 40 *g* and is submersible up to 18 in. from its base. —*Servomex Controls Ltd., Crowborough, Sussex.*

For further information circle 10 on Service Card

11. Miniature Wirewound Trimmer

Miniature Electronic Components have adapted their sealed rotary type TP5 precision trimmer to meet the stringent reliability requirements and environmental conditions of space and aircraft applications.

This single-turn, ½-in. diameter, potentiometer is of robust construction with an end-stop torque of 3 lb-in.; the operating torque is less than 6 oz-in. It is for panel mounting with a functional angle of 300°. The base is sealed by a coating of epoxy resin and the shaft by 'O' rings. The

precision setting is secured by a collet locking device. Readily available in a standard resistance range of 50 Ω to 50 kΩ, it is rated at 1½ W up to 80 °C. Operating temperature range is −55 to +150 °C. — *Miniature Electronic Components Ltd., St. Johns, Woking, Surrey.*

For further information circle 11 on Service Card

12. Interval Timer

An interval timer, designed by Advance to measure the operating times of relay contacts, can be used equally well for the determination of any time interval delineated by an external contact or contacts.

Internal pulses at a rate of 1,000 per sec derived from a crystal-controlled oscillator (accuracy 0·01 %) are counted by four Dekatron tubes in cascade during the period that the external contact(s) are operated and the resultant time (up to a maximum of 9.999 sec) is read directly from the tubes.

A 6-position selector switch and two pairs of spring-loaded input terminals allow the timer to be started and stopped by any combination of one or two contacts either opening or closing. Several alternative versions are available with maximum counts up to 999.99 sec. Provision can also be made for operation by external pulses or d.c. voltages at a small extra charge. — *Advance Controls Ltd., Imperial Lane, Cheltenham, Glos.*

For further information circle 12 on Service Card

13. Printed-Circuit Connectors

Souriau printed-circuit connectors, now available in Britain from Lectropon, are for $\frac{1}{16}$ in. thick boards with $\frac{5}{100}$ in. contact pitch. Single-face connectors offer 6, 10, 15, 18 or 22 contacts and double-face connectors offer 12, 20, 30, 36 or 44 contacts.

The moulding is of diallyl phthalate, giving a temperature range from −65 °C to +100 °C, and the contacts employ a separate spring piece so that contact pressure of 250 gm can be achieved with contact resistance better than 0·002 Ω.—*Lectropon Ltd., Kinbex House, Wellington Street, Slough, Bucks*

For further information circle 13 on Service Card

14. Timing Devices

English Clock Systems have recently been appointed sole U.K. distributors for the Paragon range of time switches, which includes the J.W. series (illustrated) suitable for bulk agitation and pump control. These fixed cycle timers have an 'on' time adjustable on a percentage basis. The cycle is repeated continuously for as long as power is supplied to the motor. Three fixed cycles are available: 10, 30 and 60 min. The 'on' time for all models is adjustable from 0 to 90% of the cycle, with a 100% 'on' position and a 100% 'off' position for switch use when timing is not desired.

The 1015 series provides a control for industries requiring operations in 15-min multiples on a flexible schedule. Ninety-six self-retaining trippers, each equivalent to a 15-min period on the 24-hr dial, can be simply slid in or out with the finger to set up a programme. —*English Clock Systems, Time Switch Section, 179-185 Great Portland Street, London, W.1.*

For further information circle 14 on Service Card

15. Miniature Packaged Circuit

Newmarket Transistors announce that they are now in production with a further addition to their range of miniature packaged circuits. This is a transformerless audio amplifier suitable for the audio stages of a car radio receiver, high power domestic radio, high power record player or tape recorder. With an input impedance not less than 1 kΩ, it is available in two sensitivities: PC5, 50 mV r.m.s. for 3 W output, and PC5+, 5 mV for 3 W output.

The unit is self-contained and requires only a 12-V d.c. supply, a signal source and a 1,000-μF isolating capacitor, feeding into a standard 3-Ω speaker. Power consumption in quiescent condition is less than 12 mA and frequency response is better than 50 c/s to 15 kc/s (3 dB down on 1 kc/s). Total distortion at 1 kc/s for 3 W output is typically 3%.

The unit weighs only 2 oz and connection to the p.c. board can be made either by flying lead to end holes specially provided or by standard 0·1-in. end-connector sockets. The circuit includes thermal compensation elements which permit satisfactory operation over a range of 0 °C to 45 °C.—*Newmarket Transistors Ltd., Exning Road, Newmarket, Suffolk.*

For further information circle 15 on Service Card

16. Dry Reed Relay Insert

Hivac have now added the intermediate sized type XS4 to their standard range of dry-reed relay inserts. The glass length of the XS4 is 1·27 in. and the maximum overall length 1·77 in. The maximum diameter is 0·17 in.

The contact surfaces are plated with gold which is diffused into the base material to eliminate the risk of cold welding during dry circuit operation, and contacts will give long-life operation at currents up to 150 mA. The XS4 operates at between 33 and 59 amp-turns and has a minimum breakdown voltage of 500 V d.c.—*Hivac Ltd., Stonefield Way, South Ruislip, Middlesex.*

For further information circle 16 on Service Card

17. Multiswitch Unit

A multicontact switch unit, manufactured by Magnetic Devices and holding an R.R.E. Certificate of Limited Approval, is solenoid operated into two positions (i.e., latched or de-latched) giving open or closed circuits. Supply to the operating solenoid can be via the auxiliary contact adjacent to the latching spring and the supply to the releasing solenoid can be via a pair of normally-open contacts (in de-latched position) in the main spring-set stack. This ensures that the power supplied to the solenoids is cut off when the contacts are moved to the alternative positions.

Banks of similar switch units can be interconnected to provide rapid sequence switching through a large number of contacts using only the power necessary for one solenoid. The maximum contact stack build-up could comprise 50 normally-open contacts, 50 normally-closed contacts or a mixture of the two. By suitable interconnection of the mixed normally-open and normally-closed contacts, a maximum of 25 change-over contacts can be catered for. The ambient temperature range covered is −40 °C to +40 °C.—*Magnetic Devices Ltd., Newmarket, Suffolk.*

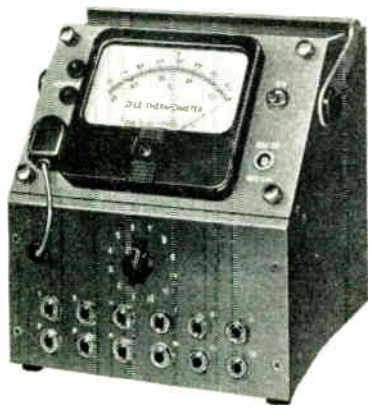
For further information circle 17 on Service Card

18. Telethermometers

Shandon Scientific Company have introduced a range of telethermometry equipment which includes a series of readily-interchangeable temperature-measuring probes.

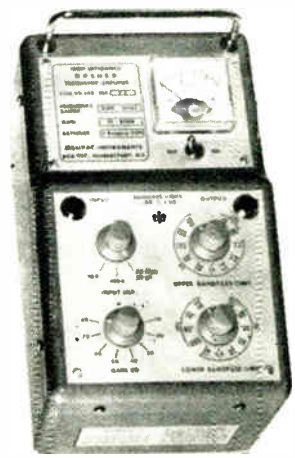
The probes of the 'YS1' equipment all follow the same resistance-temperature curve over the whole of their usable range, thus eliminating the need for recalibration or reference to conversion charts, and facilitating rapid replacement. Among the probes available are types for chemical and engineering, as well as biological and medical, applications. They cover the temperature range from −80 to +150 °C. Extension leads for making remote measurements (more than 10 ft from the telethermometer) are available.

The YS1 'Thermistemp' telethermometers for use with these probes in-



19

20



21

22

clude multi-channel and multi-input units. A twelve-point switch box is also available, enabling up to twelve probes to be monitored through a single input. By 'cascading' these switch boxes, any number of probes can be monitored through the same telethermometer. Recorder outputs are incorporated in most models. The photograph shows the model 44, 12-channel unit.—*Shandon Scientific Co. Ltd., 65 Pound Lane, Willesden, London, N.W.*10.

For further information circle 18 on Service Card

19. Polyester Capacitors

Lemco have announced a range of polyester capacitors, which includes 30 standard values from 0·01 to 1 μF for 125 V working and 0·001 to 0·47 μF for 400 V working.

The dimensions of the entire range are from 7 mm diameter, 21 mm long to 19·5 mm diameter, 35 mm long. Capacitance tolerance is $\pm 10\%$ standard, power factor better than 60×10^{-4} at 1 kc/s, and the temperature range from -40 to $+100$ °C.—*London Electrical Manufacturing Co. Ltd., Bridges Place, Parsons Green Lane, London, S.W.*6.

For further information circle 19 on Service Card

20. Inductive Proximity Switches

Intersonde have announced two new inductive proximity switches. Designated types QD19 and QD20, the switches provide a simple and inexpensive method of detecting the presence of either ferrous or non-ferrous metal objects including thin foils.

Both types use silicon semiconductors throughout and produce an output of 120 mA over an operating temperature range from 0 to +60 °C. The switches are self-contained, measure $5\frac{1}{2}$ in. long by $1\frac{1}{16}$ in. diameter, and will operate from either a 12- or 24-V d.c. supply. All the switch components are potted in epoxy resin and performance is unaffected by vibration, dust, or moisture. Both units are provided with six feet of cable which, in the case of the QD20, is enclosed in flexible conduit.

Although primarily intended for industrial batch counting applications the switches may be used in place of conventional limit switches on machine tools, conveyors, lifts, and generally in applications where switch operation must be initiated without physical contact.—*Intersonde Ltd., The Forum, High Street, Edgware, Middlesex.*

For further information circle 20 on Service Card

21. Low Noise A.C. Amplifiers

The series VS-64 and VS-68 very low noise a.c. amplifiers manufactured by Millivac Instruments Inc. are available in the United Kingdom from Claude Lyons.

The basic model VS-64 is fully transistorized and battery-operated, and features gain from 10 to 80 dB, response from 2 c/s to 180 kc/s with comprehensive low- and high-pass filters, and noise level as low as 0·15 μV for a 10-kc/s bandwidth. Input impedance is 10 kΩ or 100 kΩ.

Types VS-68A and VS-68B (illustrated) retain all these features, but in addition are provided with high input impedance: 10 MΩ with an electrometer valve stage in the VS-68A and 50 MΩ in the fully-transistorized VS-68B. Noise levels for 10 kc/s bandwidth are 1·4 μV and 4 μV respectively at high impedance. — *Claude Lyons Ltd., Valley Works, Hoddesdon, Herts.*

For further information circle 21 on Service Card

22. Servo Accelerometers

Gulton Industries announce the introduction of a range of servo accelerometers available for either triaxial, biaxial or unidirectional operation; they are hermetically packaged, complete with amplifier circuitry and require only one mounting surface. The uniaxial unit has dimensions $3 \times 1{\cdot}19 \times 1{\cdot}18$ in. and weighs 3 oz.

Alignment of the x, y, z sensors can be made to within one minute of arc. The hysteresis is very low, $\pm 0{\cdot}05\%$, and the outputs are linear to $\pm 0{\cdot}05\%$. Models are available with ranges of ± 1, 5 and 10 g and are designed for operation on 15 or 28 V. Maximum output per axis is 7·5 V.—*Gulton Industries (Britain) Ltd., 52 Regent Street, Brighton 1, Sussex.*

For further information circle 22 on Service Card

23. Spring-Loaded Terminal Block

Hellermann Terminals have introduced a spring-loaded terminal block with locking screws for rail mounting and a recommended current rating of 25 A at 230 V that will accommodate 46 terminals per foot run.

Suprafix blade terminals, with type 'A' palm, up to size 2 for conductor area 0·005 sq in. (e.g. 110/0·0076 or 7/0·029) can be used with this terminal block, which is manufactured in Melamine and will operate at temperatures up to 120 °C.—*Hellermann Terminals Ltd., Gatwick Road, Crawley, Sussex.*

For further information circle 23 on Service Card

24. Sensitive Oscilloscope

E.M.I. Electronics has recently introduced a very sensitive d.c. coupled dual-channel oscilloscope, the type WM11. The sensitivity of each Y channel can be varied from 100 μV/cm to 50 V/cm, the corresponding bandwidths being 150 kc/s to 1·0 Mc/s. The two X amplifiers are each individually controlled.

The sweep generator has an effective range from 200 nsec/cm to 5 sec/cm. A single shot facility is provided. Channel 2 Y-amplifier can be switched to channel 1 X-plates with equal phase characteristics so that accurate phase comparison may be made. The WM11 will operate from a power supply of 200 to 250 V or 100 to 125 V, 50 or 60 c/s at 450 W.—*E.M.I. Electronics Ltd., Hayes, Middlesex.*

For further information circle 24 on Service Card

25. Silicon Rectifiers

Developed for severe industrial and military applications, International Rectifier's type 25G range of silicon rectifiers is rated at 60 A with a stud temperature of 115 °C. Maximum pulse overload is 850 A for 10 msec, and the range is available in voltages from 50 to 1,000 p.r.v.

The 25G is made with an all-welded glass-to-metal hermetic seal and is tin plated for maximum resistance to salt-spray. It is available in normal and reverse polarities. The extremely small size of this diode (0·689 in. across flats × 1·453 in. maximum height) and its lug termination make it ideally suited for use in rotating machines.

The photograph shows a 25G rectifier mounted on an alloy extruded heat sink, type E, developed for use with stud mounted rectifiers rated up to 60 A.—*International Rectifier Co. (Great Britain), Hurst Green, Oxted, Surrey.*

For further information circle 25 on Service Card

26. Low Cost Power Units

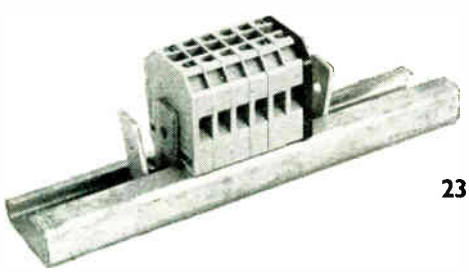
Low-cost fully-transistorized stabilized power supplies, for inclusion in manufacturers' own equipments, are now available from the Electronic Apparatus Division of A.E.I. Two units are involved, a Type FK.4BA Form A4 providing up to 1 A, and FK.4BA Form A5 providing up to 2 A. They cost £23 15s., and £26 15s., respectively, and quantity discounts up to 15% apply.

Each unit provides outputs of 12, 18 or 24 V d.c., and subsidiary outputs of 14·3, 21·4 or 28·6 V d.c. They are powered by toroidally-wound transformers and the control circuits, with the output and input terminals, are mounted on a printed board. Of open construction, they are suitable for mounting inside equipment cases or cubicles, or on existing chassis. Maximum operating temperature is 50 °C.—*Electronic Apparatus Division, Associated Electrical Industries Ltd., New Parks, Leicester.*

For further information circle 26 on Service Card

27. Printed Circuit Terminals

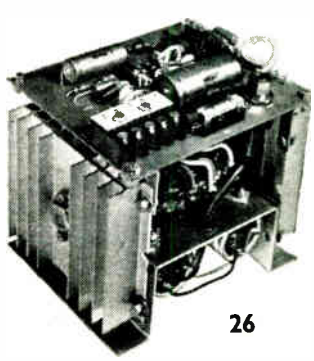
Aircraft-Marine Products have introduced the AMP-EDGE and AMP-IN solderless terminals for use with printed-circuit systems.



23

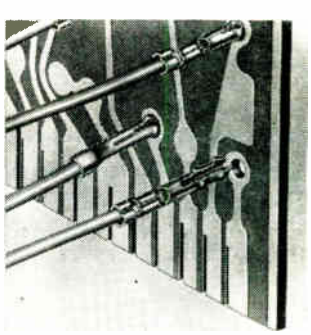
24

25



26

27



The AMP-EDGE terminals (left) provide simple, reliable connection using slots cut into the circuit at the edge of the board for single- and double-sided circuit boards. Their compactness allows very close spacing. Higher density is provided by back-to-back arrangements in a single slot for common connection. High frictional properties together with dimpling when applicable assures secure retention of the terminal in its slot when subjected to shock or vibration.

The AMP-IN terminal (right) is a shouldered tubular jack with self-aligning and self-retaining properties into a hole 0·072 in. in diameter with a tolerance of 0·003 in. The terminal is held firmly in position until solder dipping is completed and thus cuts out the danger of short-circuiting due to solder bridging. Good capillary flow of solder is promoted and the stranded conductors are protected against solder wicking damage.

Both these items can be crimped with AMP's auto-machines giving production rates of up to 3,000 an hour or, for prototype work, special hand-crimping tools are available.—*Aircraft-Marine Products (Great Britain) Ltd., Amplo House, 87-89 Saffron Hill, London, E.C.1.*

For further information circle 27 on Service Card

28. Pulse Generator System

A versatile pulse-generator system has been introduced by Research & Control Instruments. It is constructed of Philips transistorized modular units which can be arranged and programmed to provide a wide variety of pulses and pulse sequences.

The repetition frequency range is from 10 c/s to 10 Mc/s, and the delay pulse width may be set between 10 nsec and 1 sec. Maximum output is 5 V into 50 Ω, and attenuation is 300 : 1 in steps and continuously. Rise time is less than 10 nsec, and positive and negative pulses are available simultaneously. There are facilities for external triggering, single shot operation, remote control and for providing periodic bursts of pulses.—*Research & Control Instruments Ltd., Instrument House, 207 King's Cross Road, London, W.C.1.*

For further information circle 28 on Service Card

29. Miniature Ceramic Accelerometer

A miniature piezo-electric ceramic accelerometer that measures shock and vibration over wide frequency and acceleration ranges under exacting environmental conditions has been developed by the Massa Division of Cohu Electronics, Inc.

The model AC-107 senses a signal as low as 0·001 *g* and spans a dynamic range up to 1,000 *g*. The accelerometer is essentially free of resonances within its entire operating frequency range from 1 c/s to 20 kc/s. Sensitivity is 30 mV/*g*; capacitance: 500 pF; temperature range (continuous operation): −85 to 300 °F; minimum resonant frequency: 50 kc/s.

The unit mounts through a tapped hole in the base, insulated electrically from the accelerometer housing, and is furnished with a low-noise Microdot cable available in various lengths from 6 in. to 20 ft with Microdot connectors. The AC-107 weighs 1½ oz less cable, and is 0·835 in. in diameter, 0·800 in. in length.—*Massa Division, Cohu Electronics, Inc., 280 Lincoln Street, Hingham, Mass., U.S.A.*

For further information circle 29 on Service Card

30. D.C. Volt/Ammeter

Ballantine Laboratories have announced a d.c. volt/ammeter with a voltage range of 1 μV to 1,000 V, and a current range of 0·001 μA to 1 A. It has a single linear 5-in. scale.

As a d.c. amplifier, the instrument has a 100-dB gain with output of 0·1 to 1·0 V d.c. for each range selector step. This output may be applied to a digital voltmeter for measurement of very low voltages or currents.

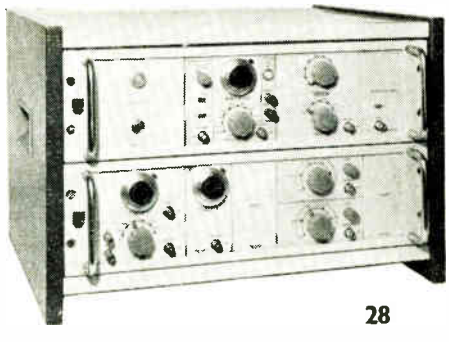
The model 365 may be operated with signal earth isolated from system or panel earth, or connected to earth if desired. Conservative operation of the valves and components, and high feedback results in an expected life in excess of 2,000 hours between calibrations or valve changes. The instrument, which has a built-in calibrator, is available in portable or rack models.—*Livingston Laboratories Ltd., 31 Camden Road, London, N.W.1.*

For further information circle 30 on Service Card

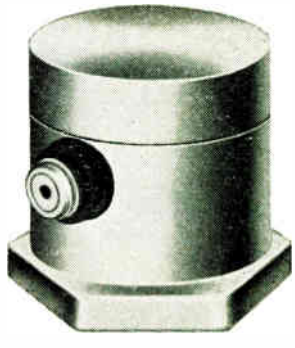
31. Laboratory pH Meter

Electronic Instruments have just announced a laboratory pH Meter, the model 46A, which is designed around a vibrating capacitor development, called the Vibret.

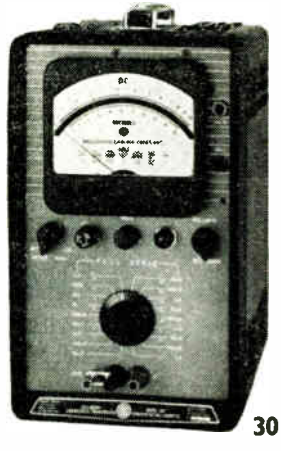
In addition to the normal 0 to 14 pH scale, this instrument has an expanded scale covering 2·8 pH units. For the measurement of redox and other potentials, two millivolt scales are



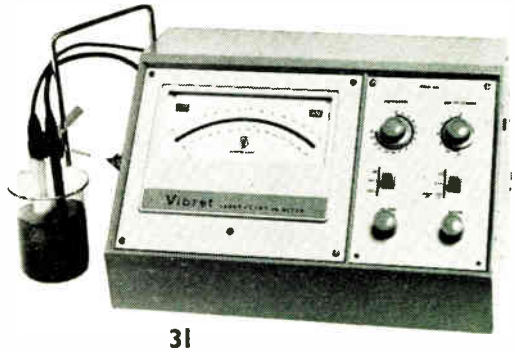
28



29



30



31

provided: 0 to 1,400 mV and an expanded scale covering 0 to 280 mV. Readings are displayed on a precision 6-in. mirror-scale meter which may be read to 0·05 pH units on the main scale and to 0·01 pH units on the expanded scale.

All pH ranges have automatic temperature compensation over the range 0 to 100 °C. The zero drift is better than 0·02 pH over a period of 12 hr, and thanks to the Vibret there is no prolonged warming-up period as normally experienced with conventional electrometer circuits. — *Electronic Instruments Ltd., Lower Mortlake Road, Richmond, Surrey.*

For further information circle 31 on Service Card

32. Temperostat

Costing no more than an ordinary high-speed stirrer, the Griffin-Grundy Temperostat unit will heat water as well as stir it. It can be used to convert any unheated water bath.

