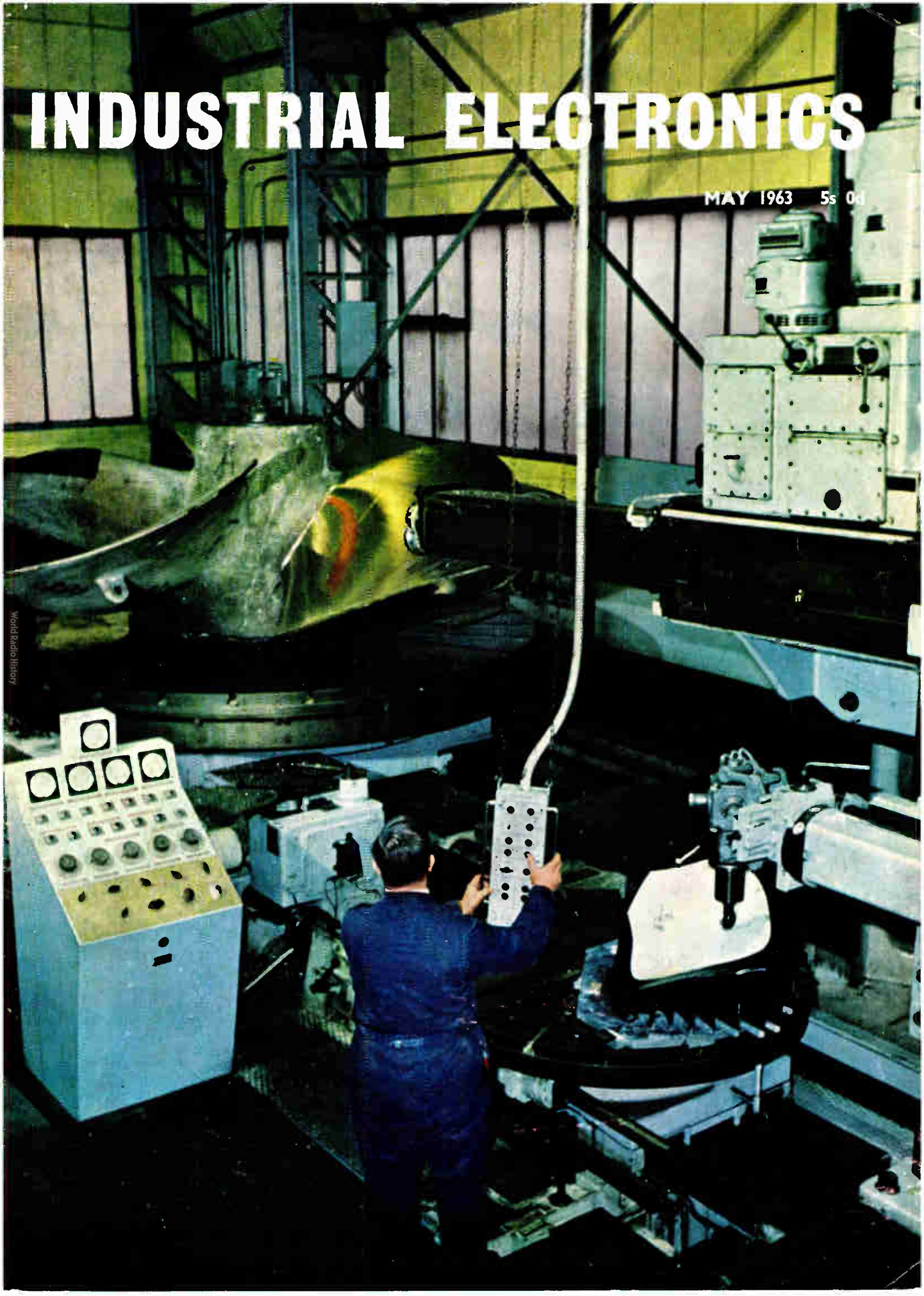
INDUSTRIAL ELECTRONICS

MAY 1963 5s 0d



BICC

R.F.

SUB-MINIATURE COAXIAL CABLES

for miniaturized electronic equipment

These extremely small coaxial radio frequency cables offer great savings in size and weight. Overall diameters are, for instance, less than 0.1 inch.

The cables are of particular interest to designers of miniaturized electronic equipment, both ground and airborne.

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BRITISH INSULATED CALLENDER'S CABLES LIMITED, 21 Bloomsbury Street, London, W.C.1

INDUSTRIAL ELECTRONICS

incorporating *ELECTRONIC TECHNOLOGY*

Volume 1 Number 8 May 1963

contents

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

Assistant Editor **T. J. BURTON**

Advertisement Manager **G. H. GALLOWAY**

continued overleaf

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ILIFFE ELECTRICAL PUBLICATIONS LTD.
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Dorset House, Stamford Street, London, S.E.1.
Telephone: Waterloo 3333.
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ANNUAL SUBSCRIPTION, £3 0s. 0d.,
CANADA and U.S.A. $8.50.

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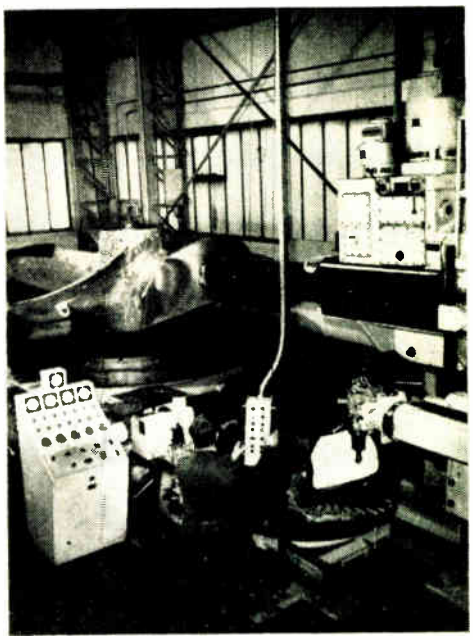
FEATURES



OUR COVER

The picture shows a ship's propeller being machined at the Greenwich works of Stone Manganese Marine Ltd. The machine has been designed and built by Craven Brothers (Manchester) Ltd. in collaboration with A.E.I. Electronic Apparatus Division and is controlled by following the contours of a small model of the propeller.

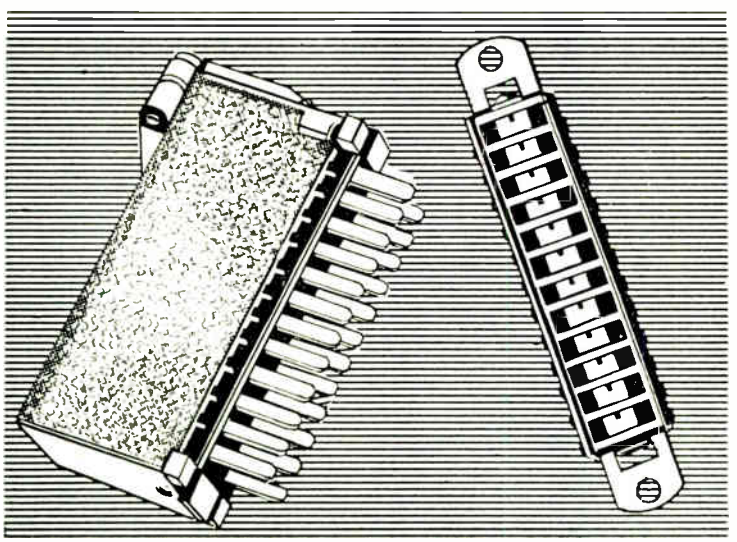
Next Month

The use and applications of storage cathode-ray tubes in instrumentation will be described in the June issue. Other articles will deal with the electronic control of register in a flying-splice printing machine and with the Radio and Electronic Component Show.

TO SAVE YOUR TIME

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

PAINTON RELIABILITY at the R.E.C.M.F



Exemplified in 159 SERIES CONNECTORS

- 7 way to 31 way
- new space saving configuration
- new metal case with bonded plastic protection
- robust construction

As a result of the years of experience gained in the production of our world-famous Multicon range, a remarkably high standard of electrical performance has been designed into this new series.

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KINGSTHORPE . NORTHAMPTON
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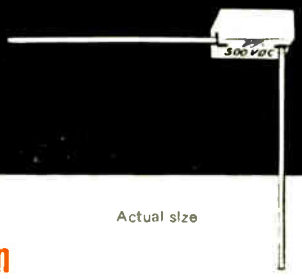
VITRAMON

high reliability micro-miniature capacitors

"VITRAMON"— world famous name in capacitors — now produce these essential components in their new factory at Harmondsworth. A unique manufacturing process; rigid production control and testing; the use of high quality materials ensure the high degree of reliability guaranteed by "VITRAMON" Capacitors.

VY



Actual size

porcelain

monolithic body
high stability
low loss
axial-radial leads

CAPACITANCE RANGE	1—4,700 pf
TEMPERATURE RANGE	—55°C to +125°C
CHANGE IN CAPACITY over temperature range	2%
PREDICTABLE within	5 ppm
STABILITY	0.05%
VOLTAGE COEFFICIENT	nil
PROOF VOLTAGE 10 seconds	
500 volts rating	2000 volts
300 volts rating	1200 volts
POWER FACTOR	
20°C	0.0006
125°C	0.0010
INSULATION RESISTANCE	
20°C	100,000 megohms
125°C	10,000 megohms
WEIGHT of VY 16	2 32 gm
CAPACITY per cubic inch	.06 μf

RELIABILITY After testing at 150% of rated voltage for 2000 hours at 125°C. power factor is .003 maximum and insulation resistance 10,000 megohms (measured at 125°C) for all parts.

VK

Actual size

ceramic

high capacity/volume
precision case
radial leads
extreme reliability

CAPACITANCE RANGE	10—10,000 pf
TEMPERATURE RANGE	—55°C to +125°C
CHANGE IN CAPACITY over temperature range	30%
PREDICTABLE within	5%
STABILITY	approx. 5%
VOLTAGE COEFFICIENT	—0.1% per volt
PROOF VOLTAGE 10 seconds	
200 volts rating	800 volts
POWER FACTOR	
20°C	0.025
125°C	0.015
INSULATION RESISTANCE	
20°C	100,000 megohms
125°C	1,000 megohms
WEIGHT	0.5 gm
CAPACITY per cubic inch	1 μf

RELIABILITY After testing at 200% of rated voltage for 1000 hours at 150°C, power factor is .025 maximum and insulation resistance 1000 megohms (measured at 125°C) for all parts.

Vitramon

For further details please write to

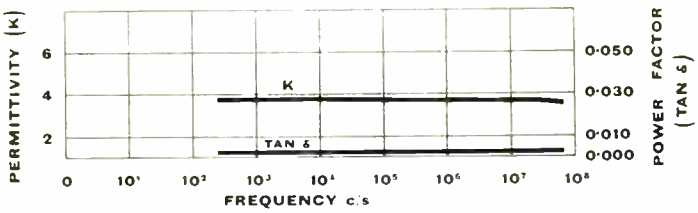
VITRAMON LABORATORIES LTD.
45 Holloway Lane, Harmondsworth, Middlesex. Telephone: Skyport 1829
Export Enquiries: Dage Corporation, 219 East 44 Street, New York 17, N.Y.

MC & P V2

SILICONE RESIN-BONDED GLASSCLOTH LAMINATES offer:

- excellent dielectric properties over a wide frequency range
- low water absorption
- high arc resistance
- operation up to 250°C.

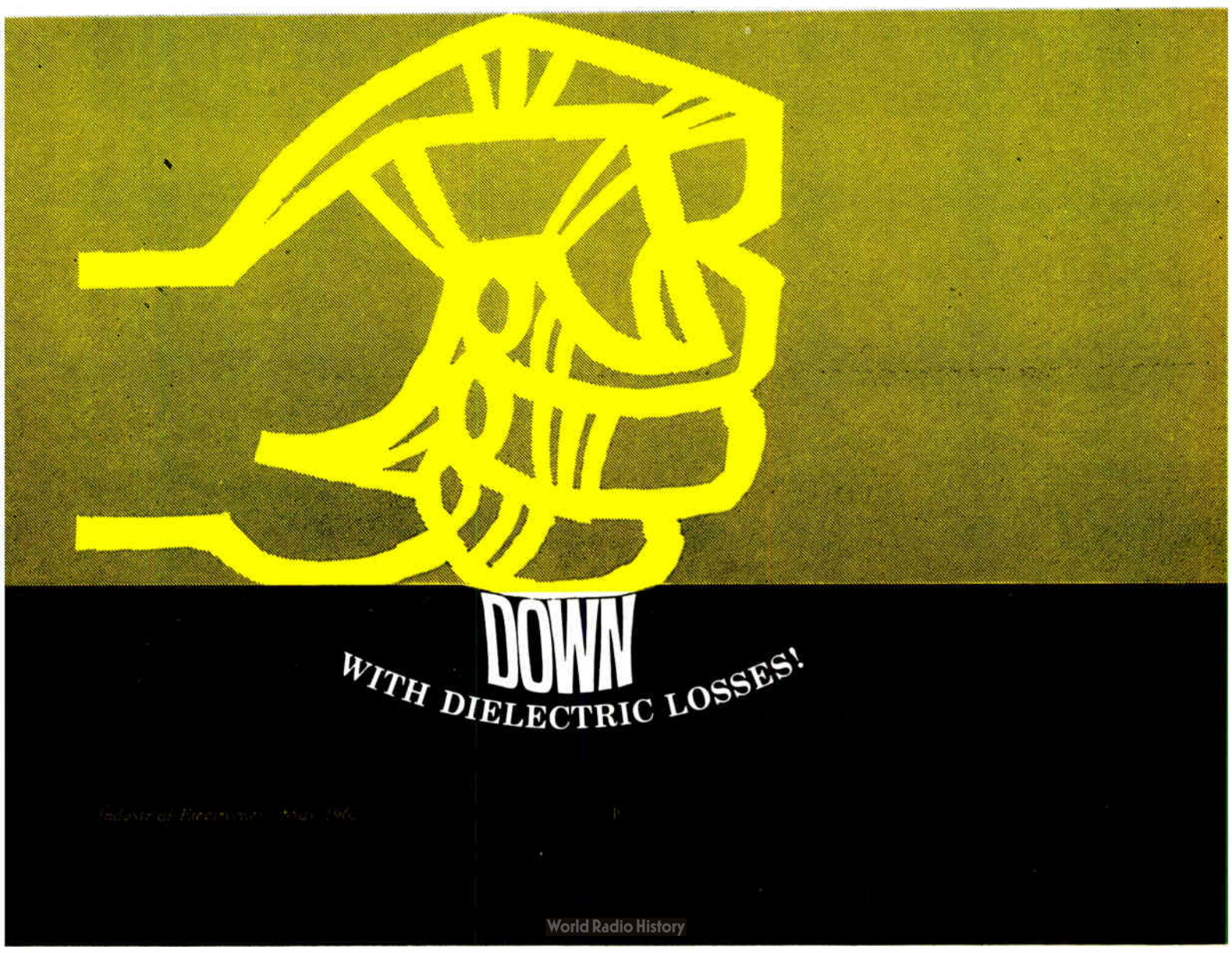
Available in a wide variety of shapes, the applications of silicone-glass laminates include: printed circuits, coil formers, and supporting or separating materials in all types of electrical equipment.

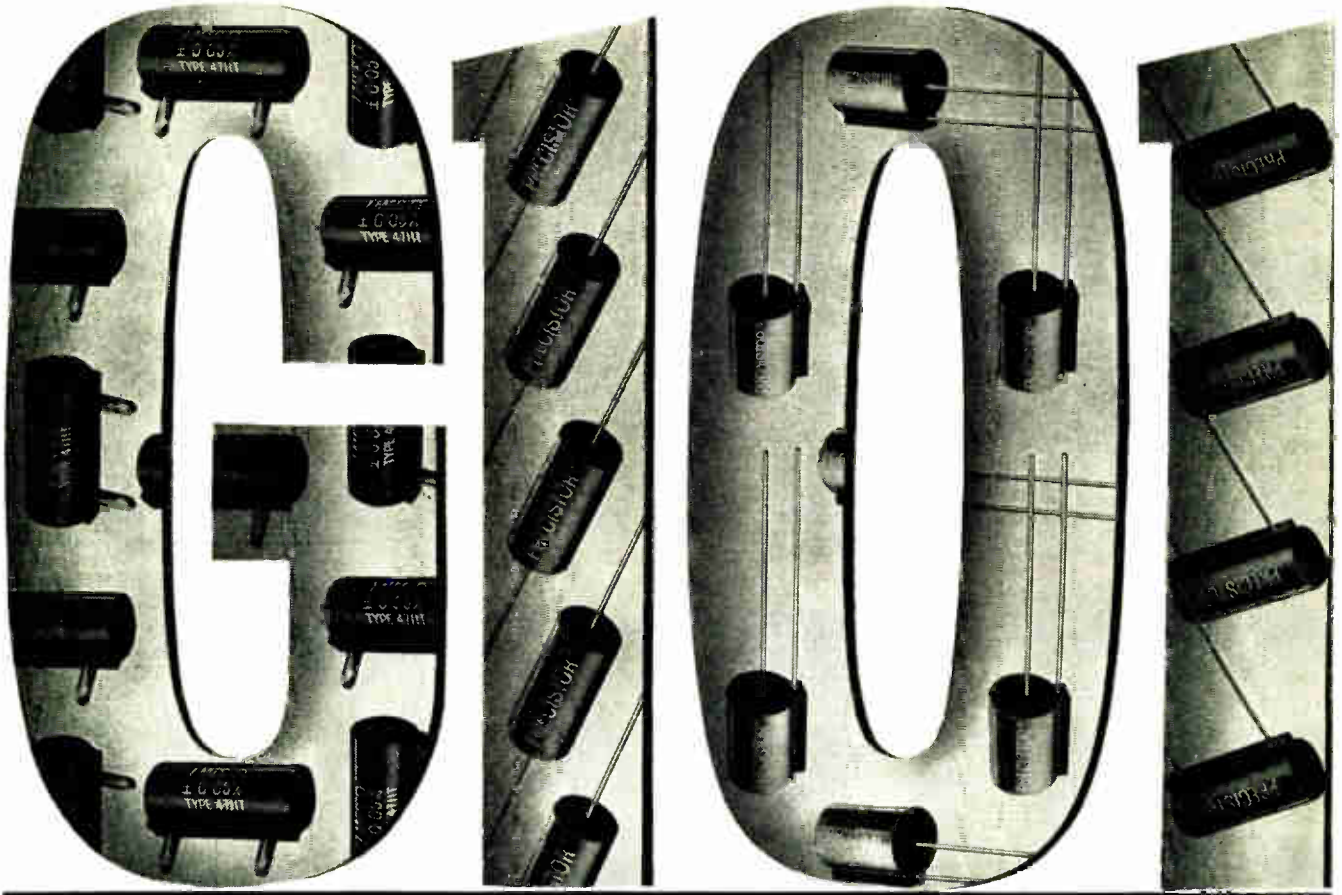


SEE how MS Silicones are used in Electronics
Stand 312, RECMF, 21st-24th May

For a guide to the properties and applications of silicone-glass laminates and a list of manufacturers please write for our booklet **L18.**

MS MIDLAND SILICONES LTD *first in British Silicones*
(Associated with Albright & Wilson Ltd. and Dow Corning Corporation)
68 Knightsbridge, London, SW1 Tel: Knightsbridge 7801
Area Sales Offices: Birmingham, Glasgow, Leeds, London, Manchester. *Agents in many countries*





NEW ALL MOULDED PRECISTOR®

This new series of moulded precision wire-wound resistors has been designed to meet the requirements of British and N.A.T.O. Defence specifications and are fully sealed to withstand extreme climatic and humidity conditions.

They can be seen in action at our "On Test" exhibit on STAND 204 at the R.E.C.M.F. Exhibition at Olympia. Please send for an illustrated leaflet (Publication No. 388) for full details of these new components.

WATTS	DIMENSIONS Length Inches	Diameter Inches
0·10	0·437	0·218
0·15	0·500	0·250
0·20	0·900	0·250
0·25	0·500	0·350
0·50	0·787	0·350
1	0·100	0·475
2	1·662	0·475
2	2·162	0·975

TOLERANCE
AS CLOSE AS 0·01%

TEMPERATURE CO-EFFICIENT
DOWN TO 5 p.p.m °C

TEMPERATURE RANGE
−65°C to +140°C

STABILITY
BETTER THAN 0·03%

VALUES
5Ω to 10 MΩ

Electrothermal
ENGINEERING LTD
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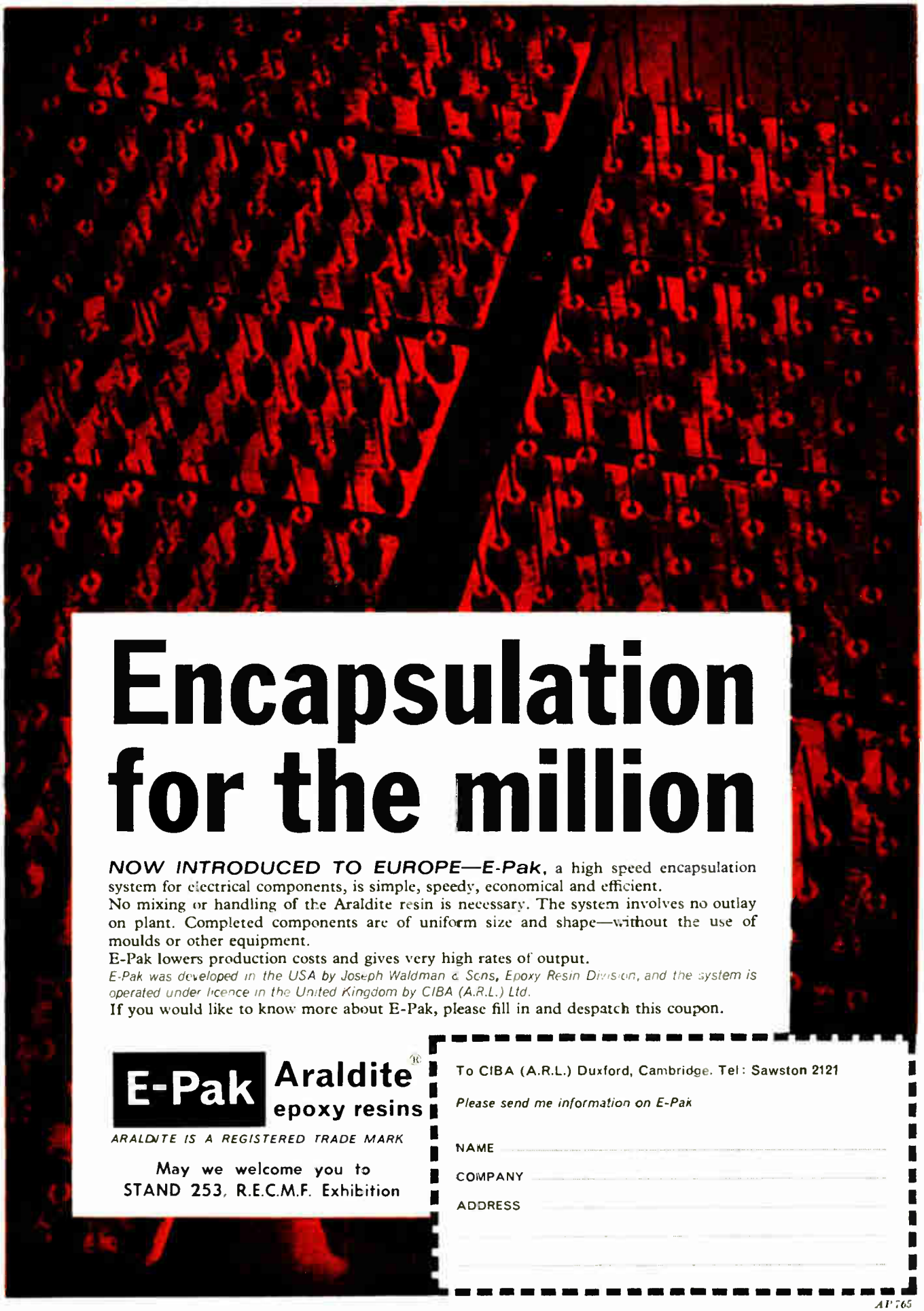
GRAngewood
9911

R.E.C.M.F.
STAND
204

See them at work on our stand



Encapsulation for the million

NOW INTRODUCED TO EUROPE—E-Pak, a high speed encapsulation system for electrical components, is simple, speedy, economical and efficient.
No mixing or handling of the Araldite resin is necessary. The system involves no outlay on plant. Completed components are of uniform size and shape—without the use of moulds or other equipment.
E-Pak lowers production costs and gives very high rates of output.
E-Pak was developed in the USA by Joseph Waldman & Sons, Epoxy Resin Division, and the system is operated under licence in the United Kingdom by CIBA (A.R.L.) Ltd.
If you would like to know more about E-Pak, please fill in and despatch this coupon.

E-Pak **Araldite®** **epoxy resins**

ARALDITE IS A REGISTERED TRADE MARK

May we welcome you to
STAND 253, R.E.C.M.F. Exhibition

To CIBA (A.R.L.) Duxford, Cambridge. Tel: Sawston 2121

Please send me information on E-Pak

NAME .....

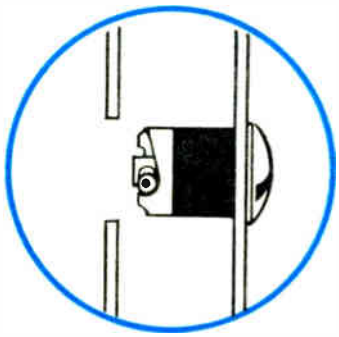
COMPANY .....

ADDRESS .....

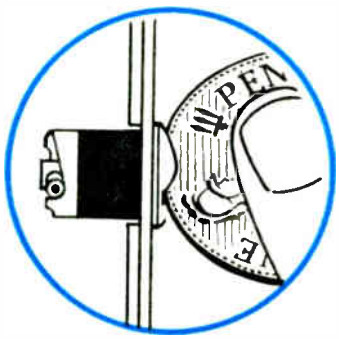
AP 765

Vibrex quick-action fasteners

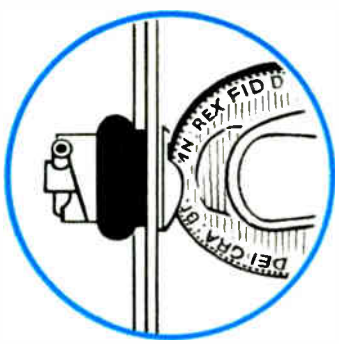
have hundreds of uses in every industry



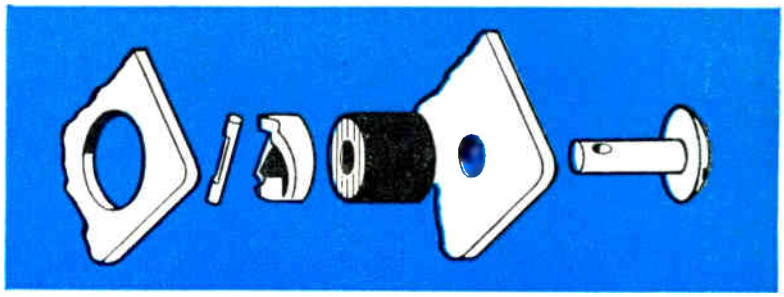
VIBREX fastener is assembled through hole in panel . . .