The Temperostat unit consists of a stainless-steel control box, a spindle with a stirrer and a heater surrounding the spindle. The control box contains a compensated hydraulic thermostat with a low differential of ±0·1 °C and a scale marked to 100 corresponding to a Celsius scale. Also housed in the control box are the stirrer motor, the cooling fan and the control gear. The spindle is 7 in. long carrying a propeller-type stirrer made of plastic, and is surrounded by a 2-kW copper-sheathed heater which is helically wound. — *Griffin & George Ltd., Ealing Road, Alperton, Wembley, Middlesex.*

For further information circle 32 on Service Card

33. Frequency Response Tracer

B & K Laboratories have announced the Bruel & Kjaer frequency response tracer type 4709 which replaces the model 4707. Typical applications include production testing of microphones, loudspeakers, hearing aids, tape recorders, audio frequency filters, and other electro-acoustic devices.

The main feature is the use of a 14-in. P-layer, long-persistence c.r.t. in conjunction with interchangeable scales which are supplied with the *x*-axis calibrated logarithmically in frequency and the *y*-axis in amplitude. The normal frequency range is either 20 c/s to 20 kc/s or 200 c/s to 5 kc/s, selectable by means of plug-in units supplied with the instrument. The amplitude range can be either 50 dB or 25 dB logarithmic or 0 to 1 V linear, selectable by front panel switching. Accuracy is 1% of full-scale deflection.

The instrument is intended to be used in conjunction with an external frequency generator such as the Bruel & Kjaer type 1022 and contains all the controls necessary for automatically stopping, starting, and reversing the drive motor, so that any part of the frequency range can be scanned repeatedly with sweep speeds variable from approximately ⅓ octave per second to 3 octaves per second.—*B & K Laboratories Ltd., 4 Tilney Street, Park Lane, London, W.1.*

For further information circle 33 on Service Card

34. Electron Stick

A new aid to technical education, which enables the chief characteristics of a wide variety of microwave tubes to be shown to students at 1/20th of the cost of using the individual tubes, is announced by E.M.I. Electronics.

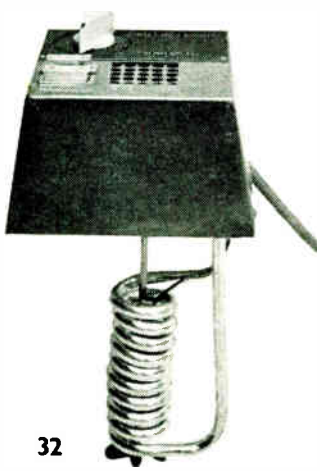
Known as the electron stick, it is in essence an isolated electron beam which may be inserted into various external circuits. By this means certain microwave tubes, such as the travelling-wave tube, two-cavity klystron amplifier, Adler tube and backward-wave amplifier, may be constructed in order to demonstrate the principles of operation in a versatile and inexpensive manner. It is 13 in. long, and of 1 in. diameter at the gun and 5 mm diameter at the tube.—*E.M.I. Electronics Ltd., Hayes, Middlesex.*

For further information circle 34 on Service Card

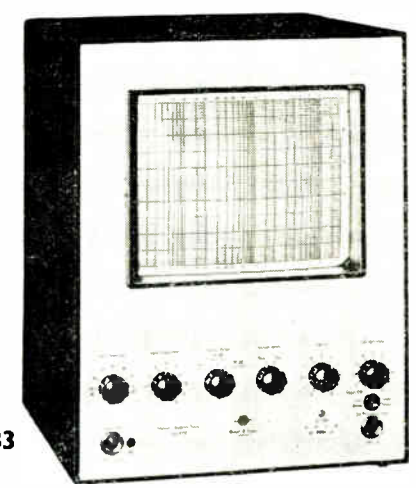
35. Ferrite Coaxial Circulators

Ferranti have increased their current range of ferrite devices by the introduction of the series 100SCD coaxial 3-port ferrite circulators. Available in the frequency range 2,500 Mc/s to 6,000 Mc/s, their performance can be varied to suit customers' requirements. These devices will find use in separating the individual information channels in broadband communication systems and in the separation of input and output signals in parametric and tunnel-diode amplifiers.

Circulators tuned to cover a 10% bandwidth at any centre frequency in this range have a decoupling to the unwanted arm of greater than 30 dB with a v.s.w.r. of better than 1·1 in all arms and a loss of less than 0·4 dB. On the other hand, 30% bandwidth tuning can be achieved with limiting

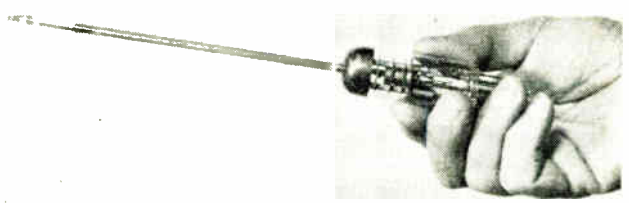


32

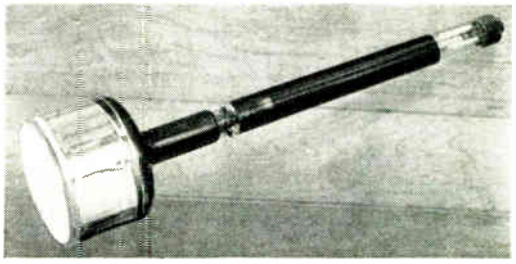


33

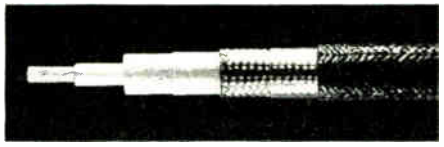
34



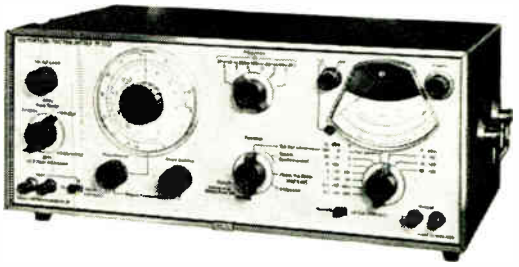
35



36



37



38

levels of 20-dB leakage to the unwanted arm, v.s.w.r. in all arms better than 1·25 and loss less than 0·7 dB. The operating temperature range of these devices is −20 °C to +55 °C.

It is possible to produce 4- and 5-port circulators by cascading two or more coaxial 3-port circulators in a combined unit. Also, by replacing the permanent magnet with an electromagnet, they can provide a variety of switching functions. By incorporating an absorbent element in the third arm they can be used as isolators with a performance superior to the more conventional resonance absorption types. — *Ferranti Ltd., Kings Cross Road, Dundee.*

For further information circle 35 on Service Card

36. Character Display Tube

Fairchild's Du Mont Laboratories have announced the type K2230 character display tube, a 5-in. diameter projection tube capable of 0·0027 in. maximum line width at 1,000 ft-L brightness on a 60·0 sq cm raster when operating the P4 screen at 27 kV.

The characters in the K2230 are formed by means of electrostatic character plates in a magnetic deflection tube. Utilization of this method for character generation and display encompasses a number of factors that contribute to improved resolution, brightness, writing speed and better overall character presentation at considerably reduced tube and system cost. Characters are formed with Lissajous or digital pattern generators or by grid modulation derived from character monoscopes.

Character or symbol generation is incorporated in a wide variety of applications including computer readout, contact or projection printing, traffic control, map and target identification, coding, and projection displays. —*Aveley Ltd., S. Ockendon, Essex.*

For further information circle 36 on Service Card

37. High Performance Coaxial Cable

The ECM 'Hi-Power' coaxial cable has been developed by Rockbestos Wire & Cable Co. for electronic countermeasure systems installed in high-flying military aircraft.

With a rating of 1,500 W c.w. at 1 Gc/s, the cable can operate in ambients from −55 to +95 °C where centre conductor temperatures at full power level may reach 200 °C. The improved semi-solid Teflon dielectric core maintains its dimensional stability at these temperature extremes, and the outer jacket is resistant to fuel and hydraulic fluids. All the materials in the cable meet the flammability test of MIL-W-27300.

Other significant characteristics are a v.s.w.r of less than 1·2 over its frequency range and a corona extinction level of 7 kV.—*Rockbestos Wire & Cable Co., Division of Cerro Corporation, Nicoll & Canner Streets, New Haven, Conn., U.S.A.*

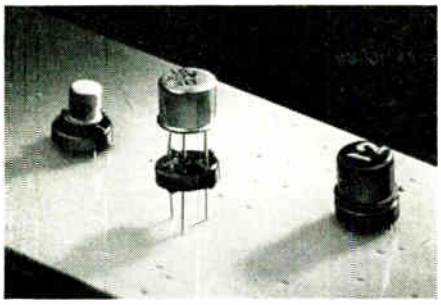
For further information circle 37 on Service Card

38. Distortion-Factor Meter

Marconi Instruments have announced the distortion-factor meter type TF 2331, featuring complete solid-state design. Although normally powered by a.c. mains, an external battery supply can be used.

The input voltage range, for measurement down to 0·05% distortion factor on a direct-reading meter of 0·1% full scale, is from 0·775 V up to 30 V r.m.s. The fundamental frequency rejection filter is tuned by a directly-calibrated dial with fine controls so that virtually complete fundamental rejection can be obtained over a frequency range from 20 c/s to 20 kc/s.

Bandwidth for noise and distortion measurement is either 20 kc/s or 100 kc/s. An l.f. cut facility eliminates mains hum and a C.C.I.F. type broadcast weighting filter enables effective noise assessment to be made. The input resistance is either a 600-Ω termination or high resistance from 10 kΩ to 100 kΩ depending upon the level. The voltmeter section has amplifier output terminals for oscilloscope examination of the residual noise and distortion or the original signal. Used as an in-



39

40

41

42

dependent voltmeter, the input resistance is 1 MΩ.—*Marconi Instruments Ltd., St. Albans, Herts.*

For further information circle 38 on Service Card

39. Nylon Transistor Mounting Pads

Nylon transistor mounting pads to reduce the risk of damaging transistors during soldering, are now available from the Telecommunications Division of A.E.I. The pads are suitable for use with both TO5 and TO18 can sizes over the temperature range −50 to +175 °C.

Moulded-in bosses hold the pad and transistor clear of the printed-wiring board and allow free circulation of air between pad and board to prevent moisture from being trapped. The pad prevents movement of, and possible damage to transistor leads after assembly, and enables transistors to be mounted in a consistent and uniform pattern.—*Radio Components Department, A.E.I. Telecommunications Division, 51-53 Hatton Garden, London, E.C.1.*

For further information circle 39 on Service Card

40. Beat-Frequency Oscillator

An oscillator covering the entire audio and sub-audio frequency bands in a single range is available from Livingston Laboratories. It is the type HO32 beat-frequency oscillator manufactured by Radiometer of Denmark.

The instrument has an overall frequency range of zero to 21 kc/s, the range from zero to 20·5 kc/s being covered in a single sweep. The maximum output power is 4 W which is available from an output transformer or from the calibrated attenuator. The transformer has tappings for impedance matching of various loads with the option of a 15-Ω output.

The attenuator provides output levels from 300 μV to 100 V. The harmonic distortion is less than 0·1% for attenuator outputs below 10 V. Good frequency stability and response, and a magic-eye indicator for easy determination of zero beat are further features of this instrument. The price is £106 exclusive of duty.—*Livingston Laboratories Ltd., 31 Camden Road, London, N.W.1.*

For further information circle 40 on Service Card

41. Analogue Computer Display Units

Repetitive operation display units designed for use with the PACE TR-10 and TR-48 transistorized general-purpose analogue computers have been announced by Electronic Associates. The units, which feature a 6½ × 4½ in. display area, are based on a solid-state design, and are available in two models.

Model 2.529 is an accessory designed for installation in the console of the PACE TR-48. It may be used to display up to four outputs simultaneously. Model 34.035 (illustrated) is a completely self-contained, portable unit for displaying outputs of the PACE TR-10 or similar devices, and is electrically identical to the model 2.529.

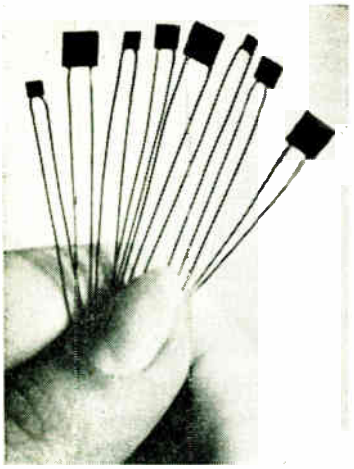
The horizontal input can be either a ramp from a sweep generator in the host computer, or can be used in a cross-plot where input number four is plotted against any or all of the other three inputs. The writing speed is up to 20,000 in./sec and power requirements are 115/230 V a.c., 50 to 60 c/s, 1 A.—*Electronic Associates Ltd., Victoria Road, Burgess Hill, Sussex.*

For further information circle 41 on Service Card

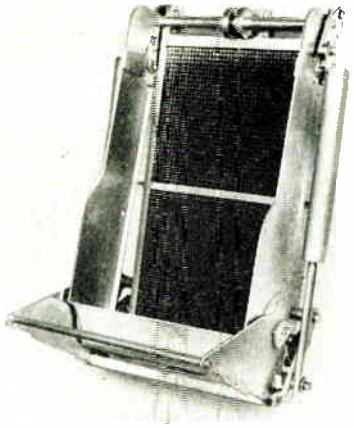
42. Mobile Television Recording Unit

The 'Minicruiser', a complete mobile television recording centre in a compact station wagon, has been placed on the market by Ampex. It makes use of the 97-lb Ampex VR 660 Videotape recorder to provide convenience and flexibility at low cost.

The Studebaker 'Wagonaire' is specially fitted with a sliding roof to permit the cameraman to shoot directly from the vehicle. The recorder is housed in a shock-mounted protective case at the rear and is easily accessible. A vidicon camera with zoom lens and 200 ft of cable to permit camera work away from the vehicle, a communications system for cameraman and recorder operator and an 8-in. preview monitor are included. Pictures from



43



44

the camera also may be fed through the electronics of the VR 660 direct to transmitter, monitors, or another recorder without actual recording.—*Ampex Great Britain Ltd., 72 Berkeley Avenue, Reading, Berks.*

For further information circle 42 on Service Card

43. Thin Film Capacitors

A range of subminiature ceramic capacitors, suitable for by-pass, coupling and decoupling applications at all frequencies in transistor circuits, has been introduced by Plessey.

Four capacitance values are available: 1,000, 2,200, 4,700 and 10,000 pF at 30 V d.c. working. Each of the components is 0·0625 in. in thickness; the size of the largest is 0·18 in. square and the smallest 0·08 in. square. Terminations are of 28 s.w.g. tinned copper wire.

Temperature category of the 'Casmin' range is − 40 to + 70 °C, humidity classification H5 and insulation resistance not less than 5,000 MΩ.—*Chemical & Metallurgical Division, The Plessey Company (UK) Ltd., Wood Burcote Way, Towcester, Northamptonshire.*

For further information circle 43 on Service Card

44. Plugboard Programming Systems

Jenkins Fidgeon have recently introduced into this country a range of plugboard programming systems, manufactured by Virginia Panel Corporation, which have applications in accounting machines, computers and, generally, in any equipment requiring multiple and variable switching.

The system consists of a basic receiver mechanism, permanently attached to the equipment, and prewired plugboards which can be rapidly fitted and removed from the receiver for programming. The receiver mechanism comes in a range of sizes which will accommodate plugboards with 234 to 5,120 contacts. A wide range of accessories is available.—*Jenkins Fidgeon Ltd., Linley Road, Talke, Staffs.*

For further information circle 44 on Service Card

45. Flux Paste

Johnson, Matthey & Co. announce that they are now supplying Easy-flo flux in the form of a ready-mixed paste. This product should prove of interest wherever low temperature silver brazing is employed and especially where production is carried out on a large scale.

The flux paste is claimed to be smoother than pastes that can be produced using dry powder. Time and labour are saved by users, who no longer have to prepare their own mixtures. In addition they should obtain more consistent results.

Easy-flo flux paste is supplied in lots of 2 lb in specially designed polystyrene containers that have straight sides to simplify complete removal of the paste. The screw caps of the containers ensure that the paste is kept fresh in storage and in use.—*Johnson, Matthey & Co. Ltd., 73–83 Hatton Garden, London, E.C.1.*

For further information circle 45 on Service Card

46. Gallium Arsenide Diode

A gallium arsenide diode, believed to be the world's fastest, has been developed by Mullard. Under typical operating conditions in a VASCA test circuit, the diode showed a reverse recovery time of between 0·25 and 0·5 nsec.

It is expected that the diode, type M54CAY, will have extensive applications in high-speed logic switching circuits in computers, and in microwave and u.h.f. communications equipment. It is available from stock.—*Mullard Ltd., Mullard House, Torrington Place, London, W.C.1.*

For further information circle 46 on Service Card

47. Subminiature Diodes

Special junction fabrication techniques used in the manufacture of the ZS130 series of Ferranti subminiature silicon micro-alloy switching diodes make them particularly suitable for high speed logic and pulse switching purposes. Extremely low capacitance is another feature of these diodes since the typical capacitance at 1 Mc/s, 1 V is 5 pF, and at 1 Mc/s, 10 V it is 1·75 pF.

The series consists of types ZS130, ZS131, ZS132, and ZS133. Both the ZS130 and ZS131 have a maximum p.i.v. of 50 V, but the ZS130 has a fast switch-on capability whereas the ZS131 has a fast reverse recovery characteristic and is suited to high-current pulse-switching applications in which recovery times of the order of 20 to 50 nsec are required. Type ZS132 has a maximum p.i.v. of 100 V and a higher reverse current rating than the other diodes in the series. Type ZS133 is similar to type ZS131 but it has a maximum p.i.v. of 70 V and a slightly increased reverse recovery time. The power rating for all types is 450 mW at an ambient temperature of 25 °C.

All types are of double-ended construction (DO-7 outline) and are protected by a hermetically-sealed encapsulation. Maximum overall body length is 0·300 in. and the maximum body diameter is 0·106 in. Connection is by means of flexible leads.—*Ferranti Ltd., Hollinwood, Lancs.*

For further information circle 47 on Service Card

48. Transistor

The Sylvania 2N.2784 is an n-p-n silicon epitaxial planar transistor designed for extremely fast switching and ultra-high-frequency applications. The main feature is a gain–bandwidth product in excess of 1,000 Mc/s combined with an excellent beta response over a wide range from microamps up to 50 mA.

Storage time is less than 5 nsec. Turn-on and turn-off times are less than 9 nsec and saturation voltage is less than 0·26 V.—*Thorn Electronics Ltd., 105-109 Judd Street, London, W.C.1.*

For further information circle 48 on Service Card

Multiple Pin-Hole Camera for Microelectronics

Photographic methods are used in one stage of the manufacture of microelectronic devices and the microphotographs employed must contain an array of many identical images. This article describes the principles of a multi-pin-hole camera which automatically produces this multiplication of images.

By T. E. PRICE, Ph.D.*

THE production of microphotographs comprising an array of many identical images is an important process in the manufacture of semiconductor devices and circuits.

Any one device requires a set of two or more microphotographic negatives or positives. Because large numbers of devices are made on a single wafer, each microphotograph must contain an array of many identical images each of which must be in register with the other members of the set.

The multiple pin-hole camera is a simple and inexpensive means of producing such microphotographs.

A previous article[1] described a camera using two cross-line screens to produce the multiple pin-hole arrays. Some examples of microphotographs were given together with camera dimensions for one particular set of cross-line screens, but no design details were given. It was found by experiment at this laboratory that the image resolution depended on pin-hole size, image-object distances, and exposure times. A multiple pin-hole camera has been built using design equations based on diffraction theory, and the results obtained together with the necessary formulae are presented below. The basic theory used in deriving the formulae is given and the effect of diffraction and exposure time on the resolution is shown with the aid of graphs and diagrams. Details are given of a practical camera. From measurements made on multiple image masks obtained with this camera it is shown that line widths of 10 microns (1 micron = 10^{-4} cm) or 5 microns with slightly reduced accuracy are obtainable.

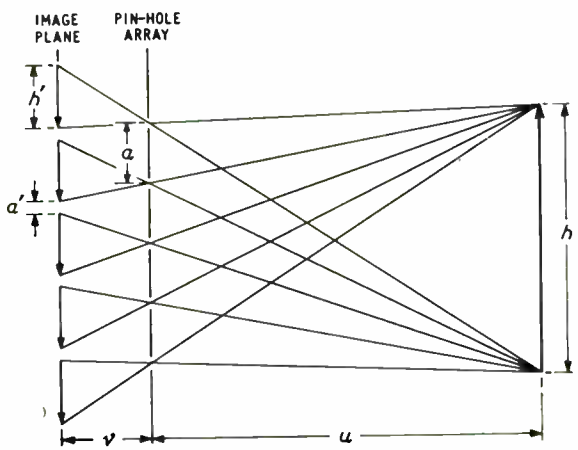
*Royal Radar Establishment.

Theory

The ray diagram of the camera is shown in Fig. 1. Unlike the lens the image produced by a pin-hole is not sharp and well defined and it may be shown that there is an optimum size of pin-hole in relation to the distance from the pin-hole to the image for which the image is sharpest. A large hole will pass more light and give a brighter image but the image will not be sharp due to aberrations. With a smaller hole the brightness will be reduced, but the image will again be less sharp because of diffraction. The relationship between pin-hole size and image distance may be obtained from simple Fresnel diffraction theory and may be shown to be

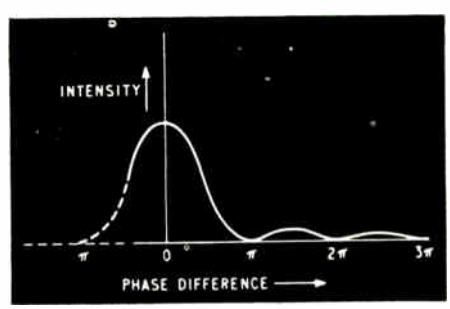
$$r^2 = 0{\cdot}9\lambda v.\frac{m}{1+m} \qquad (1)$$

where r is the radius of the pin-hole; λ is the wavelength of the light; v is the image to pin-hole distance; m is the magnification factor = object to pin-hole distance/image to pin-hole distance. The factor 0·9 is arrived at empirically, and its significance may be seen by referring to Fig. 2, which shows the variation of light intensity across the diameter of a circular patch of light produced on a screen by a point source and a pin-hole of arbitrary diameter.



Left: Fig. 1. Ray diagram of a multiple pin-hole camera

Below: Fig. 2. Variation of light intensity with phase difference



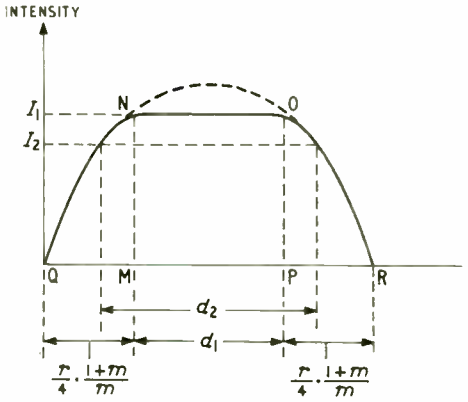
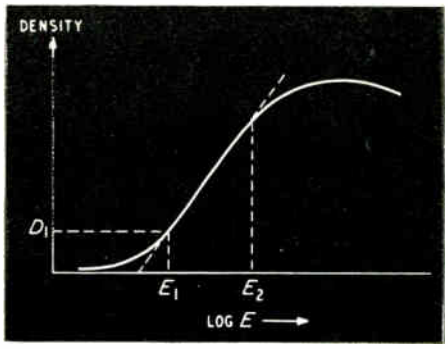


Fig. 3. Variation of light intensity across a circular image

Fig. 4. Sensitometric curve



It will be noted that there is a series of minima at π, 2π, 3π. These minima or dark zones, which are produced by diffraction, will be present if the radius of the pin-hole is $> \left(n\lambda v \frac{m}{1+m}\right)^{\frac{1}{2}}$, Equ. (1), where n is a positive integer. Setting $n = 0{\cdot}9$ ensures that there are no dark zones in the image formed on the screen.

The relationship between pin-hole spacing a, image size h' and image spacing a' may be obtained from the geometry of Fig. 1 and may be shown to be

$$a = \frac{m}{1+m}(a' + h') \qquad (2)$$

The effective resolving power of the pin-hole camera depends on the exposure time. Consider a circular illuminated aperture as an object of a pin-hole camera having a pin-hole of radius $r = [0{\cdot}9\lambda vm/(1+m)]^{\frac{1}{2}}$. The light image produced on a screen will be a circular patch. If there were no diffraction the variation of the light intensity across the diameter of the image would be represented by MNOP of Fig. 3 with MP = NO = d_1; i.e., the screen is black everywhere except for the region of the image where the light intensity is I_1. Because of diffraction, however, the variation of the light intensity is represented by QNOR. The edge of the image is not sharp and well defined but changes from maximum intensity I_1 to zero over the regions QM and PR. It may be shown that the region l = QM = PR is given approximately by

$$l = \frac{r}{4}\frac{1+m}{m} \qquad (3)$$

If now the screen is replaced by a photographic plate, a negative may be obtained in which the image is a black circular patch on an otherwise clear plate. The density D of the photographic image depends on the exposure E. The variation of D with log E is shown in the sensitometric curve of Fig. 4. Over the straight region the density varies with exposure; below E_1 there is a region of uncertainty where unexposed grains of emulsion are developed as quickly as exposed grains; above E_2 the density first saturates and may then decrease.

The exposure E is equal to the product of the image light intensity I and the exposure time t.

$$E = It \qquad (4)$$

Consider now the image represented in Fig. 3. If the illumination is kept constant and the exposure time adjusted to a value of t_1 so that the product of the maximum light intensity I_1 and t_1 is equal to E_1, then the density of the photographic image will be D_1 and the image diameter will be nearly d_1 with a certain amount of *density* variation at the edge of the image resulting from the *intensity* variation below I_1 in the regions QM and PR of Fig. 3. The variation of edge density of the image may be reduced to a minimum by using a film in which the straight region of the sensitometric curve (E_1 to E_2 of Fig. 4) is nearly vertical and having a sharp cut-off at E_1. If the exposure time is increased to t_2, then the same exposure E_1 may be obtained with a reduced intensity, say I_2 in Fig. 3, and the image diameter will be d_2, greater than d_1 of the previous image. With a sufficiently long exposure the image diameter will be d_1 + QM + PR = $d_1 + 2l$. The variation of change of photographic image size (δl) with exposure time will be of the form shown in Fig. 5.

The circular images produced by two point sources will be resolved if the images are just touching; i.e., the centres separated by one diameter. But the diameter depends on the exposure time and so the resolving power also depends on the exposure. It is necessary, therefore, to standardize the exposure time to ensure repeatable results.

Implicit in the above is the assumption that the developing solution, developing temperature and developing time are all standardized.

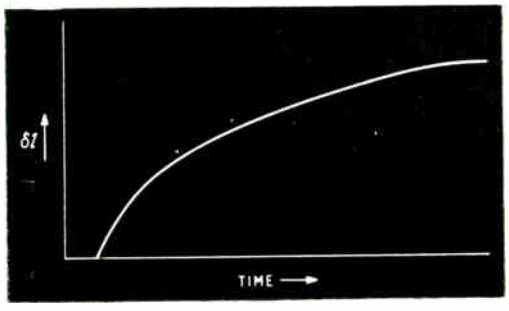
Design Philosophy

The proposed stages in the preparation of a multiple image mask are:

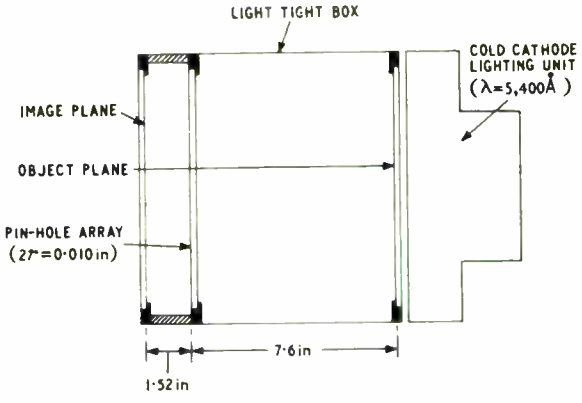
1. Original artwork
2. First photographic reduction and image reversal
3. Multiple images and reduction
4. Final reduction

The original artwork is a black and white drawing of a single image some 250–500 times larger than the final image; the image reversal after the first reduction is necessary if the final images are to be positives of the artwork; an array of images is made with the pin-hole camera together with a further reduction. The final reduction is made with a good quality lens.

The reductions are standardized to avoid continual readjustment of camera settings; this is particularly important for the last stage which uses a lens having a depth of focus



Above: Fig. 5. Variation of change of photographic image size with exposure time



Right: Fig. 6. Schematic of pin-hole camera

of approximately $\frac{1}{500}$ in. The dimensions of the artwork are also standardized for a number of final image sizes.

Practical Details

Overall reduction factors of 250 and 500 are considered suitable for the majority of masks required for microelectronic devices and circuits. The intermediate stage reductions are listed in Table 1. The spacing of the pin-holes for three

TABLE 1
Reduction Stages

Process	Overall Reduction	
1	250	500
2	5	10
3	5	5
4	10	10

TABLE 2
Pin-hole Array Dimensions

Final Size of Individual Images (in.)	Pin-hole Arrays	Image Spacing (a') (in.)	Pin-hole Spacing (a) (in.)
0·1×0·1	4×4	0·010	0·916
0·05×0·05	7×7	0·015	0·542
0·025×0·025	10×10	0·020	0·375

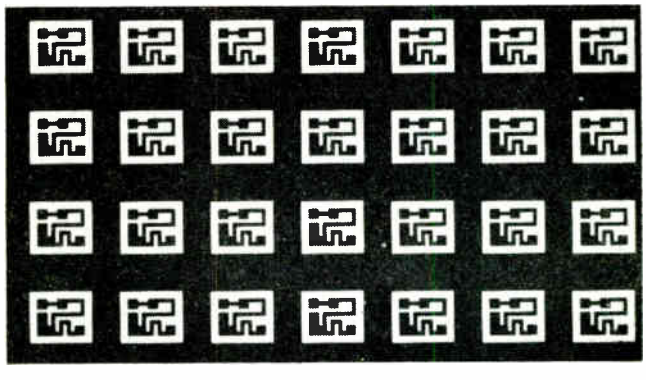
TABLE 3
Artwork Dimensions

Individual Images (in.)	Overall Reduction 250 (in.)	Overall Reduction 500 (in.)
0·1×0·1	25×25	50×50
0·05×0·05	12·5×12·5	25×25
0·025×0·025	6·25×6·25	12·5×12·5

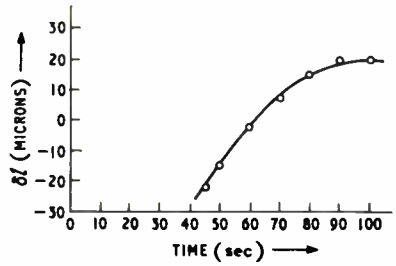
square arrays together with the dimensions of the individual images after the final reduction are listed in Table 2, and the artwork dimensions for different image sizes and overall reductions are listed in Table 3. The dimensions of the complete array after stage 4 is approximately 0·5 × 0·5 in. A schematic of a complete camera is shown in Fig. 6; the photographic plates used for the object, image and pin-hole array are whole-plate ($8\frac{1}{2}$ × $6\frac{1}{2}$ in.). The pin-hole array is made as a photographic reduction of a large scale artwork—in this case holes accurately drilled and spaced in a metal sheet. The cold-cathode lighting unit provides uniform illumination over a large area; the unit used emits a green light having a wavelength of approximately 0·54 micron. (The use of light of one colour is recommended for all micro-photography—a similar unit is used for the stage-4 reduction.)

Experimental Results

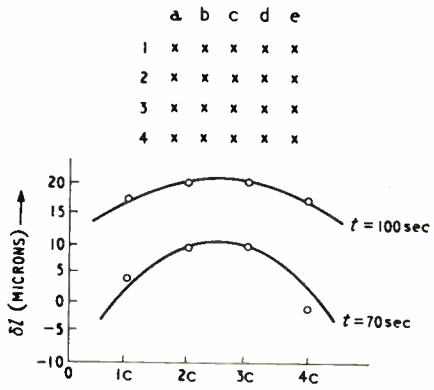
A pin-hole camera having a reduction factor of 10 and pin-hole diameter of 0·005 in. was used as a test vehicle. An object, consisting of a number of black lines 0·040 in. wide, W, on a white background was used to produce a number of multi-image negatives for different exposure times. The photographic images consist of white lines on a black background. The theoretical line width of the images is $W/10$ = 0·004 in., but because of diffraction the real images are narrower, W_R, and the error (δl) between theoretical and real image size is $\frac{1}{2}(W/10 - W_R)$. (Both sides of the pattern produce an error, and thus the error for one is half the total.) The variation of δl with the exposure time is shown in Fig. 7. The variation of l across the array was also measured for



Section of a multi-image mask before the final 10× reduction (Actual size)



Above: Fig. 7. Variation of δl with exposure time



Right: Fig. 8. Variation of δl across array of images

two different exposure times and the results are shown in Fig. 8.

Discussion

Diffraction results in a dimensional error which varies with exposure time in the manner shown in Fig. 5. It will be noted that the experimental curve of Fig. 7 is of similar shape with the exception that δl is negative for exposures of $<62{\cdot}5$ sec, indicating that the intensity variation of Fig. 3 is not correct. The results indicate that the variation should be of the form shown dotted between N and O. This result is likely if there is interference at both the object and the pin-hole. The error depends only on the camera dimensions and not on the size of the object or image and therefore solving Equ. (3) for the camera dimensions used yields $l \simeq 17$ microns. The maximum value of δl in Fig. 7, which is equal to the value given by Equ. (3), is 20 microns, in good agreement with the theoretical value.

The intensity of the light emitted from a source varies as the inverse square of the distance from the source and thus the images at the centre of the array will be more exposed than those at the edges because of the different path lengths. This will result in a variation of l across the image array. The curves of Fig. 8 indicate that the variation is less for longer exposure time when δl tends to a constant value.

Because of diffraction and the uncertainty of development of the photographic emulsion for exposures less than E_1 (Fig. 3), the edges of the photographic images tend to be slightly ragged. It was found in practice that this raggedness amounted to about 5 microns. Thus assuming a perfect lens for the stage-4 reduction, this raggedness will be reduced to 0·5 micron. This is satisfactory for reproduction of 5-micron wide lines.

Therefore, summarizing, the multiple pin-hole camera is a simple and inexpensive means of producing multiple-image masks in one step (cf. step-and-repeat camera, one exposure for each image). To obtain the best resolution it is necessary to use a high resolution lens for the final reduction. Results indicate that final line widths of 5 microns are possible provided that high-contrast emulsion is used for stages 2 and 3 and maximum resolution emulsion for stage 4. To ensure uniformity of image dimensions across the array it is necessary to 'over-expose' and to correct for l either in the original artwork or in one of the reductions.

The author wishes to acknowledge Mr. R. D. Callan for constructing the cameras and doing the photographic work.

Reference

Murray, Joseph J., 'Microphotographs for Microelectronic Components', *Semiconductor Products*, Feb. 1962, pp. 30-32.

Measuring Oxygen in Hot Gases

There are several methods already available for the measurement of oxygen in gases. Apart from chemical methods, with a range extending down to perhaps a fraction of 1 per cent, the paramagnetic gauge and the Hersch meter now have ranges extending down to a few volumes-per-million.

An alternative method would be to measure the reversible e.m.f. of an electrochemical cell in which the gas of unknown oxygen content was applied at one electrode and a gas of known oxygen content at the other electrode. Such a method is not feasible at room temperature because of irreversibility of the oxygen electrode reaction. At higher temperatures, however, it is now established that certain solid oxide mixtures have properties which make them suitable as electrolytes in such a cell in particular a zirconia-lime ceramic.

Studies by BISRA's Chemistry Department indicate that such a device can be used to measure oxygen partial pressures in gases ranging from 1 atmosphere (i.e., pure oxygen) down to at least 10^{-20} atmosphere (i.e., 1 part in 10^{20}).

The instrument developed is extremely simple and robust. The sensing head consists of a cylindrical tube of the ceramic (which is commercially available), closed at one end, with an inner and an outer platinum electrode in contact with the ceramic. It functions from about 550 °C up to at least 1,200 °C, so it can often be inserted directly into the furnace gases.

The measuring instrument is simply a voltmeter. For measurements on gases at temperatures above 1,000 °C, a simple instrument with a relatively low impedance might suffice. At lower temperatures, a valve-voltmeter or pH-type electrometer is suitable, or the e.m.f. can be fed directly to a potentiometric recorder. Continuous measurement of oxygen content is obtained and the response time is very short.

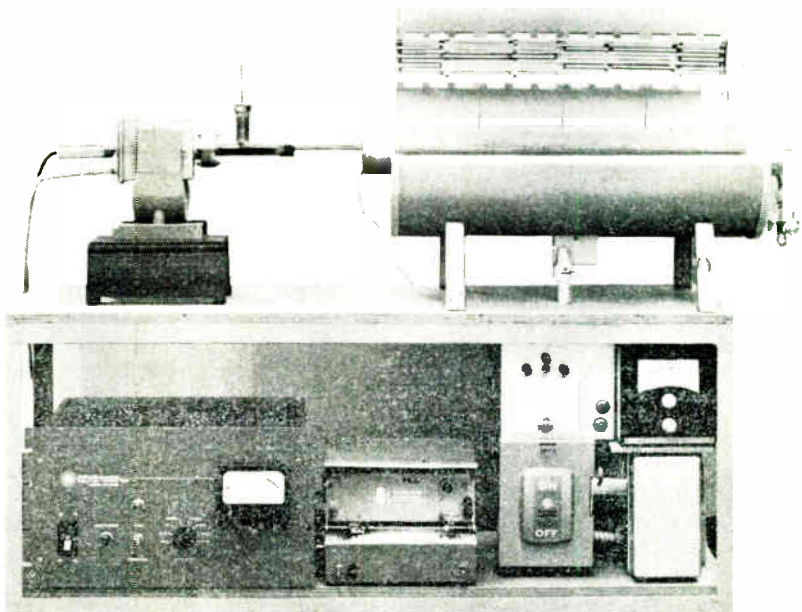
The instrument has been used to measure oxygen contents between 100 and 10^{-18} per cent. It is known that the range at 700 °C extends below 1 part of oxygen in 10^{30}.

Here are typical applications where Vaclon pumps are helping customers produce higher quality products. Can Varian help you in your work?
For technical or sales information write or call our office.
These offices are staffed by trained engineers thoroughly familiar with the latest vacuum technology.

WILL VARIAN Vaclon PUMPS HELP YOUR WORK?

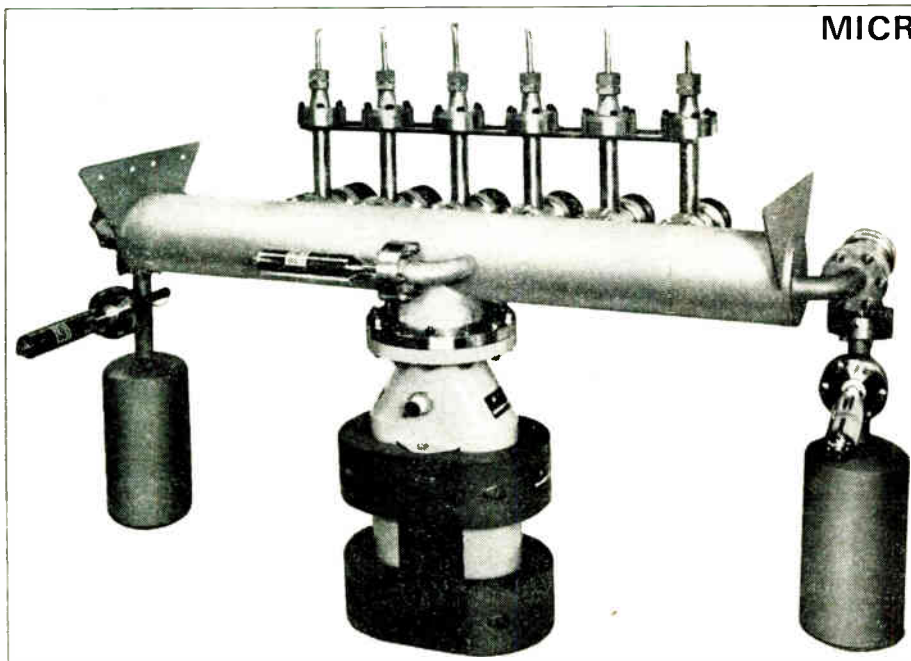
TWT PROCESSING

Travelling wave tubes are given complete 450 °C bakeout on this portable pumping cart
high vacuum – 15 l/s Vaclon pump, water-cooled



MICROWAVE TUBE EXHAUST

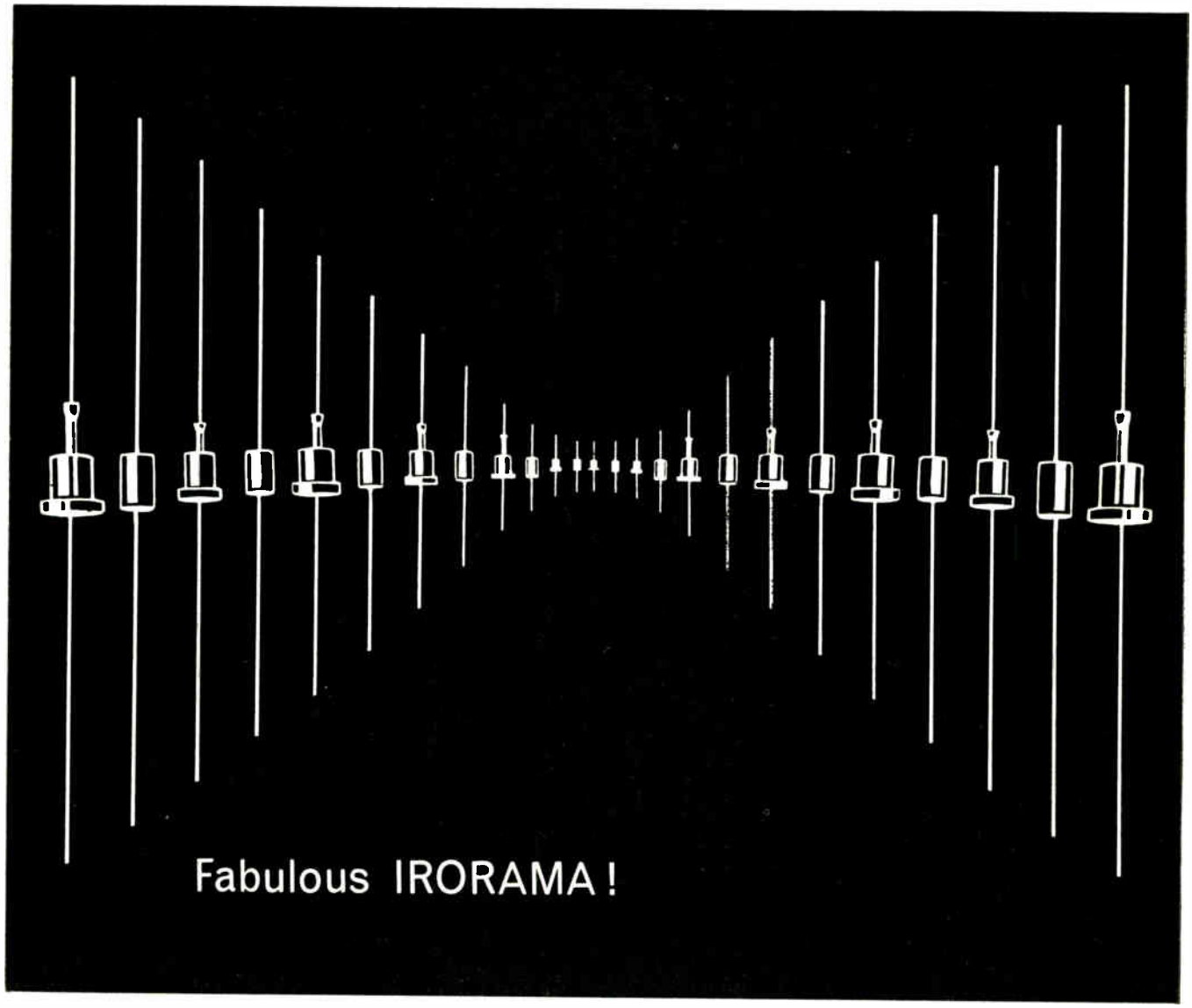
Six individually valved tubes are mounted on compression ports and pinched off after processing
high vacuum – 40 l/s Vaclon pump
roughing vacuum – VacSorb roughing pump



VARIAN Associates Ltd., Surrey, England **Telephone: Weybridge 48174**

Fox Oak, Seven Hills Road, Walton-on-Thames

VARIAN AG, Gubelstrasse 17, Zug, Switzerland. Tel. 042 445 55
VARIAN GmbH, Industriestrasse 54, 7 Stuttgart-Vaihingen, Germany. Tel. 78 33 51
VARIAN AB, Bagartorpsringen 48, Solna 8, Sweden. Tel. 85 50 23
VARIAN SpA, Via C. Battisti 2, Turin, Italy. Tel. 4 09 91
VARIAN SA, 48-50, bd des Batignolles, Paris-17e, France. Tel.: LABorde 41-11



IR present a new concept in designer-gratification — *the 2-dimensional range of silicon rectifiers*—unequalled in *breadth* and in *depth!* A wide range of types for every possible application in electronics, each available in all the ratings that anyone could need! See them described in starkly factual data tables and alluring performance curves in IR technical literature . . . available *free!*

SPECIAL ATTRACTION Authorised Industrial Distributors throughout the country carry stocks of all the most popular IR silicon rectifiers . . . *at ordinary prices!*

INTERNATIONAL RECTIFIER

Immediate off-the-shelf delivery from IR distributors—phone

GLASGOW DOUGLAS 8671 · (MIDDLESEX) SKYPORT 13'4 · COLCHESTER 6173 · LEEDS 35111
(LONDON S.E.27) GIPSY HILL 6166 · PORTSMOUTH 61785 · LEICESTER 25071 · REDHILL 5050

International Rectifier Europe S.A. · 38 Avenue Des Arts · Brussels · Belgium · Telephone 11.17.38/74 · Telex 02/22201

INTERNATIONAL RECTIFIER CO. (GREAT BRITAIN) LTD · HURST GREEN · OXTED · SURREY · TELEPHONE OXTED 3215 · TELEX RECTIFIER OXTED 8819

By including suitable radioactive isotopes in solid, liquid or gaseous material, it is possible to trace the movements of the bulk material. This article deals with the choice of isotope and its detection and describes a number of industrial applications.