. . . inserted in hole in base . . .

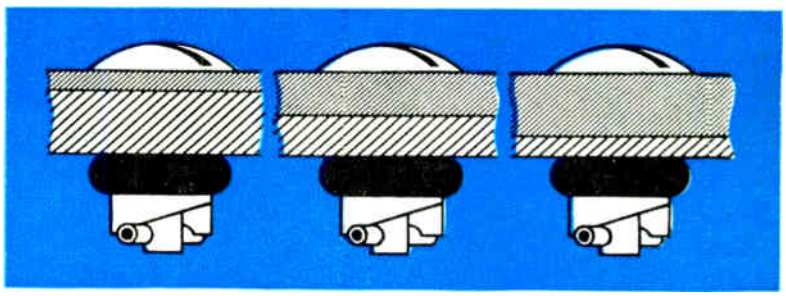


. . . a half-turn of the head locks or unlocks instantly . . .



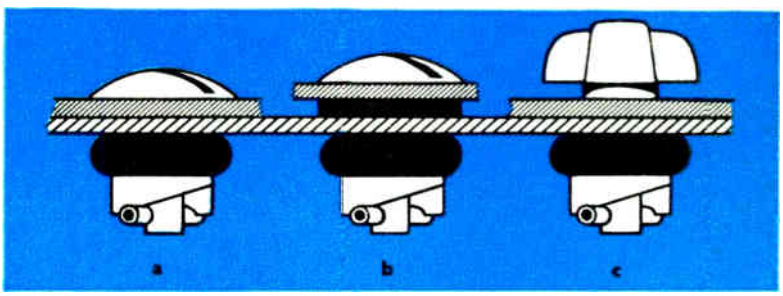
SIMPLICITY:

only two holes to drill—no tapping, brazing, welding or rivetting.



ADAPTABILITY:

standard VIBREX fasteners are available to accommodate any combination of panel and base thickness up to 1″. Greater thicknesses to special order.



CHOICE OF TYPES:

as well as the standard type (a), VIBREX fasteners can be supplied with rubber cushions (b) giving electrical and mechanical insulation. In certain sizes, either type is available with wing head (c) instead of the standard slot head.

Vibrex quick-action panel fasteners by

SILENTBLOC

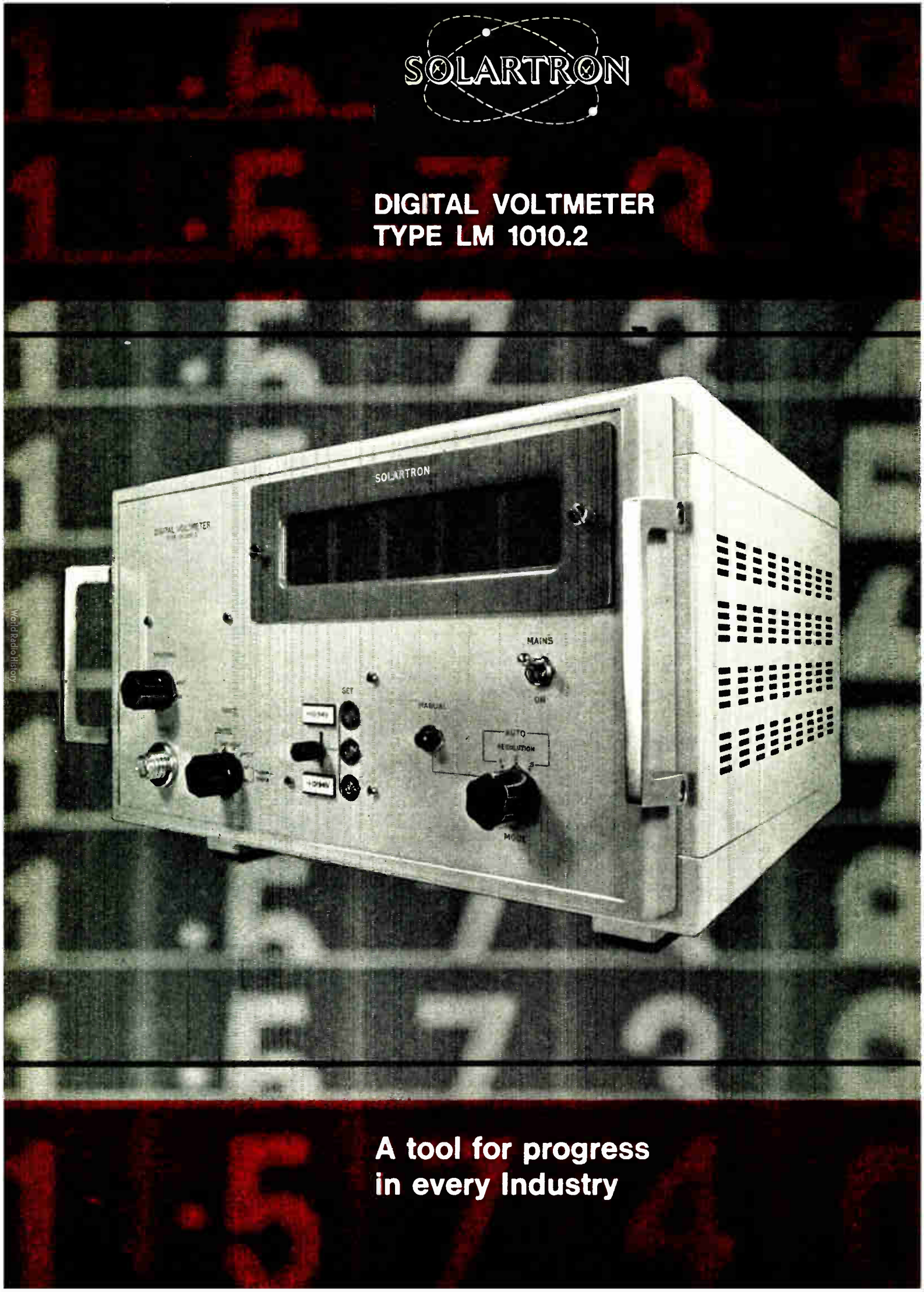
SILENTBLOC LTD
MANOR ROYAL · CRAWLEY · SUSSEX
Telephone: Crawley 27733 Telegrams: Silentbloc Crawley

Andre Rubber Co. Ltd. is another Silentbloc Company

Silentbloc products are also manufactured by Silentbloc (Australia) Pty. Ltd., Melbourne Broadway 5207

SOLARTRON

DIGITAL VOLTMETER
TYPE LM 1010.2



A tool for progress in every Industry

SOLARTRON

DIGITAL VOLTMETERS

HAVE THESE ADVANTAGES

Constant percentage accuracy of reading over the entire voltage range – not just at full scale!
Successive approximation techniques using solid state switching to give greater reading speeds (50 per second) and improved reliability.
An input impedance greater than 1000 M_Ω on the most sensitive ranges ensures accuracy of reading and permits capacitance transfer techniques for high common mode rejection.
Automatic resolution control and a.c. filtering facilitates use on noisy inputs.
Decimal or binary-coded-decimal print-out signals for use with the Solartron High Speed Printer.
Oven controlled Weston standard cell and sampling resistors to maintain high accuracy.
Co-planar projection displays free from flicker.
New plug-in modular concept gives greater accessibility.

3 DIGIT LM 901
Accuracy: ± 0.25% of full-scale.
Range (f.s.): 0.999 V-99.9 V in 3 ranges.
Max. Resolution: 1mV.

4 DIGIT LM 902.2
Accuracy: ± 0.07% of full-scale or ± 1 bit.
Range (f.s.): 0.1599 – 1599 V in 5 ranges.
Max. Resolution: 100μV.

5 DIGIT LM 1010.2
Accuracy: ± 0.02% of reading ± 1 bit.
Range (f.s.): 0.15998 – 1599.9 V in 5 ranges.
Max. Resolution: 20μV.

6 DIGIT LM 904
Accuracy: ± 0.01% of reading
or 0.003% of range.
Range (f.s): 2.99980 – 2999.80V in 4 ranges.
(Input limited to 1.5kV).
Max. Resolution: 50μV.

For full details write to:

THE SOLARTRON ELECTRONIC GROUP LTD. (Instrument Division)

Victoria Road, Farnborough, Hants.
Telephone: Farnborough (Hants) 3000
Telex 8545 Solartron Fnbro.
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M & P S141

"Here's a really lively character!"

says Mini Tronic

THE NEW HARWIN 12 Character INDICATOR UNIT

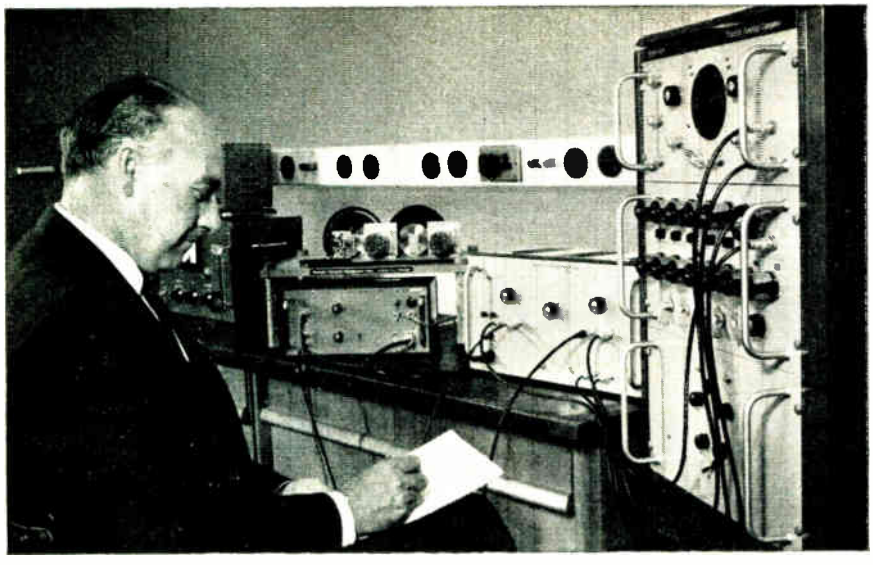
The new HARWIN Indicator Unit is a marvel in miniature equipment. Only $2\frac{31}{32}$" long × 1" wide and $1\frac{7}{64}$" deep, (excluding plug pins), it is fitted with a plug base and mounting socket for instant interchange without tools, and it uses bulbs of 28, 12 or 6 volts. Although its glass window is only 1" · $\frac{3}{4}$", it gives a brighter display and maximum clarity and visibility. Like all HARWIN miniature electronic components it's a precision made instrument, backed by the HARWIN speed of service.
Send for illustrated leaflet.

Smaller... Lighter... Brighter

HARWIN

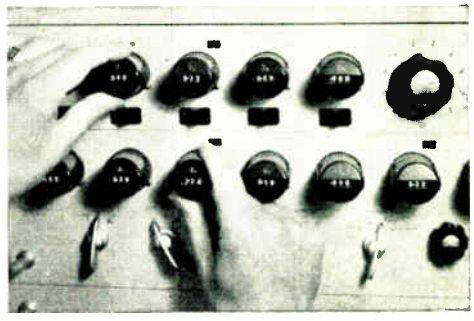
Great for miniature electronic components

HARWIN ENGINEERS LTD.
RODNEY ROAD
PORTSMOUTH, HANTS.
Tel: Portsmouth 35555 (4 lines)



Transfer Function Computer SA100 with Modulator/ Demodulator SA400 measuring the transfer function of a carrier-type velocity servo-system in the Development Laboratories of Vactric Control Equipment Ltd.

Close up of coefficient potentiometers showing n-line read-out of numerator and denominator terms.



Control system analysis made easy

SA100 MEASURES TRANSFER FUNCTIONS DIRECTLY

COEFFICIENTS DETERMINED IMMEDIATELY

The Wayne Kerr Transfer Function Computer measures the transfer functions of electrical, mechanical or chemical control systems directly in the form:

$$\frac{\text{Response}}{\text{Excitation}}(p) = \frac{b_0 + b_1p + b_2p^2 + b_3p^3 + b_4p^4}{(a_0 + a_1p + a_2p^2 + a_3p^3 + a_4p^4)(c_0 + c_1p + c_2p^2)}$$

where all the coefficients, a, b and c, are read from calibrated potentiometers.
It is no longer necessary to make many tedious measurements of phase and gain followed by involved mathematical calculations. It is no longer necessary to draw Nyquist plots or Bode diagrams or become lost in the Laplace transform. *In a matter of minutes the complete characteristics of a system are given in a form which can be used at once to determine the damping factors and resonance frequencies.*

NOISY AND NON-LINEAR SYSTEMS

Analysers based on phase/gain measurements are unable to distinguish between noise and true non-linearity in a system. The Computer, since it uses the derivatives of the response and excitation, does not lose accuracy when measuring this very common type of system. A significant measure of noise rejection is possible by visual interpolation of the c.r.t. display. Non-linearity is shown clearly on the Lissajous figure but does not interfere with the measurement of the transfer function. The type of non-linearity can often be deduced from the display. Gross non-linearity can be measured using the small perturbation technique.

FREQUENCY RANGE AND ACCURACY

Standard Model: 0.015 c/s to 500 c/s
Additional Models: 0.0015 c/s to 50 c/s
0.15 c/s to 5000 c/s
Accuracy: a_0, a_1, a_2, b_0, b_1, b_2 ±1 per cent
a_3, a_4, c_1, c_2, b_3, b_4 ±5 per cent

A.C. AND D.C. SYSTEMS

D.C. systems can be connected directly to the 'Excitation' and 'Response' leads of the Computer. For a.c. systems the excitation must be superimposed on a carrier, and the response signal detected before being passed back to the Computer. Both these operations are performed by the Modulator/ Demodulator SA400. The standard version of this unit can be switched to suit carrier frequencies of 50, 60, 1200, 1600 or 2400 c/s.

TRANSIENT RESPONSE AND FUNCTION GENERATOR

In addition to measuring transfer functions, the Computer can be used to display the transient response of a system to various types of excitation. Both the Excitation and Response signals can be viewed independently and, since the time-base of the monitor unit is derived from the same generator as the excitation, the pattern is completely jitter-free. Positive and negative responses are displayed simultaneously, giving the overall response of the system. Functions available are SINUSOIDAL, STEP, RAMP, PARABOLIC and IMPULSE.

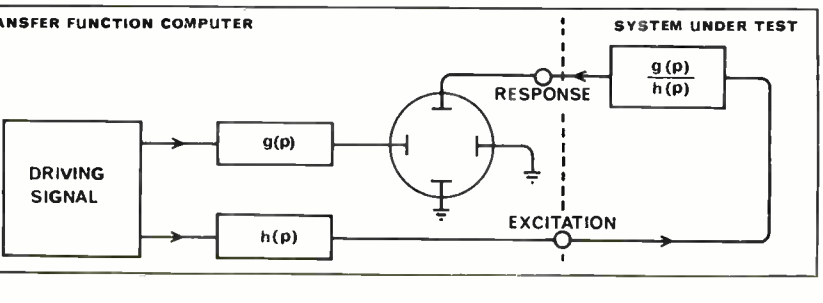
ENSURES RAPID PRODUCTION TESTING

The Computer greatly simplifies the problem of production testing of servo systems. The Design Engineer can now quote the transfer function as the overall specification of the system. During servo-system manufacture the Computer can be used 'in reverse'—the correct transfer function being set up on the Computer and the servo adjusted on the assembly line to meet the specification.

BASIC METHOD

The Computer is in effect composed of a function generator, two derivative chains and a monitoring unit, as shown below. One derivative chain is adjusted to be equal to the denominator of the system and the other to the numerator. The coefficients are read directly from the calibrated front-panel potentiometers.

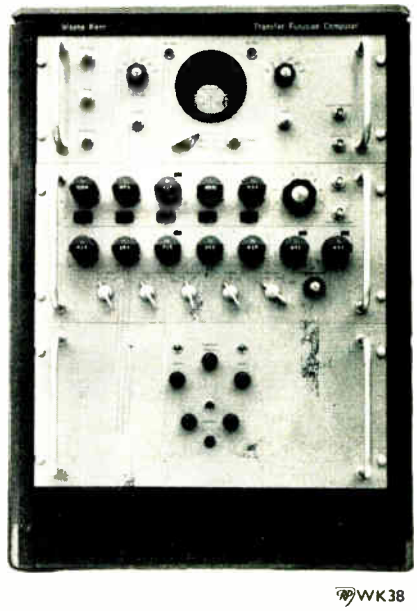
Please write or telephone for the 24-page booklet describing this system or ask for a demonstration.



WAYNE KERR

The Wayne Kerr Laboratories Limited
New Malden, Surrey, England
Telephone Malden 2202

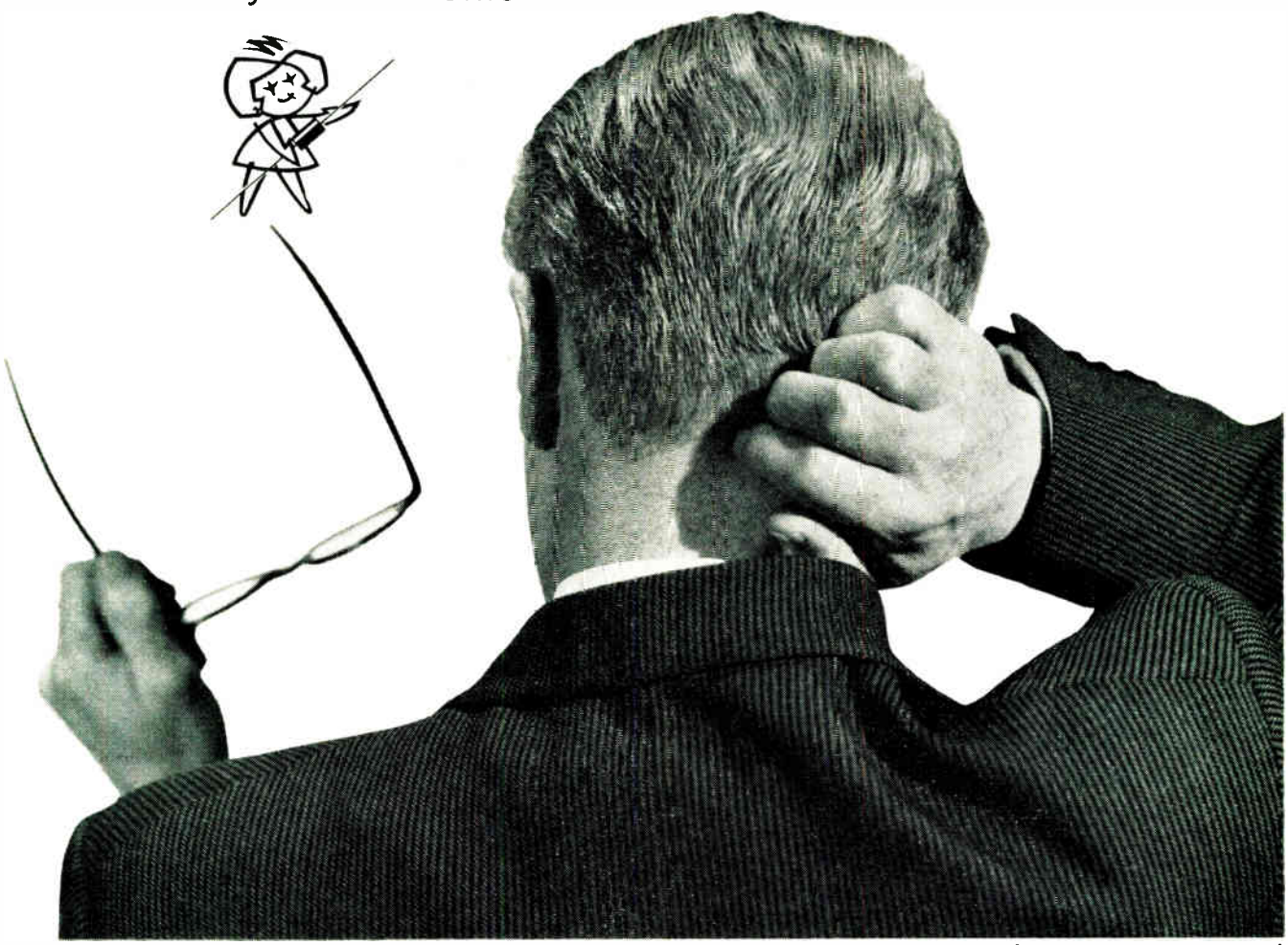
Wayne Kerr Corporation
1633 Race Street,
Philadelphia, 3, Pa, USA
Telephone LOcust 8-6820



WK38

Resistors are no problem - if you're a HARWIN customer

Says Mini Tronic



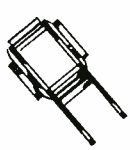
PRECISION WIREWOUND RESISTORS

Resistance Range 1 Ohm to 30 megohms
Tolerance Range ±1% to ±0.015%.
Temperature Coefficient better than 24 parts per million.

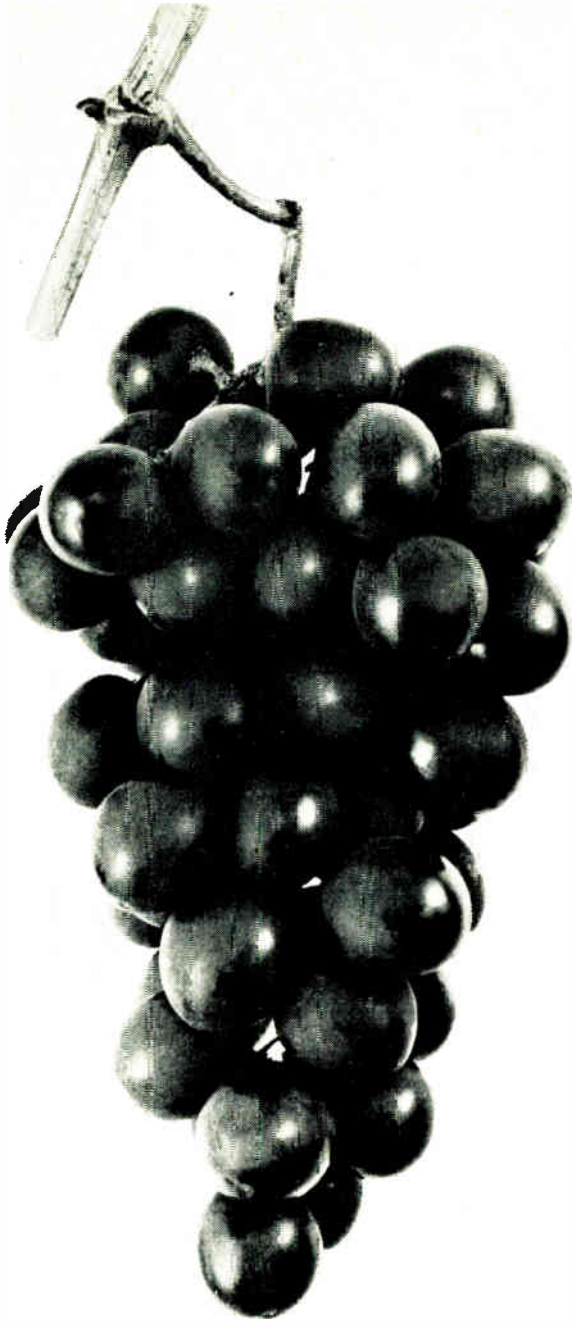
HARWIN have a really fine range of precision wirewound resistors with wire or lug terminations, low temperature coefficient, in either normal, encapsulated or hermetically sealed styles. Harwin Engineers' service is unsurpassed, better get in touch with them right away, for a firm price, and reliable delivery or details of our full range.