INDUSTRIAL APPLICATIONS OF RADIOACTIVE TRACERS

By DENIS TAYLOR, M.Sc., Ph.D., M.I.E.E., F.Inst.P.

MAN-MADE radioactive materials are now produced in huge quantities in nuclear reactors by the burning of the uranium fuel (nuclear fission), and by the exposure of ordinary materials to the neutrons emitted in the fission process. These artificial radioactive materials have many uses, not the least being their use as tracers or indicators. Their use in this role depends on two facts:

(i) the radioisotope is indistinguishable chemically from any other atom of the same element.

(ii) it emits ionizing radiation.

It is therefore possible to use the radioisotope as an 'indicator' or 'tracer' to follow the movements, or trace the whereabouts of much larger quantities of the stable (non-radioactive) material. In all cases the activated atoms undergo exactly the same chemical reactions as the bulk material, but always indicate their presence (and therefore that of their companion stable atoms) by the radiations emitted.

The most reliable radioactive tracer is one which is the radioactive isotope of the element to be traced. Such a tracer once introduced in the same chemical form as that element, will follow it quantitatively through any chemical reaction to which it may be subjected. It therefore follows that the measured radioactivity at any stage in a chemical process is proportional to the quantity of the labelled element (i.e., the tracer or indicator) present.

Selection of Radioactive Tracer

An important consideration at the commencement of any investigation using radioactive tracer techniques is obviously the selection of the tracer. The following factors usually affect the choice.

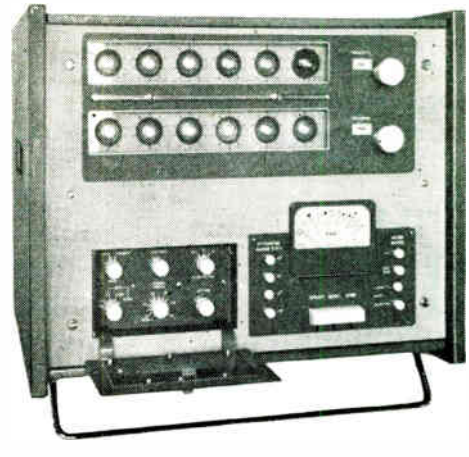
(1) *Half-Life of Radioactive Isotope.* The half-life is the time in which the amount of radioactivity has decayed to half its original value. Obviously the half-life must be sufficiently long to provide sufficient activity to allow easy detection during the whole course of the investigation. However, other things being equal, it is an advantage to choose the shortest half-life which is acceptable on measurement grounds as the activity remaining in the bulk material at the end of the investigation will then quickly decay.

(2) *Specific Activity.* This is the activity per unit weight. The important consideration here is that samples taken during the investigation must have sufficient activity to be measured with reasonable statistical accuracy, allowing for any dilution with the bulk material which takes place during the investigation. Thus, in using tritium (^3H), a radioactive isotope of ordinary hydrogen, for tracing and determining the age of underground water, calculations must be made of the probable dilution during the experiments and the limits of detectability to decide the specific activity of the tritium to be introduced as tracer. This matter will be returned to when discussing the measurement of activity.

(3) *Type and Energy of Radiation.* When selecting a radioactive tracer for a specific purpose, one has the choice of selecting an α-emitter, a β-emitter, or a γ-emitter.

In those cases where the tracer is introduced into some bulk material, which cannot be wholly controlled, or may subsequently in whole or part be absorbed, inhaled or ingested by human beings or any other form of life, the question of the health hazard must also be considered. Leaving this aside, however, for the moment, the type and energy of radiation is an important matter from the point of view of the detectability and measurement of the tracer. If the material is being examined in bulk, it is usually preferable to make use of a γ-emitting isotope, because of the greater range of γ-rays as compared with α- and β-particles. However, if the taking of samples back to the laboratory is permissible then α-, β- and γ-emitters may be employed. From the point of view of the external radiation hazard, it is often preferable to employ α- or β-emitters, as operators working near the installation in which the tracer is introduced can be so much more easily shielded from the effects of this radiation than would be the case if γ-emitters were employed. However, if there is any danger of the radioactive materials escaping to atmosphere and being inhaled or absorbed by operatives, then it may be wiser to avoid the use of α-emitters as the ingestion hazard with such materials is usually higher.

(4) *Form of Tracer.* The chemical and physical form of a tracer is another important matter to be decided. In some cases this can be introduced in a solid form. This is possible, for example, when investigating the wear of cutting tools, the



Auto-Scaler (Isotope Developments Ltd.)

wear of piston rings and internal combustion engines,[1] etc., and obviously permits easier handling of the radioactive material when setting up the installation.

In other cases the tracer is in the form of a liquid or a solution, or in some cases even a gas. These obviously require more careful handling, but the rule should be in all cases to use the minimum quantity which will give the required statistical accuracy of measurement and to take proper precautions against possible health hazards. In many cases, as will be seen later, it is possible because of the high sensitivity of radiation detection possible, to ensure that the radioactivity introduced into the bulk material is well below the maximum permissible level known to be safe.[2]

(5) *Measurement of Radioactivity.* In most cases the highest sensitivity is required, as already indicated, and it is then preferable to use what is called a counting system. This is shown schematically in Fig. 1 and comprises:

(a) the radiation detector (a Geiger counter) itself, which produces a discharge for each particle or photon which enters its sensitive volume and is detected;
(b) a stabilized power unit to supply the high voltage needed to operate the detector;
(c) an amplifier to amplify the pulses produced by the detector to the necessary level to operate the following apparatus; and
(d) the scaler which registers and totalizes the pulses received.

Also shown in the same figure are two other important components of the system, namely a source mounting to ensure that the radioactive source preserves a standard geometry with respect to the detector, and a lead housing for the detector, source mounting and the source to be assayed to ensure that the background counting rate is reduced to a constant minimum value during the measurement period.

In carrying out an activity measurement, the sample is placed in position within the lead housing and the number of pulses totalized by the scaler in a certain time t is noted. The time t is decided by the precision of measurement required.[3] In the simpler systems t is determined by means of a stop watch, the counting being started by depressing the start key of the scaler and at the same time starting the stop watch. At the end of the required time the scaler is stopped and the number of counts registered read off.

In other forms of apparatus an automatic timer is built into the scaler. With this system, the time of measurement t can be pre-set into the apparatus by setting up the controls before the measurement is started. Then, on depressing the start key of the scaler the pulses are totalized as before and, at the end of the counting time t, the count is automatically terminated. This system has the advantage that once the apparatus has been set up and the counting period started, no attention on the part of the operator is required since the totalizer is automatically switched out of the circuit at the end of the counting period (t) and can be read off at any convenient time. This facility is particularly useful when the conditions of the measurement require that the counting period (t) must be very long. A photograph shows an automatic scaler of this type. It should be noted that decade counting tubes are employed both for the scaler proper for totalizing the pulses from the detector and in the timer for totalizing the pulses (usually 1 sec pulses) from a built-in time source. The decade counting tubes are self-indicating, the arrival of a pulse causing the glow to move on one digit. These digits range from 0 to 9 in all cases, the first tube on the right corresponding to the *units*, the second to the *tens*, the third tube the *hundreds*, etc. A useful facility with this type of apparatus is that before a measurement begins it is possible by the operation of a key on the front panel of the instrument to set all the tubes to read zero. This provision avoids the necessity for reading two figures, one at the beginning and the other at the end of the counting period and doing a subtraction. Instead the number indicated by the scaler at the end of the counting period directly indicates the measured total counts.

(6) *Use of more than one Tracer.* In some cases it is necessary to employ more than one tracer to sort out a problem. Thus, two different radioactive tracers have been used together in studying wear problems, one being introduced on to the cylinder wall of an internal combustion engine and the other on the piston rings. The radioactivity in the lubricating oil is then a measure of the wear, but to sort this out into the wear of the cylinder wall and the wear on the piston rings, it is necessary to use two radioisotopes having different γ-energy spectra which may be sorted using a two-channel spectrometer, the channels being set to monitor the activities due to each of the radioisotopes respectively.

Scintillation counters are used in this case instead of Geiger counters. Scintillation counters give output pulses directly proportional to the energy of the radiation detected. If, therefore, two amplitude discriminators are employed in the scintillation-counter circuit they may be set up in such a way that only pulses whose amplitudes are between the two bias settings are counted. It is therefore possible to maintain a definite channel setting and move the double discriminator through the spectrum. In this way, it is possible to determine the pulse-amplitude distribution of the emission being examined, which is, of course, the energy spectrum. This is illustrated in Fig. 2.

For tracer studies these single-channel analysers are in wide use, but for many purposes multi-channel analysers are required. Some examples of the γ-spectra obtained from various radioisotopes with such multi-channel analysers are shown in Fig. 3.

Applications of Radioactive Tracers

Many uses have been made of tracers in studying the ventilation of mines and factories. For these investigations a radioactive gas is used and it is preferable to use one of relatively short half-life so that after the work has been completed the radioactivity will quickly decay, although, of course, it will be quickly dispersed and diluted with the air.

J. E. Johnston[4] has described experiments carried out about

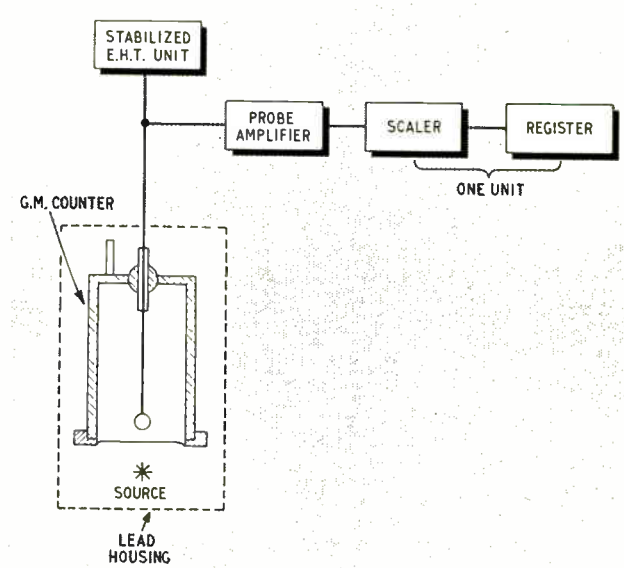


Fig. 1. Components of simple Geiger-counter system

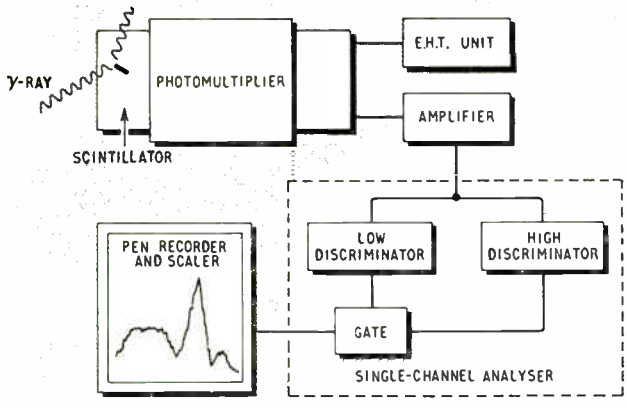
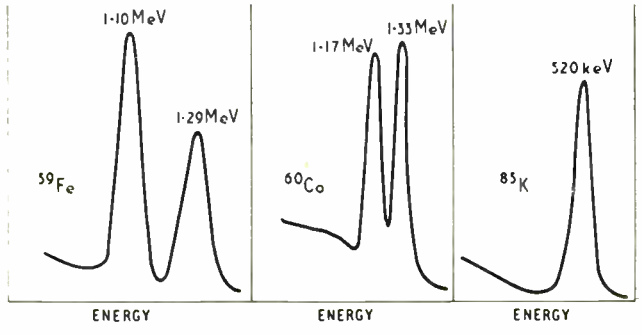


Fig. 2. Scintillation counter with single-channel analyser

Fig. 3. Examples of gamma spectra obtained with a scintillation counter and a multi-channel analyser



the origin of troublesome dusts in factories. The radioactive tracer employed was bromine 82 (^{82}Br) with a half-life of 34 hours, and this was used to investigate how asbestos dust produced in one part of the factory was making its way to other parts of the factory against the general direction of the ventilation stream. To confirm the origin of the dust, a radioactive vapour was liberated at the carding machines where the asbestos dust was produced.

Samples of air were then taken at various places in the factory and the radioactive vapour was absorbed out of this air and measured with a counter. In this way a value was obtained in different parts of the factory. From this information it was possible to decide what structural changes were necessary to prevent the unwanted asbestos dust from getting into the remainder of the factory. It should be noted that the air-sampling technique used in these experiments allowed much less radioactive material to be employed and was to be preferred on this account.

Another interesting example of the tracer technique is in investigating the flow of molten metal and distribution of metal in a casting. Radioactive metal can be added in place of ordinary metal to study where the metal added at various stages is distributed in the final casting. Another somewhat similar application is to feed billets of metal built-up of alternate layers of ordinary and radioactive material into an extrusion press. By measuring the radioactivity in the metal, the shape of the flow lines of the materials can be deduced. In some cases experiments of this sort have led to improvements in the design of the extruders and dies.

As a final example we include an application reported by the Nuclear Science and Engineering Corporation of Pittsburgh. The problem is that of a pressurized field, which is an oil field which has been partially depleted, and, in order to force out the remaining oil, natural gas is pumped under great pressure into the centre well of a group of wells, and in this case the oil companies wanted precise data on the movement of these gases underground.

Obviously radioactive tracer techniques provide an excellent tool for this investigation and N.S.E.C. used two radioisotopes for the tests—Krypton 85 and tritiated methane (methane with one of the hydrogen atoms replaced with tritium, a radioactive isotope of hydrogen). Krypton 85 (^{85}Kr) is a gas with a half-life of 9·5 years, and emitting both β-particles and γ-radiation in its decay. Tritium (^{3}H) is also a gas, has a half-life of 12·5 years and emits only β-particles. Several curies of activity were necessary in each case and were conveyed to the oil wells in standard steel gas cylinders, equipped with special leak-proof valves. No special precautions were necessary with the methane, but it was necessary to wrap the krypton cylinder in a half-inch thick blanket of lead.

At the oil fields the isotopes were injected into two pressurizing wells, the ^{85}Kr into one and the methane into the other. During the handling of the isotopes all personnel concerned carried radiation dosimeters so that a proper check could be kept on radiation levels. Samples of gas were taken daily in 7 test wells and shipped to the N.S.E.C. Laboratories. These were processed to remove radon, a naturally occurring radioactive gas, and the sample then checked for its activity.

It may be wondered why two isotopes were used, when since only the movements of gas were involved one isotope would provide this information. The N.S.E.C. scientists apparently used two isotopes to provide a cross check, and also in case one of the isotopes would react, exchange or combine with the materials of the oil strata.

Use of Kryptonates

Recently a new tracer technique has been proposed[5] in which Krypton 85 is employed. ^{85}Kr has a half-life of 10·6 years and emits a 0·7 MeV β-particle with very little gamma-radiation. Hence safety problems are of a minor character since krypton is chemically inert and diffuses quickly through the atmosphere when released.

The new method is to entrap the ^{85}Kr in the material during crystallization from the liquid phase. These kryptonates, as the materials with entrapped atoms of kryptons are called, are apparently stable with time and at elevated temperatures. However, the krypton is released from these materials when they take part in a chemical reaction, or physical removal of the surface. Apparently, the workers quoted have succeeded in kryptonating a large number of materials and so krypton is becoming a universal 'tracer'.

Work has been done already on many different applications. Thus, in studying reactive gases, the solid concerned is kryptonated. Then, if the solid reacts with the gas there is a proportionate loss of ^{85}Kr which can be monitored by the methods already described. In studying chemical kinetics, the evolution of ^{85}Kr follows the course of the chemical reaction, and therefore allows this to be monitored. In friction and wear studies, the surfaces concerned are kryptonated, and the wear is monitored by monitoring the ^{85}Kr released.

References

[1] See 'Friction and Wear Studies', *Industrial Electronics*, April 1963, p. 359.

[2] See D. E. Barnes and D. Taylor. 'Radiation Hazards and Protection', 2nd Edition 1963. Geo. Newnes Ltd., London.

[3] If the counts totalized is N, the standard deviation is $\sqrt{N}$, and so the answer is known with a precision of $\pm \sqrt{N}$.

[4] 'Radioactive Tracers in Industry', *J. Brit. Inst. of Radio Engrs.*, July 1951. Vol. 11, pp. 279–285.

[5] D. Chleck, R. Maehl and O. Cucchiara, *Nucleonics*, July 1963, Vol. 21, p. 53.

The 1964 IPPS Exhibition

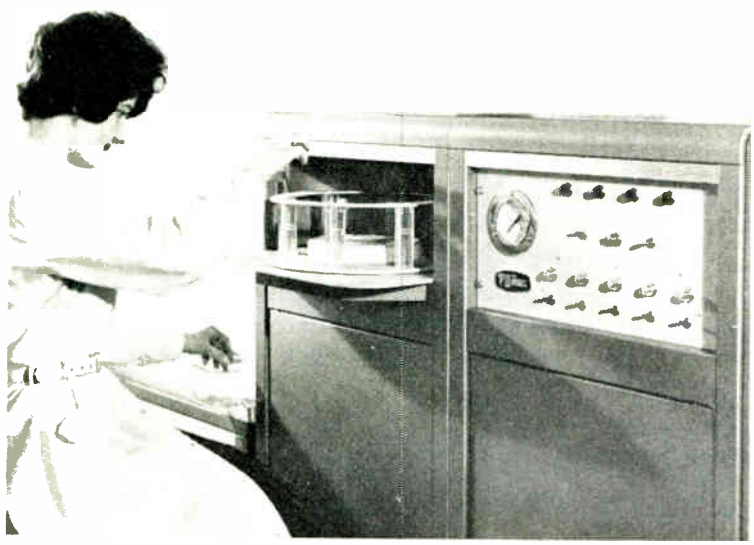
A Report of Some of the Highlights of the Show

FORTY-EIGHTH in the series, the annual exhibition of The Institute of Physics and The Physical Society was held from 6th to 9th January in the Royal Horticultural Society Halls, London.

To help to present a more balanced survey of current research and development work, and to emphasize the character of the exhibition as a scientific occasion rather than a trade show, the Council made some modifications to the stricter exhibit selection procedure introduced in 1963. Still, manufacturers were invited to submit up to six items to referees. However the closing date for receipt of proposed exhibits was set at four months before the exhibition, rather than six months as in previous years. Also provision was made for 'late entry' items maturing up to within a month of the exhibition.

The net result was more exhibitors, 154 compared with 144 in 1963, and an impression of a more balanced show for those interested in physics. Although the predomination of electronics was less obvious this year, this still formed the major part of the exhibition.

At this show one expects to see new and fundamental developments with no specific practical application, but also it is expected that many of the developments will have been designed for practical use in the near future. An abundance of both categories was evident this year. Some of the more interesting developments which are likely to become industrial 'hardware' in the not too distant future are described here.

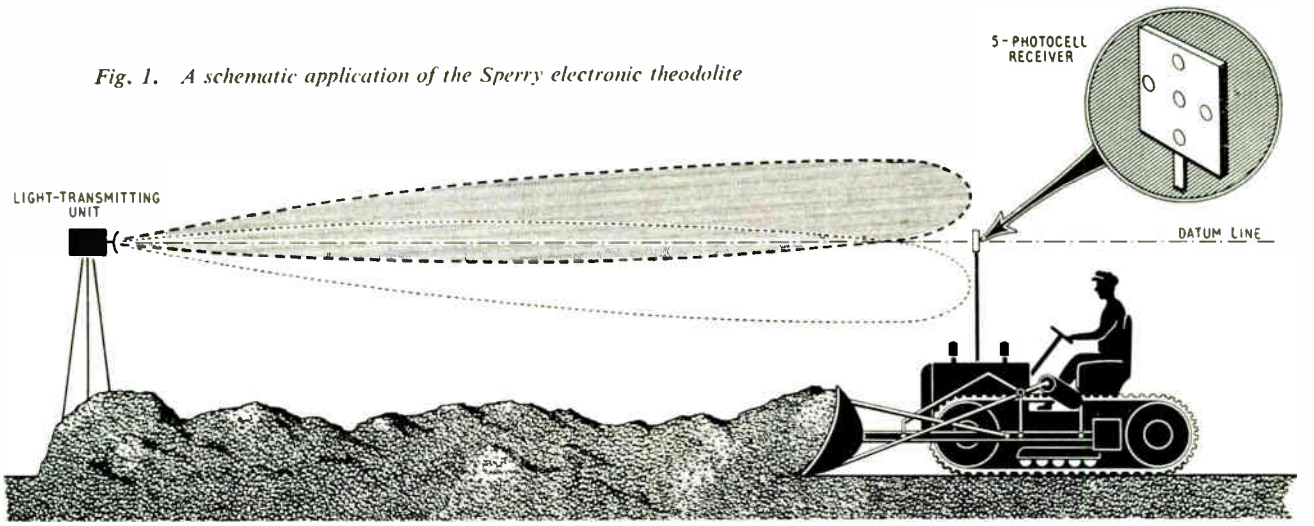


This automated leak detector, demonstrated by 20th Century Electronics, will vacuum test individually up to 1,000 devices per hour. Any that leak are rejected. Maximum dimensions for components are 0·5-in. dia. × 2·5-in. long. The leak rejection threshold may be set to less than 10^{-5} l/μsec **(57)**

A system that may be used to measure continuously, during processing, the diameter of wire, wool and other fine fibres **(55)** illustrates the advantages of combining optics and electronics. This is a development by Paton Hawksley Electronics. Fibres of 0·001-in. diameter are measured to a 1% accuracy. Designed initially for silica fibres, the system provides an optical scan of the fibre by projecting a ×100 image on to a plane mirror which is mounted on a rotating motor spindle. The image of the fibre is focused in a slit set in front of a photomultiplier tube. When the mirror revolves a series of light-dark-light-dark-light d.c. levels is obtained from the tube. This varying d.c. level is displayed on a c.r.t. The positive- and negative-going pulses produced by the light signal are processed and used to open and close the gate of a millisecond timer. The resultant output, a direct measure of the diameter of the fibre, is displayed in digital form.

Optics and electronics are again combined in the Sperry 'electronic theodolite' **(56)** which was demonstrated at the show. In engineering a requirement often arises for a datum line to be set-up over tens or even hundreds of feet; typically, in the levelling of land and road making. The Sperry system is designed to meet these requirements. It comprises a tripod-mounted light-transmitting unit, a 5-photocell receiver and an electronic unit. The light transmitter comprises a projection lamp and motor. The lamp assembly is off-set on the motor spindle in such a manner that the beam conically scans around the datum axis. In the receiver array two photocells are positioned on the *Y* or vertical axis, two on the *X* axis and the fifth at the centre of the axes' intersection.

Fig. 1. A schematic application of the Sperry electronic theodolite



When the light transmitter operates, the receiver array, which is at the required distance away, is illuminated. Should the centre photocell be aligned with the spin or datum axis, it will experience constant illumination. The four other photocells, situated off the spin axis, will experience a fluctuating level of illumination. Thus the electrical output from the four cells will consist of d.c. with an a.c. component. Since the cells are distributed around the spin axis, displaced 90° with respect to each other, their a.c. outputs are also 90° out of phase.

Should the receiver be moved so that the centre cell is no longer on the spin axis, an a.c. output representing the radial position error of the cell from the spin axis will be obtained from this. The electronic unit is used to resolve the centre-cell output into component errors along the X (horizontal) and Y (vertical) axes. These error signals are fed to separate phase-sensitive detectors which use the outputs from the appropriate X or Y pair of photocells as references. The output from one phase-sensitive detector will show the X-axis error while the second will show the Y-axis error. The system therefore produces an electrical signal which is a function of the position error. Thus it is admirably suited for use in error-actuated automatic control. Fig. 1 illustrates diagrammatically one possible function of the system.

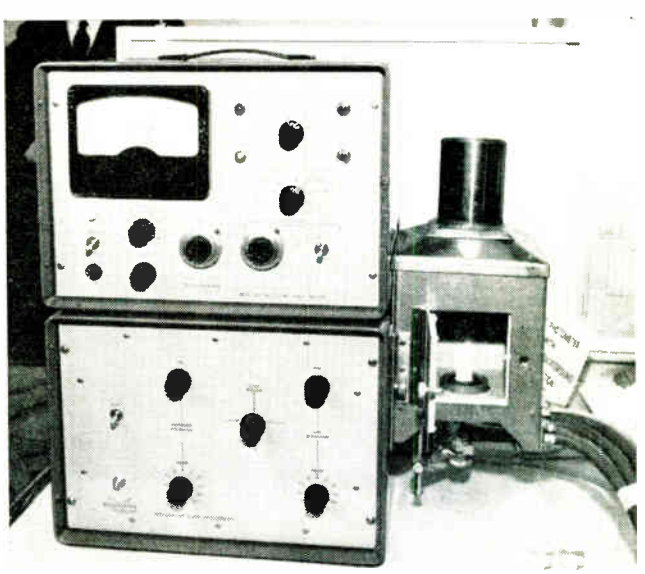
The Chemical Engineering Division of A.E.R.E., Harwell, demonstrated a further combination of optics and electronics in liquid film thickness measurement by fluorescence spectrometry.

Liquid film flow is of interest in a large number of industrial processes including gas absorption, distillation and condensation. Climbing film (or 'annular') flow occurs in water boiler tubes. Water rises in a liquid film around the periphery of the tube while the steam flows in the centre. Part of the water may also be carried as entrained droplets in the steam phase. Flow waves, occurring at the film-gas phase interface, affect the behaviour of the system. A study of these waves called for a method of metering film thickness continuously—hence fluorescence spectrometry.

In the fluorescence spectrometer method, a small amount of fluorescein is added to the circulating liquid. Using a microscope illuminator system, blue light is fed through the transparent wall of the flow tube in a fine focused beam. On passing through the liquid film, the blue beam causes fluorescence in the added dyestuff. From this fluorescent light there is separated out a fluorescing band in the green. The intensity of this green light is metered by a photomultiplier tube fixed to the end of the spectrometer (see Fig. 2). The output from the photomultiplier is fed to an averaging instrument or to an oscillograph. This signal is a direct and continuous measure of the film thickness.

An interesting demonstration by Specto Avionics of their integrated information display system combined cleverly many of their recent developments. The experiment was designed to show the reaction times of a controller between two forms of metering systems; (a) a conventional meter system and (b) an integrated information display system combining a number of signals in symbolic form on one display.

In order to demonstrate human reaction four varying input signals are supplied to each system in turn for a



This shows the demonstration of Southern Analytical's flame photometer with automatic background compensation. The instrument uses a combination of transistors and electrometer valves and is highly sensitive. Detection limits down to about 0·0001 p.p.m. for lithium may be expected (58)

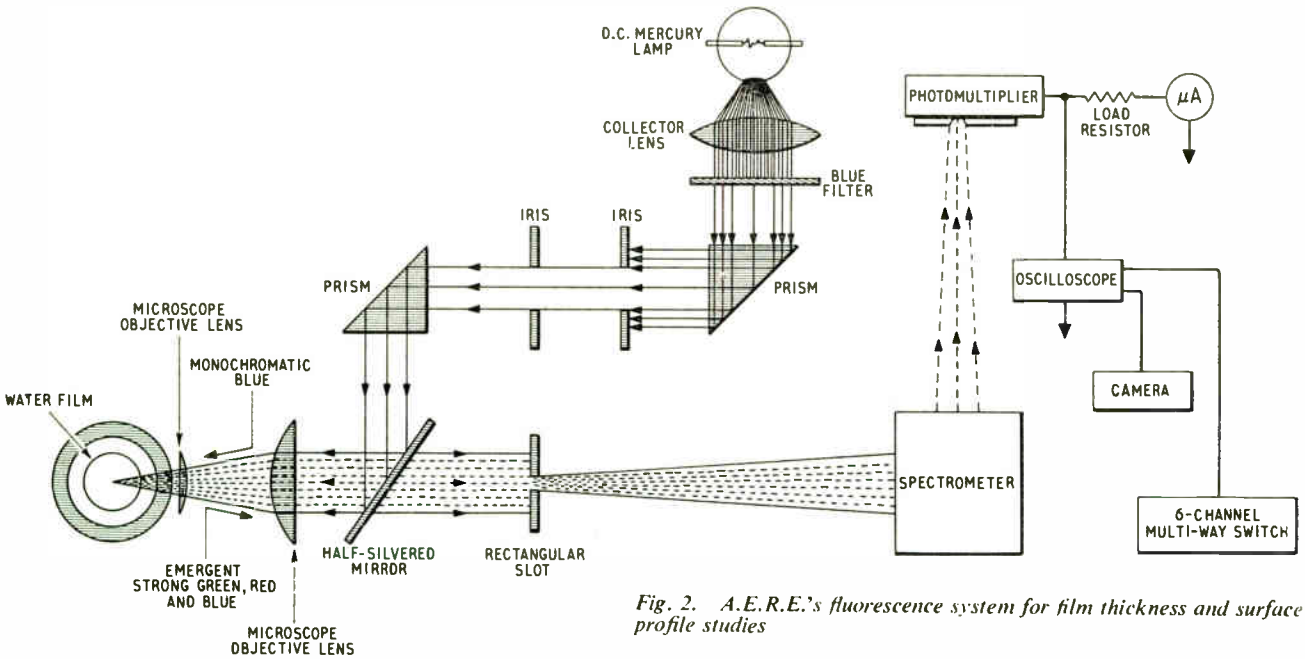
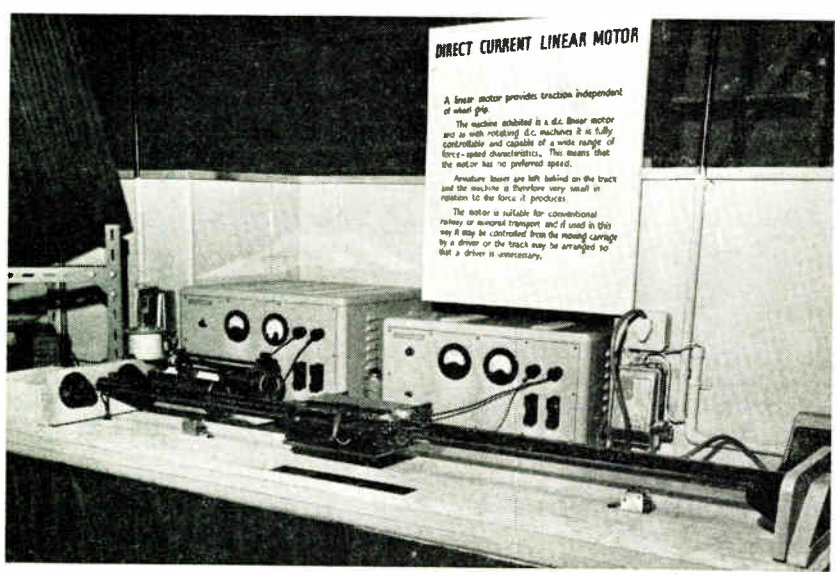


Fig. 2. A.E.R.E.'s fluorescence system for film thickness and surface profile studies



This novel linear d.c. motor with a force to weight ratio of about 3 to 1 was demonstrated by the University College of North Wales. The central track is a steel rod wound with copper wire and carrying rails for the carriage. When the carriage field coils are energized the flux path is completed through that part of core on which the carriage is standing. Brushes mounted on the carriage provide energy to the central armature winding beneath the carriage. Resultant forces cause the carriage to move

Using a high-speed counter, Ferranti demonstrated latest prototype Moiré fringe measuring equipment. It operated at twenty counts per grating pitch from a 250 line/mm grating giving a digit size of 0·2 micron **(61)**

period of approximately 1½ min. The operator must maintain these signals at their null positions by controlling them with two 'joystick controls'. The operator's failure to maintain the null results in an error signal. The error signal is fed to a deci-microsecond chronometer and hence comparative scores for the two systems are obtained. It was found that with the electronic integrated display a wider variety of parameters can be more easily measured and controlled.

The electronic integrated system used was in its commonest form of a pilot's head-up display **(59)**, where it monitors and shows symbols relating to flight direction, take off and landing, etc. These symbols are projected via a lens system from the screen of a c.r.t. on to a semi-transparent reflector mounted in the pilot's normal head-up view. The modified Specto chronometer **(60)** which provided the comparison of the scores is essentially a crystal-controlled instrument for measuring time over the range 0·1 μsec to 1 sec, to an accuracy of 2 parts in 10^7 per week ±1 count.

Needless to say a great number of new instruments was shown at the exhibition—not just devices for the electronics engineer, but measuring tools and machines for almost every industry.

The British Jute Trade Association were demonstrating, in a small way, their drying rate moisture meter. This has been designed for the textile industry to control accurately the drying of material in sheet form.

When hygroscopic materials are dried they have two distinct drying mechanisms. At very high moisture levels evaporation takes place at a rate independent of moisture level. This continues until the critical point is reached when further evaporation can only take place from the fibre by diffusion of moisture from the interior of the fibre. During the first phase (constant rate period), evaporation takes place at approximately the wet bulb temperature. In the second phase (falling rate period) the surface temperature rises to the airstream value at zero moisture.

If a stream of air is blown over the fibres the fall in temperature will be proportional to the amount of water evaporated and hence to the moisture regain of the material. The temperature drop is small but by using a platinum resistance thermometer connected in a Wheatstone bridge the small differential can be accurately measured.

The output of the bridge is amplified and displayed on a 1-mA meter calibrated in percentage moisture regain (relative to a dry weight). Alternative output displays can be used. Apart from the accuracy of this system, its main advantage over resistive or capacitative types is that the presence of normal quantities of dyestuff or other ionic material has little effect on its operation.

Metallurgists were well catered for at the show. An example of an instrument for basic research was demonstrated by Metals Research. This is their quantitative television microscope **(62)** designed to provide an economical and accurate device for the rapid measurement of grain size, inclusion area percentage, etc.

It consists of a metallurgical microscope fitted with a beam splitter. The image is passed both into a conventional eyepiece and into a television camera. The output from the camera is displayed on one of two television screens as a normal image. It is also passed to a selector unit which responds to the changes in intensity when the scanning spot within the camera passes over a boundary between two features in the specimen surface. The selector unit signal is displayed on the second screen and is then passed to an indicating unit which displays either the mean linear intercept of the feaures or the fraction of the area of the observed field that they occupy.

'Loss - of - vacuum' sensing equipment demonstrated by Londex Ltd., a member of the Elliott-Automation Group. This detects and rejects imperfectly sealed metal capped jam jars. The equipment comprises a sensing head, which carries out electrically the action normally performed by an operator, without physical contact with the container. This is achieved by inducing eddy currents into the metal cover **(63)**

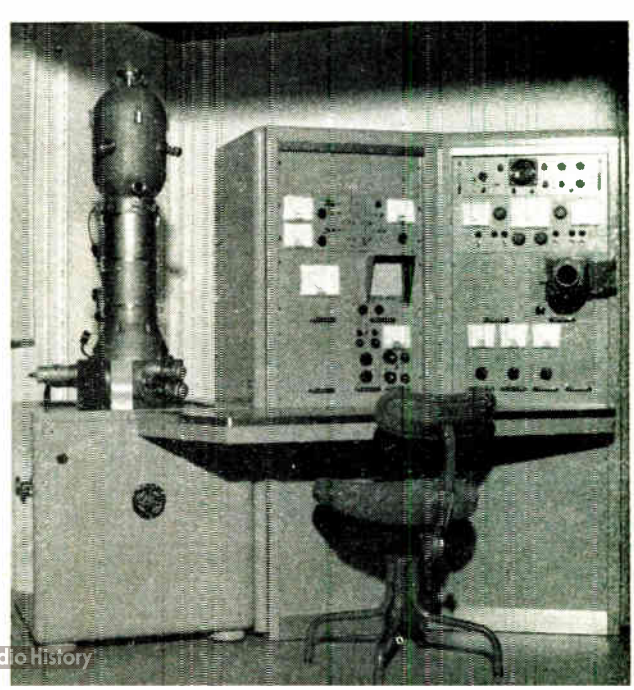
The equipment incorporates a sizing circuit which rejects signals from features of less than the chosen width. Resolution is limited by the microscope to 1 μ.

Also for materials research, Instron Ltd. were demonstrating a prototype optical extensometer **(64).** The measurement of the extension of light extensible, tensile test specimens has always been a tricky problem. Many types of extensometer impose loads or gripping stresses on the specimen. Instron have overcome these limitations by using two servo-controlled photocells which accurately follow white paint marks on the specimen. By measuring, with a transducer, the relative movement of the photocells a direct and automatic record of the extension of the gauge length of the specimen is obtained. The resultant signal is used to drive the load-elongation chart via the normal X–Y equipment.

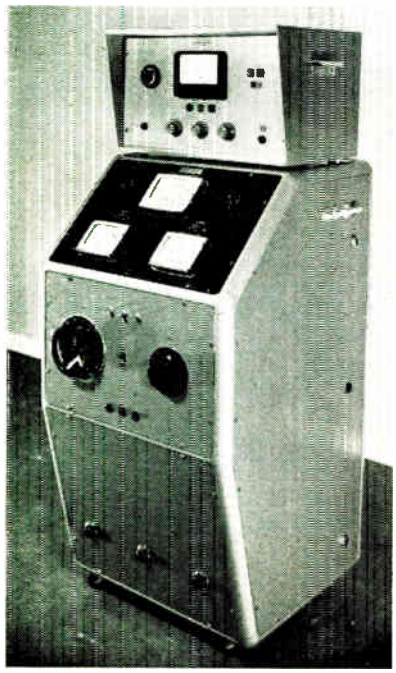
In this way accurate curves can be obtained for difficult materials such as rubber, plastic, thin films, etc. In addition this extensometer can 'look' through the window of an environmental chamber and so enable measurements to be made under conditions where normal extensometers may be unreliable.

For yet another industrial use, Electronic Applications were showing their new ultrasonic level gauge **(66).** This has been designed primarily to measure the level of liquids in tanks and is particularly suitable where the problem of regular cleaning prevents the use of a probe in the vessel. The high order of accuracy makes it attractive to many applications. The gauge comprises a combined generator and level display unit and a transducer which is mounted above the tank. The transducer is connected to the main unit by a cable which can be up to about 100-ft long. The maximum depth of level range is 8 ft and an accuracy of 0·1 in. is typical.

The instrument operates on an ultrasonic echo sounding principle through



The Cambridge 'Stereoscan' scanning electron microscope. This prototype instrument has been further developed to provide a consistent resolution of better than 500Å. The inherently great depth of focus makes possible the application of stereo micrographic techniques to the comparatively large specimens that can be accommodated, permitting three-dimensional measurement **(65)**



Illustrated here is the G. V. Planer electron beam heating equipment with a controlling ratemeter. This is suitable for the vacuum deposition of metals and non-metals. It is designed for either direct electron beam heating of the evaporant or for indirect heating, by electron bombardment of the evaporant container. The direct heating system produces higher temperatures and hence permits evaporation of more refractory materials (67)

air. Direct measurement is obtained by electronically counting the number of pulses from an internal clock frequency source during the period between a transmitted ultrasonic pulse and its resultant reflected echo from the surface of the liquid. These clock pulses are counted by a 3-decade transistor counter and the result is displayed on a 3-digit display on the main unit. For greater utilization of the basic unit, four separate transducers can be used and selected by a switch. Level limit control can also be built into the system.

So far most of the 'instruments' described are complete systems, but in addition to these there was shown a multitude of the latest developments in portable devices.

Typical of the extensive use of transistor techniques is the new E.M.I. Electronics WM41 general-purpose transistor oscilloscope **(68).** This is a small truly portable instrument that can be operated from the normal a.c. mains supply (100 to 265 V, 50 to 60 c/s) or, alternatively, from a 12-V battery. It has a bandwidth of d.c. or 3 c/s to 10 Mc/s (−3 dB) and a maximum sensitivity of 50 mV/cm. Input impedance is 1 MΩ in parallel with 30 pF on all ranges. Eighteen switched timebase ranges together cover sweep speeds from 200 nsec/cm to 100 msec/cm, unexpanded; continuous expansion from ×1 to ×5 is also provided. Versatile trigger facilities are included along with a built-in voltage calibrator.

A second oscilloscope using semiconductors was that shown by Cossor. Known as their 'transistorized modular oscilloscope' **(69),** this is an oscilloscope system. It basically comprises the main cabinet, containing the tube and power supplies, with a large aperture to accept a range of plug-in units. Typical modules include a range of single- and dual-trace d.c. amplifiers of bandwidths up to 35 Mc/s and sensitivities up to 500 μV/cm; a range of sweep generators, some with sweep facilities. Also sampling units for bandwidths up to 1,000 Mc/s and swept frequency oscillator heads for spectrum analysis from 20 c/s to 1,000 Mc/s are available.

Transistors again are the active elements in the new Avo electronic testmeter 5 **(70).** Designed in the Avo tradition this has two switches, 'function' and 'range', which select all the available facilities. Two amplifiers, one a.c., one d.c., form the basis of the meter. Ranges cover 100 mV to 1 kV a.c. or d.c.; 30 μA to 3 A a.c. or d.c. ±3% of f.s.d. Resistance may be measured with this from 0·5 Ω to 20 MΩ. The meter has a dBm scale, it is fully protected against overload and provides for centre-zero operation. Power is supplied by two internal 9-V batteries.

Measurement of all variables is fundamental to engineering. This was particularly emphasized at the 'Physoc' exhibition. Frequency, time, temperature, noise, length measuring devices were all there in abundance.

For example, for the direct measurement of signal frequencies up to 50 Mc/s and time measurement in units of 0·1 μsec Venner Electronics were demonstrating their transistor TSA 333 frequency and time measuring equipment **(71).** In addition it is capable of multi-period measurement and random pulse counting. Accuracy is ±1 count ±1 part in 10^6.

An 8-digit projection display system is used and the measured units and decimal point are displayed automatically. Variable trigger level and slope controls are provided for the signal input and start and stop lines.

The standard output signal frequencies, derived from an internal decade divider chain, are brought out to front-panel sockets. The unit employs a 2-Mc/s oven-controlled crystal reference. For applications where greater accuracy is required provision is made for feeding in an external 1-Mc/s standard signal. This instrument is a.c. mains operated.