HARWIN ENGINEERS LTD · RODNEY ROAD · PORTSMOUTH HAMPSHIRE · TELEPHONE: PORTSMOUTH 35555 (4 lines)

GREAT FOR MINIATURE ELECTRONIC COMPONENTS



HARWIN



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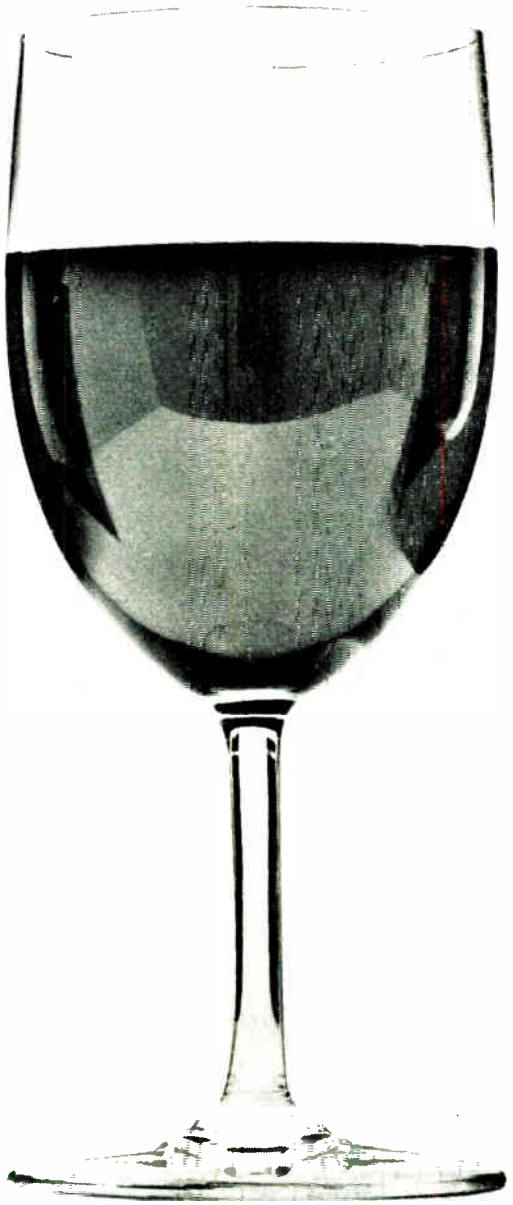


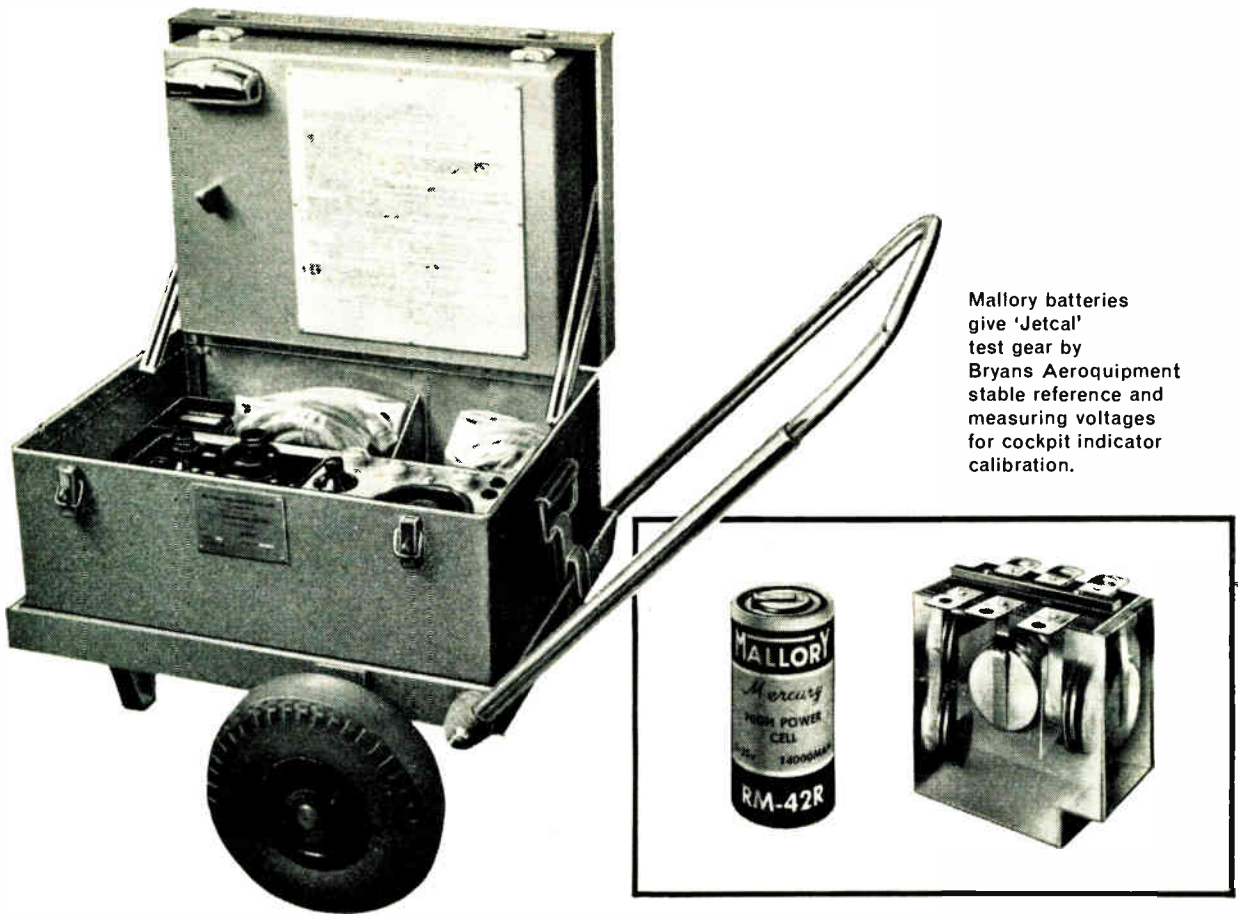
Processed

Two Elliott computers—the 503 and the 803. Price range: £20,000 to £200,000. Between them, they cover the chief scientific and industrial applications.□First, the 503. Built to meet the increasing demand for high speed computers for use in research and development. The 503 has no competitor as a replacement for older/smaller/slower installations. And its low price puts it within reach of organisations that now use computing centres.□The National-Elliott 803 is the smaller machine, from which the 503 has been developed. With over 120 already delivered, the 803 is far and away the most successful British computer.□The two systems are compatible—programs written for the 803 can be used on the 503. Elliott's provide Autocode, ALGOL 60, and over a hundred library programs—and an active users' association provides for exchanges of application programs. If you're thinking about a computer, call early on Elliott's who can do much of your thinking for you.

The Elliott 503 *100,000 operations per second. 6192 word magnetic core store. 3½ microsecond cycle time. Up to 131,072 word auxiliary core store. Input by 8-channel punched paper tape at 1,000 characters per second. Typewriter controlled. Incorporates time-sharing of peripheral data-transfers. High-speed input and output devices include punched card input/output, magnetic tape and line printer. Control interrupt facilities.*

ELLIOTT **computing division**

ELLIOTT BROTHERS (LONDON) LIMITED
ELSTREE WAY BOREHAMWOOD HERTFORDSHIRE ELSTREE 2040
EA A Member of the Elliott-Automation Group



Mallory batteries give 'Jetcal' test gear by Bryans Aeroquipment stable reference and measuring voltages for cockpit indicator calibration.

'JETCAL' CHECKS AIRCRAFT WITH MALLORY POWER!

'Jetcal' test gear by Bryans Aeroquipment Ltd. checks thermocouples in jet aircraft without running the engine and without breaking down the assembly. For the reference and measuring sources, Mallory batteries were chosen . . . They have the voltage stability for precision calibration work, pack the power for sustained accuracy. And they give the same supreme performance under adverse conditions.

LASTING POWER FOR MODERN APPLICATIONS 'Jetcal', with its one specially adapted and three standard cells, is typical of important applications throughout the aircraft industry that depend for power on Mallory batteries. They provide a consistently reliable, compact supply for research work by the Ministry of Aviation, for vital equipment by English Electric, Bristol Siddeley, De Havilland, Saunders Roe. Mallory's wide range of unique high capacity mercury cells – coupled with their proven ability to adapt and combine them into stacks and packs – offers designers the freedom to choose exactly the right battery for product requirements.

Manufacturers are advised to consult Mallory at the design stage so that full benefit can be gained from the world's most space saving source of power. Write today for details.

MALLORY BATTERIES LIMITED CRAWLEY SUSSEX Crawley 26041

Export Offices: 33 Duke Street London W1

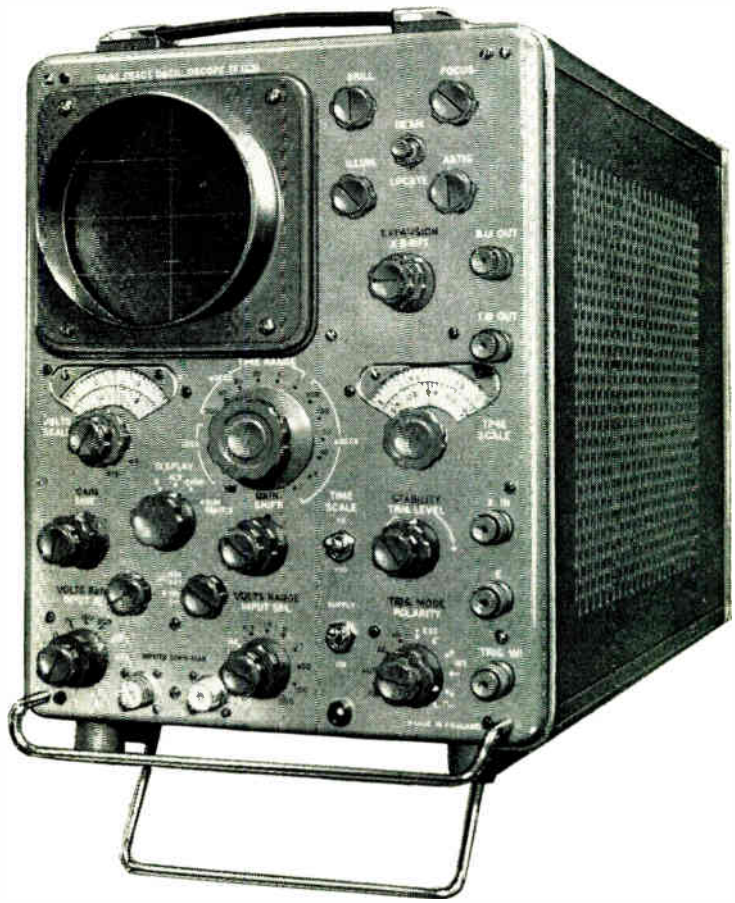
RECMF

MALLORY *for new ideas in batteries*

When your work is worthy of the world's finest instruments...

Marconi Instruments Type TF 1331 DUAL-TRACE OSCILLOSCOPE

* Two identical input channels selected by beam-switching multivibrator providing chopped or alternate-sweep displays. Each channel has independent a.c./d.c. coupling sensitivity and shift controls.
* D.C. to 15 Mc/s passband.
* Rise time: 0.025 µsec.
* Writing speed: 0.02 µsec/cm.
* Sensitivity: 50 mV/cm.
* Direct time and voltage calibration.
* Comprehensive trigger selection.
* Price: £390. Available accessories include High Impedance Probe, Delay Generator, and 3 c/s — 100 kc/s Pre-amplifier which increases sensitivity to 500 µV/cm.



Type TF 1330 Series OSCILLOSCOPES

Alternative models of this versatile general-purpose oscilloscope provide exceptionally high measurement accuracy, discrimination and resettability, by precision cam-corrected time- and voltage-measuring potentiometers (type TF 1330/2), or differential input facilities (type TF 1330/3).

Please write for full technical particulars of these and other oscilloscopes and pulse generators in the Marconi Instruments range. Address your enquiries to **Marconi Instruments Limited** at your nearest office.

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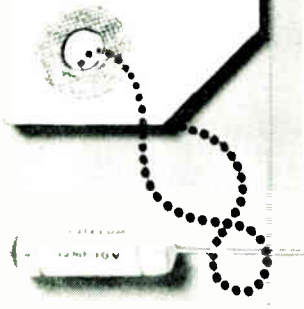
23/25 Station Square, Harrogate. Telephone: Harrogate 67454
Head Office—Home and Export Sales:
St. Albans, Herts., England. Telephone: St. Albans 59292

TC 226

MIL SPECIFICATION TYPE

This range, designed to MIL-C-3965, includes a large case size housing up to 470 µF.

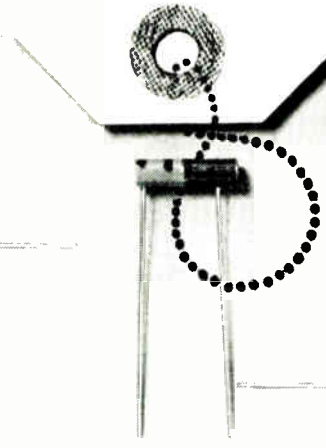
-25°C to +125°C



MINIATURE TYPE

Tantalum Foil capacitors in the smallest and most economic form.

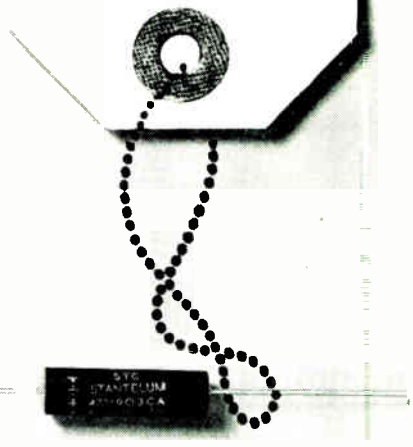
-25°C to +70°C



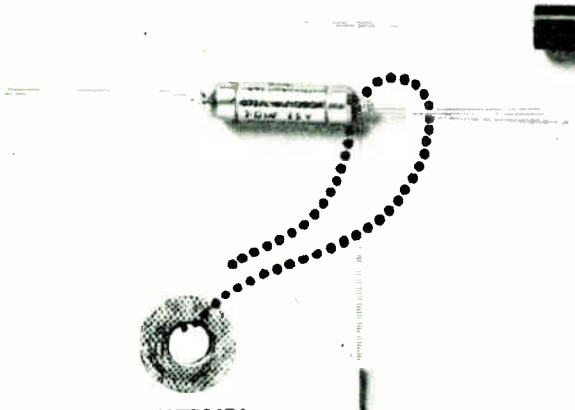
SPECIAL QUALITY HIGH TEMPERATURE TYPE

Another range of Special Quality capacitors for equipment demanding extra reliability.

-55°C to +125°C



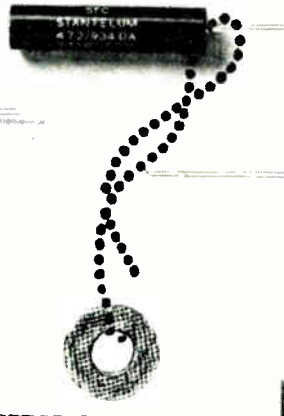
TANTALUM FOIL? STC MAKE ALL OF THESE



STANTELUM

Fully Type Approved to RCS 134B

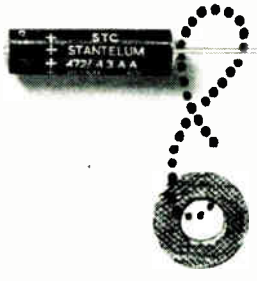
-55°C to +85°C



SPECIAL QUALITY TYPE

Manufactured in batches under full Quality Control (with Acceptance Sampling tests) to ensure exceptional reliability.

-55°C to +85°C



HIGH TEMPERATURE TYPE

Specially constructed to withstand extreme vibration and shock.

-55°C to +125°C

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Standard Telephones and Cables Limited

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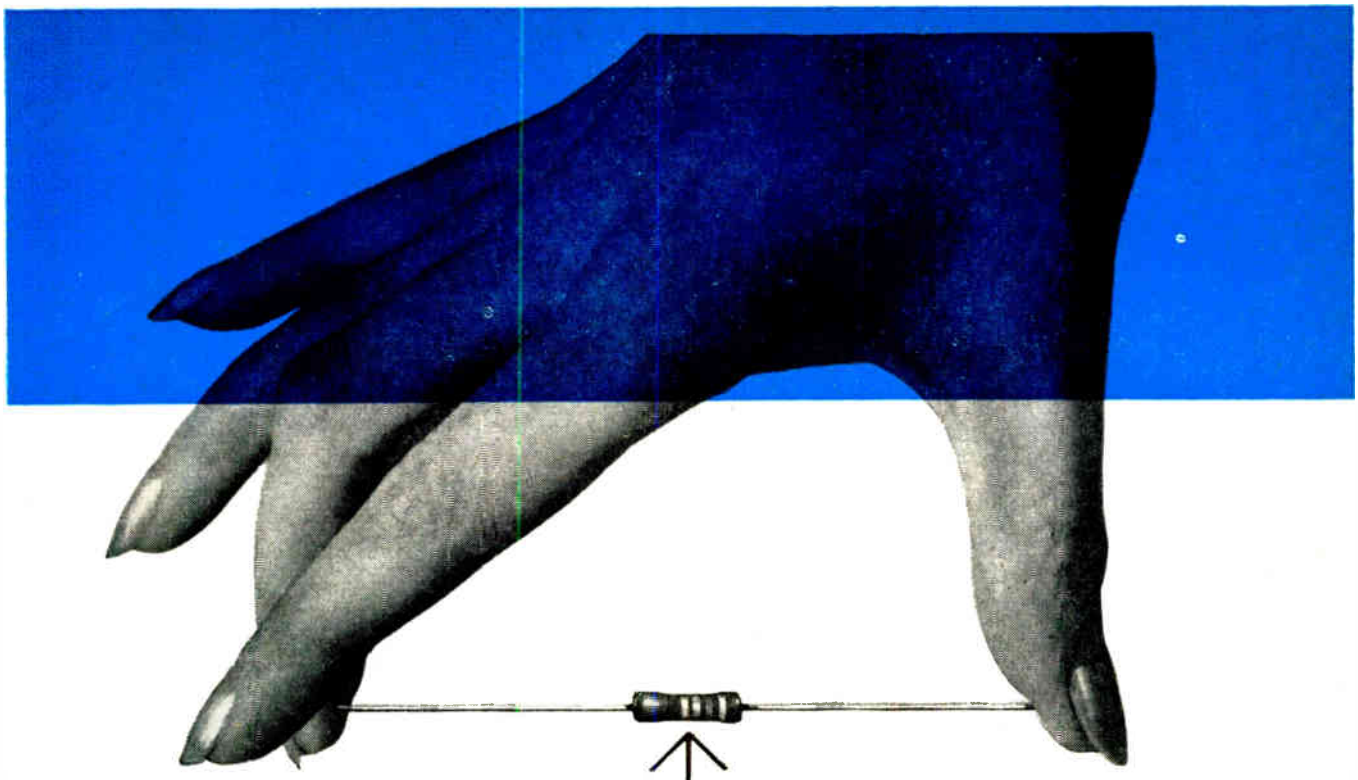
63/IMC



one resistor range meets all your needs

Electrosil Metal Oxide Film Resistors have a resistance track which is fired on to a glass substrate at red heat and is virtually impervious. This gives resistors which have much greater stability than others both on the shelf and in the circuit.

SEMI-PRECISION	SIZE	GENERAL PURPOSE
N55 1% 1/10W	1/4" x 3/32"	C-07 2% 5% ¼W
NJ60 1% ¼W	3/8" x 5/32"	CJ20 2% 5% ½W
NJ65 1% ½W	9/16" x 13/64"	CJ32 2% 5% 1W

RESISTANCE RANGES HAVE NOW BEEN EXTENDED. WRITE TODAY FOR FULL DETAILS.

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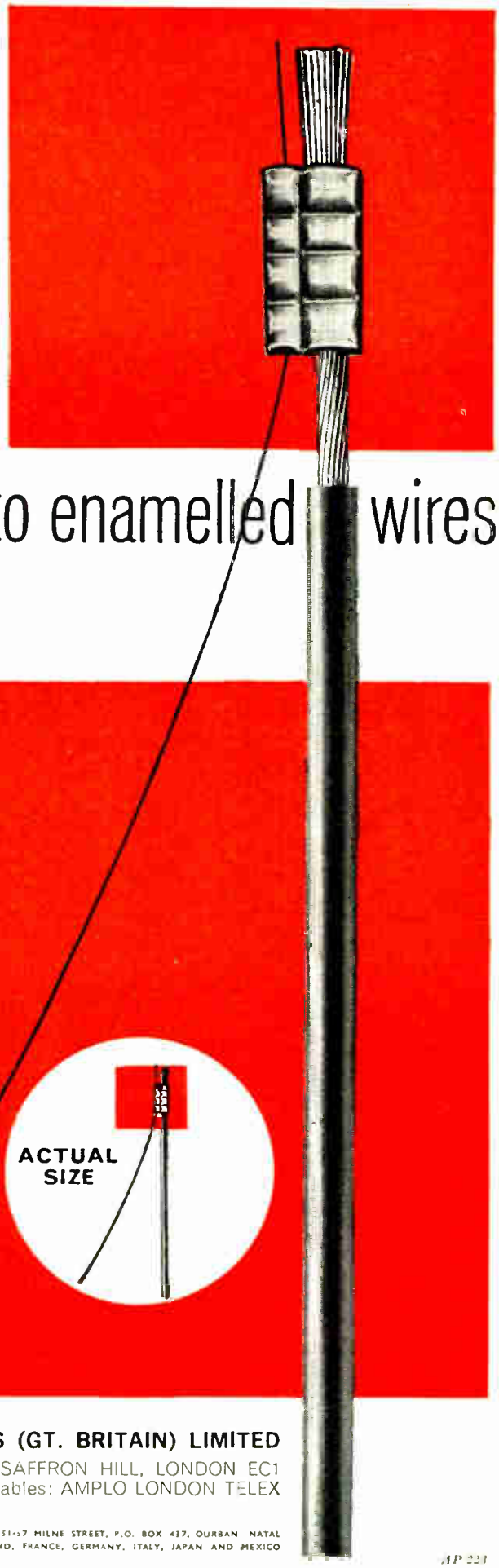
AMP
Fine-Y-R SPLICE

Joins stranded leads to enamelled wires 47-37 swg



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They have evolved the Fine-Y-R splices and a special automatic machine which is capable of over 500 completed connections per hour.

Here are some Fine-Y-R features:

- Tape mounted splices are applied by an automatic machine
- Magnet or similar wires of 37-47 swg can be used
- Machine automatically cleans enamelled wire before crimping
- Upwards of 500 splices an hour are possible
- Operation by comparatively unskilled personnel
- Splices are pre-insulated on one side
- Connections are electrically stable
- No contamination or heat damage
- No handling problems
- No machine adjustment for change of wire size

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AMP

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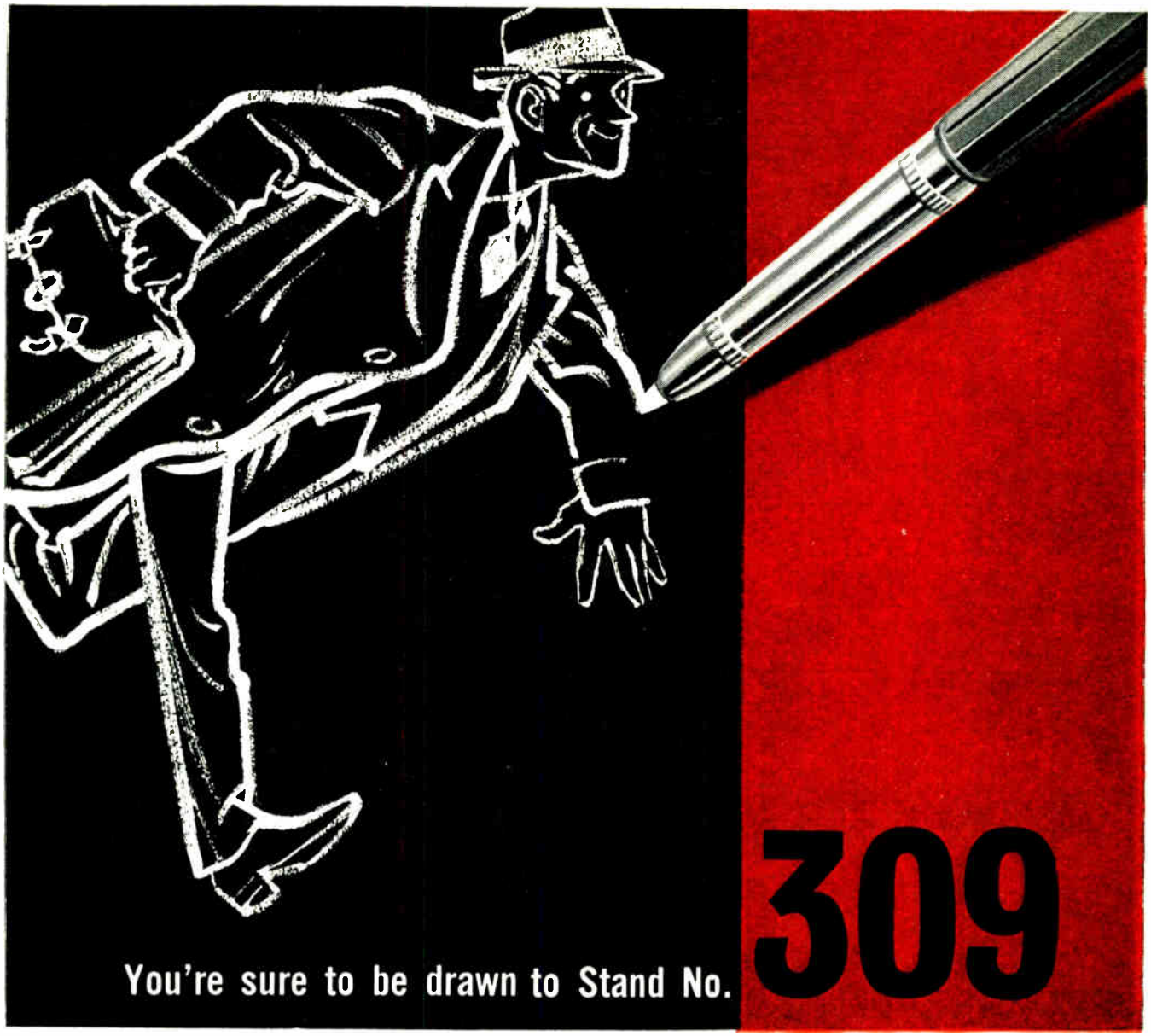

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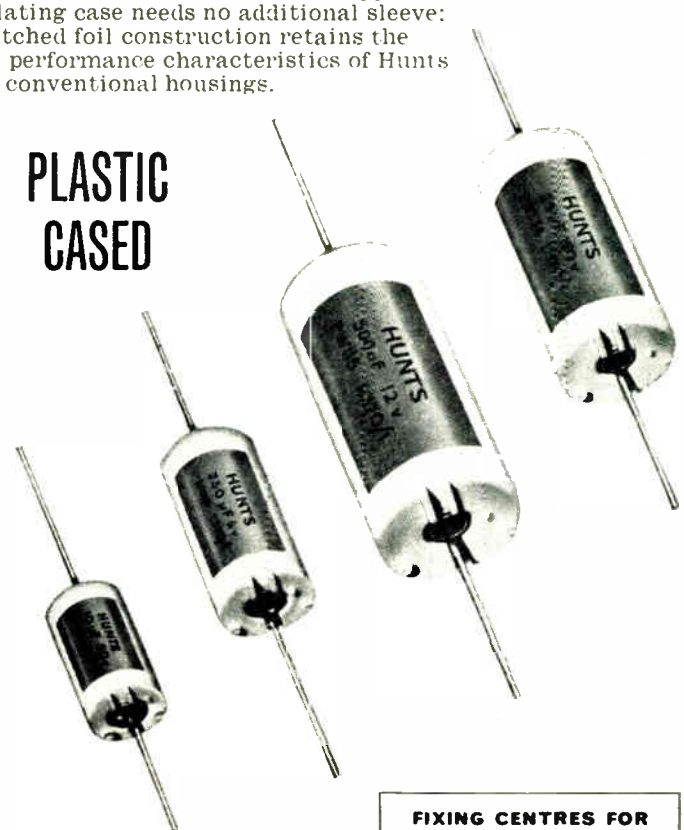
FG. 396/2

TYPE L370/1 ELECTROLYTIC CAPACITORS

High performance and price economy are outstanding features of this new range of plastic-cased electrolytic capacitors, admirably suited to printed circuit assembly. On horizontal boards the positioning of the rivet head and the provision of channels moulded into the case allow the terminations to be brought out naturally to fixed centres. On vertical boards the anode or cathode termination can be brought down the side of the capacitor case to finish diametrically opposite the other terminal. The insulating case needs no additional sleeve: and the etched foil construction retains the excellent performance characteristics of Hunts ranges in conventional housings.