General-purpose temperature-measuring instruments are typified by Sangamo Weston's 'portable multi-range temperature indicator' **(72).** Here robustness, realistic accuracy and ease of operation appear to be the criteria governing design. Using a new high accuracy platinum resistance thermometer this covers the temperature range 400 °C to −100 °C in five steps. The ranges are selected by reasonably-sized push-button switches. A linear 6-in. scale allows a readability of better than 0·25 °C. Using transistors has enabled the device to be battery powered. Accuracy depends on the range selected and varies from ±0·5 °C to ±1 °C.

Attention has been focused recently on noise and its measurement by the Wilson Committee report and the Ministry of Transport draft regulations.

Anticipating the need for an easy-to-read sound level indicator, Dawe Instruments have developed, and were demonstrating, equipment that provides a thermometer type of display of illuminated numbers **(73).** This display has the appearance of a thermometer of about 2-ft high. It will display 20 measured sound levels in 2-dB steps over an arbitrary range, say 60 to 100 dB. The display remains lighted until manually reset.

Nuclear Enterprises were showing this dual-channel automatic liquid scintillation spectrometer type NE8303. Designed to give low-cost fully automatic counting, it uses transistor modular construction. Measurements may be made at high efficiencies of tritium, carbon-14, iron-55 and other radiostopes with up to 60 samples being handled in rotation or in selected batches (74)

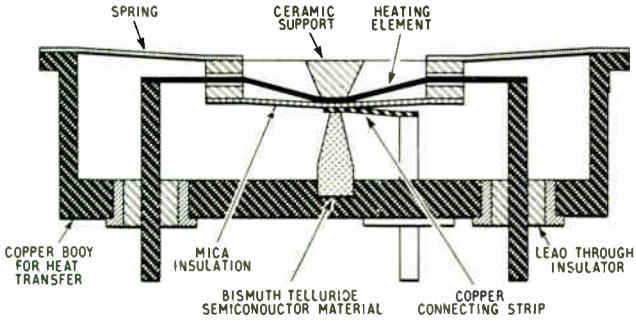
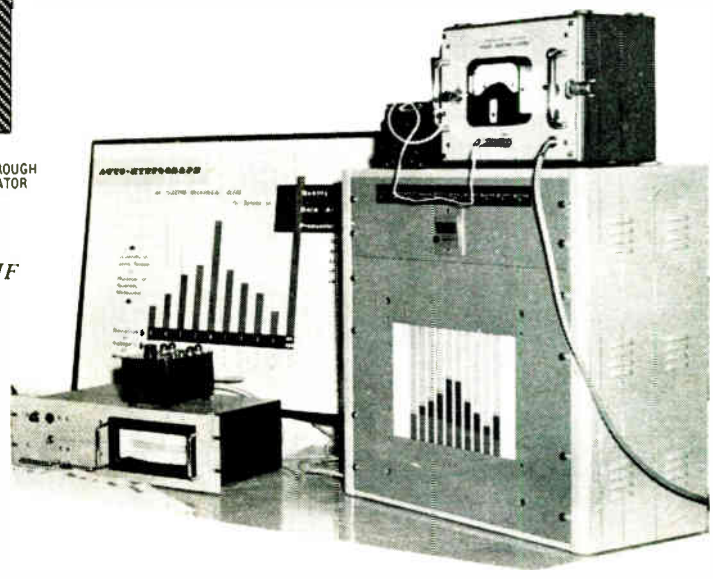


Fig. 3. The heater and thermo-junction assembly of the AMF thermo-electric ammeter



A main exhibit of Aveley Electric was their quality control monitoring and recording equipment. It is a system designed to collect statistical information of measurements made on products or quantities which may then be employed in the manual or automatic correction of 'mean' and 'deviation' of product or quantity. The same equipment provides for automatic control of production test and inspection machinery (75)

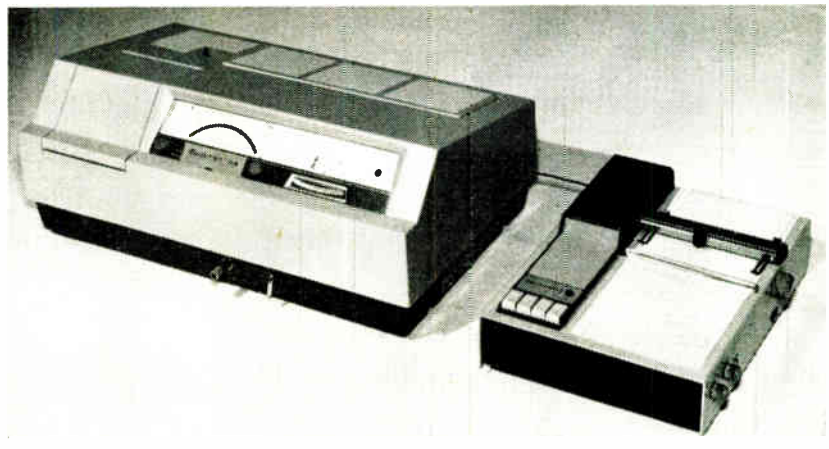
An 'A' weighting network is employed to give the best correlation between sound level and annoyance value for many noise sources. This also complies with British Standards requirements for sound level meters used to check vehicle noise. Operation is by mains or batteries.

So far in this report most of the items are of reasonable size. However, size is no measure of technical novelty as was ably demonstrated by the host of miniature devices and components on show—though some were difficult to find!

AMF Ltd. were demonstrating a small thermoelectric ammeter using a bismuth telluride-copper thermojunction. In this version, current is passed through a metal strip which is in contact with the junction, but electrically insulated from it. The slug of bismuth telluride is reduced almost to a point and a narrow copper foil is used to reduce heat loss from the junction. Fig. 3 shows the arrangement, which improves the response time. The experimental relationship between heater current and junction voltage is very close to a square law.

Prototypes are 5 times better than normal high-sensitivity thermocouples and experiments suggest that they could be made 10 times better.

The Services Electronics Research Laboratory were demonstrating an array of 20 of the new semiconductor crystal lamps. This made it possible to see them while not illuminated. A single lamp is about one-quarter the size of a pin's head. These are basically a p-n junction in suitable doped gallium phosphide. They have a fast response time—typically 0·2 μsec—and may be modulated at speeds up to 1 Mc/s. The lamp can be operated either d.c. or pulsed. Under d.c. drive conditions (at 2 V, 25 mA) a brightness of 10-40 foot-lamberts is achieved. This makes it possible to see a single lamp with subdued daylight illumination.



This model DB ultraviolet spectrophotometer was shown by Beckman Instruments. This is a direct-reading, easily-operated double-beam instrument. At a relatively low cost it provides for transmittance and absorbance measurements in the 205 to 770 mμ. range. Double beam operation is achieved through the use of a vibrating mirror assembly. This mirror alternately directs the monochromatic beam through the sample and reference paths, without using any non-common mirrors (76)

Finally, another semiconductor light device was shown by Mullard. Known as the transluxor, this is a light-operated solid-state device with a power gain. This depends for its operation on the highly efficient emission and collection of light in order to obtain a current gain approaching unity, as in the transistor. The major advantage of the transluxor is that its operating speed is not limited by the transit time of the signal across the base since the signal is carried by light. It is expected that operation at frequencies above 1 Gc/s will be possible.

To summarize an exhibition like this in a few words is difficult, nay almost impossible. Suffice to say that it provided an excellent opportunity for engineers and scientists to gather and discuss their work and problems.

Both the organizers and exhibitors are to be congratulated on providing a vintage 'Physoc' exhibition.

For further information about specific items circle the appropriate number, shown in the brackets in this report, on the Service Card

Personal and Company News

C. R. Wheeler has become chairman of **A.E.I.** in succession to Lord Chandos. Sir Joseph Latham and H. West have become vice-chairmen. The responsibilities of the new vice-chairmen reflect the philosophy now being introduced into A.E.I. of making individuals, as opposed to boards or committees, responsible for specific functions or sections of the company's activities. For example, Sir Joseph Latham becomes responsible for planning, finance and administration. He is also the new chairman of A.E.I. Appliances Ltd. Mr. West becomes generally responsible for technical matters and for research, while remaining in charge of the Power, Industrial and Electronics Groups.

Two publicity appointments have been announced for the recently-formed **A.E.I. Electronics Group:** Allen G. Hickman becomes deputy group publicity manager, and S. Scott MacTaggart has been appointed group press officer.

The United Kingdom Atomic Energy Authority announce the appointment of **Dr. R. Spence,** C.B., F.R.S., as director of the Atomic Energy Research Establishment, Harwell.

M.B. Metals Ltd., a member company of Carbon Electric Holdings Ltd., of Portslade, Sussex, announce that they have taken over the Data Handling Systems activities previously carried out by the Electronics Division of Microcell Ltd.

Thorn Electronics Ltd. have announced the appointment of Dennis W. Machin as sales manager for closed-circuit television equipment and microwave components. He will be based at 105–109 Judd Street, London, W.C.1.

Dr. J. A. Powell, assistant managing director of **Texas Instruments Ltd.,** has succeeded A. N. Provost as managing director.

The Institution of Works Managers has now moved from 196 Shaftesbury Avenue, London, W.C.2, to larger premises at 34 Bloomsbury Way, London, W.C.1, and the telephone number has also been changed to HOLborn 5273-4. The new premises, of which the I.W.M. is the sole head tenant, has street-level reception and accommodation for committee meetings. It now has facilities to act as a meeting place for individual members who wish to have a point of venue in London.

Bowden Bros. Ltd., of Grand Buildings, Trafalgar Square, London, W.C.2, have been granted the sole agency for products manufactured by Industrial Instruments Ltd., of 29 Burnt Ash Hill, London, S.E.12.

Alister D. Mackay, finance director of **Standard Telephones and Cables Ltd.,** has been appointed deputy managing director. In this new assignment Mr. Mackay, while retaining responsibility for financial matters, will assist the managing director, Rex B. Grey, in the overall operations of the company.

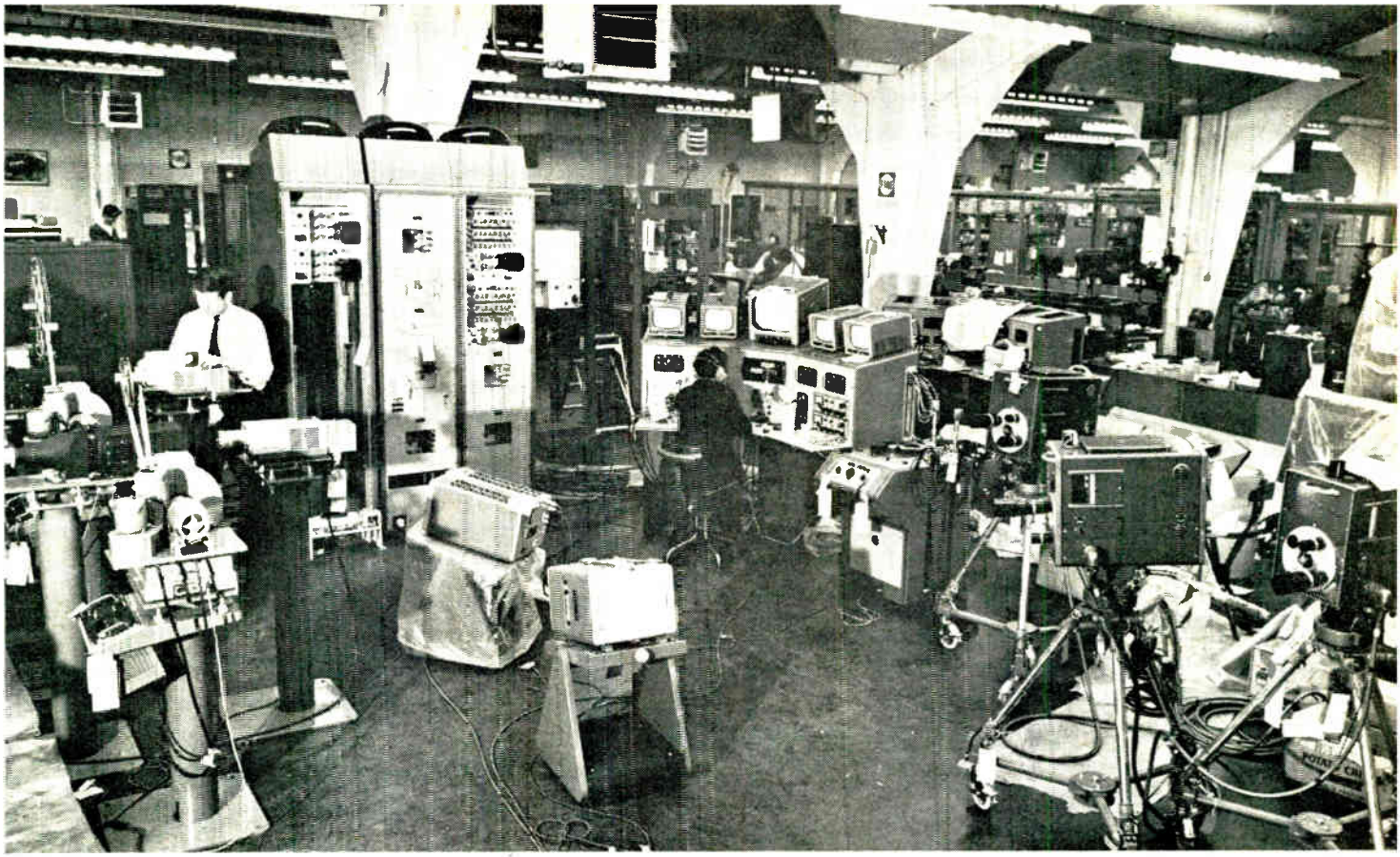
STC is to manufacture the Eimac range of high performance u.h.f. television klystrons at its Paignton plant, as the result of an agreement signed between Eitel McCullough Inc. and the International Telephone and Telegraph Corporation, of which STC is a British associate.

As a further stage in the growth of Amphenol-Borg Ltd. a separate company, **Amphenol-Borg (Electronics) Ltd.,** has been formed to carry on the business previously conducted under the name of Amphenol-Borg Ltd., Electronics Division. This new subsidiary will take over the existing business and facilities at Thanet Way, Whitstable, Kent.

Marconi Instruments Ltd. announce the following appointments in the engineering department: H. V. Beck, B.Sc., M.A., A.M.I.E.E., is appointed research manager, and A. G. Wray, M.A., M.Brit.I.R.E., is appointed engineering manager.

Formica International Ltd. has announced a number of changes on the board of Formica Ltd., its U.K. operating subsidiary. These changes are:—D. A. Moore to become chairman, R. R. Hudson to be managing director; T. M. McKain and P. J. Hallbery to be directors.

Associated Automation Ltd., a member of the Elliott-Automation Group, is to manufacture and market a new range of peripheral equipment for data processing, data logging and data communications applications. A licence agreement concluded with the Invac Corporation of Waltham, Massachusetts, U.S.A., gives Associated Automation the exclusive right to manufacture and market the Invac range of equipment in the United Kingdom, the British Commonwealth (excluding Canada), Europe and the Middle East. The printer illustrated incorporates a 20-character per sec tape punch and a photoelectric reader



A complete television broadcasting station, supplied to the Government of Liberia, is shown in this photograph during its final tests at the Pye T.V.T. factory in Cambridge, prior to delivery. The equipment consists of a 500-watt 625-line transmitter, three studio cameras, a twin telecine suite and vision and sound mixers, which are now being used by Liberia's first commercial television station, E.L.T.V. This station came into being on 6th January 1964 with the televising of the fifth inauguration of President Tubman, the equipment being delivered less than one month after the order was given to Pye T.V.T. Ltd. by Overseas Rediffusion Ltd

Bryan Richard Overton, B.Sc., M.I.E.E., has been appointed technical manager of the Mitcham plant of **The Mullard Radio Valve Company.** He will be responsible for the technical development and management of the electron tubes, ferrite components, and other devices made primarily for use in professional electronic equipment. Leonard Graham Cripps. B.A., succeeds Mr. Overton as head of the Circuit Physics and Applications Division of Mullard Research Laboratories.

The Plessey Company (U.K.) Ltd. is to extend its manufacturing and trading interests to the ticket machine field. A recent announcement states that it has bought a 49% share of the equity of Ticket Equipment Ltd.

Evershed & Vignoles Ltd. announce an extension of their selling rights for the Steromotor to include Canada, U.S.A., South Africa, Rhodesia and Eire.

E. J. Pritchard, Grad.I.Mech.E., has been appointed sales manager for **C.G.S. Resistance Co. Ltd.**

S.E. Laboratories are drawing up an agreement with Hartmann & Braun, the Frankfurt Instrumentation manufacturers, to handle the complete range of their equipment in Germany and other European countries. The German firm will hold stocks and spares, and are placing an initial order worth £100,000 for u.v. recorders, transducers, amplifier/demodulators and other equipment.

The formation is announced of **Gemco (Electronics) Ltd.,** a company with £10,000 issued capital, manufacturing industrial electronic systems and components. The company will specialize in the following fields: aviation, bulk storage and nuclear engineering.

Varian SpA, a subsidiary of Varian Associates in Palo Alto, California, has been established in Italy to serve the company's sales to the European Common Market. The address is Via C. Battisti 2, Turin.

G. A. G. Rowlandson has succeeded R. Roper as the senior sales engineer of the Merchandising Division of the **Solartron Electronic Group Ltd.**

Stewart Aeronautical Supply Co. Ltd. have appointed four new sales engineers: S. J. Ashpool, F. A. W. Gillam, J. J. Pink and M. E. Lower.

Thomas Edmondson, president and director of Ferranti-Packard Electric Ltd., Toronto, and Ferranti Electric Inc., New York, has been appointed to the board of directors of **Ferranti Ltd.,** Hollinwood, England.

Mrs. Gladys Lillian Worwood, F.C.C.S., who has been secretary of **A. F. Bulgin & Co. Ltd.** since October 1957, has been appointed to the board of directors. She continues to serve as the company secretary.

R. J. Clayton has been appointed managing director of **G.E.C. (Electronics) Ltd.** He was formerly general manager of the company.

John J. Routledge has taken up his duties as sales manager of **Continental Connectors Ltd.**

Obituary

Percy Huggins, technical director of Lancashire Dynamo & Crypto, who was to have retired at the end of last year, died suddenly on 23rd December.

New Year Honours

Knighthood

Jules Thorn, Chairman and Managing Director, Thorn Electrical Industries Ltd.

John Norman Toothill, C.B.E., for services to Scottish industry.

C.B.E.

Richard Eric Sainsbury, Director General of Guided Weapon and Electric Production, Ministry of Aviation.

O.B.E.

Edward William Hayes, Head of Planning and Installation Dept., B.B.C.

Keith Inglis Jones, Chief Engineer, Ferguson Radio Corporation Ltd.

Ernest Clive Slow, B.Sc., A.M.I.E.E., Senior Principal Scientific Officer, Royal Radar Establishment.

Robert Williamson White, B.Sc., F.InstP., A.M.I.E.E., Assistant Staff Engineer, Research Station, G.P.O.

M.B.E.

John Bartram Lovell Foot, A.M.I.E.E., Group Leader, Research Engineer, G.E.C. (Electronics) Ltd.

Reginald Alfred John Harrison Kirkman, Experimental Officer, Royal Aircraft Establishment.

Jack Reginald Moore McNally, General Manager, Beckman Instruments Ltd.

Charles Nicolson, B.Sc., Senior Experimental Officer, Radio Research Station, D.S.I.R.

Edward Daniel Northcott, Engineering Technical Grade B, Directorate of Electronic Production (Telecommunications).

Francis Leslie Reed, Government Contracts Manager, E.M.I. Electronics Ltd.

B.E.M.

Albert Lee, Technical Officer, Post Office Research Station.

BEAMA/Nigeria Overseas Committee

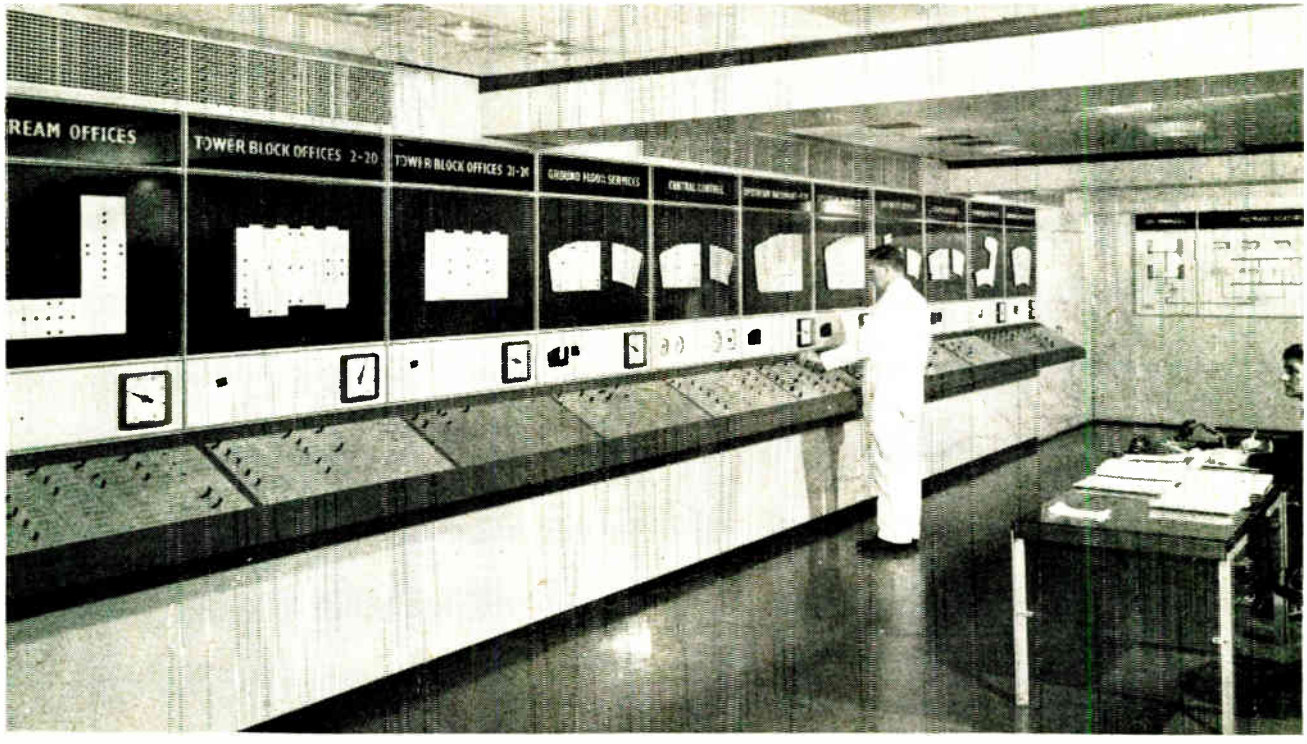
The BEAMA has established an overseas committee in Nigeria. Mr. J. A. Streeter, of the English Electric Co. Ltd., took a leading part in the discussions which led to the formation of the committee, following BEAMA's participation in the Nigerian International Trade Fair in Lagos. Mr. Streeter is now leaving Nigeria, and Mr. P. A. Lake, of British Insulated Callender's Cables Ltd., has been elected chairman of the new committee. There are ten founder members and proposals have been made to elect a number of agent members and associate members.