DC Working Volts	Surge Volts	μF	List No.	Case Ref.
6	7.5	10	PW101	A
6	7.5	25	PW102	A
6	7.5	50	PW103	A
6	7.5	100	PW104	A
6	7.5	250	PW105	B
6	7.5	500	PW106	C
6	7.5	750	PW107	C
6	7.5	1000	PW108	D
12	15	10	PW109	A
12	15	25	PW110	A
12	15	50	PW111	A
12	15	100	PW112	B
12	15	250	PW113	C
12	15	350	PW114	C
12	15	500	PW115	D
25	30	5	PW116	A
25	30	12	PW117	A
25	30	25	PW118	A
25	30	50	PW119	B
25	30	100	PW120	C
25	30	200	PW121	C
25	30	350	PW122	D
50	60	5	PW123	A
50	60	10	PW124	A
50	60	25	PW125	B
50	60	50	PW126	C
50	60	100	PW127	C
50	60	200	PW128	D
150	200	1	PW129	A
150	200	2	PW130	A
150	200	4	PW131	A
150	200	8	PW132	B
150	200	16	PW133	C
150	200	25	PW134	C
150	200	50	PW135	D

PLASTIC CASED



Case Ref.	Length ins.	Length mm.	Diameter ins.	Diameter mm.	FIXING CENTRES FOR PRINTED CIRCUITS Horizontal ins.	Horizontal mm.	Vertical ins.	Vertical mm.
A	$\frac{13}{16}$	20.6	$\frac{13}{32}$	10.3	0.9	23.0	0.35	9
B	$1\frac{1}{16}$	27.0	$\frac{1}{2}$	12.7	1.1	28.0	0.40	10
C	$1\frac{7}{16}$	36.5	$\frac{5}{8}$	16.0	1.4	35.5	0.50	12.7
D	$1\frac{11}{16}$	43.0	$\frac{3}{4}$	19.0	1.7	43.0	0.60	15.2

For horizontal mounting prefix list number by PWH. For vertical mounting prefix list number by PWV (on anode) or PWK (on cathode).

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HUNTS CAPACITORS
THE TRADE MARK OF RELIABILITY

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- Rugged, sub-miniature all-glass construction
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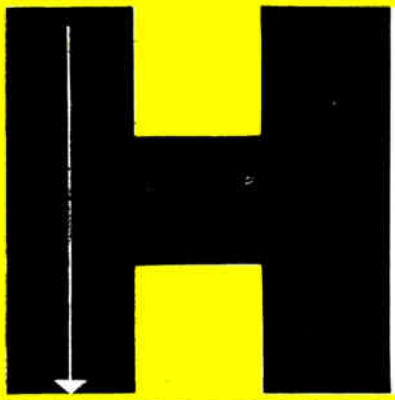

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- Nominal capacitance—0·2pF @ −10V

HG 10

CV448
CV7041
CV7130

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Type	P.I.V.	Max. D.C. or Mean Forward Current (mA @ 25°C)	Min. Forward Current @ 1V (mA)	Max. Reverse Current @ −50V (μA @ 25°C)
HG1005	100	45	5	50
HG1006	100	45	5	100
HG1012	75	45	5	100

- Extremely high forward conductance
- Max. stored charge 350pC @ 10mA
- Nominal capacitance—0·4pF @ −10V
- Max. average power dissipation 30mW

HG 50

CV7076
CV7127
CV7128

GOLD-BONDED COMPUTER DIODES

Type	Min. Breakdown Voltage	Max. D.C. or Mean Forward Current (mA @ 25°C)	Max. Forward Voltage (@ 100mA)	Max. Reverse Current @ 25°C (μA @ V)
HG5003	100	100	0·8	25 —50
HG5004	70	100	0·8	25 —50
HG5008	40	100	0·8	25 —30

- High forward conductance
- Typical stored charge @ 10mA—HD 1810 . . . 125 pC
HD 1840/1 . . 110 pC
HD 1870/1 . . 66 pC
- Nominal Capacitance 1·5pF @ 1V

HD 18

CV Approval Pending

FAST RECOVERY COMPUTER DIODES

Type	P.I.V.	Max Forward Voltage @ 10mA	Max Forward Voltage @ 100mA	Max. Reverse Current @ −10V (25°C)
HD1810	50	0·45	0·75	5μA
HD1840	30	0·45	0·70	10μA
HD1841	20	0·45	0·70	20μA
HD1870	15	0·42	0·70	15μA
HD1871	10	0·42	0·70	20μA (@ −5v)

Write now for complete data on the full range of Hughes semi-conductor products, which also includes:—
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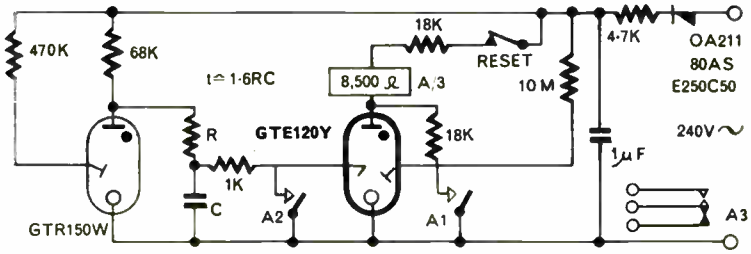
Perfectly adequate for simple repetitive timing but hardly a practical proposition for the hundreds of timing applications in industry. For simple reliable electronic timing and sequence switching without fuss the answer is inexpensive Trigger tubes.

GTE 120 Y TRIGGER TUBE

Operating directly from rectified mains, they require no special power supplies, they are not affected by severe transient overloads, they give visual indication of current flow and their characteristics are unchanged by temperature fluctuations. Reliable to the point of outlasting the useful life of their parent equipments, Ericsson Trigger tubes meet the most exacting industrial and commercial requirements. The simple timing circuit illustrated gives for example an accuracy of better than 1%. For tube data and other timing circuits please write to the address below.



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

ERICSSON TELEPHONES LIMITED
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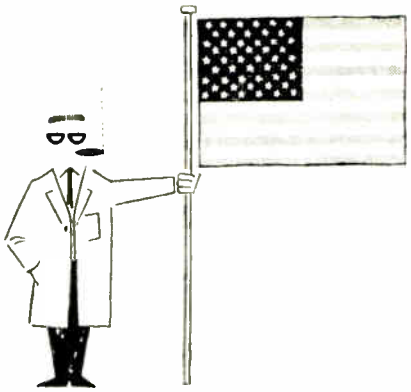
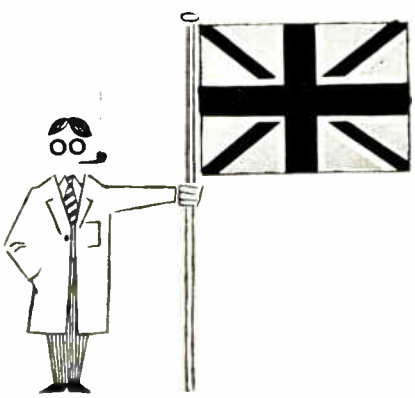
ER 53



America's best-selling solid tantalum capacitors



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The Kemet J & N Series solid tantalum capacitors, in a range from 75 to 6 volts in polar and non-polar components, are now made here in England. They equal and in many cases exceed the MIL-C-26655A, and U.K. manufacture give the advantages of technical liaison and prompt delivery.

Union Carbide's plant at Aycliffe also produces Getters for radio valves and cathode ray tubes. These, the only U.K. manufactured Getters, are made to an extremely high standard.

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AYCLIFFE INDUSTRIAL ESTATE, CO. DURHAM, AYCLIFFE 2180
HEAD OFFICE: 8 GRAFTON STREET, LONDON, W.1. MAYFAIR 8100

To: Union Carbide Limited, Kemet Division, Aycliffe Industrial Estate, Co. Durham

Please send me information about

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- Getters ☐

and these other Kemet products

- 100 Volt J-Series Solid Tantalum Capacitors ☐
- P-Series Solid Tantalum Capacitors for printed circuits ☐
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4

CIRC/K7

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COMPONENTS FOR THE EUROPEAN MARKET

Illustrated here are the first examples of a new range of components designed to meet the requirements of European equipment makers.
The wander plugs and sockets feature the long contact generally favoured in these countries—the fuseholder accommodates 5 x 20 mm. cartridges.
These new components will also be of interest to British manufacturers of equipment and instrumentation intended for export.
Enquiries for these and other items will be welcomed.

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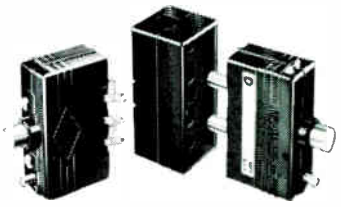
MINIATURE CIRCUIT-BREAKERS AND CUT-OUTS

Scaled down in size to modern requirements, yet handling currents up to 20A, these are the latest additions to our range of circuit-breakers and cut-outs.
Thermal and thermal magnetic versions, with or without auxiliary signalling contacts; chassis mounting or plug-in types; temperature-compensated and tropicalised versions available.



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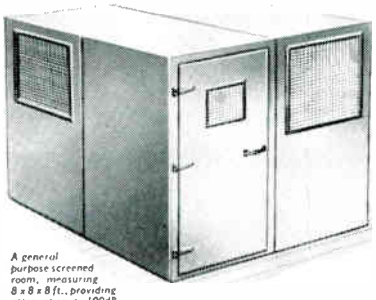
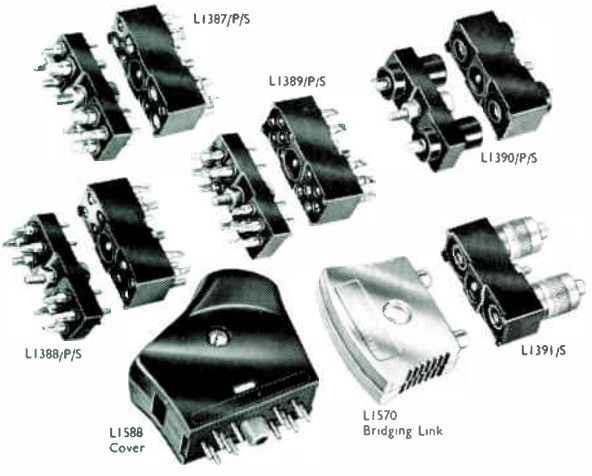


A general purpose screened room, measuring 8 x 8 x 8 ft., providing attenuation > 100dB.

These new screened rooms are of modular construction and embody the accumulated experience resulting from many years specialisation in interference supression problems.
From a standard range of panels and penetration units a wide variety of different enclosures can be constructed economically, to suit almost any requirements in the way of lay-out and performance.

"Belling-Lee"

MINIATURE UNITORS



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BROADBAND DOMESTIC TV AERIALS for the new U.H.F. services
(channels 21-33)

The most important requirements of an U.H.F. aerial are—
High gain, to combat signal attenuation and the greater receiver noise at U.H.F.
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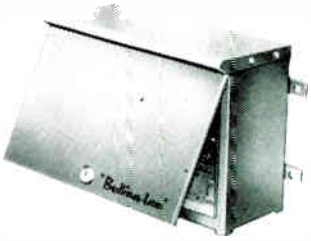

Repeater Amplifier L4444

STAND 310 R.E.C.M.F. EXHIBITION

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STC COMPONENTS REVIEW

Microminiaturization with
THIN FILM CIRCUITS

STC Thin Film Circuits are a major breakthrough in electronics microminiaturization and reliability. They are developed and marketed:

(1) From standard ranges of circuits as, for example:

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

(2) As custom-built circuits. Facilities have been established to meet specific customer requirements at short notice.

Transistor-Resistor Logic Elements (*actual size*).

Wide Band Amplifiers (*actual size*).

STC Thin Film Circuits are made by the sequential deposition of capacitors, transistors, interconnexions and a protective layer on to a thin substrate. Special transistors and diodes are then affixed and the circuit encapsulated. The TFC's are manufactured in a vacuum chamber under highly controlled conditions. Full Quality Control and Quality Assurance testing is in operation.

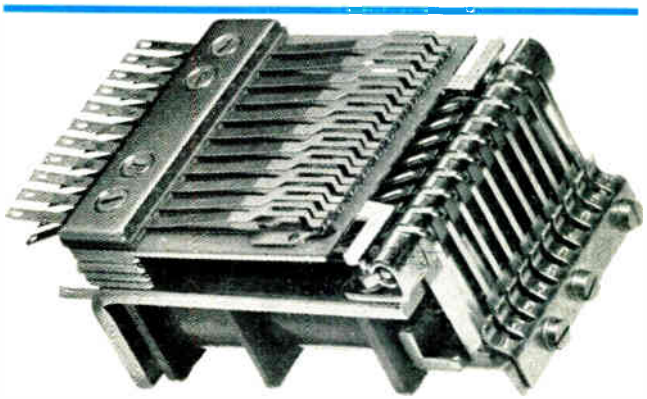
TFC's can be used in conjunction with conventional components in standard circuitry, printed circuitry or modular techniques such as the STC MINISTAC.

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

UNIQUE COUNTING RELAY

performs multiple switching operations

This versatile component is an electro-magnetic counter which features high speed operation and long maintenance-free life. It is designed to perform counting, storing and switching functions and has been used widely in control engineering to solve many complex problems. In most cases one of these new components is used to perform, more efficiently and economically, operations previously controlled by several switching devices.



Brief Specification

The ZM53 is an electro-magnetic relay with 10 separate armatures and associated contacts and with one operate and one release winding. It is available with either 24 V d.c. or 60 V d.c. windings. The contacts will switch 20 W and carry a maximum current of 1 ampere. The counter can be mounted on a relay panel and requires the space of two 3 000 Type relays. It has a service life in excess of 20 million operations.

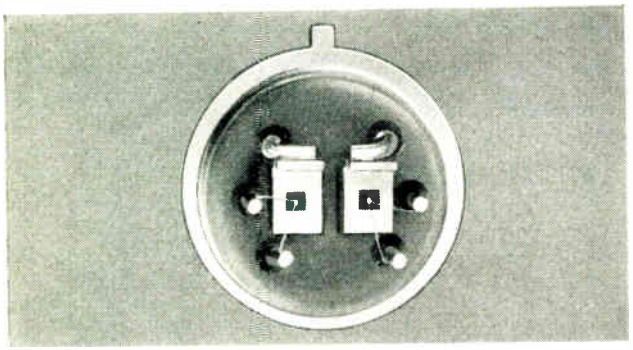
	24 V d.c.	60 V d.c.
Maximum voltage variations (V d.c.)	22-30	56-72
Windings (a) Operate resistance (Ω)	37	145
No. turns	1200	2200
(b) Release resistance (Ω)	100	240
No. turns	930	2460
Operate current (mA)	650	324
Minimum pulse time (ms)	25	20
Minimum pulse interval (ms)	20	20
Minimum release pulse time (ms)	40	40
Dimensions (inches)	3·3 x 1·57 x 2·2	

Typical Applications

The ZM53 is especially suitable for adding facilities with storage, for indication, rated value adjustment, and coincidence circuits in electrical equipments, ranging from entertainment apparatus to scientific equipment: Machine and Machine tool control systems • Vending machines and juke boxes • Adding and subtracting operations and program control • Control and automatic handling of assembly line lubrication programs • Production and packing machines for counting purposes • Train announcing systems (destination, times etc.) • Time storage devices including electrical scanning and correction facilities • Very long switching time limitations and delays • Pulse transmitters incorporating pulse supervision facilities for various control apparatus • Control of automatic car washing installations.

Write, 'phone or Telex for Data Sheets to STC Electromechanical Division, West Road, Temple Fields, Harlow, Essex. Telephone Harlow 21341. Telex 81184.

SILICON PLANAR DOUBLE TRANSISTORS



The range of STC silicon planar double transistors has now been increased to four devices including both matched and unmatched pairs. Each pair is mounted on a 6-lead header and encapsulated in a TO-5 case, the transistors being electrically isolated.

This is a matched pair of BFY18 silicon planar transistors. The common mounting minimizes the temperature difference between the two transistors, making the device ideal for use in d.c. amplifiers.

Brief Data

f_T	(V_{CE} = 9 V, I_C = 10 mA)	245 Mc/s	(Typ)
I_{CBO}	(V_{CB} = 9 V, I_E = O)	10 nA	(Max)
h_{FE}	(I_C = 100 µA, V_{CB} = O)	10	(Min)
V_{BE}	(matched to within)	10 mV	
P_{CM}	(total)	600 mW	

This is similar to the BFY20 but the two transistors are unmatched. It is suitable for use in circuits where two v.h.f. amplifiers are required to work in close proximity.

A pair of silicon epitaxial planar transistors of the BSY26, BSY27, 2N708 class for use in v.h.f. switching circuits at mean current levels up to 100 mA.

Brief Data

f_T	(V_{CE} = 9 V, I_C = 10 mA)	200 Mc/s	(Min)
I_{CBO}	(V_{CB} = 9 V, I_E = O)	25 nA	(Max)
h_{FE}	(V_{CE} = 2 V, I_C = 10 mA)	25 – 120	
V_{BE}	(I_C = 10 mA, I_B = 1 mA)	0·9 V	(Max)
P_{CM}	(total)	600 mW	

A pair of silicon epitaxial planar transistors of the BSY28, BSY29, 2N743, 2N744 class. This is similar to the BSY42 but is intended for use at higher frequencies.

Brief Data

f_T	(V_{CE} = 9 V, I_C = 10 mA)	300 Mc/s	(Min)
I_{CBO}	(V_{CB} = 9 V, I_E = O)	50 nA	(Max)
h_{FE}	(V_{CE} = 2 V, I_C = 10 mA)	25 – 120	
V_{BE}	(I_C = 10 mA, I_B = 1 mA)	0·85 V	(Max)
P_{CM}	(total)	600 mW	

SILICON EPITAXIAL PLANAR DIODES

UP TO 60V PIV

The BAY31, 36, and 49 are new silicon epitaxial planar high performance diodes. They are specially designed for use in logic circuits working at frequencies of up to 10 Mc/s. Exceptional ruggedness and standardized dimensions make these diodes eminently suitable for use on printed circuit boards.

- LOW COST
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- HIGH FORWARD CONDUCTANCE
- LOW REVERSE LEAKAGE CURRENT
- PLANAR EPITAXIAL CONSTRUCTION
- RUGGED DESIGN
- DO-7 OUTLINE

Actual Size

CHARACTERISTICS (AT 25 C)

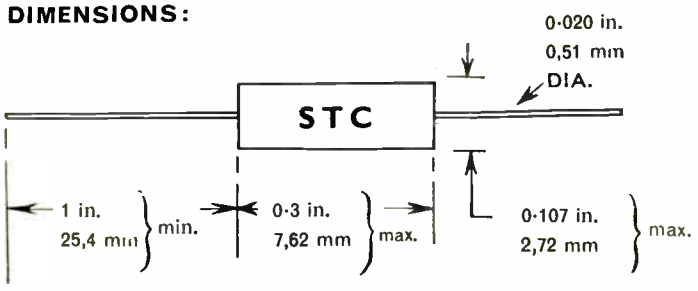
I_R	(Max) at −10V	100nA
V_F	(Max) at 30mA	1·0V
*t_{rr}	(Max) to 1mA	5·0ns

*(I_F = 10mA, V_R = −10 V, R_L = 100 Ω)

MAX. RATINGS

V_R	(mean, peak or transient)	15V	(BAY 31)
V_R	(mean, peak or transient)	30V	(BAY 36)
V_R	(mean, peak or transient)	60V	(BAY 49)
I_F	(mean)	100mA	
I_F	(peak)	200mA	
P_{tot}		200mW	
T	(operating)	100 °C	

DIMENSIONS:



Write, 'phone or Telex for advance Data Sheet to STC Transistor Division, Footscray, Sidcup, Kent. Telephone FOOtscray 3333. Telex 21836.

THERMAL DELAY

These miniature switches in the STC range are mounted on a B7G valve base and have a single pair of contacts which make after a specified delay, following the application of heater voltage. Heaters are made for operation at 6·3, 19 or 27 volts and the choice of these voltages with delay times are shown in the table below. Other combinations of these heater voltages and delay times between 10 and 60 seconds can be offered where the number of switches involved warrants a new type. Extended delays can be obtained by cascade connexion of these switches.

Delay time is not seriously affected by changes of ambient temperature over the range −35°C to +70°C due to the use of a bimetal strip for the stationary as well as for the active contact.

In addition to the obvious use for delaying the application of h.t. voltage to valves requiring a preheat time, thermal delay switches are also suitable for use as VLF relaxation oscillators, for switching 3-phase circuits from star to delta arrangement for starting induction motors and for automatically reclosing a circuit breaker after a temporary current surge has caused it to trip. These applications are described fully in booklet MS/117 which can be obtained from the address below.

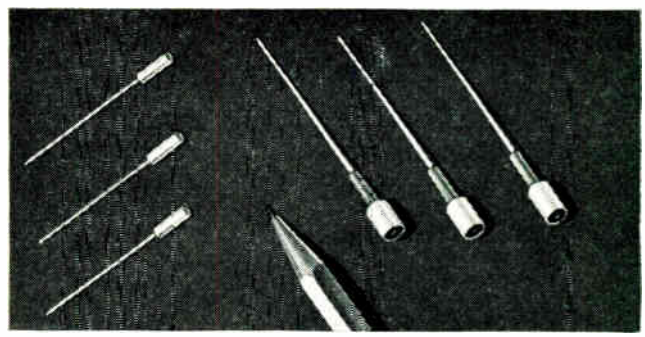
ABRIDGED DATA

Type	Delay (seconds) at 20°C		V_h (V)	Contact Rating		Base
	min.	max.		(V d.c.)	(V r.m.s.)	
S102/1G	44	66	6·3	220	100	B7G/F
S102/1K	44	66	6·3	220	100	B7G
S103/1K	36	54	27	220	100	B7G
S104/1K	25	35	6·3	220	100	B7G
S105/1K	20	30	27	220	100	B7G
S106/1K	44	66	19	220	100	B7G
S107/1K	8	15	6·3	220	100	B7G

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

PHOTOELECTRIC CELLS

STC manufacture two types of Germanium photoelectric cells. Designated PG40B and PG50A respectively, these two devices have identical spectral characteristics but differ in their case sizes and electrical parameters.

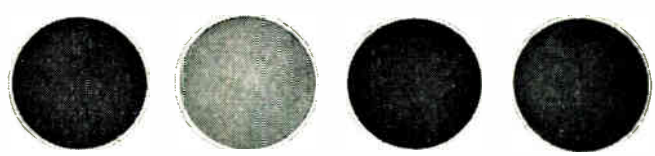


ABRIDGED DATA	PG40B	PG50A
Maximum overall dia.	0·080 in. (1,99 mm)	0·218 in. (5,55 mm)
Average sensitivity	30 mA per lumen	30 mA per lumen
Maximum bias voltage	50 V	100 V
Maximum dissipation	15 mW	50 mW

STC Photoelectric cells are hermetically sealed and are mechanically strong for their small size. The PG50A is suitable for direct relay operation and the PG40B has been developed to allow mass grouping for scanning punched card and perforated tapes.

OPTICAL FILTERS

Many types of infra red Optical Filter in the 1·0 to 8·0 micron range have been developed by the STC Rectifier Division.



These absorption and interference filters are ideally suited for such applications as the investigation into process control in the petrochemical industries and in respiratory functions. The diversity of uses covers the detection of hydrofluoric acid in pipelines to temperature measurement of molten masses.

A particular advantage of these infra red filters is that any gases or material under investigation are unaffected by analysis.

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

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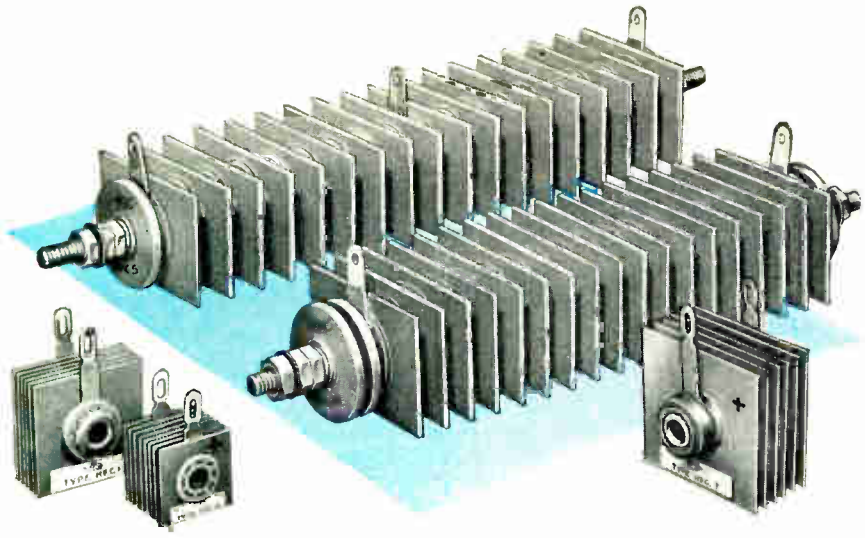

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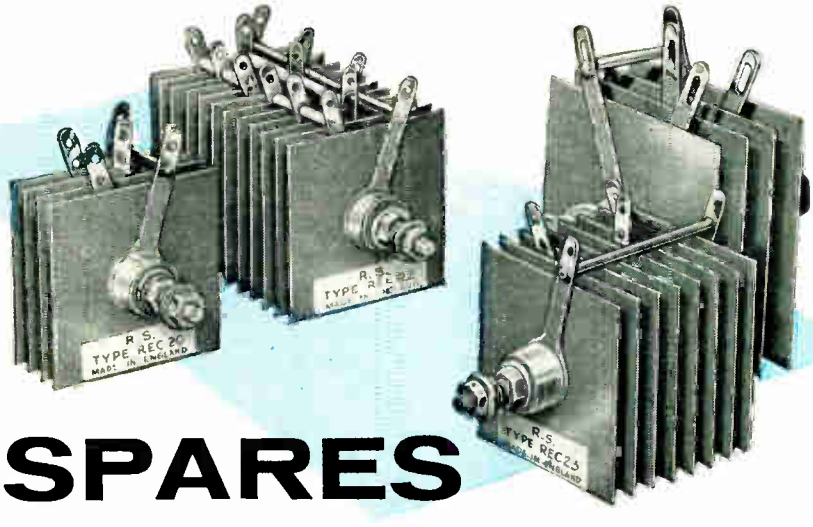

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Comment

Electronic engineers are familiar with the idea of codes. The Morse code is the best known, but there are widely-used telegraph and teleprinter codes. Data transmission and computers have other codes. These codes are all adapted for the transmission of information in electrical form and usually groups of pulses represent letters, numbers or other information.

One thing that all codes have in common is that each code symbol always has the same meaning. It is true that sometimes a symbol may have more than one meaning, but invariably some additional symbol is used to indicate which meaning is intended. This is really equivalent to having separate symbols. Except for mistakes, and interference, the code is a precise representation of an original message and enables it to be reproduced without error.

Ordinary language is also a form of code, although few realize it. It is a code for the communication of thoughts to other people. This verbal code has nothing like the precision of the engineer's codes. The meanings of words are not so precisely defined as the meanings of code symbols; how can they be when they are themselves defined in other words? Language functions, and functions very well, because it contains great redundancy. Because of this, conciseness of expression is not always best adapted for conveying a precise meaning.

Precision in the use of words is often advocated. Dictionaries and glossaries exist to help in this, but are often ten years out of date. Words change their meanings with time and new words come into use. In technical language, in particular, new terms are invented and used in limited circles, where they soon become so familiar that when their users write for a wider audience they forget that they are using words meaningless to their readers. A word is used with one meaning in one circle and another in a different one. This causes serious confusion and ends by everyone having to abandon the word altogether; 'flip-flop' is the most notorious of such words.