Nearly 50 years ago, the representatives of BEAMA member firms in Australia and India decided to form BEAMA overseas committees in their territories. The reason for setting up these committees was to maintain and improve the standing of the British electrical industry in the territories concerned, to increase the volume of trade and encourage the demand for high standards of quality, and to provide a means by which the representatives could co-operate in solving mutual problems. Since then, overseas committees have been formed in many parts of the world.

Acoustics Research

Amplivox Ltd. have announced that they are providing a research bursary in the Physics Department of Imperial College under the supervision of Dr. R. W. B. Stephens. The research will be concerned with the transmission of sound and vibrations in a variety of materials, and the behaviour of sub-miniature mechanical-acoustical systems embodying such materials. Very little work has been carried out in this field and the lack of information is a serious limiting factor in the design of very small hearing aids. A better understanding of the problem should benefit deaf people, as it is believed that the acoustic performance of very small and inconspicuous hearing aids can be substantially improved.

This mobile demonstration unit, shown for comparison alongside a London bus, was recently commissioned by Avo. It has been designed mainly for Continental use and can accommodate a complete range of testing and measuring instruments as well as coil-winding machinery



The control room in the boiler house of Shell International's new London headquarters. All systems (air conditioning, hot water, refrigeration, sprinklers, oil, etc.) in the 43 acres of office space are controlled by two men. The control panels, main feature of the room, were designed by Douglas Scott, F.S.I.A. of DS Associates and Electroflow Meters Co. Ltd. built the systems. The state of all services in every part of the building is shown at a glance by means of a simple modular system

Effects of Computers on Office Employment

The Manpower Research Unit of the Ministry of Labour is launching a new enquiry to establish what effects the introduction of computers has had or is likely to have on office employment. This enquiry is intended as a first step in a broader survey which the Unit will carry out into the whole future of office employment. Over 300 firms or organizations who have already installed a computer for office work or are about to do so are being asked to co-operate by completing a detailed questionnaire about the impact of the change on their office staffs. Among those to be approached are Government departments, nationalized industries, local authorities, banks and insurance companies, as well as a wide range of manufacturing and other industries, and business and commercial undertakings.

The primary object of the enquiry, which was foreshadowed by the Minister of Labour in the House of Commons last month, is to find out what happens to workers whose jobs are transferred to a computer. It is important to know to what extent they are able to be trained for work in the new installation, or to be transferred to other work in the organization, and whether redundancy is always avoided, either in one of these ways or by normal wastage through retirement, marriage and so on. By studying this information and evidence of the job opportunities created by the new machines, valuable information will be established which will help both Government and industry in planning for the future.

At the same time, the enquiry will seek to establish any relationship between the introduction of computers and, for instance, location and organization. It will also endeavour to find out just what makes firms invest in computers and to what extent original expectations have been realized. All this material, combined with views of future technical developments in the computer world, should give a much clearer picture of the future impact of computers on office employment. This is the first time such an extensive study has been undertaken in this country.

Rapid Colour Matching Service

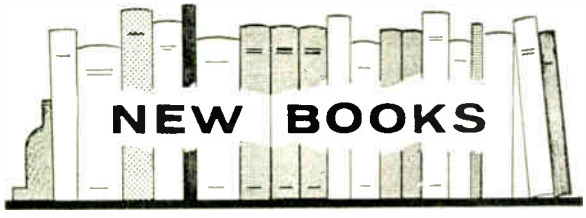
I.C.I. Dyestuffs Division is now offering customers a new speedy colour-matching service, known as IMP (Instrumental Match Prediction), in which colours are matched by an Elliott 803 computer. Hitherto, as with all dyestuff makers, colour matching enquiries have involved submitting the coloured pattern to a Technical Service Laboratory, where they are examined by skilled colourists, who carry out a series of test dyeings to arrive at a recipe to give the required shade. This procedure can be a lengthy one.

With the inception of the new service, no transfer of pattern is required (thus eliminating postal delay) since the colour to be matched can be measured on a colorimeter by the dyer or printer and a numerical specification can be sent to the I.C.I. Technical Service Laboratories by telex or telephone. Within one minute, the '803' gives the recipe to match the shade required. A special feature of the service is that information, which allows the dyer to adjust the recipe to overcome the normal processing variations when he is dying on a bulk scale, is also provided by the computer and despatched simultaneously with the dyeing recipe. The need for trial dyeings before commencing production is thereby greatly reduced and in many cases eliminated entirely.

Computer Price Cut by 25%

The basic price of the National-Elliott 803 is being cut by nearly 25%, from £29,000 to £22,000. The saving on a typical large system would be even greater, in some cases exceeding £10,000. Elliott-Automation, who designed and manufacture the computer and market it for scientific and on-line control applications, and N.C.R. Electronics, who sell it for business data-processing applications, say they have been able to make this reduction for two main reasons: with increased demand there has been a significant drop in electronic component prices and the introduction of new manufacturing methods and equipment has resulted in a substantial saving in manufacturing costs.

For further information circle 77 on Service Card



Digital Computer Technology and Design Vol. 2

By WILLIS H. WARE. Pp. 548 + xx. John Wiley & Sons Ltd., Glen House, Stag Place, London, S.W.1. Price 90s.

This book deals mainly with the design of the circuit elements used in digital computers and it does this very well indeed. The first chapter, which is chapter 7 because this is Vol. 2, is a short one dealing with reliability. This emphasizes the need for the derating of parts and for considering component tolerances and ageing effects. Chapter 8 is a long one (100 pages) headed 'Toggle Circuits' and comprises one of the best discussions of bistable circuits that we have encountered. We mean best from the designer's point of view, for the treatment is eminently practical with virtually no mathematics, and throughout the importance of tolerances is kept well to the fore. In the main it is specific to neither valve nor transistor, for most diagrams are drawn with a block which can represent either.

Succeeding chapters deal in a similar fashion with gates and miscellaneous circuits, which include amplifiers, monostable multivibrators, pulse generators, slicers, encoders and decoders, etc. Then come chapters on sections of the computer in which the individual circuits are combined into major sub-units. Chapter 11 deals with arithmetic and considers in detail what is involved in serial versus parallel operation, among other things. The following chapters cover the store, control, and input-output devices and the book concludes with a chapter on generalities.

Microwave Tubes and Semiconductor Devices

By G. D. SIMS, M.Sc., Ph.D., D.I.C., A.M.I.E.E. and I. M. STEPHENSON, M.Sc.(Eng.), Ph.D., A.M.I.E.E. Pp. 388+xxii. Blackie & Son Ltd., 5 Fitzhardinge Street, Portman Square, London, W.1. Price 75s.

The authors of this book clearly intend that the 'microwave' in the title be taken as an adjective qualifying both 'tubes' and 'semiconductor devices'; those who take it as qualifying 'tubes' alone will be misled by the title. Semiconductor devices are dealt with in one chapter of the twelve forming the book and of this chapter's 29 pages microwave transistors have no more than a page and a half. Most of the space is given to diodes.

The first two chapters are general, one covering general principles, the other electron guns and focusing. The following chapters deal with specific classes of valve, klystron amplifiers, reflex klystron and other v.m. oscillators, travelling-wave-tube amplifiers, magnetrons, parametric devices, cyclotron wave tubes and masers. Interspersed is a further general chapter on slow-wave structures.

The treatment is by no means highly mathematical and is explanatory rather than analytical.

Recommendations for the Selection, Formation and Definition of Technical Terms

British Standard 3669: 1963. Pp. 17. British Standards Institution, 2 Park Street, London, W.1. Price 5s.

One of the problems confronting technologists, scientists and others in industry who must communicate with one another is the need to agree on standard terminology—so that all concerned can speak the same technical language.

Help towards this end now comes in this new British Standard.

Much has already been done through B.S.I. glossaries of terms (of which there are now 80 in print and many more in the pipeline) to provide individual industries and technologies with their own, agreed standard language. Even so, the approach may often vary from industry to industry.

Internationally, the I.S.O. (International Organization for Standardization) is preparing recommendations on the principles to be followed by all industries in defining terms. The new British Standard embodies some of these I.S.O. recommendations, setting out the procedure which should be followed—whatever the field—in establishing technical terms and in drafting their definitions.

It should prove of great value to all who have the job, even if only occasionally, of helping to define technical terms in national or company standards, in complete glossaries of terms, or for that matter in technical writing generally.

Manufacturers' Literature

International Rectifier Short Catalogue. This 16-page publication gives the essential ratings, characteristics and dimensions of over 400 different silicon rectifiers, zener diodes, thyristors (s.c.rs) and other semiconductor devices. Details of a wide range of standard and custom-built rectifier assemblies are also given.

International Rectifier Company (Great Britain) Ltd., Hurst Green, Oxted, Surrey.

For further information circle 78 on Service Card

Environmental Test Laboratories. A 10-page illustrated catalogue describes J. Langham Thompson's environmental test laboratories which are equipped for testing equipment, subassemblies and components to most current specifications.

J. Langham Thompson Ltd., Dalston Gardens, Stanmore, Middlesex.

For further information circle 79 on Service Card

E.E.A. Guide for Joints on Electronic Equipment: Section 2, Crimped Joints for General-Purpose Electronic Cables. A 12-page publication which is clearly described by its long title.

Electronic Engineering Association, 11 Green Street, London, W.1.

For further information circle 80 on Service Card

Testing Synchros in High and Low Temperatures. In this 8-page brochure a new test fixture, known as Haltata K-165-A, is described. It enables synchros inside temperature cabinets to be remotely positioned; it operates over the range 150 to −65 °C.

Muirhead & Co. Ltd., Beckenham, Kent.

For further information circle 81 on Service Card

Ferranti Numerical Control. Four booklets under this title cover various aspects of the Ferranti system. Section 1, comprising 8 pages, forms an introduction. Section 2 covers the continuous-path control system for machine tools in 12 pages. A co-ordinate positioning control system is the subject of the 8-page Section 3. Finally the 8-page Section 4 deals with industrial measuring equipment.

Ferranti Ltd., Thornybank, Dalkeith, Midlothian.

For further information circle 82 on Service Card

Dentronics Denfoil Precision Die-Cut Strain Gauges. Following a recent agreement Dentronic strain gauges are now available in the U.K. and this 12-page booklet gives comprehensive details of the types available. Distributed by

Coutant Electronics Ltd., 3 Trafford Rd., Richfield Estate, Reading, Berks.

For further information circle 83 on Service Card

COMPONENTS
IMMENSE RANGE—IMMEDIATE DELIVERY

Batteries
Capacitors
Circuit Breakers
Connectors
Counters
Dials
Electronic Sub-Assemblies
Ferrox Cubes
Flip Flops
Fuses & Fuse-holders
Heat Sinks
Instruments
Knobs
Lamps
Lampholders
Motors, Synchronous & Stepping
Potentioneters
Potkors
Printed Circuit Boards & Accessories
Rectifier Stacks
Relays
Resistors
Semiconductors
Switches
Terminals
Terminal Blocks
Thermistors
Valves
Vinkors
Wire (High Temperature)

Distributors for:

American Super Temperature Wires Inc.
Amphenol Borg Limited
Belling & Lee Limited
Casemakers Limited
C.W.C. Equipment Limited
Gulton Industries Limited
A. H. Hunt (Capacitors) Limited
Magnetic Devices Limited
Mallory Batteries Limited
McMurdo Instrument Co. Limited
Measuring Instruments (Pullin) Limited
Mhoglas Limited
Mullard Limited
Mullard Equipment Limited
Painton & Co. Limited
Plessey Company Limited (Havant)
Self-organising Systems, Inc.
Standard Telephones & Cables Limited (E.M. Division, Harlow)
Taylor Electrical Instruments Limited
Thermoplastics Limited
Thorn Electrical Industries Limited
Vero Electronics Limited
Yellow Springs Instrument Co.

SASCO

STEWART AERONAUTICAL SUPPLY CO. LTD.
Adastral House, Nutfield, Redhill, Surrey
Tel.: Redhill 5050 (10 lines)
Cables: SASCO, REDHILL, TELEX
Telex No. 21433

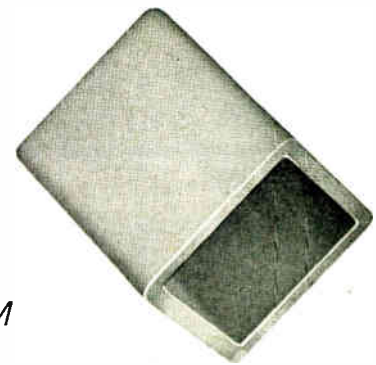
The Materials with the 101 Applications

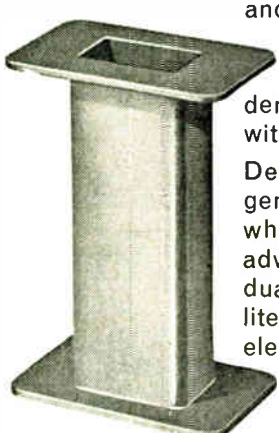
Ask the

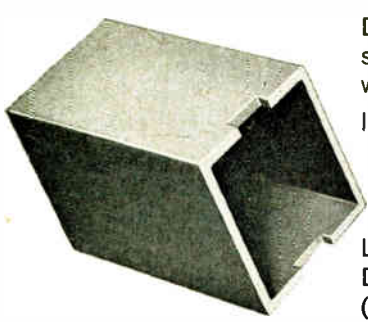
Delanco

BAKELITE TUBE DIVISION

TO ANSWER YOUR PROBLEM







You'll be surprised at the number of applications for Delanco S.R.B.P. and S.R.B.F. tube, both in the electrical and mechanical sections of industry.

In the radio and T.V. worlds they are extensively used for coil formers, sleeves and stand-off insulators and for internally threaded tuning coils to take iron dust cores, as Transformer Bobbins.

In the Condenser trade they are used as condenser casings, from $\frac{5}{8}$" up to 8" internal diameters, with wall thicknesses up to $\frac{1}{2}$".

Delanco S.R.B.F. material has a host of uses in general engineering, for example as pump sleeves, where its resistance to corrosion is a definite advantage over metal. Fuse holders made from a dual material Vulcanised fibre and Delanco Bakelite, giving on the one hand the highest degree of electrical insulation and on the inner tube (vulcanised fibre) the best insurance against arcing.

These are only a few of the many uses, but we want to know of YOUR special problems wherein a bakelite tube might well be a cheaper and more efficient medium.

Delanco tube can be threaded, drilled, tapped, slotted and metal insertions can be incorporated where necessary and desirable.

It is made in round, square and rectangular sections, and we will gladly send your design department an actual sample with technical data, on request.

It conforms to British Standards specs S.B.AC LPT 59, 40, 42, and 58. BS 1314. Types A and C DEF. 500. S.E.S. 12 and BS 1885 Grades 1 and 2. (rectangular).

For reliability and quality use only DELANCO S.R.B.P. Tubes.

ANGLO-AMERICAN VULCANIZED FIBRE CO LTD

CAYTON WORKS · BATH STREET · LONDON E.C.1

CLE 8484 (20 LINES) GRAMS: PROMPSERV, CENT, LONDON

GETTING THE MEASURE OF NOISE

DAWE Type 1419A OCTAVE-BAND SOUND-LEVEL METER

Fully meets B.S. 3489 requirements for Industrial Sound-Level Meters and I.E.C recommendations for Octave Band Filters.

Sound-Level Range	24dB to 140dB in 10dB steps with A, B and C weighting curves to I.E.C. and B.S.
Filters	Band — Cut-off Frequencies Low-Pass 31.5c/s and 90c/s 125c/s 90c/s 180c/s 250c/s 180c/s 355c/s 500c/s 355c/s 710c/s 1000c/s 710c/s 1400c/s 2000c/s 1400c/s 2800c/s 4000c/s 2800c/s 5600c/s High-Pass 5600c/s 8kc/s
Response Relative to Weighting Curve C	Filters 0.5 to −2dB within centre half of an octave (typically ± 0.5dB except 125c/s band) −2 to −6dB at nominal cut-off frequencies (typically −3dB ± 0.5dB except 125c/s band) −35dB min. at frequencies one octave below and above cut-off frequencies (typically −40dB)
Microphone	Rochelle-salt crystal diaphragm type microphone. Temperature range 0 C to 45 C. Maximum relative humidity 85%
Meter	Calibrated from −6dB to +10dB
Output	Full scale deflection of the meter corresponds to approximately 1V into a resistive load of 20k Ω
Power Supply	Three dry cells Type PP4 Ever-Ready or equivalent, or external mains-operated power unit which can be supplied as an accessory
Weight	Only 7lb (3kg)

The Dawe range includes a complete series of instruments for measuring, analysing and recording sound and vibration. Ask for details

DAWE

Full technical data from:—

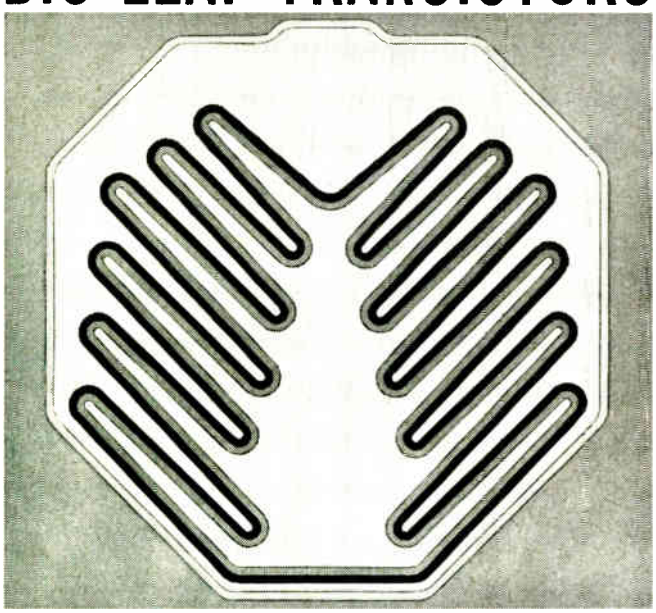
DAWE INSTRUMENTS LTD., WESTERN AVE., LONDON, W.3 Tel: ACOrn 6751

A member of the Siemens group of companies

For further information circle 231 on Service Card

NEW Bendix®

BIG LEAF TRANSISTORS



Bendix Silicon 'Big' Leaf Planar Epitaxial NPN Power Transistor

. . . highest power-frequency combination in the industry

Now with 12 digits instead of six, and 40% greater emission area. This range of leaf transistors will give you Class C power outputs of 25 watts, and gain-bandwidths up to 300 mcs. Applications include HF mobile and portable transmitters; high current switching and high frequency inverters; HF, VHF, Class A and Class C amplifiers and oscillators. 'BIG' stands for *Bendix Interdigitated Geometry*. It stands for still greater overall efficiency—even than its predecessors.

4 FULL RANGES OF SPECIALISED SEMI-CONDUCTORS

- **SILICON LEAF TYPE POWER TRANSISTORS**
- **SILICON POWER VARACTOR DIODES**
- **GERMANIUM DIFFUSED ALLOY POWER TRANSISTORS**
- **SILICON POWER RECTIFIERS**

Full information from the U.K. Distributors for Bendix International Operations, the Bendix Corporation:—

FieldTech Ltd

LONDON AIRPORT·HOUNSLOW·MIDDLESEX

Telephone: SKYport 2141 · Telex 23734 · Cables: Fieldtech Lonconairport

For further information circle 232 on Service Card

KEEP COUNT

with ENM Electrical Impulse counters

Any measurements of quantity, size, time, weight, speed, temperature, fluid-flow, when converted to electrical impulse, can be recorded and printed.

Model 481

Six figures—Add only or add and subtract. Manual, Semi-Automatic and Fully Automatic printing on paper roll, card or card sets.

Up to 3000 counts per minute (add)—2600 (add and subtract).

Electrical reset to zero, or non-reset.

Panel Size: 3.75 in. (95.3 mm.) x 8.30 in. (210.8 mm.).

1 2 3 4 5 6

Actual Printing Size

Model 443

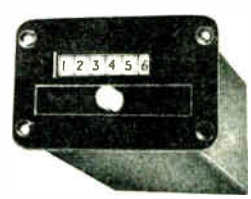
Six figures—Add only or add and subtract. Manual or Electrical Reset or non-reset.

Standard Models—up to 2100 counts per min.

High Speed Models—up to 3000 counts per min.

Panel Mounted only.

Panel Size: 1.8 in. (46.0 mm.) x 2.75 in. (69.0 mm.)



1 2 3 4 5 0

Actual Indicating Size

Write for fully illustrated data sheets and information regarding your particular counting applications.

ENGLISH NUMBERING MACHINES LTD

DEPT. E.10, QUEENSWAY, ENFIELD, MIDDLESEX. TEL: HOWARD 2611. TELEX: 24725

For further information circle 235 on Service Card

ARE YOU UP-TO-DATE WITH YOUR SOLDERING TECHNIQUE?

A popular Adamin mains model is the C10L, shown on a Bench stand, which we also manufacture. This model is probably the smallest mains voltage model in the world. BIT DIAMETER, 3/32 in. LENGTH, 7 in. WEIGHT, ½ oz. (Less Flex). HEATS IN 30 seconds.

There is a large range of instruments (BIT sizes 1/32 in. to 13/32 in.) and accessories marketed under the names of . . .

ADAMIN and LITESOLD

Get the brochures and see for yourself what others are using !

Brochures A & L33

post free from the sole proprietors:—

LIGHT SOLDERING DEVELOPMENTS LTD.

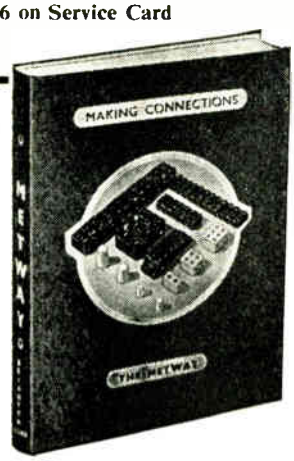
28 SYDENHAM ROAD, CROYDON, SURREY. Telephone: CROydon 8589

For further information circle 236 on Service Card

Just issued!