Verbal difficulties of this kind are a serious hindrance to communication. In order to alleviate the situation we propose from time to time to include notes on technical words and phrases in these pages. They will be in these Comment pages since as well as saying what the words mean, we think we shall often want to express an opinion about them!

Open Gate

In the computer field, which should surely be a home of logic, an open gate is a gate-circuit which does *not* pass a signal.

Presumably, it is used because an open gate is a gate in an open-circuit condition and, of course, an open-circuit does not pass a signal. This is a case where abbreviation has resulted in a term which most people will interpret to mean exactly the opposite of what it is intended to mean.

Enable

This word is being used in an apparently logical manner as the opposite of 'disable' but in a manner which does not accord with normal English usage. As a result, apparently meaningless sentences occur.

No one is likely to be in doubt

about 'The removal of the input disables the circuit'. Few people will at once understand 'The connection of the input enables the circuit'. To be intelligible it is necessary to add 'to operate' after circuit.

It so happens that it is normal English usage for 'disable' to be used in one way and for 'enable' to be used in another.

However logical and convenient it may be to use 'enable' and 'disable' in precisely the same way and with opposite meanings, the fact remains that it is not the way that these words are used in English. To use them like this is to hinder communication.

Fan

Used mainly in connection with transistor logic circuits, this word is spreading into more general usage. It is usually employed with the suffixes '-in' and '-out'. Fan-out means the *number* of transistor bases which can be fed from a transistor collector.

To say that a stage has a fan-out of five means that the collector of the transistor in that stage can be connected to the bases of five transistors. It is virtually a measure of the current output of a transistor, for the meaning is clearly that the transistor has sufficient output current to provide the base currents of up to five other transistors.

Similarly, a fan-in of five means that up to five inputs may be applied to the base of a transistor and carries the implication that each alone must provide sufficient current to operate the transistor.

Gain

This simple and widely-used word is not as straightforward as it appears. At one time the word was not used at all; the ratio output/input of a device was called its amplification and when necessary it was qualified by voltage, current or power. Gain came into use about the same time as the decibel and there was a definite tendency to restrict its use to amplification expressed in decibels. One had an amplification of so many times and a gain of so many decibels.

This was a useful distinction but one which few people now make, presumably because gain is so much shorter to say and write. Indeed, B.S. 204 : 1960 no longer gives amplification at all although the word is still current. It defines gain primarily as the ratio of output load power to the input power. It gives a secondary meaning of the ratio of output/input voltages or currents under specified conditions of impedance termination.

It is quite clear that in current usage gain is basically a dimensionless quantity, the ratio output/input, both output and input being expressed in the same units. It may also be expressed in decibels.

In the control field, however, the word gain is also being used for the quotient of output current by input voltage and we get gain measured in amperes per volt. This is very confusing. It has the dimensions of conductance and as applied to an amplifier the ratio is clearly closely analogous to mutual conductance or transconductance as applied to a valve.

In our view the proper word to employ for the quotient of output current by input voltage is transconductance.

Ratio

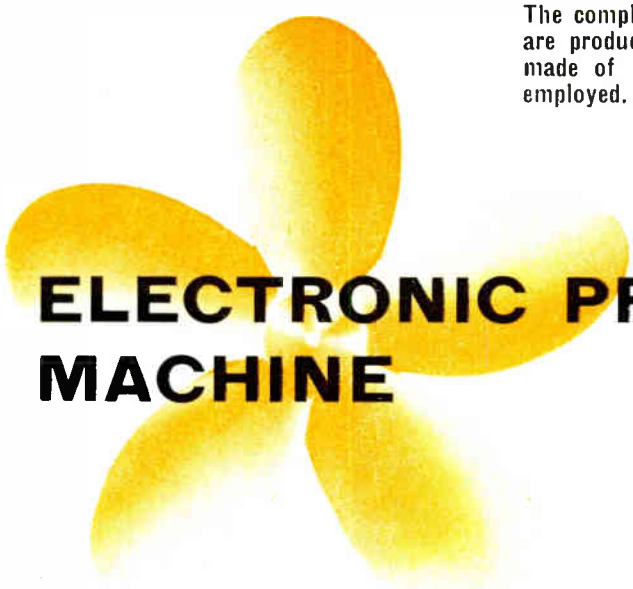
It will be noticed that we have used the expression 'quotient of . . . by . . .' instead of 'ratio of . . . to . . .'. This is because strictly the two quantities involved in a ratio must be of the same dimensions. In fact, the word is very commonly used without this restriction. We ourselves feel that it is a little pedantic to use ratio so strictly, but we know that if we had used it above we should have had several letters of protest about it!

New Theory of Adhesion

Adhesives are now quite widely used, but one must use the right one for the job. There is as yet no universal 'glue'.

A hint that this may be possible comes from the Bell Telephone Laboratories, where a new theory of adhesion has been worked out. It contradicts the de Bruyne adhesion rule that strong joints cannot be made between polar materials with non-polar adhesives. According to the new theory the requirement for strong adhesion between two pure substances is that one must spread on the other. Spreading requires that the surface tension of the solid equals or exceeds the sum of the surface tension of the liquid and of the boundary between the two. It is non-reciprocal; if one spreads on the other, the other will not spread on the one.

Materials like polyethylene have a low surface tension, which is why they are difficult to stick things to. If they themselves are used as a glue, however, they will stick to other things. For instance, an epoxy resin does not stick to polyethylene if cured in contact with it; on the other hand, polyethylene adheres strongly to cured epoxy resin if it is melted on to it.



The complex surfaces required in a modern ship's propeller are produced by copy-milling using a small-scale master made of fibre-glass. This article describes the machine employed.

ELECTRONIC PROFILING MACHINE

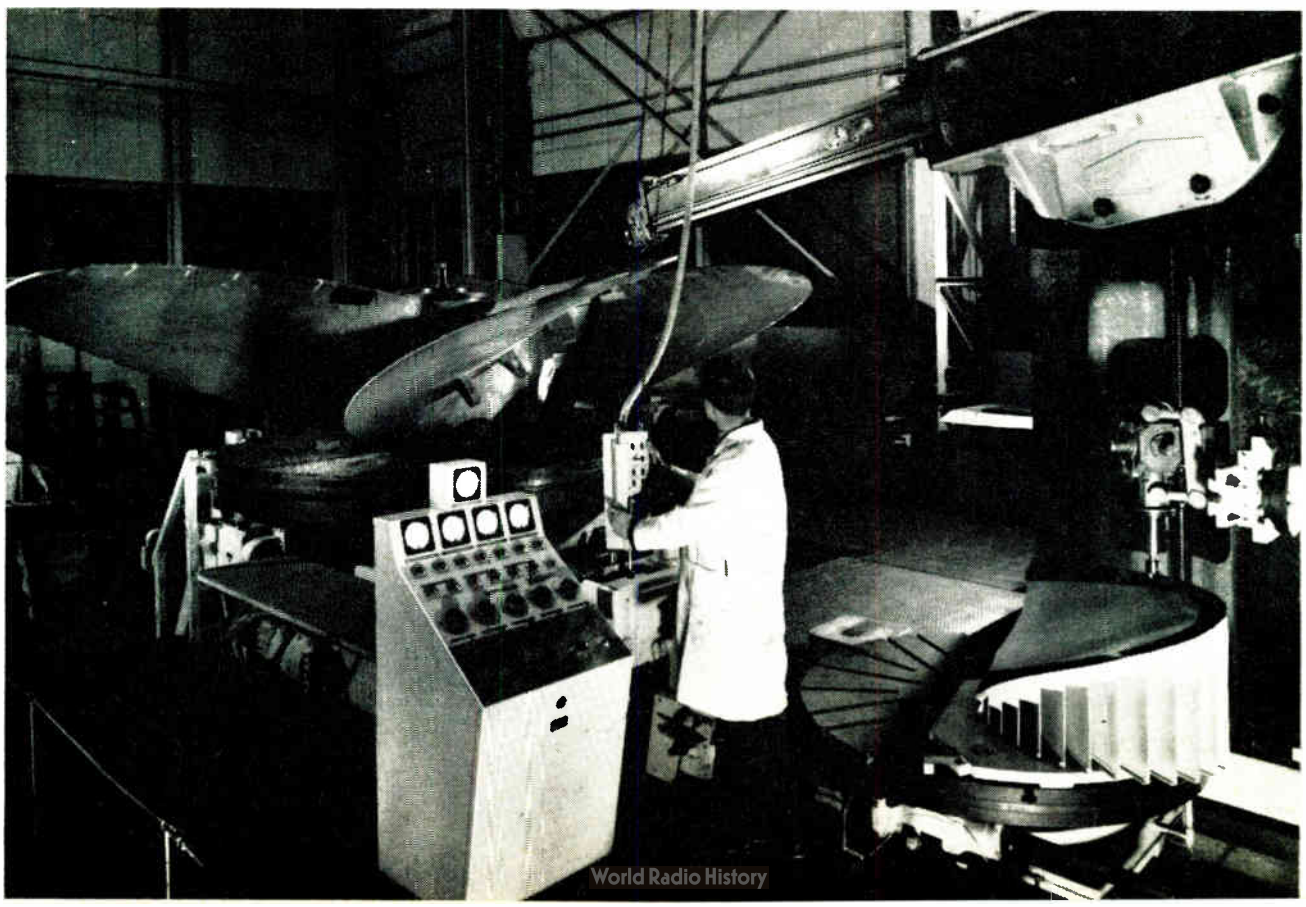
By J. PYE*

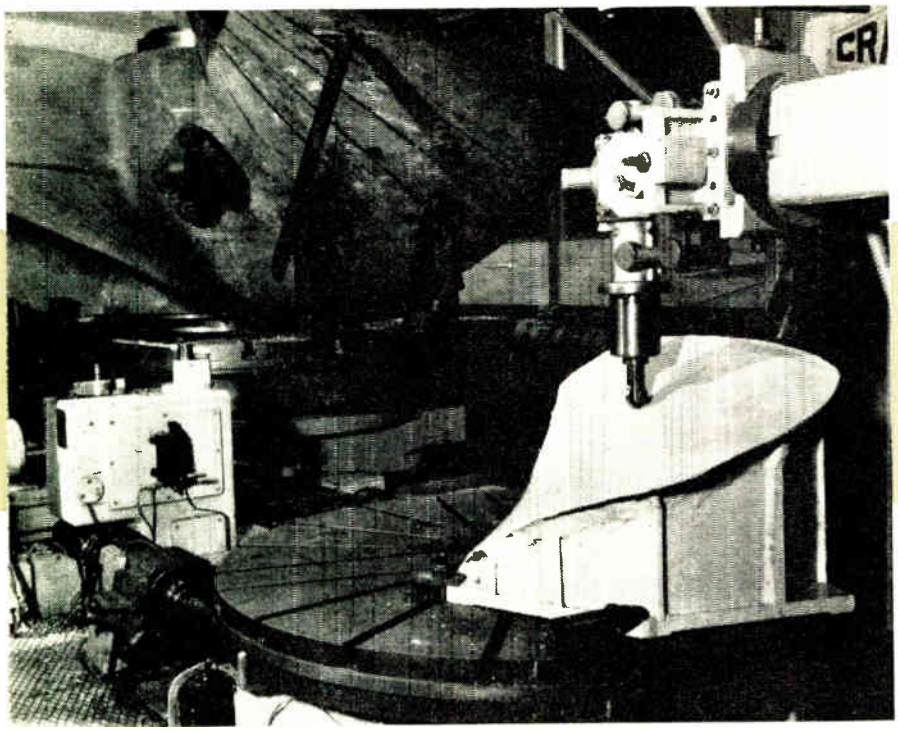
THE modern marine propeller has, over the years, developed from the simple uniform pitch and radial section design to the present high efficiency design incorporating non-uniform pitch and aerofoil sections. More complex designs, incorporating concave and radial pitch faces, are becoming more general and concurrent with these latter designs have come demands from designers for improved manufacturing tolerances.

By the application of copying techniques, a scale model of the blade surface can be employed to control the path of a milling cutter over the workpiece and the machining operation can be carried out automatically. The surface form can be held to much greater accuracy than is possible with conventional hand methods and the variations from one blade to another can be kept to close tolerances. The machine shown in the illustrations has been designed and built by Craven Brothers (Manchester) Ltd., in collaboration with A.E.I. Electronic Apparatus Division, to allow shaping of the pressure face and to copy-mill the pressure and suction faces either by tip-to-root or circumferential milling. The propeller casting is mounted on a 12-ft diameter continuously-rotatable table, supported on a saddle carried by the main double-shear bed and having a total traverse of 10 ft 6 in. An electronically-controlled 20 h.p. d.c. motor drives the main saddle via a multi-ratio gearbox and lead screw. The linear motion of the main saddle is transmitted

* Stone Manganese Marine Ltd.

A 29-ton Heliston propeller being machined under the control of the fibre-glass model in the foreground





Close-up of a model showing the tracing stylus in contact with it

via racks and a ratio box to a saddle mounted on an auxiliary bed. This latter saddle carries a 5-ft diameter table on which the model of the propeller blade is mounted.

The main 12-ft diameter table and the 5-ft model table are driven in unison by an electronically-controlled 20 h.p. d.c. motor which is geared to allow independent rotation of either table, enabling the workpiece to be indexed relative to the model.

While the tables are arranged to rotate in step, the linear motion of the model table saddle is scaled down from that of the main saddle in the ratio of 4, 3 or 2 : 1 by the use of appropriate change wheels in the ratio box. This ratio is determined by the scale of the model, which may be one-quarter, one-third or one-half full-size.

A relieving tool holder or one of two milling heads may be fitted to the nose of the ram, which has a 7-ft stroke. In order to facilitate the machining of steeply raked blades, the ram housing is arranged to swivel on the slide on which it is mounted. This slide has a 9-ft vertical traverse on the main column and carries an overhung vertically-mounted rack engaging a pinion at the top of a small auxiliary column. The shaft of this pinion drives via a further pinion, a rack attached to a small slide mounted on the auxiliary column.

A 5-h.p. copying motor, mounted on top of the column, drives the main slide. The slide, which is over-balanced by 1 ton, and its counterbalance, together weigh 22 tons.

A short adjustable ram is mounted on the auxiliary slide and carries, at the nose end, a compound setting slide to which the tracer head is attached.

When the machine is used to plane a true helical face, the ram executes a planing motion. The ram is driven by a 21 h.p. d.c. motor mounted on top of the ram housing. The motor is controlled by a Ward Leonard generator whose field current is supplied by two thyratrons, connected in inverse parallel, in series with the field winding. The thyratrons are controlled by an electronic amplifier which compares a pre-set speed signal with the output of a tacho-generator coupled to the motor shaft, thus providing closely controlled speed regulation. Independent ram feed rate controls for cutting and return strokes are provided on the control desk. All the necessary push-button controls for the shaping duty are mounted on one of the three pendant stations. The length of the stroke is governed by limit switches operated by adjustable tappets mounted on a dial driven from the ram by a self-synchronizing selsyn link. During the ram return stroke a rotary incremental feed is applied to the main table.

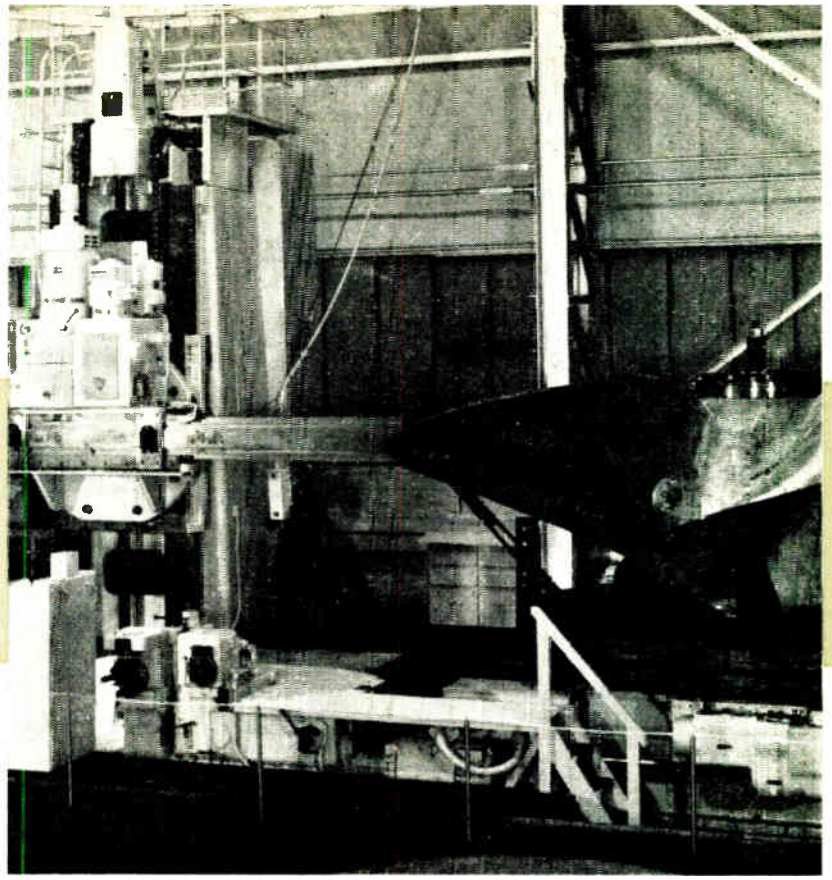
The incremental feed, which may be switched in or out at the pendant, is regulated by an adjustable planer-type feed dial controlling the main table drive; the latter is a thyratron-controlled Ward Leonard speed regulator of the same form as the ram driver. The control circuits ensure that the incremental feed is completed before the next cutting stroke can occur.

The whole of one blade surface may, therefore, be machined without intervention by the operator, except to reset the stroke length at the beginning and end of the sequence where only a short stroke is required.

The more commonly used copying duty is tip-to-root milling. The model of the blade surface to be profiled is set on the model table in the correct angular relationship to the workpiece. When the tracer head stylus contacts the model, all control of the main slide position is through the tracer head and the copying motor.

Owing to the compound curvature of the blade surface, the stylus must have compliance in all axes. To measure the direction and amount of the stylus deflection, three balanced a.c. inductive bridges are mounted in the head, one on each of the three principal axes. Each bridge will generate an output voltage whose amplitude and phase depend on the amount and direction of deflection resolved along the axis of the bridge.

The two bridges in the horizontal plane are supplied in phase and quadrature from a 1,500-c/s source and their output signals are added together after passing through a fixed-gain amplifier. The resultant signal represents the net deflection in the horizontal plane. It is then rectified and remodulated to produce an a.c. signal of the original amplitude but in phase quadrature with the supply to the



This photograph shows the rear of the milling machine with a propeller on the main table

remaining bridge. The remodulated signal is added to the amplified output of the remaining bridge and then rectified, resulting in a d.c. signal whose amplitude is linearly proportional to the absolute deflection of the stylus. This d.c. deflection voltage is subtracted from a fixed d.c. bias voltage and the net voltage becomes zero when the stylus is deflected by an amount known as the index deflection.

In this condition, there is zero input voltage to the copy-motor speed regulator and the motor will be stationary. If, for any reason, deflection decreases below the index value, there will be a net negative input signal to the speed regulator, causing the motor to drive the main slide downwards until the deflection reaches the index value. Similarly, excessive deflection results in a net positive signal which will cause the main slide to be driven upwards. The tracing system, therefore, attempts always to maintain the stylus deflection at the index value.

Since the rack and pinion coupling between the slides is within the position-servo loop of the tracing system, the loop gain will vary as the pinion ratio is changed. This is compensated for electrically by a 'model ratio' switch on the control desk which controls the tracer head sensitivity.

The copy motor speed regulator comprises a pre-amplifier feeding a hard valve amplifier which supplies the split-field Ward Leonard generator. The system is designed for 40 min/in. main slide speed while tracing, and a total cutting error of ±0·010 in. Should the error at the tracing head exceed pre-set limits, the machine will be stopped automatically and a lamp on the control desk illuminated.

The milling cutter traverses a tip-to-root path and a rotary incremental feed is applied on the completion of each pass. A corresponding linear motion of the work-piece is repeated by the model due to the drive coupling the saddles—enabling a continuous profiling operation to be carried out.

For circumferential milling, the coupled tables are reciprocated through a pre-set arc and a linear incremental feed is applied to the coupled saddles at both ends of the rotary feed motion. The incremental feed may be selected to occur at one end only if desired, and in either direction. It is applied in the same manner as the rotary incremental feed, but in this case to the saddle drive which is again a thyratron-controlled Ward Leonard system.

Auxiliary milling and drilling operations may also be carried out on the machine.

The control equipment is housed in totally enclosed cubicles. These have access doors at front and rear and all the electronic equipment is mounted on swinging frameworks to facilitate maintenance.

All the machining sequences are fully interlocked to prevent incorrect operation and indication is given on the control desk of the direction of machining feed which will occur at the commencement of shaping or copy milling.

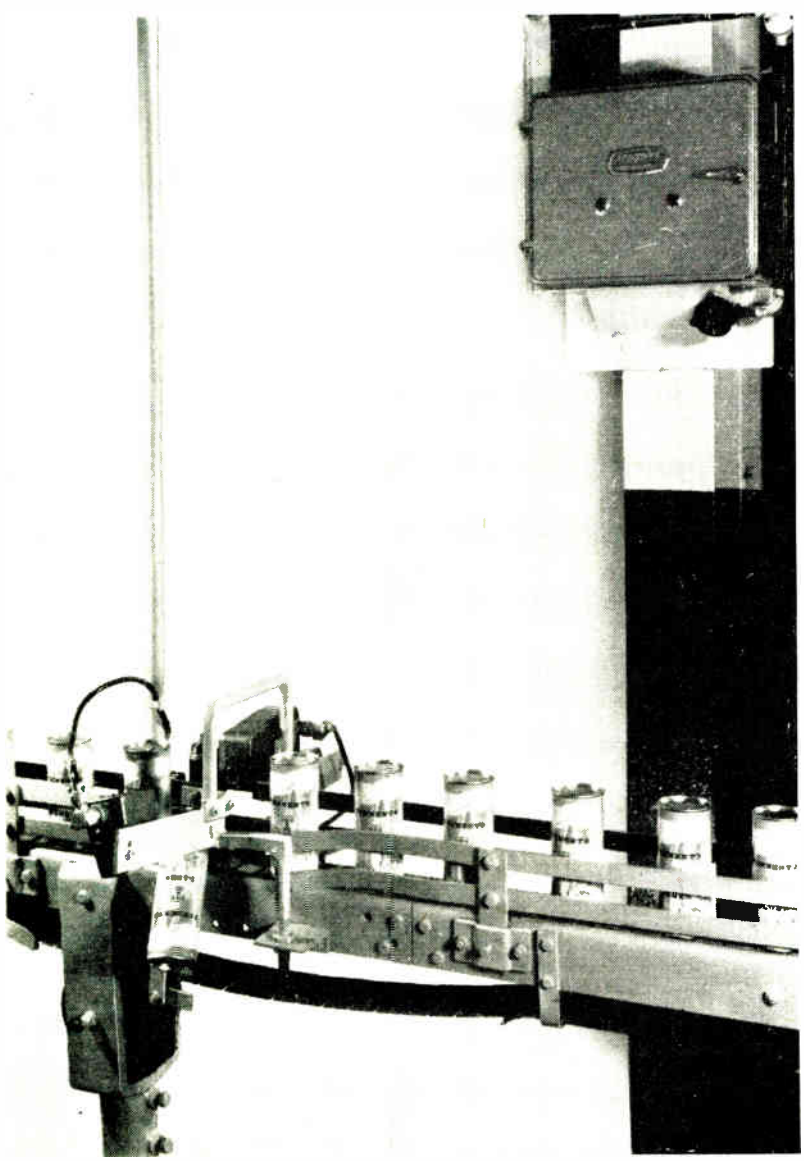
Since the introduction of the Craven profiling machine by Stone Manganese Marine Ltd. at the Greenwich works, it has been in continual production on varying types of propellers and is giving a satisfactory performance. A considerable tonnage of high efficiency heavily loaded Admiralty and commercial type propellers has been profiled on this machine. The 27-ton 4-bladed 'Queens' propellers in Novoston (a copper-manganese-aluminium alloy—U.T.S. 45 tons/sq in.) were completely profiled using this equipment. Using the latest techniques of carbide tooling, the milling operations have been carried out on the various types of material used in propeller manufacture and a satisfactory profile has been obtained. The rate of stock removal is considerably greater than with older procedures and greater accuracy has been achieved in the final surface form.

An advantage of nuclear methods of measuring liquid level is that they can be employed without any apparatus inside the containing vessel. Among other applications, they are particularly convenient for detecting improperly-filled packages as they pass from a production line.

LIQUID LEVEL MEASUREMENT

using nuclear methods

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



Photograph of typical installation for removing imperfectly-filled packages (courtesy Isotope Developments Ltd.)

MANY different physical techniques are employed in liquid level measurement, and the ready availability of radioactive materials in recent years has resulted in an extension of some of these methods, as well as the invention of a number of completely new ones. There is a wide diversity of requirements for fluid level gauges in chemical manufacturing processes. The special feature of many of these nuclear level gauges is that they can operate entirely from outside the containing vessel. They may be designed to provide on/off control at a fixed level in the vessel, or to provide continuous indication of level over a short range. Applications range over many manufacturing processes and a wide diversity of containing vessels, fluids and working conditions is encountered. For example, the containers may range from glass-lined steel drums to refractory-walled furnace tanks and the contents may vary from corrosive chemicals at high pressure, slurries, molten metals and glass, to viscous liquids such as tar, latex, etc.

There are two basic methods of level measurement using radiation techniques. The first involves the mounting of a gamma-ray emitting radioactive source inside a float, or in a float arm positioned inside the vessel. Its position is then located by means of an external detector. The second and more important method depends on the difference between the attenuation of the gamma-rays in passing through the liquid and the corresponding attenuation in passing through the airpath above the liquid. It is usual to collimate the gamma-radiation by using suitable shields of material of high atomic number (e.g. lead). The beam of gamma-radiation is then directed through the tank to a diametrically opposed detector

Plessey Nucleonics Limited.

which can sense the presence of the liquid in the beam according to the magnitude of the received signal. This latter system operates by traversing the height of the vessel (or range of liquid levels) vertically and thus locates the liquid level. Essentially, the same method is employed for sorting properly-filled from improperly-filled packages in the manufacturing industries.

Sorting of Imperfectly-Filled Packages

The basic system for the sorting of perfectly-filled from imperfectly-filled packages is illustrated in Fig. 1. A gamma-ray beam is directed through the packages as they pass, one at a time, past a radiation detector. Properly-filled packages, because of the attenuation of the signal produced, give rise to a standard output signal. Improperly-filled packages provide a much reduced attenuation path (because the path is mostly an air path) and the resulting output signal is much greater than the standard signal. This increased signal is sufficient to operate a trigger circuit, causing the sorting mechanism to operate with the result that such packages are deflected to a 'reject' line. The photograph shows a system of this sort in use under factory conditions.

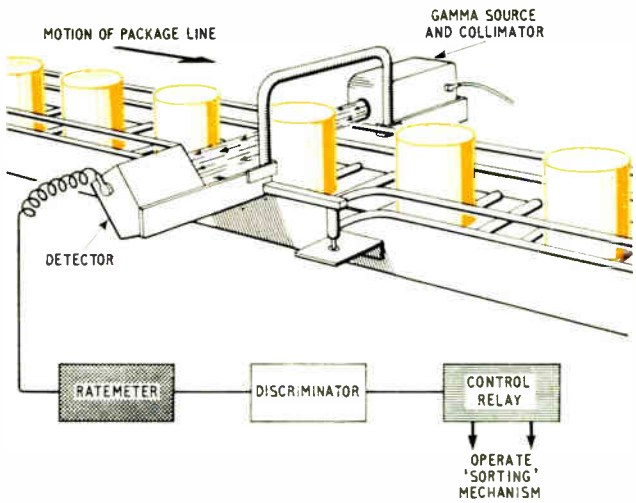


Fig. 1. Sorting of imperfectly-filled packages

On-Off Gamma Level Controls

It has been mentioned in earlier articles that on-off level controls find many applications in the process industries. In batch processes it is necessary to ensure that the correct quantities of ingredients are measured out into the reaction vessel. It is in applications of this sort that on-off level gauges find an important application. In this case it is only necessary to mount the radioactive source and the detector on opposite sides of the tank at the critical level. This is shown in Fig. 2. The reduction of signal strength as the contents rise above this level is used for the operation of the control relay to shut the valve and stop the passage of further fluid into the reactor vessel. Similarly, when a vessel is being emptied, the increase of signal strength as the contents fall below this critical level is usually sufficient to operate the control relay. In general an accuracy of $\pm \frac{1}{4}$ in. is obtainable with this method.

Continuous Measurement Level

The continuous measurement of level* involves a number of difficulties. First, the calibration curve is not always linear, unless special care is taken to distribute the source of activity, or the detector sensitivity. Secondly, it is always necessary to calibrate the instrument by making absolute determinations of the contents level over the required range. Thirdly, the meter calibration becomes inaccurate as the source decays†, unless the electronic apparatus is adjusted periodically to compensate for this decay.

When an extended range of measurement is necessary it is preferable to use a strip gamma-ray source and a long tubular detector as shown in Fig. 3. This provides a linear relationship between the detector response and the level, and installations have been satisfactorily designed to provide measurements of level over vertical distances of up to 10 ft. However, long tubular detectors of this type are not a normal commercial item and such installations can be expensive. An alternative system, applicable to the measurement of level over a more restricted range (e.g. a few feet) is to use a gamma-ray source at the bottom of the tank and the detector placed above the tank. In this case the measurement involves measuring the gamma-ray absorption by projecting the gamma-rays vertically through the tank. The response/level characteristic is logarithmic resulting in poor accuracy over the high level part of the range. It should be noted that this particular variant gives a system in which the signals are dependent on the density of the contents of the tank, so that the instrument in this case measures the weight of the contents rather than the volume.

A variant of the method which has sometimes been employed is to introduce a small gamma-emitting source in a guide tube along the side of the tank. The detector in this case is above the tank. Then, as the source is moved up and down, there will be a sudden change in the response of the detector as the source moves past the liquid level because of the greater attenuation introduced in the liquid-air path to the detector as compared to the 'air-only' path (with the source above the liquid level).

Although the method shown in Fig. 3 is used, probably

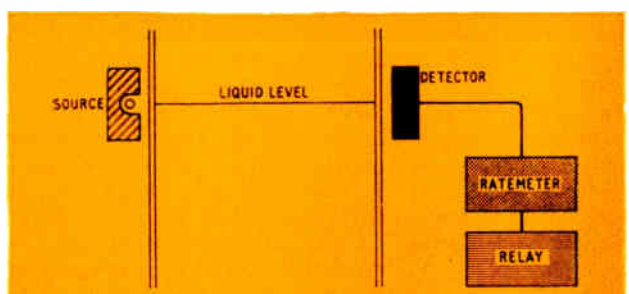


Fig. 2. On-off gamma level control

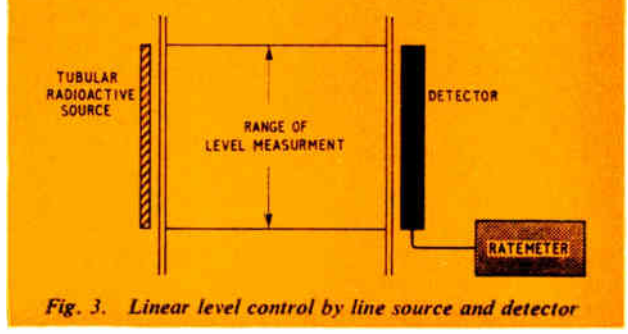


Fig. 3. Linear level control by line source and detector

* A good summary of this subject has been given by Trost, A., 'Check and Control of Content Level by Radioactive Isotopes', *Atompraxis*, February 1959.
† All radioactive sources decay with a measurable half-life. The difficulty can be avoided to some extent by using a source of long half-life. A cobalt[60] source (half-life 5.3 years) decays by 1% in about 24 days, whereas a caesium[137] source (half-life 37 years) decays by 1% in about 6 months.

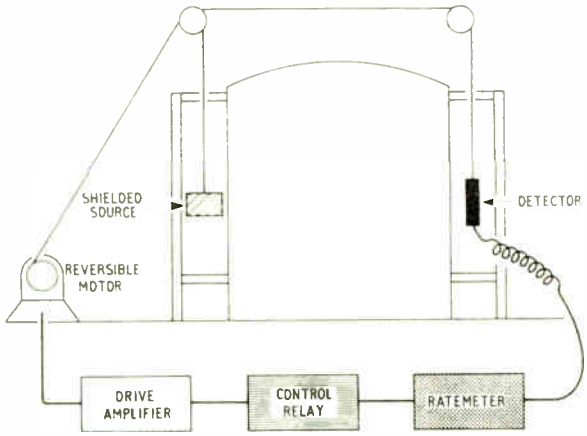
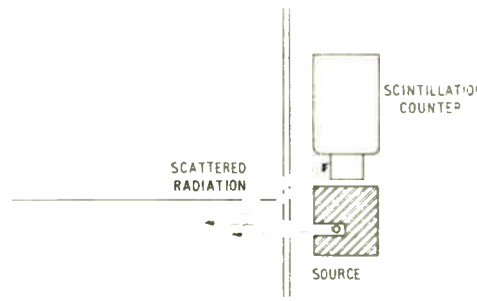


Fig. 4. (Left) Moving source and detector level gauge

Fig. 5. (Below) Motorized back-scattering gauge



the most popular method of covering a large vertical range of level variation is to employ an on-off system and arrange for both source and detector to be traversed vertically together. The traversing gear can be driven by a reversing motor controlled by the relay current, so that the source and detector follow any changes in level and are always positioned in line with the liquid surface. This system is shown schematically in Fig. 4.

In some cases it is not convenient to use the source and detector on opposite sides of the tank. It is then reasonable to consider a back-scattering system. The source in a suitable housing and the detector are moved up the side of the tank together. The position of the liquid level can be located by the variation of the back scattering in the transition from liquid to air. It is possible to use a motorized system as shown in Fig. 5, but so far back-scattering systems have not found appreciable application in industry.

In recent years interest has been taken in another nuclear method. This depends on the fact that with liquids containing hydrogen or other low-atomic weight elements, the passage of a fast neutron beam produces appreciable slowed-down neutrons. Hence, by placing a fast neutron source (i.e., one emitting high energy neutrons) on one side of the tank and a slow neutron detector* (i.e., a detector which responds to slowed-down neutrons) on the other side and moving the assembly vertically the position of the liquid level can be determined. An accuracy of ± 2 mm is claimed for this method. Less shielding is required than is needed for the gamma-ray gauge, and the advantage of completely external measuring equipment is retained. However, this method can only be used for hydrogeneous and other light liquids.

* Detectors can be made sensitive to slow (i.e., low energy) neutrons while ignoring fast (i.e., high energy) neutrons.

BINARY-DECIMAL CONVERSION

It is not very often that one has occasion to convert between the binary and decimal systems with pencil and paper, because the conversion is normally carried out by machine. Occasions do arise, however, when conversion is necessary. The student especially finds it desirable to do so in order to attach some meaning to binary numbers.

The usual methods of conversion are very laborious, but there are relatively easy ways which are not as well known as they should be. They involve nothing more difficult than repeated multiplication or division by two.

To convert a binary number to decimal form, write out the binary number in the usual way, but space out the digits much more widely than usual. Start at the left. Double the first digit, add the second digit, and write the sum below the second digit. Double the sum, add the third digit, and write the new sum below the third digit. Proceed until the last (right-hand) binary digit is added in. The result is the decimal equivalent of the binary number.

Example

Convert 101110010101 to decimal form.

1	0	1	1	1	0	0	1	0	1	0	1
	2	5	11	23	46	92	185	370	741	1482	2965

The answer is 2965.

To convert a decimal number to binary form, write out the decimal number in the usual way. Divide it by two and write the result underneath it. On the right, write the remainder. This is 0 if the number is an even one and 1 if it is odd. Repeat the process until the process ends with the division of 1 by 2 which gives the answer 0 with remainder 1. The column of noughts and ones is the binary number if read from bottom to top.

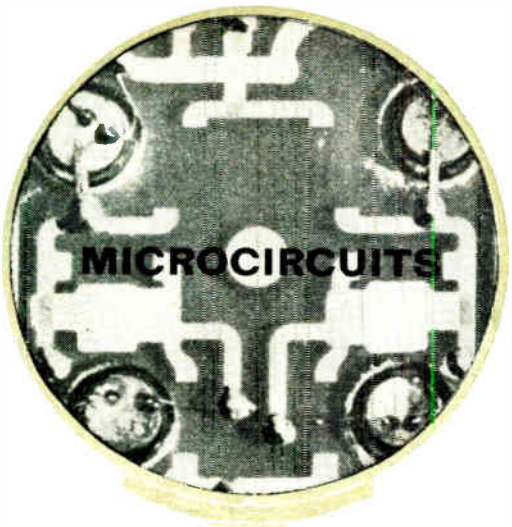
Example

Convert 2965 to binary form.

2965	
1482	1
741	0
370	1
185	0
92	1
46	0
23	0
11	1
5	1
2	1
1	0
0	1

The answer is 101110010101.

It will be noted that the two processes are the opposite of each other and that the intermediate decimal numbers obtained are the same in each case.



Now that microcircuits have reached the production stage they are becoming available for use by any equipment manufacturer. Any suitable circuit can be produced quite quickly and this article explains the special requirements which the circuit designer must bear in mind.

By A. T. WATTS*

A GREAT deal has been heard about microcircuits in the last few years. However, most people think of them as being still in the experimental stage and few realize that they are now beyond this. Their production in large or small quantities is now practicable and equipment designers must now give serious consideration to their use.

It is generally accepted by equipment manufacturers that the microcircuit can offer real advantages in size and weight reduction, increased reliability and low cost. It is felt by some people, however, that the use of circuits or assemblies of circuits produced by a component manufacturer means that the equipment manufacturer loses his freedom of circuit design.

It is true that in the development stages of microcircuit techniques the circuit manufacturers handled the circuit design. This was necessary in order to discover and allow for the advantages and limitations of the technique. A similar close liaison between device development and application has always existed for valves and semiconductors.

Now that the microcircuit has reached the production stage, however, it is both possible and desirable that users should design their own circuits. Since there are obviously limitations as well as advantages to the technique, it is necessary that the requirements be fully understood.

Advantages and Limitations

A typical microcircuit is shown in one of the photographs. Resistors, capacitors and conductors are produced by vacuum deposition on to a glass substrate 3 cm × 2 cm × 1 mm thick. Semiconductors are attached to the substrate by soldering and connections are brought out by means of wires soldered to conducting lands.

The completed microcircuit may be encapsulated individually or used in stacks of up to twenty in hermetically sealed cans as shown in the photographs. In the latter case, connections between individual circuits are made by means of etched wiring. Connections between modules are brought through an array of glass-to-metal seals at one end of the can.

The main advantages of the microcircuit technique are small size, low weight, high reliability and low cost. In module form an overall system packing density of approximately 350,000 components/cubic foot is obtainable and this is adequate for almost all applications.

The reliability of microcircuits has been the subject of considerable study, the results of which will be published separately. In the meantime, it may be noted that modules, each containing 15–20 microcircuits, have operated for over 15,000 hours, so far without failure.

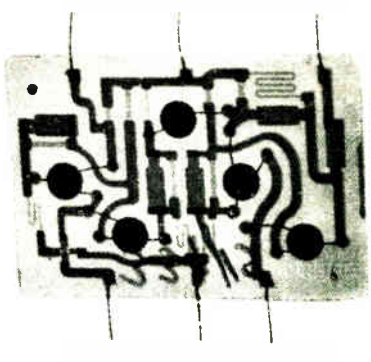
It is already established that the microcircuit in quantity production can be low in cost. A further advantage of the technique, however, is that the tooling costs involved in making a particular circuit are such that small batch production is possible at very reasonable cost. Furthermore, the technique is such that the time between circuit diagram and production of microcircuits can be only 6–8 weeks. This compares favourably with other methods of circuit production involving the ordering of separate components.

The use of modules gives advantages over singly-encapsulated circuits. The component packing density is increased considerably, since the individual cans are not present, and it is possible to ease the problem of interconnections and to reduce the number of soldered joints.

The limitations of the microcircuit technique lie mainly in permissible power dissipation and in range and tolerances of passive components available. Development is still proceeding on passive components, but the values given below indicate what is being achieved in production quantities today.

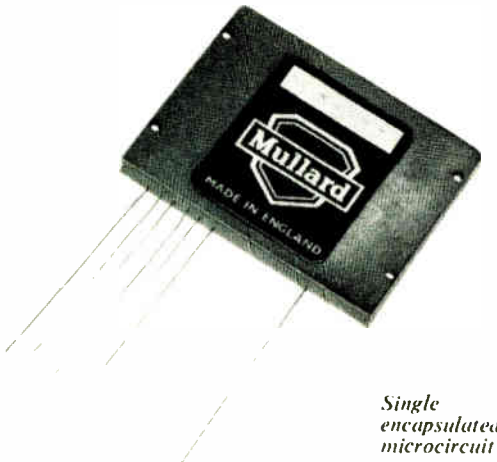
Resistors

Resistors are deposited at 300 ohms/square and are available in the range 10 ohms to 50 kilohms. This range covers almost all requirements for transistor circuits, but

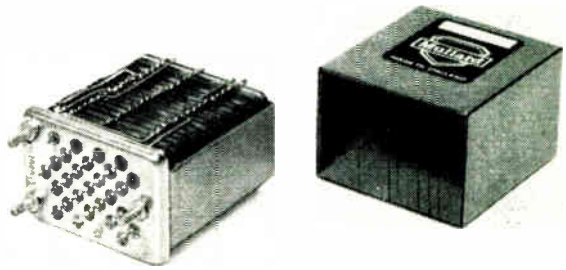


Typical microcircuit

* Mullard Ltd.



Single encapsulated microcircuit



Module with its can removed; such a module can comprise up to 20 microcircuits

higher values could be produced if necessary, at the expense of packing density. The tolerance available at the moment is ±10%, but relative values of resistors on one substrate are within ±2%.

Resistors have a temperature coefficient of less than 100 p.p.m./°C and are extremely stable. Batches of resistors on life test have exhibited drifts of the order of +0·2% in 7,000 hours at +25 °C and under typical loading conditions.

The high-frequency characteristics of thin-film resistors have been measured at up to 200 Mc/s and are almost identical with those of cracked carbon resistors.

Capacitors

The range of capacitance available is 10 pF to 5,000 pF, and capacitors are deposited at 90 pF/sq mm. The tolerance obtainable is ±15%. If higher values of capacitance are required separate miniature tantalum components may be used, and these are soldered into the microcircuit in the same way as semiconductors.

The temperature coefficient of thin-film capacitors is less than +250 p.p.m./°C and the power factor is less than 0·01 at up to 50 Mc/s. Drift is typically less than 1% in 7,000 hours at 25 volts.

Inductors

Thin-film inductors have been produced, but the maximum value obtainable at the moment is 2·5 μH. A typical Q value is 60 at 50 Mc/s.

It is obviously possible to use miniature wound inductors or transformers if necessary, but it should be noted that separate components such as these introduce more joints.

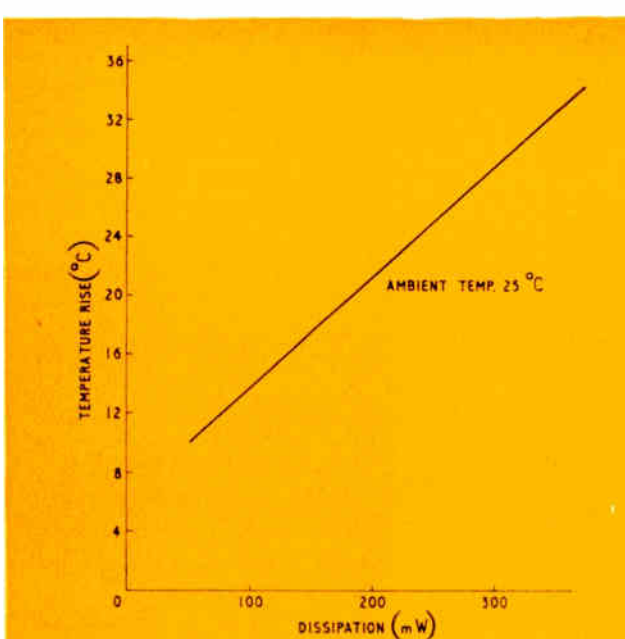


Fig. 1. (Above) Temperature rise v. dissipation for singly-encapsulated microcircuits

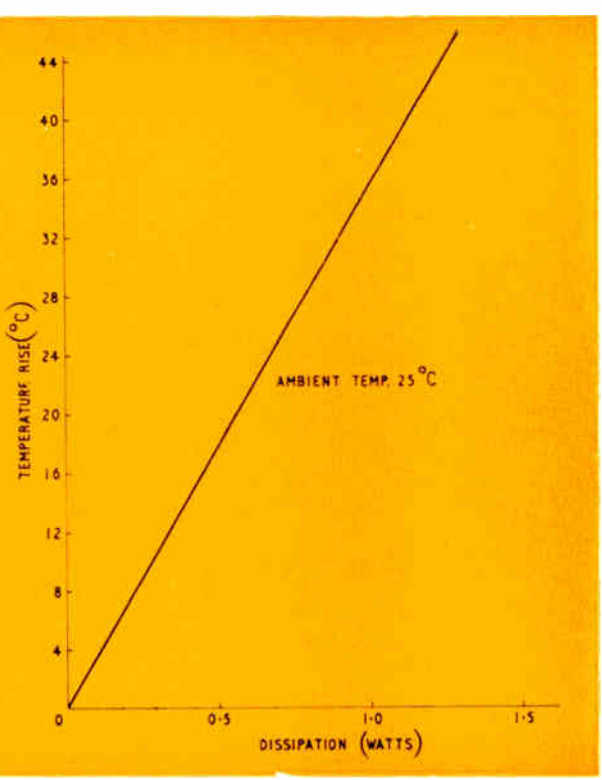


Fig. 2. (Right) Temperature rise v. dissipation for a module containing 12 microcircuits

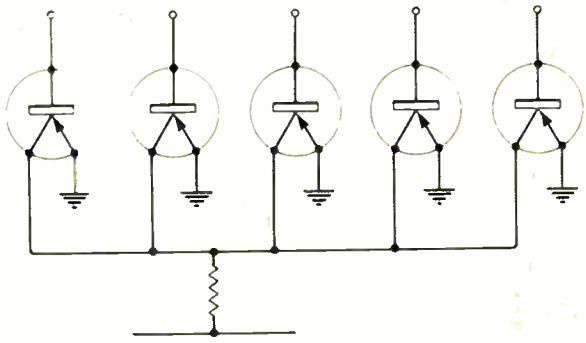


Fig. 3. Circuit of gate using direct-coupled transistor logic

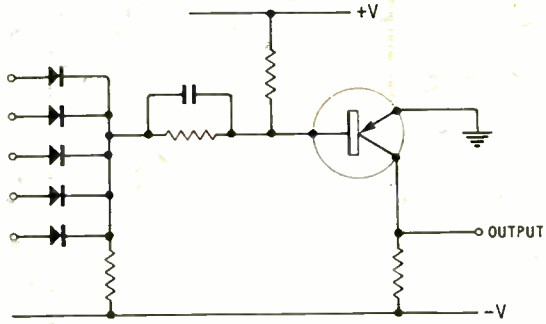


Fig. 4. Gate using base-current switch logic

Power Dissipation

There is no hard and fast rule for permissible power dissipation since this must depend on the required ambient temperature, type of semiconductor used and the method of mounting. The curves shown in Figs. 1 and 2, however, provide a rough guide.

Fig. 1 shows temperature rise in the centre of a stack of five singly-encapsulated microcircuits plotted against dissipation. All circuits are dissipating the same amount of power, which is uniformly distributed over the substrates.

Fig. 2 shows a similar curve for a stack of microcircuits occupying one cubic inch. The temperature rise for a given power dissipation per unit volume will obviously be greater here, since the packing density is increased and the individual cans are no longer available as heat-sinks.

As an example of the use of these curves, assume an assembly occupying one cubic inch, using silicon transistors in circuits designed for a maximum operating temperature of 100 °C. If a maximum ambient temperature of 60 °C is expected, then the permissible temperature rise in the module is 40 °C. This allows a dissipation of approximately 1·1 W.

It should be noted that the curves apply to the particular configurations described. If, for example, the module is surrounded by other similar modules, allowances must be made for this fact.

Circuit Design

If the above limitations are taken into consideration at the circuit design stage, no modifications are necessary in order to produce the circuit in thin-film form.

It may appear that the tolerance of ±10% on resistors is too wide for many applications. It should be borne in mind, however, that many circuits depend for their operation on the ratio between two or three resistors. In order to obtain this ratio with individual components it is necessary to specify tight tolerances. With the microcircuit, this ratio is ±2%. A further advantage for the circuit designer lies in the fact that he is not restricted to standard values of resistors or capacitors and this again eases tolerance requirements.

Since the semiconductors contribute a large part of the cost of microcircuits, it is desirable to use circuits involving as few semiconductors as possible. Consider a requirement for a logic gate having a fan-in and fan-out capability of five.

Three possible circuits to fulfil this function are: —

1. Direct-coupled transistor logic (d.c.t.l.)—See Fig. 3.
2. Base-current switch logic (b.c.s.l.)—See Fig. 4.
3. Transistor-resistor logic (t.r.l.)—See Fig. 5.

All these circuits can be and have been produced in microcircuit form. D.c.t.l. has the advantage of dissipating very little power and requires only wide tolerance passive components. The microcircuit, however, becomes little more than a printed-wiring board, since only one resistor is required for five transistors. For certain types of transistor, current-sharing resistors are required in each base, but the circuit is nevertheless expensive in semiconductors.

B.c.s.l. circuits make better use of the thin-film technique, but are still expensive in semiconductors. These circuits have the advantages of relatively low dissipation and high speed for a given transistor.

The t.r.l. circuit is slower for a given transistor than either d.c.t.l. or b.c.s.l. and dissipates more power in performing a similar function. It takes full advantage of the thin-film technique, however, and since relatively high operating speeds can be obtained in such circuits with modern transistors, t.r.l. would be the recommended circuit for operation at up to 1 Mc/s.

In linear circuits, the number of semiconductors used is generally considerably lower than is the case for digital circuits. The designer here is more concerned with production of tuned circuits and variable components.

Although it is possible to make hybrid circuits involving both thin-film and conventional components, it is desirable

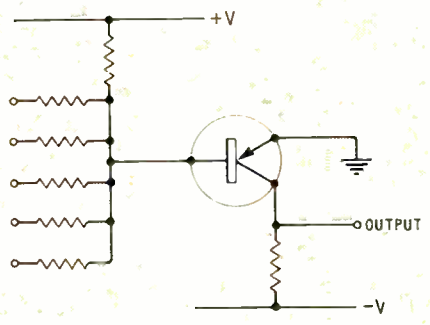


Fig. 5. Gate using transistor-resistor logic

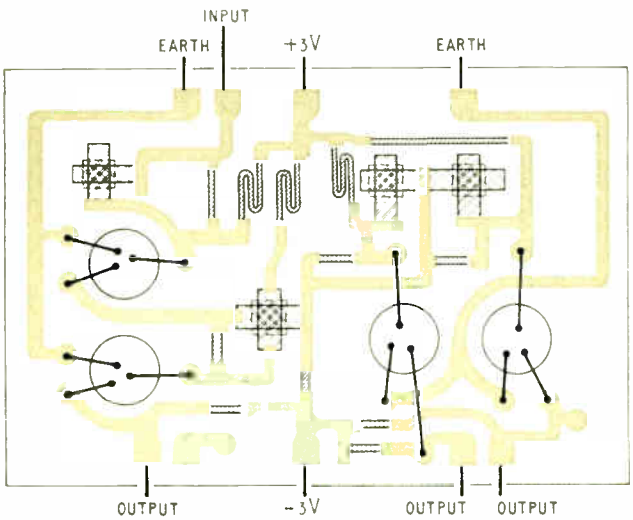


Fig. 6. Typical substrate layout

for circuits to be designed to use thin-film only wherever possible. Such circuits will be lower in cost and more reliable, since the number of joints is considerably reduced and no special engineering is necessary, as may be the case with hybrid circuits.

It is possible to produce i.f. amplifiers, for example, by the use of wideband amplifiers in conjunction with filters. This means that the major part of any i.f. amplifier, irrespective of intermediate frequency or bandwidth, would be standard and therefore lower in cost and more reliable. Such circuits do not require inductors—a useful feature, as the maximum value of inductor available at the moment restricts their application to high-frequency circuits.

It is possible to make preset step-variable resistors and capacitors by depositing padding components which may be connected by wires and these have proved adequate for many applications in which a variable component is required.

Two well-known techniques which are applicable to thin-film linear circuits are the use of RC feedback networks to produce selective amplifiers and the use of variable capacitance diodes for tuning purposes.

Layout of Microcircuits

The final drawings for mask production are produced many times full size and are drawn to great accuracy. However, there is no reason why the circuit designer cannot produce initial layouts, in order to satisfy circuit requirements and fix interconnections.

A number of rules are necessary in order to make this possible and these are given below.

Area Available on Substrate

The substrate size is 3 cm × 2 cm × 1 mm thick. In order to allow for edge effects, jigging, etc., a 1-mm margin must be allowed around the edges of the substrate.