METWAY 1964

TERMINAL BLOCK CATALOGUE



175 PAGES OF TERMINATIONS

Block Connectors to suit every application . . .

We are proud to announce our new catalogue detailing the widest range of Terminal Blocks ever collected into one catalogue. Included also are numerous other useful Wiring Accessories—Rubber Grommets, Plastic Cable Bands, Clips, Saddles, etc.

● Please note that this extensive catalogue can only be sent against direct application on Trade Letter Heading.

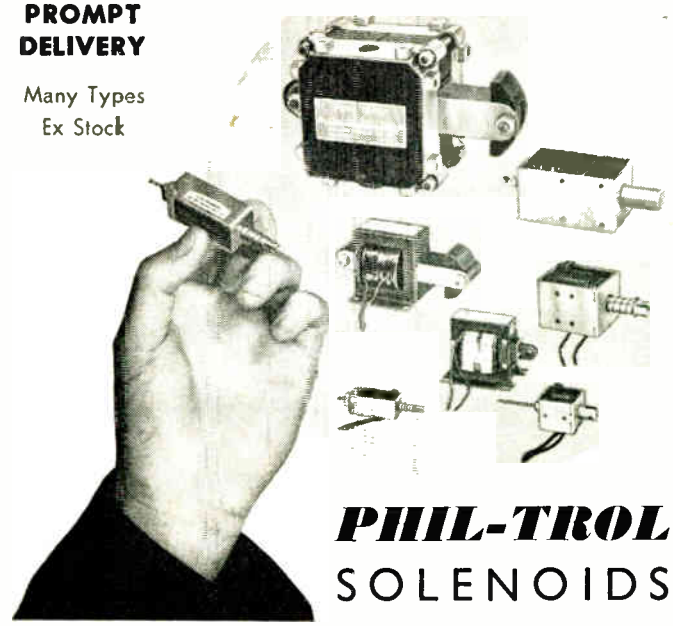
Ask for Cat. No. ME1 62 IE

METWAY · KEMP TOWN · BRIGHTON 7

For further information circle 237 on Service Card

PROMPT DELIVERY

Many Types Ex Stock



PHIL-TROL SOLENOIDS

Type 45 with spring return and thrust as shown in the hand is one of the most popular of the Phil-trol range—can be arranged in banks with ⅜" spacing suitable for typewriter keys, etc. Phil-trol offer a complete range of AC and DC miniature, medium and large solenoids, Push or Pull, spring return and C.O. switched models if desired.

Send for leaflet No. 108a and complete price list.

PHILLIPS CONTROL (G.B.) LTD.

Dept. K7, Farnborough Rd., Farnborough, Hants

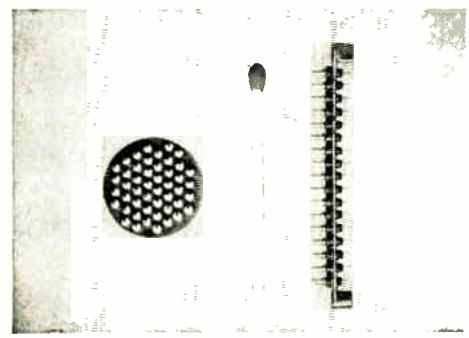
Telephone: Farnborough 1120 *Grams & Cables: Philtrol, Farnborough, Hants*

For further information circle 238 on Service Card

OXLEY

BARB INSULATORS

TYPE 062



Working voltage 500 V DC

Capacity less than .5 pF

Temperature range −55°C to +200°C

Resistance to pull in either direction 3 lbs.

Chassis thickness ⅛" = 22/24 SWG = .022"/.028" = 0.56/0.72 m/m.

Mounting hole dia. .062" = 1/16" = 1.58 m/m.

A new subminiature insulator, which is speedy to assemble, and with outstanding physical characteristics. The P.T.F.E. bush, which is supplied with the heavily silver plated brass 'barb' partly inserted, is located in an ordinary .062" dia. hole and the barbed spill is pressed firmly through the assembly, thus expanding the P.T.F.E. bush on the far side of the chassis and locking the complete assembly firmly in the chassis.

Write for technical details of these and other Oxley products:

OXLEY DEVELOPMENTS CO. LTD.

ULVERSTON, LANCASHIRE

For further information circle 244 on Service Card

Brady Pressure-Sensitive, All-Temperature Wire Markers for small gauge wires are exactly ¾" long to fit wires under ¼" o.d. They cut your small gauge wire marking costs in half because:

1. They cost half the price of Standard Markers, and
2. They go on the wire twice as fast.

You can't drop Brady Wire Markers—*they stick to your finger from Card to wire.** Stick and *stay stuck*—at temperatures to 400°F.! Choose from over 3,000 different stock markers—both Standard and Small Gauge Size. Specials made to order. Write for big new bulletin and free testing samples *today!*

* Remember, too, Brady makes the only marker that can be machine applied.

W. H. BRADY CO. LTD. (formerly SIMPSON BRADY LTD.)

BREAKSPEAR ROAD, RUISLIP, MIDDX. Tel: RUISLIP 2245

Manufacturers of Quality Pressure-Sensitive Industrial Tape Products, Self-Bonding Nameplates, Automatic Machines for Dispensing Labels, Nameplates, Masks and Tape.

For further information circle 245 on Service Card

An essential book for research workers and designers . . .

MICROWAVE DATA TABLES

by A. E. Booth, M.I.R.E., GRADUATE I.E.E.

This book forms an accurate and labour-saving aid for computations involving basic microwave quantities which occur continually in design and development work on waveguides and similar transmission lines, such as decibel relationships, guide and free-space wavelengths, voltage standing-wave ratio, and voltage or power reflection coefficients. Printed on stout paper and strongly bound to withstand constant usage in design office or laboratory, it contains 26 tables comprising over 23,000 separate computations. The figures in the tables have been computed on a Pegasus electronic digital computer to the limit of practical measuring accuracy.

27s. 6d. net

by post 28s. 8d.

Over 23,000 separate computations

from leading booksellers

Published by

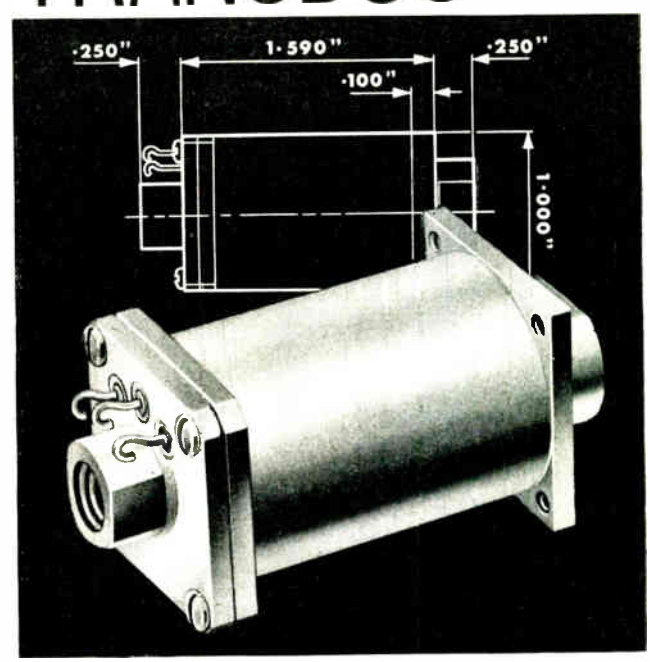
ILIFFE Books Ltd.,

Dorset House, Stamford Street, London, S.E.1

For further information circle 246 on Service Card

SMALLER...STURDIER

MINIATURE TRANSDUCERS



for higher outputs without amplifiers

Great accuracy, robustness and reliability make these miniature transducers specially suitable for use in aircraft and missile applications. They comply fully with military vibration shock and temperature specifications, and their performance is unaffected by a wide range of adverse conditions, including accelerations up to 30G.

Colvin transducers, supplied by Rotax, have extremely small space requirements, yet produce the fast responses and high output voltages necessary for advanced systems. Why not contact Rotax and talk over your transducer problems with one of their engineers?

Rotax supply transducers in three ranges:

Differential Pressure	± 0.5 to ± 200 psid
Absolute and gauge pressure	0—0.5 p.s.i. to 0—10,000 p.s.i.
Displacement	Strokes from 0.1 to 0.5 in.

ROTAX

INSTRUMENTATION DIVISION

ROTAX LIMITED, INSTRUMENTATION DIVISION, WILLESDEN JUNCTION, LONDON, N.W.10 TELEPHONE ELGAR 7777

INDUSTRIAL ELECTRONICS

Press date for the March 1964 issue is first post 27th February 1964

CLASSIFIED ADVERTISEMENTS

Advertisement Rates. *6d. per word, minimum charge 6/-, each paragraph charged separately. Remittances payable to "Industrial Electronics", Dorset House, Stamford St., S.E.1. Series discount of 15% is allowed for 12 consecutive insertions.*

Box Numbers *are available at an additional charge of 2/- to defray cost of registration and postage. Replies should be addressed Box No. 0000, c/o "Industrial Electronics", Dorset House, Stamford Street, London, S.E.1.*

Semi-Display *advertisements with centralized lines £1/15/- per single column inch,*
Display *advertisements £2/10/- per single column inch—no additional charge for Box Numbers. The Publishers are not responsible for clerical or printers' errors although every care is taken to avoid mistakes.*

SERVICES OFFERED

Precision Sheet Metal Work for the Radio & Electrical Trade. Chassis, Panels, Brackets, etc. Power Press Capacity up to 100 tons. Press brake capacity up to 105 tons 8ft. x 7/32in. All spray and stove finishes. A.I.D. approved. — The Kaymet Company, Kaymet Works, Sylvan Grove, London, S.E.15. Telephone: NEW Cross 6644.

|2036

CAPACITY AVAILABLE

AIRTRONICS LTD.

for coil winding assembly and wiring of electronic equipment, transistorised sub-units.

4 Ashmead Road, London, S.E.8

Telephone: Tideway 2249

|2043

PATENTS

Patent No: 862,129 entitled "Interlocked Contactor for the Control & Reversal of Three-phase Electric Motors", is for sale or licence. For details apply to CHATWIN & COMPANY, Chartered Patent Agents, 253, Gray's Inn Road, London, W.C.1.

|2045

MISCELLANEOUS

PHOTO-ELECTRIC CONTROLS
for industry

Send for catalogues
HIRD-BROWN LIMITED
FLASH STREET, BOLTON
Telephone 27311

|2027

SCRAP METAL

Non-ferrous Scrap Metals, all grades, Swarf, Off-cuts, etc., purchased at highest rates.
H. Barnett Ltd.,
Victor Road, London, N.7.
Est. 1865 ARChway 5461

|2041

MAGNET PRODUCTION

Assistant Plant Manager

required preferably with experience in production of magnets. Excellent opportunity for young Physicist interested in production of permanent magnets, development of their application and control of magnetic testing, etc. Good progressive salary.

Write giving full details to

Staff Department

MUREX LTD

Rainham, Essex

CRANFIELD

POSTGRADUATE SHORT COURSES

MICROWAVE LABORATORY PRACTICE — 27th April to 1st May, 1964

This is a predominantly practical course of instruction provided for those qualified in the theory of microwaves and wishing to gain practical experience in modern techniques of ultra high frequency and microwave measurement.
Fees, covering tuition, full board and accommodation **25 guineas**

DIGITAL TECHNIQUES — 4th to 15th May, 1964

The scope of the course which will include theoretical and practical work, will be broad, covering not only digital computer fundamentals but also the important industrial fields of application of digital instrumentation and control.
Fees, covering tuition, full board and accommodation **50 guineas**

Further information and forms of enrolment from:
The Registrar
The College of Aeronautics
Cranfield, Bletchley, Bucks.

For further information circle 250 on Service Card

Numerical methods for high speed computers

G. N. Lance, M SC, PH D, MAIS, AFR AE.S

This book assembles the most useful numerical methods developed by research mathematicians, with the particular aim of explaining the facilities that computers offer. Most of these methods have never been published before except to a very limited readership and all have been tested for their practical value. The book will be found invaluable by mathematicians, programmers, engineers, physicists and scientists generally.

42s net by post 42s 11d 166 pages **from leading booksellers**

Published by ILIFFE Books Ltd.
DORSET HOUSE, STAMFORD STREET, LONDON, S.E.1

AUTOMATION STAFF TECHNICIANS

Following developments affecting the Automation Department, The Steel Company of Wales Limited, Steel Division, will appoint Staff Technicians for the maintenance of advanced Process Control Systems associated with the hot and cold rolling of steel sheets. Applicants should have experience of electronic applications in heavy industry and/or a knowledge of Digital and Analogue techniques, including preferably Digital Computers.

Successful applicants may be called upon to work shifts. They will be given training on two different Digital On-Line Process Control Computers and associated electronic control equipment.

An academic qualification to H.N.C. or final City & Guilds standard is expected. Applicants not having these qualifications but possessing considerable experience in the Computer field will also be considered.

The successful candidates will be required to work at the Abbey Works of the Company which is situated on the sea coast at Port Talbot. The Company operates a generous Contributory Pension Scheme and provides generous assistance with removal and other expenses.

Please write for application form to:

THE SUPERINTENDENT OF PERSONNEL SERVICES
THE STEEL COMPANY OF WALES LIMITED
STEEL DIVISION, PORT TALBOT, GLAMORGAN

Index to Advertisers

Adcola Products Ltd. 11
Aircraft Marine Products Ltd..... 2
Anglo-American Vulcanized Fibre Co. Ltd. 22
Appointments Vacant 31
Aveley Electric Ltd. 6

Brady, W. H. Co. Ltd. 29

Cannon Electric (G.B.) Ltd. 28
Cole R. H. (Electronics) Ltd. 25

Datum Metal Products Ltd. 12
Dawe Instruments Ltd. 23

Electrothermal Eng. Ltd. 25
English Numbering Machines Ltd. 24
Ericsson Telephones Ltd. 15
Erie Resistor Ltd. ..... *Cover iv*

Ferranti Ltd. 13
Fieldtech Ltd. 24

Hughes International (U.K.) Ltd... 18

Iliffe Books Ltd. 29, 30, 31, 32
International Rectifier (Gt. Britain) Ltd. 20

Karstens Georg GMBH 30

Light Soldering Developments Ltd. 26

Martindale Electric Co. Ltd..... 30
Metway Electrical Industries Ltd... 26
M.O. Valve Ltd. 1
Mullard Equipment Ltd. .... *Cover ii*
Mullard Ltd. 4, 5
Murex Ltd. 27

Oxley Developments Co. Ltd. 26

Phillips Control (G.B.) Ltd. 26
Plannair Ltd. 3

Reliance Controls Ltd. 14
Rotax Ltd. 29

Siemens & Halske A.G. 25
Silentbloc Ltd. 10
SPS International Ltd. 28
Standard Telephones & Cables Ltd. 7, 8, 9, 17
Stewart Aeronautical Supply Co. Ltd. 21

Telegraph Condenser Co. Ltd. *Cover iii*

Varian Associates Ltd. 19

Walmore Electronics Ltd. 32
Welwyn Electric Ltd. 16
Whiteley Electrical Radio Co. Ltd. 27

Printed in Great Britain for the Publishers, Iliffe Electrical Publications Ltd., Dorset House, Stamford Street, London, S.E.1, by The Chapel River Press Ltd., Andover, Hants. Distributed in U.S.A. by Eastern News Company, 306 West 11th Street, New York, 14

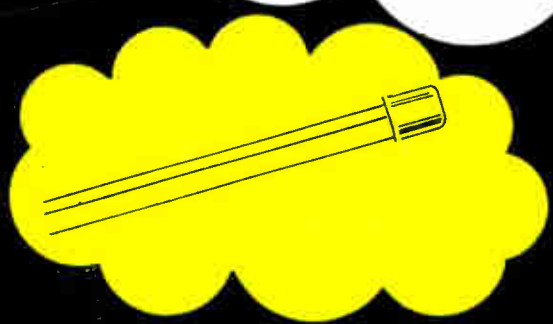
TRANSISTOR SUPPLY PROBLEMS ?

TCC

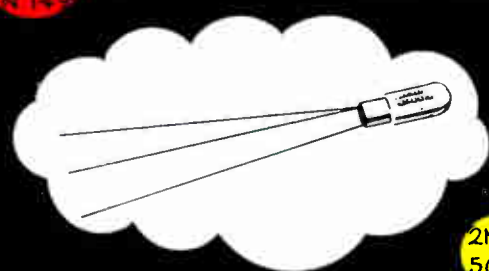
SPRAGUE®

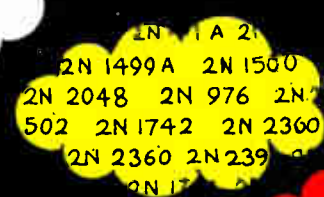
THE MARK OF RELIABILITY

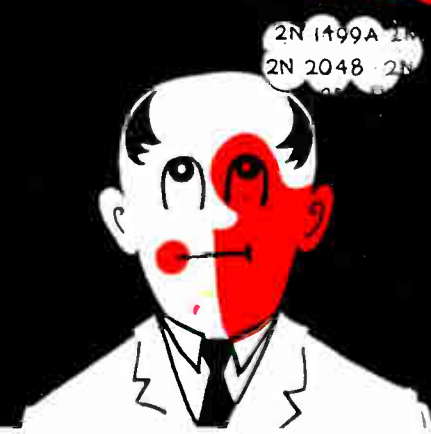
MADT, PNP, SPAT, MAT, ECDC
TRANSISTORS
NOW AVAILABLE IN BRITAIN



Full ranges of silicon planar and germanium transistors previously manufactured by Philco International are now made available to the British market by T.C.C. with the co-operation of their American associates, Sprague Electric Company, who have been manufacturing Philco transistors under licence for the past few years. Many of these high grade transistors meet American military specifications.





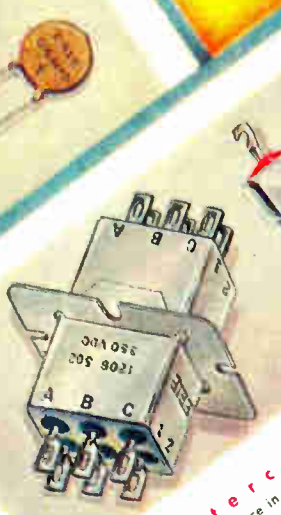


Solve your particular transistor problem by writing to us at Acton for further details of this latest product of the T.C.C. Sprague association.

THE TELEGRAPH CONDENSER CO. LTD.

(*Head Office and Works*) North Acton, London, W.3. Tel: ACOrn 0061
Telex 261383
(*Also at*) Chessington, Surrey · Bathgate, Scotland

For further information circle 202 on Service Card



Erie Filtercons

provide optimum performance in the UHF range of 100 to 2000 Mc/s, for exceeding the performance of a theoretical 1000pF capacitor. They are available as single section units with large or small eyelet mounts as well as in six- and twelve-section units.

Minimum att: 45dB, 200 to 2000 Mc/s
50dB, 100 to 2000 Mc/s
56dB, 50kc/s to 2000 Mc/s
Working volts: 200, 350 or 500 d.c.
Operating Temp: -55°C to +125°C

Write for 'Filtercon' literature

Erie 'Weecon' Ceramicons

are designed to provide the ultimate in miniaturization in ceramic capacitors. The square shape saves expensive printed circuit space. Dimensions: from 0.100in square x 0.100in thick to 0.600 x 0.500 x 0.150in. Operating temperature: -55°C to +85°C at 200V d.c., also available for +125°C operation at lower working voltages.

Capacitance: 2.2 to 43,000pF
Tolerances: ±5% to -20, +80%
Dielectric: P100 to Hi-K

Write for 'Weecon' literature

Erie Solid Moulded Carbon

Erie Metal Oxide Film Resistors

are a precision product made to DEF.5114. Type MOK3 is khaki silicone insulated and Type MOG65 is green silicone insulated. Type MO65 is a ceramic insulated unit made to NATO Specifications. Standard tolerances of ±2% or ±5% apply to the MO65 and MOG65 and Life Tolerances of ±5% or ±7% to the MOK3.

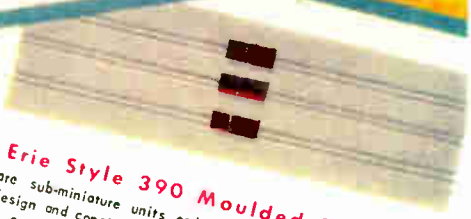
Write for 'Metal Oxide' literature

Erie EDM Series Silver Mica Plate Capacitors

are noted for their outstanding stability and close tolerance characteristics and the dip-coated process which contributes to economy, small size and reliability.

Capacitance: 1 to 40,000pF
Tolerance: ±0.5% (or ±0.5pF) to ±10%
Working Volts: 100 to 2500 d.c.
Operating Temp: -55°C to +125°C
Temp. Coefficient: -0, +70 to ±200 parts/million/°C
Q Factor: 1000 min (except very low values)

Write for 'EDM Plate Capacitor' literature



Erie Style 390 Moulded Capacitors

are sub-miniature units embodying revolutionary features of design and construction to attain a wide range of capacitance in a moisture resistant moulding. Style 390 meets or exceeds requirements of MIL.C-11015.

Capacitance: 5.6 to 1200pF
Tolerance: ±10% to -20, +80%
Working Volts: 100 d.c. at +85°C
50 d.c. at +125°C

Write for 'Style 390' literature

Erie Microcaps

are micro-miniature, high value, disc Ceramicons and represent a further step in Erie developments in the field of micro-miniaturization.

Capacitance: 1000, 2200, 4700, 10,000pF
Tolerance: +80, -20%
Dimensions: 0.08in to 0.20in diameter
Working Volts: 30 d.c. at from -40°C to +85°C
Power Factor: 3% max.
Dielectric: K7004

Write for 'Microcap' literature

Erie Feed-Thr

...on efficient means of by-pas... ...at all frequencies and they are therefore, ideal fo...

...Carbon resi... ...preferred ...values

ERIE ★ ELECTRONIC COMPONENTS

*Registered Trade Marks

ERIE RESISTOR LIMITED SOUTH DENES GT YARMOUTH • Telephone: 4911 Telex: 1720