Termination pads are placed along the 3-cm edges of the substrate at a pitch of 1·9 mm. If the substrate is intended for individual encapsulation, only one edge may be used. The maximum number of termination pads on one edge is fourteen.

Conductors

The minimum permissible width for conductors is 0·5 mm, and the minimum spacing between conductors is 0·4 mm. It is desirable to make conductors as wide as possible as with conventional printed wiring boards.

Resistors

Resistors are deposited at 300 Ω/square, and dissipation may be up to 1 watt/sq cm. The minimum permissible width of resistors is 0·25 mm. The resistors may be made in meandered form if necessary. Since the conductors have a resistance of 0·5 Ω/square, it is desirable to use resistors as connectors wherever possible, thus reducing the length of conductors.

Capacitors

The standard value of capacitance is 90 pF/sq mm. An overlap of 0·5 mm all round should be allowed on the dielectric to allow for misregistration.

Semiconductors

There are a large number of microminiature semiconductors available in different encapsulations. The encapsulation most used with microcircuits is 3·175 mm maximum diameter.

Termination Pads

These are 1 mm diameter and are normally arranged at the minimum distance from the semiconductor can. It is

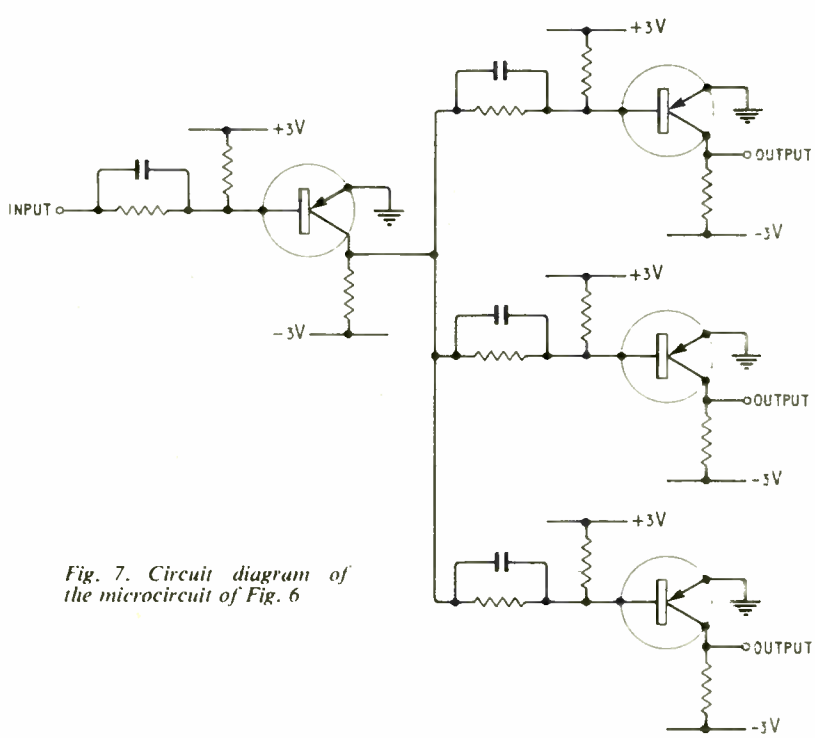


Fig. 7. Circuit diagram of the microcircuit of Fig. 6

possible, however, to use the semiconductor leads as jumpers where necessary.

The initial layouts for microcircuits are drawn six times full size and roughly to scale. A typical layout is shown in Fig. 6 and Fig. 7 is a circuit diagram of this substrate.

Conclusion

The microcircuit is now a production item, and will find large-scale application in low-power electronics. It is essential, therefore, that the circuit designer shall be able to provide circuits suitable for manufacture in thin-film form.

It is clearly impossible to list all the possibilities open to circuit designers and there is no doubt that many ingenious circuits will be devised in order to make full use of thin-film techniques.

It is hoped, however, that this article will serve as a general guide.

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Selvin, G. J., 'Microcircuitry: Special Considerations for Military Quality Systems', Proceedings of Agard Conference on Microminiaturization. (Book) p. 159, Pergamon Press, 1962.

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INDUSTRIAL APPLICATION OF MICROWAVE POWER

MICROWAVE tubes, developed for radar and communications purposes, originally delivered power only in short pulses. In recent years a number of continuous-wave devices of relatively high power have been produced, opening up entirely new fields of application.

Microwave power is readily absorbed by certain non-metallic substances and is converted to heat in the process. An early application of this property was in the cooking of food by microwave power in a fraction of the time normally required.

Elliott-Litton Ltd. have been concerned for some time in investigating the possible application of microwave power to many industrial processes, particularly those involving the heating and drying of materials with poor thermal conductivity. It was found that microwave heating techniques could be more effective because energy was absorbed only by the product which required heating and was not dissipated, as in industrial ovens or convector drying plant. Heating was also more uniform, as energy was applied to all parts of the material at the same time, to the centre as well as the outside surface. Research has been concentrated particularly on the drying of paper and pressed fibre board, and on the heating and curing of plastics material.

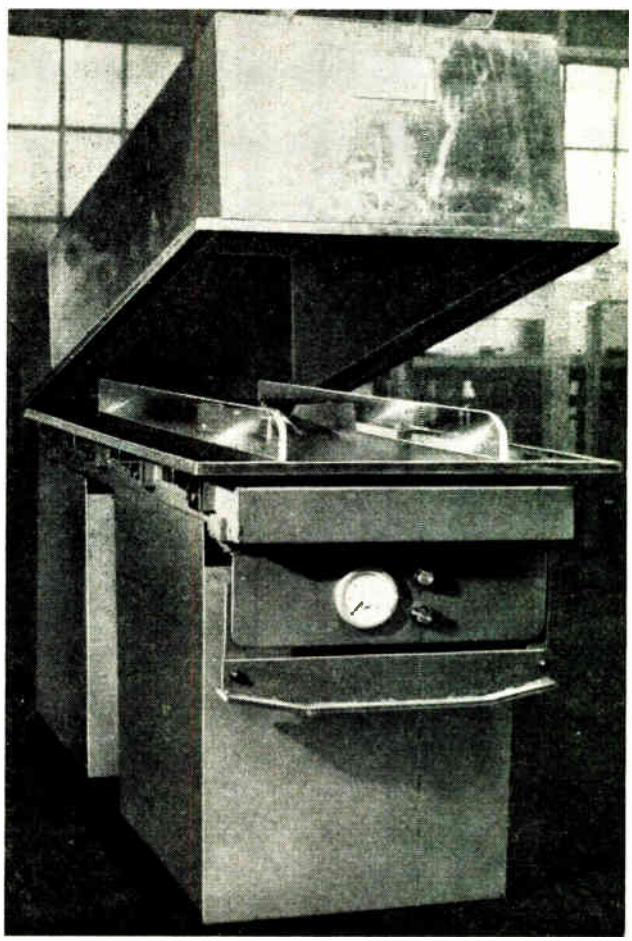
At a recent reception in London, Elliotts demonstrated a small-scale laboratory microwave heating equipment designed to illustrate the drying of paper and the curing of polyurethane foam plastic moulding.

The idea that microwave power could be used for curing polyurethane foam plastic mouldings came first from the British Motor Corporation. They are in fact installing prototype production line plant for producing foam plastic mouldings cured by microwave power—this will be the first in the world. Viking Engineering Co. is supplying the plant fitted with an Elliott-Litton microwave power source.

The advantages of the microwave curing plant can only be fully assessed after the prototype installation has been working for some time. However, at this stage it is possible to state that, compared with a conventional system for a given output, the microwave plant is smaller, requires fewer moulds and costs considerably less. For example, to cure 10,000 foam plastic pieces per week, at present B.M.C. require an 80-ft long oven and 138 aluminium moulds. For the same output with the prototype microwave oven, they require only 40 epoxy resin moulds and a proportionally smaller unit.

It is anticipated that the maintenance of the microwave plant will be carried out by factory electricians since the electronics comprises only a self-oscillating magnetron and a d.c. power supply.

For further information circle 32 on Service Card



This shows the Viking Engineering 'Vitherm' microwave foam plastic curing unit. This is the standard unit which provides the basic design for the B.M.C. installation

CONVEYOR BELT COUNTING & SIZING

By R. D. CARTER-PEDLER, B.A.*

This article describes a semi-automatic counting and object-sizing system which is working on conveyor belts in a laundry. In this application the system is being used to count and indicate the size of each work piece passing on conveyor belts through a flat-ironing machine.

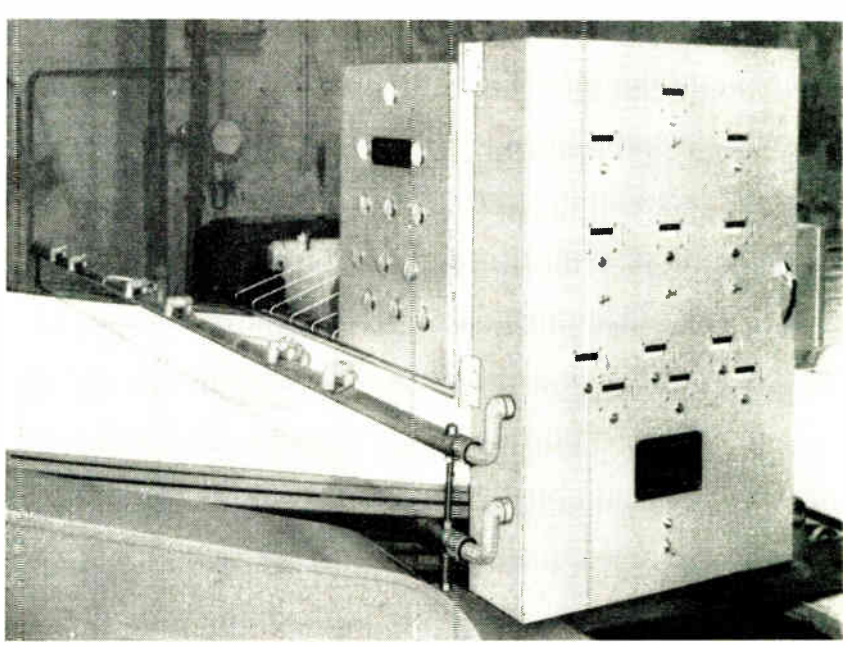
IN almost every industrial process where operators are employed to handle various types of articles, an automatic or semi-automatic counting system can be used to provide the management with information which, when used correctly, will aid efficiency.

When related to time the basic article counts can, for instance, be applied directly to: (a) The assessment of incentive bonus, either to collective operator groups or to each operator individually or (b) assessing the handling costs of different types of articles. A close 'work study' is particularly important where a process service is being rendered, as in the case of a laundry, but applications for these techniques exist in almost every industry. Manual counting is expensive and unfortunately complete reliance cannot be placed on the figures thus obtained so that an automatic counting system free from the human element is an essential foundation to effective work study.

While it is obvious that the installation of automatic counting and sizing equipment can lead towards mechanical data processing and automatic accountancy, it is proposed here to describe a simple semi-automatic system which has proved successful in practice in a laundry where the figures are read off the counters and entered on forms by hand. Although with this system the electronic apparatus is fixed to a machine in the works it forms part of the wages and cost office equipment.

Fully automatic systems have since been built and if fitted with automatic

* Photoelectronics (M.O.M.) Holdings Ltd.



A view of the semi-automatic system installed at the works of the Welcome Laundry Co. Ltd.

timing for each run ('lot' of washing) and print-out counters this could feed a complete daily analysis into the office automatically. It is felt, however, that the extra cost of print-out counters may not be justified as it is necessary for a full analysis to know the name of each operator (and the total number of operators) employed for each 'lot' of washing. These will vary continually according to the kinds of articles being processed, thus it may be preferable for the totals to be read off ordinary display counters and entered at the end of each 'lot', along with the time taken.

For the purpose both of paying bonus and costing, the various articles normally handled are grouped into four main size categories, the biggest being sheets or large table-cloths and the smallest serviettes or dishcloths. The smallest size can be fed down the flat-ironing machine six at a time, taking six operators, whereas only three operators are needed to feed large sheets which naturally carry a lower bonus target figure per hour ; i.e., fewer units per hour / ratio to earn a bonus on the basic rate.

The recording sheet for each 'lot' therefore, provides for the entry of totals from six small work counters—these figures being subsequently added together to arrive at group performance—three medium size work counters, two large size and one very large work counter. Adding facilities can be provided in the electronic equipment to reduce the foregoing to four sets of figures only. This would mean that individual operator performances cannot be studied, but where group bonus is paid on a team-work basis a saving in the extent of office calculations is effected.

Provision is made for the entry of operators' names, so that a change of team can be noted, time started and finished, etc.; i.e., all relevant information required to complete the daily analysis sheet made up in the office, for study by management. A summary prepared from the detailed analysis shows daily totals of articles processed, bonus earned, idle time, etc., to give an overall picture. Thus the 'paperwork' consists of three forms, the first of which appears in quantity, one for each 'lot' of washing, prepared by the supervisor or chargehand in the laundry from the automatic counting equipment and time clock, then forwarded to the cost clerk while the second two, prepared by the cost clerk are forwarded to management, viewed by the supervisor and returned to file (for future comparison purposes). Fig. 1 shows a typical production sheet for one 'lot' of washing. The figures for this sheet are taken from the counter display units. Fig. 2 shows part of an 'Operator Time Daily Analysis Sheet' which is made up with details from the individual production sheets and a 'Production Shift Summary Sheet'.

Combined Three- and Six-Lane System

Semi-Automatic.—In this installation, comprising three separate work lanes alongside each other, it was necessary to design a simple system which could be used to count work pieces travelling on conveyor belts in the three separate lanes or two small work pieces per lane, effectively making six lanes, or single large work pieces occupying two lanes. This is done by making use of a number of simple circuits comprising eight phototransistors with light projectors operating eight relays directly to switch the electromagnetic counters. Only two discharge tube timers and three interlocking relays are needed to complete the system, apart from the manual selection switches employed on the semi-automatic model. The timing and interlock circuits are used to mute either the six-lane or three-lane sensing systems when a large work piece occupying two major lanes passes through. These circuits arrange that the smaller work counters are not re-alerted until the tail end of the large work piece has passed the bank of photodetectors.

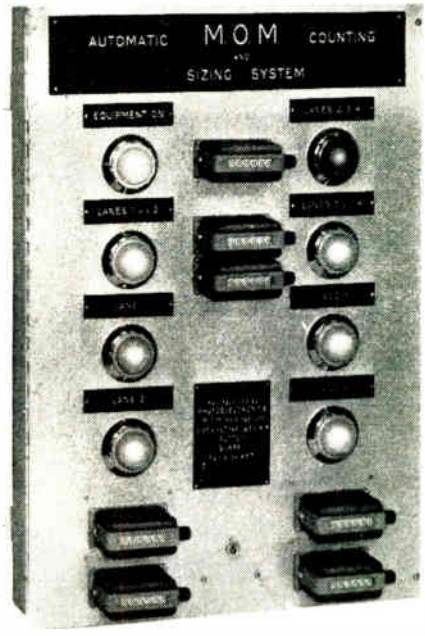
Very large work pieces occupying more than two major lanes are recorded on the counter by operating a selector switch.

Fig. 3 (a) shows the arrangement of the phototransistors which are mounted on a bridge over the conveyor belts. Each of the eight phototransistors has a corresponding light projector mounted beneath the conveyors and projecting their light beams through slits between the conveyor belts on to the appropriate phototransistor. Objects on the conveyor belt will cut the light beam and cause an output signal from the phototransistor to operate one of the electromagnetic counters. When operated individually, phototransistors 1 to 6 can be used to count very small work pieces. For medium-sized work pieces occupying one lane a selector switch is provided to gang detectors 1-2, 3-4, and 5-6 in pairs. Detector number 7 senses large work pieces occupying lanes 1 and 2 and provides a cut-off signal for detectors 1, 2, 3 and 4; detector 8 operates in a similar way for lanes 2 and 3. For very large work pieces occupying more than two lanes, detectors 7 and 8 are ganged by a selector switch and their combined outputs are fed to a separate 'large-work' counter. By using a total of twelve separate counters the system provides counts for each item and an indication of the size of each item.

Fig. 3 (b) shows in schematic form the arrangement of the twelve counters.

Automatic System.—The fully automatic counting and sizing system is somewhat similar to the semi-automatic model already described. The arrangement of the sensing heads and associated circuits is such that no pre-setting of switches is required but the feeding in of work pieces must be confined to the clearly marked channels at the machine inlet according to their size. The fully automatic unit only requires one additional discharge tube timer.

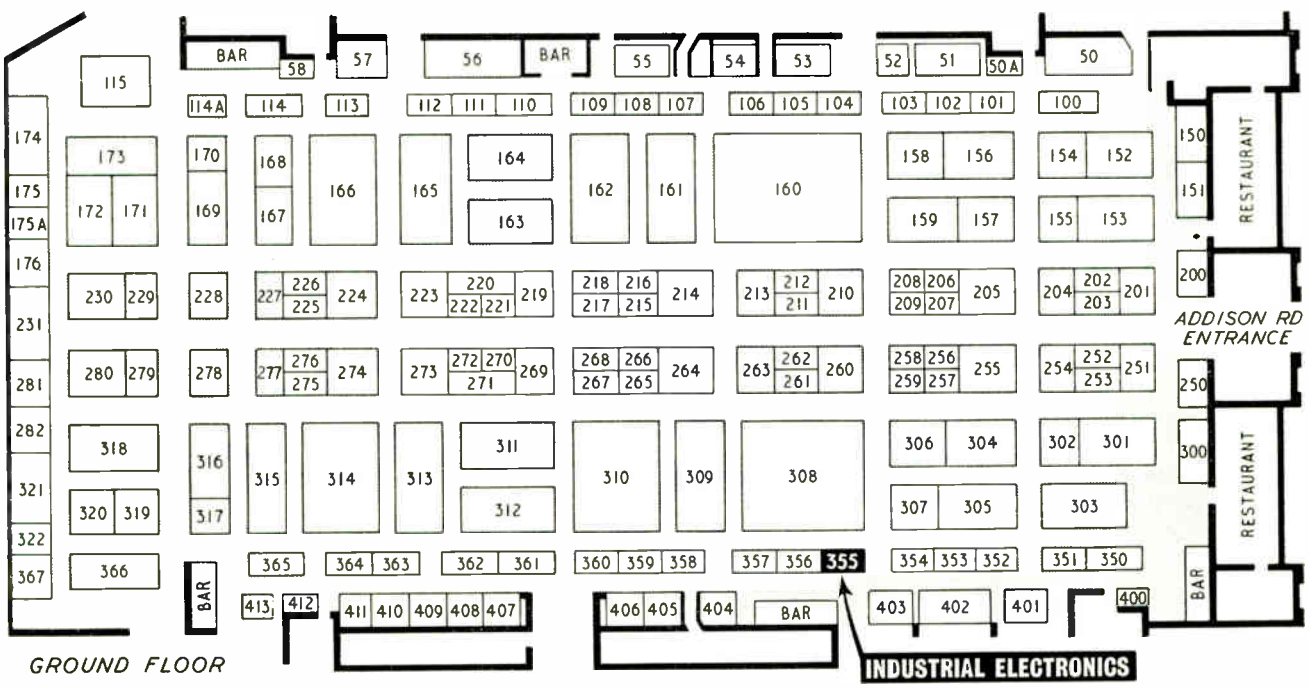
By including adding facilities in the electronic unit, the number of display counters can be reduced to three as follows: Lanes 1, 2, 3 and 4 (small work) counter 1. Lanes 1 and 2 or lanes 3 and 4 to counter 2 (medium work) from sensing heads 5 and 6, and very large work from sensing head 7 on counter 3. The advantages are freedom from mistakes due to easy reading of daily totals article-wise, but the subsequent works study is limited to *operator groups*

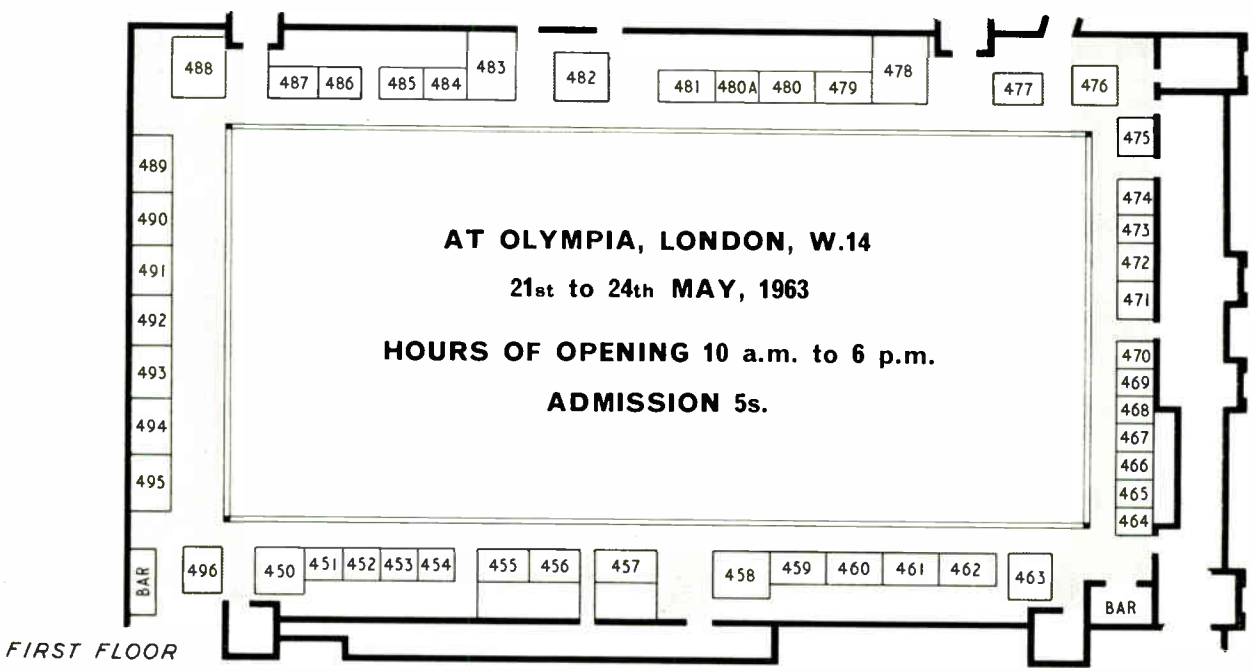


The control panel for the fully automatic system

1963

Radio and Electronic Component Show





PREVIEW OF EXHIBITS

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

The Radio and Electronic Component Show is the 18th of the series. Previously known as the R.E.C.M.F. Exhibition, it is now held in alternate years. On pages 416 and 417 are plans showing the layout of the exhibition, which will occupy a total area of around 80,000 sq ft, an increase of 6,000 sq ft compared with the 1961 show.

While it is no surprise that the emphasis this year is on microminiaturization, the exhibition will also provide a glimpse into the future in respect of components designed for the rigours of advanced airborne and space research. As part of the Government stand, the Ministry of Aviation will be showing how electronic equipment is designed and manufactured for use by H.M. Forces. The theme of the Ministry's presentation is the importance of component reliability in the production of equipment which has to withstand the environmental extremes met in military operations.

To demonstrate the part played by the manufacturer in achieving this reliability, a typical component has been selected in order to illustrate its various stages of manufacture. This section is contributed by members of the Electronic Valve and Semiconductor Manufacturers' Association (VASCA), who will also be showing examples of their own test procedures.

One of the outstanding component developments of recent years is the application of microminiature techniques on a production basis. One example of this, which will be featured by Mullard **(56)**, is an integrator developed for rocket guidance systems in which 3,438 components are packed into a unit measuring 3·8 by 2·6 by 1·8 in.

Among new developments to be seen on the Technograph **(57)** stand will be working models of printed-circuit motors. Multi-layer circuits will also be displayed. Although these circuits are at the moment only being manufactured for prototype evaluation, they appear to have a promising future. Construction is in the form of alternate layers of insulating material and conductor patterns with inter-circuit connections made via holes plated through the circuit where required.

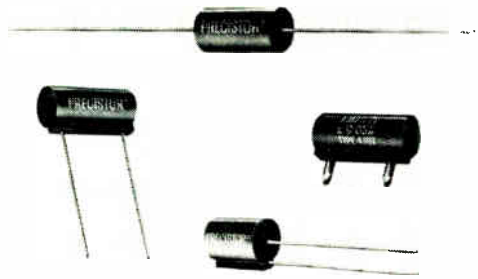
The ever-increasing use of printed circuitry has stimulated the development of cheaper and faster methods of fixing components on to printed circuit boards. J. & S. Engineers **(58)** will be demonstrating their 'Jastac' range of fixing techniques, a project sponsored by N.R.D.C. With this method, standard electronic components have their lead-wires fitted with special inserts and are loaded on to the circuit by means of a press-tool: in a single operation the component is rigidly mounted on the board and at the same time connected electrically to the copper track without the need for pre-drilling or pre-punching holes, and without the use of soldered joints. Contact resistance per insert is approximately 1 mΩ. This system is claimed to be equally suitable for both small-scale use and mass-production.

On the B.I.C.C. stand there will be a selection of products from B.I.C.C.-Burndy emphasizing the wide application of compression-jointing techniques **(59)** as applied to r.f. and power connectors. A particular feature will be an edge-type printed-circuit connector utilizing removable crimped contacts which can be fitted either by automatic or hand-operated tools. This development enables high-speed assembly methods and a considerable degree of quality control to be employed.

The evolution of instruments which simplify industrial testing processes and minimize the possibility of human error has been well marked in the past two or three years. Companies in the Derritron Group will be showing some examples of this trend, including a digital Wheatstone bridge **(60)**, the readings from which can either be displayed directly or made available as pulses, thus allowing the bridge to form part of a control system.

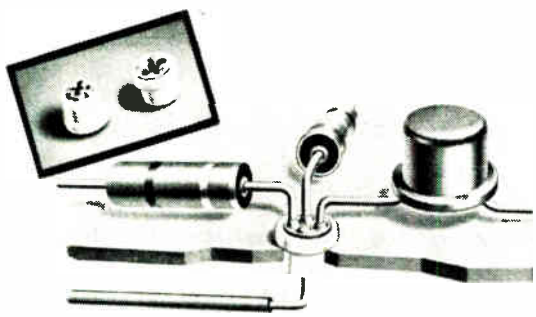
Several new semiconductor ranges will be displayed on the Brush stand **(61)**. These include: silicon transistors specially designed for chopping applications, which can be supplied in pairs or quadruples matched by offset volts to within 50 μV; silicon power epitaxial transistors; silicon zener diodes available in 1%, 5% and 15% voltage tolerances; and p-n-p-n four-layer diodes in a wide range of switching voltages.

Reliance Controls will be showing what is claimed to be a major advance in multi-turn potentiometer design.



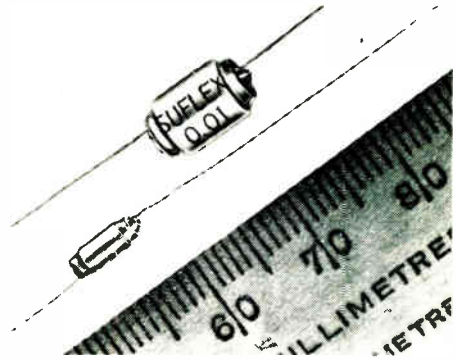
One of the 'live' exhibits this year will be an experiment to demonstrate the stability of Electrothermal precision wire-wound resistors: this will consist of a Wheatstone bridge balanced by two identical 'Precistors', one frozen in a block of ice and the other immersed in boiling water. Precistors are available from 0·5 Ω to 10 MΩ; tolerances down to 0·01%; stability better than ± 0·3% **(62)**

This general-purpose laboratory crucible furnace suitable for small-scale metal melting, heat treatment, etc., will be one of several exhibits from Barlow-Whitney. The 'Vertical Crucible Furnace' has a maximum operating temperature of 1,200 °C and features a short heating-up time **(65)**



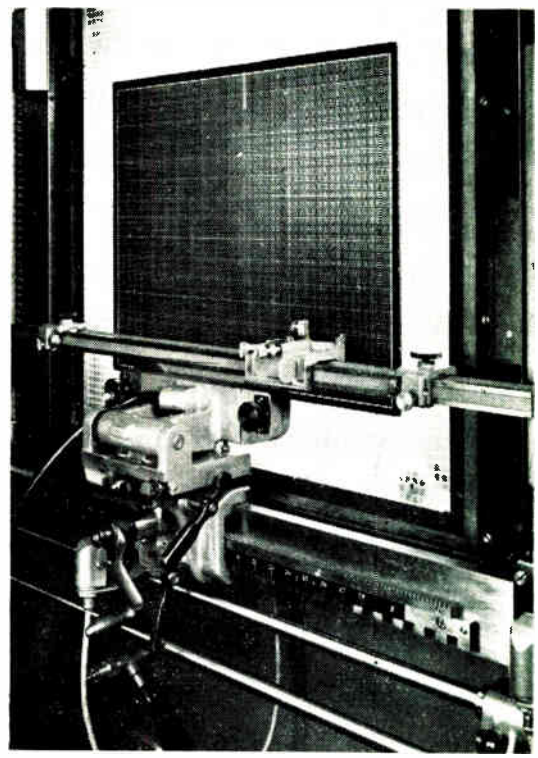
Sealectro will be showing the Cloverleaf terminal system in which a new 'Press-Fit' receptacle allows the economy of dip-soldering to be combined with the reliability and repairability of hand-wired metal chassis construction. The Cloverleaf receptacle provides four insertion points for wire leads, with a centre hole. The system is for use in metal chassis from 0·040 to 0·065 in. thick **(66)**

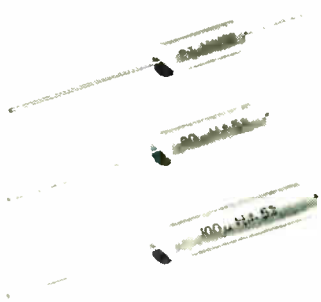
A range of photomechanical equipment used in the production of all types of printed circuitry will be featured by Pictorial Machinery. Their main exhibit will be a Lithoprintex Junior step-and-repeat machine designed for the production on film or glass of multi-image negatives or positives up to 30 by 24 in. in area. This machine also offers the facility for vertical and horizontal scribing upon photographic plates with a setting accuracy of better than 0·0005 in **(67)**



Among components offering a useful reduction in size compared with those currently available for transistorized circuitry, is a comprehensive range of 30 V d.c. wkg. double-ended polystyrene film capacitors by Suflex. The lead wires are of 36 s.w.g. tinned copper. In the illustration, one of the new range is shown below a standard version **(63)**

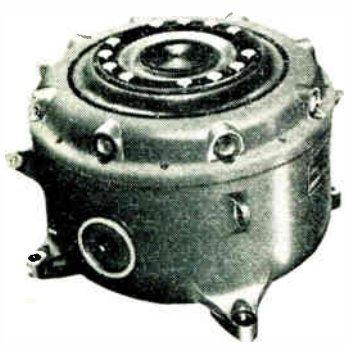
The Harwin B.1001 digital indicator provides a 12-character optical display, using Acrylic plates directly edge-lit by J/S pattern midget bulbs of 6, 12 or 28 V. This method of construction, by avoiding deflections of the light, gives a significantly sharper and brighter image than has hitherto been possible with the bent-plate technique. At the same time it has resulted in a marked decrease in size and weight. This plug-in unit measures 2$\frac{21}{32}$ in. high by 1$\frac{7}{64}$ in. deep (excluding plug pins), with a width to allow mounting in banks at 1 in. centres **(64)**



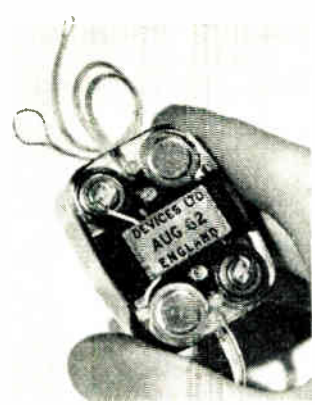


Among new Plessey components on show will be a series of encapsulated inductors. These compact units are available in three wattage ratings with tolerances of ± 5% or ± 10%. The smallest inductor of 2·7 μH (top), rated at ¼ W, is 3/16 in. long **(75)**

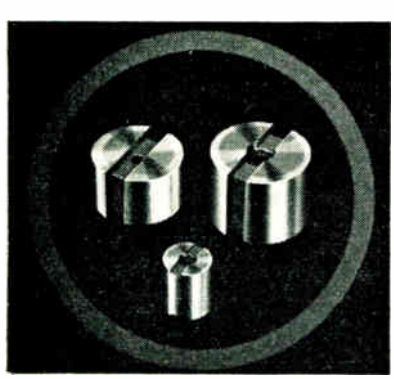
A range of E.H.T. transformers with resin-cast assemblies offer a reduction in size compared with conventional oil-filled units and ionization-free operation at working potential. The compactness of the Forest series, which will be seen on the Gardners stand, is well illustrated in the photograph which shows a 12 V, 40 A unit rated at 40 kV wkg. with a plan area of 8½ by 7½ in. and a height of 12 in **(76)**



A selection of vibration generators with their associated driving and monitoring equipment will be displayed on the Goodmans stand. The VG.1K. Mk. 1 (illustrated) will be shown in operation. It has an overall weight of 1,260 lb, a maximum thrust of more than 1,000 lb and an excursion of ¼ in **(77)**



One of CIBA's exhibits will be this cardiac 'Pacemaker' unit. Developed at St. George's Hospital, London, and made by Devices Sales, the unit is designed for complete implantation within the human body. The unit contains a transistor pulse generator powered by four batteries. Special flexible electrode leads have been developed to withstand many millions of fatigue cycles to which they are subjected by the physical movement of the heart. Both leads are duplicated and can be transferred from one 'Pacemaker' to another to facilitate minimum disturbance of the connection to the heart. The average battery life is over three years **(78)**



Murex will be showing internal magnet assemblies in which the problem of attaching the iron shoes has been overcome by pressing and sintering the magnet material and iron powder as one piece, thus avoiding the introduction of high reluctance gaps into the circuit. With this 'Sincomax' technique, pole shoes of high density iron can be thin in section and designed to give linear distribution of flux over their entire length. Three typical assemblies are shown in the photograph **(79)**

The SYN 11-00 series **(68)** is intended for applications which demand very low inertia and quick response, e.g. in servo equipment, computers, etc. A light, rugged wiper assembly is made possible by the use of a very compact spiral element wound from bare polished precious-metal wire. These units are to be made available in both synchro-mounting and bush-mounting versions.

This year's show will include a number of instruments which can be regarded as 'component' parts of complete systems; for example, panoramic display units **(69)**, which give a 'picture' of radio signals available to a receiver, will be exhibited by Stratton & Co. One unit is for v.h.f./u.h.f. operation and shows on a c.r.t. the signals over a bandwidth of 1 Mc/s; the other, for h.f. work, operates over a smaller spectrum. Among the many applications of this equipment is the frequency-checking of 'fixed-tune' receivers and the accurate assessment of frequency drift. In communication networks, it enables an operator to call a wanted station and see immediately when that station replies, giving him the facility of tuning-in accurately without searching.

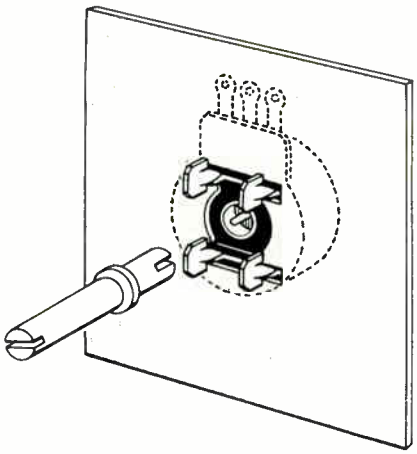
The growing interest in 'piped' television services, which will no doubt be reinforced by the introduction of u.h.f. transmissions, is to be covered at Olympia by Belling & Lee, who will be showing their distribution systems **(70)**. These feed multiple programmes from a central receiving station to the individual receivers. Working on a wide-band system (from 40 to 220 Mc/s) this equipment has been designed to cater for all the foreseeable needs of piped services: colour, pay-TV, v.h.f. and u.h.f. picture transmissions and sound radio.

Bonella will be featuring a new range of 'Cherry' micro-switches **(71)** rated at 5, 10 and 15 A, 250 V a.c., in addition to their standard ranges of miniature moulded-body switches.

Solid tantalum capacitors **(72)** in a voltage range from 6 to 75 V will be the main exhibit on the Union Carbide stand. Other components to be shown include getters for radio valves and cathode-ray tubes.

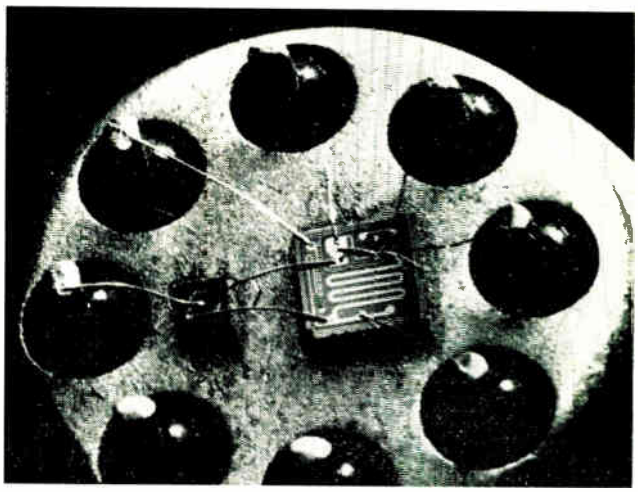
A. H. Hunt (Capacitors) Ltd. will be showing comprehensive ranges of fixed capacitors for all purposes. New developments **(73)** include 'Dipseal' (resin-impregnated) metallized dielectric, and 'Metalac' metallized lacquer types.

Manganese alkaline batteries **(74)**, together with a wide range of mercury batteries, will be featured by Mallory. Advantages of the manganese battery include long life, constant output and high resistance to corrosion.

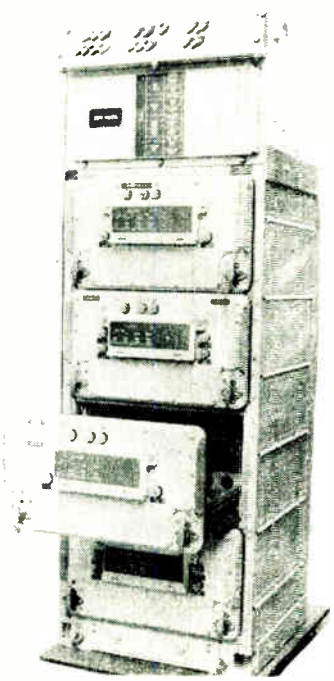


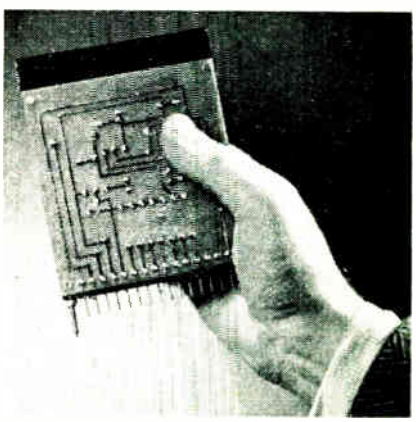
East Grinstead Electronic Components will be exhibiting a full range of 'Radiohm' miniature and semi-miniature carbon-track potentiometers which will incorporate several novel features, two of which are illustrated. The drawing shows a tab-fixing system, which it is claimed will offer a considerable reduction in time and expense on the assembly line. The potentiometer is fixed, after insertion, simply by twisting two of the four tabs provided. The non-conductive detachable spindles have the advantage that they can be inserted after the chassis has been completed; they fix firmly into position and can be supplied with knobs to customers' specifications **(81)**

Featured on the Ferranti stand will be developments in silicon solid-state integrated circuits for linear amplification (Microlin) and for high speed logic functions (Micronor). The circuit illustrated (magnification: approx. 20 times) is a linear amplifier from the Microlin range, encapsulated in an 8-lead case measuring 0·36 in. in diameter and 0·18 in. in height. This circuit is composed of two silicon chips, one containing a p-n-p transistor, the other containing an n-p-n transistor and 6 resistors **(80)**



Bribond will be showing this K114-approved cabinet, designed to provide a flexible system for housing electronic and electromechanical equipment. Each unit is self-contained with built-in cooling and heating facilities. Removable side panels allow through-wiring where cabinets are used in multiples. Also to be exhibited is a modular-chassis printed-circuit cabinet with standard racking **(82)**





This plug-in static switching unit will be among the items on display relating to the A.E.I. Logicon static switching system which can be used in place of conventional control gear in many industrial applications. These units, which have been available for some time in heavy-duty encapsulated form, operate approximately 1,000 times faster than conventional relays and have no moving parts to get dirty or wear out **(83)**

The main exhibit from Wingrove and Rogers will be Polar gang capacitors **(84)**, most of which can now be supplied with gear and pinion drive. Trimmers for printed-circuit board mounting will also be shown.

Westinghouse Brake & Signal Co. will be demonstrating how 'Trinistor' silicon-controlled rectifiers **(85)** can be linked to driver and controller units to form various control systems. Other components will include silicon diodes, selenium surge suppressors and selenium rectifiers.

In addition to their established products, Midland Silicones will be showing some new materials **(86)** including a clear, flexible silicone resin, a self-healing dielectric gel, and a one-component cold-curing silicone rubber sealant.

Miniature Electronic Components will exhibit a wide range of multi-turn trimmers **(87)** in values from 10 Ω to 125 kΩ, precision wire-wound resistors with tolerances from 1% down to 0·01%, and a miniature toggle switch.

Electrical measuring instruments of many kinds will be featured by Sifam, including meters and indicators for pyrometric applications **(88)**. The new 'Harmony' and 'Clarity' ranges incorporate a number of interesting features, in particular with respect to ergonomic considerations.

New developments to be shown by Telcon Metals include details of their thin-foil rolling facilities which are capable of producing ultra-thin foils down to 0·00015 in. thickness in a variety of alloys **(89)**. Non-magnetic tools in beryllium copper will also be on display.

Venner Electronics will be showing a new frequency meter specially designed for portable use **(90)** and a millisecond stopclock of matching appearance. Other exhibits will include a digital voltmeter, a digital clock and a variable rise-time pulse generator.

New products on show from J-Beam Aerials will include helical aerials, omnidirectional colinear arrays, and a $\frac{5}{8}\lambda$ mobile whip aerial **(91)** which enables users of high-band mobile radio-telephones to have a wing-mounted aerial similar in performance to a $\frac{1}{4}\lambda$ roof-mounted unit.

The main feature of the S.T.C. display will be Ministac **(92)** high-density circuit assemblies and associated

devices such as thin-film circuits, transistors and integrated-circuit modules. Also represented will be a wide range of conventional components.

Marconi Instruments will be showing examples of their new '2000' range of telecommunications measurement equipment **(93)**. Standardization, including the extensive use of common sub-assemblies, has resulted in greater reliability and lower costs.

Two of the principal items to be shown on the Elliott-Automation stand are the Minilog 'F' series of microminiature logic elements **(94)** and the Arch range of compatible analogue and digital modules.

As well as a comprehensive range of terminals and connectors, A-MP will be exhibiting their fine YR splice **(95)** which makes it possible to splice wires as fine as 47 s.w.g., at a rate of up to 450 splices per hour.

Among their range of test instruments and coil-winding machines Avo will be showing the 'In-Situ' transistor tester **(96)**. It enables current gain to be measured with the transistor still connected in circuit.

Magnetic Devices will exhibit, among other things, the series 850 relay **(97)** which meets Ministry specifications for pentance, ethylene and hydrogen classes; it is termed an intrinsically safe relay.

Transformers will be found on many stands. Hinchley are featuring types with special mounting arrangements for printed circuits **(98)** and have a range of laminations in metric sizes. Geo. L. Scott can now supply toroidal cores ready coated with an epoxy resin so that they can be wound without further treatment **(99)**.

In addition to their range of transistors, Newmarket Transistors will show miniature packaged circuits for inclusion as complete units in more complex apparatus. Selective assembly is used to take up transistor and component tolerances and provide a complete unit of close tolerance **(100)**.

T.C.C. will exhibit a wide range of capacitors; two new types are the Supamolds **(101)** and Duomolds **(102)**. The first is a paper tubular capacitor especially designed to cater for the higher temperatures met with in modern television receivers. The second is also a tubular capacitor but one with a mixed dielectric, giving a considerable reduction in size over the conventional 750-V 85 °C type.

In the capacitor part of their exhibit, Dubilier **(103)** will be featuring tantalum electrolytic types and subminiature electrolytic types. They also are showing samples of the 'Bluecon' and 'Greycon' ranges.

In computers and control systems there is now considerable application for precision potentiometers and quite a number will be on show. Ancillary Developments have among their range a low torque model; the linearity is 0·1% and the torque 1 gramme/cm **(104)**. Beckman Instruments will show a range of Helipot **(105)** potentiometers.

Rendar Instruments will exhibit push-button switches. The PBS/1 range **(106)** is available in two styles, push to make and push to break. Pye will show micro-switches as well as miniature types and limit switches **(107)**.

An interesting new development to be shown by Thorn (Special Products Division) is the application of electroluminescence for lighting instrument panels. This has been accomplished by using electroluminescent plates instead of a series of pea-lamps in the Thorn 'Plasteck' **(108)** system. An 'image retaining panel' will also be on display: this is an electroluminescent device for the detection and controlled retention of two-dimensional images formed by a wide band of electromagnetic radiation.

Diamond H Controls will be exhibiting a range of hermetically-sealed and general purpose relays **(109)**; primarily designed for use with these, and also on show, will be two series of time delay units. Other items will include snap-in toggle switches and neon indicators in various colours.

Tectonic will be exhibiting a representative range of products including flexible multi-layer circuits **(110)** composed of printed wiring on flexible base materials. These are being proposed as a replacement for bulky cable runs, e.g. in aircraft and general electrical wiring.

Also in this field, one feature of the Sellotape stand will be an illustration of the possible uses of polyester film in printed circuitry. A typical example, consisting of 0·00015 in. of electrodeposited copper laminated to a polyester film by a thermosetting adhesive, will, when etched, form an extremely flexible printed circuit **(111)**.

Sanders (Electronics) will be showing examples of a wide range of microwave components **(112)** suitable for use in measuring systems. Working exhibits will include a new microwave power meter and, in the industrial field, a low ripple, constant voltage source (using the module s.c.r. power amplifier) with an output of 200 V at 5 A.

Amongst a variety of machines to be displayed by Rejafix will be a power-driven marking and printing machine for transistors or similar articles. The 4T/TPR transistor printer **(113)** has an output of up to 2,000 prints per hour, depending on the shape and size of the articles, and can handle diameters up to $\frac{1}{2}$ in. Special hand-made blocks enable a considerable amount of information to be printed on very small surfaces.

Exhibits from Gulton Industries will include a range of capacitors, transducers and thermistors based on their new thin-sheet ceramic process **(114)**. Demonstrations will be given showing the uses of ultrasonic transducers and low noise coaxial cable and connector equipment.

Burndept will be showing a new range of sealed nickel-cadmium rechargeable accumulators **(115)** which require no maintenance and cannot be overcharged. The range at present comprises outputs from 50 mAH to 2·5 AH. Larger sizes up to 6 AH are under development.

Relays are finding increasing use in modern apparatus when the high speed of electronic switches is not needed. Erg will show a range of encapsulated dry-reed types in which the contacts are sealed in an inert gas atmosphere. This firm also has a miniature type AB 1434 **(116)** with an operating time of 0·5 msec.

Resistors are naturally shown by many firms and the standard 'stick' resistors are too well known to need description. Accuracy requirements, however, are continually increasing and precision wire-wound resistors are now no longer the rarity that they once were. Rivlin, for example, have a range of four-terminal resistors covering 0·001 Ω to 100 Ω with tolerances of 0·02% for values above 1 Ω and 0·2% for values below **(117)**. Other types range from 1 Ω to 3 MΩ with tolerances from 0·02% to 1% and power ratings from $\frac{1}{8}$–3 W.

Erie have introduced the first three of a new range of metal oxide high stability resistors **(118)**; they are all rated at $\frac{1}{2}$ W at 70 °C and have a minimum value of 51 Ω. The MO65 and MOG65 (ceramic insulated) are available in values up to 180 Ω and with tolerances of 2 per cent and 5 per cent. A third type is available with higher values but wider tolerances.

Electrosil are featuring metal oxide resistors with values from 10 Ω to 470 kΩ, or in the $\frac{1}{4}$ W type up to 1 MΩ **(119)**. Special purpose types based upon the standard product but with extra processing controls are available.

For further information on specific items circle appropriate number on Service Card

Automatic Measuring Stop for a Hot Saw

IN hot sawing and shearing operations in a steel works the length to be cut off is decided by the position of a stop which arrests the moving piece.

It is frequently necessary to alter the measured length quickly and accurately and the alteration may be one of 20 ft or more.

Lamberton & Co. Ltd., of Coatbridge, has developed a measuring stop of multiple head design which is now in steel-works operation. Some time ago B.I.S.R.A. decided there was a need for a position control system for mechanisms such as these and accordingly they developed a system.

In consultation with B.I.S.R.A. and Lamberton & Co., a method of control has been produced by Lancashire Dynamo Electronic Products Ltd.

The stop is designed to measure lengths from 10 to 70 ft. It has six stopper heads mounted on a carriage which travels parallel to the roller table on wheels. Each head is raised and lowered by an individual air cylinder. The travel of the carriage need only be the distance between a pair of heads, that is 10 ft. It is obtained by a motor-driven screw working in a nut mounted on the carriage.

By selecting the appropriate head and setting the carriage in the 10 ft range, any length from 10 to 70 ft can be obtained.

The shock of the moving piece is cushioned by heavy springs and is transferred to the foundations through a collar on the screw. The screw is turned by an electric motor through a reduction gear box.

The driving motor used is the recently invented Rawcliffe 2-speed a.c. motor. This motor enables very accurate positioning to be attained. The high speed is used for length adjustments over 6 in. Below this only the low speed is necessary. The final approach to the chosen position is always made at low motor speed.

To ensure consistency of stopping, the approach to the selected position is always made from the same direction. This obtains uniformity of backlash and other clearances which otherwise would cause inaccuracy. This means that when adjusting in one direction it is necessary to overshoot the position and return to it.

Approach is thus always made at the same speed and from the same direction and a consistent accuracy of plus or minus $\frac{1}{16}$ in. has been obtained on test.

The operating method is to set the required position on a rotary switch with an illuminated scale. The start button is pressed and no further attention is needed.

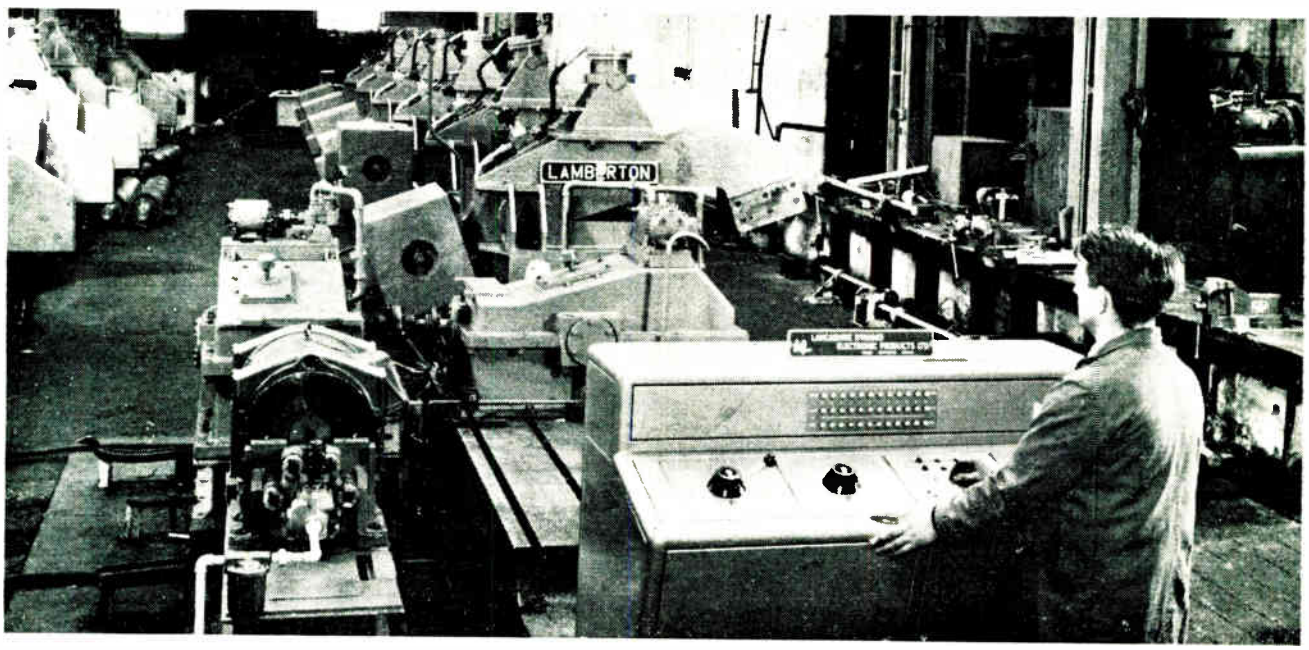
The control equipment works on a digital system, the digital value of the required position being set up by the selector handle already mentioned. This is compared with the actual position of the carriage which is obtained from the digitizer operated directly from the moving carriage through a steel wire. The digitizer is of an electromagnetic type, which eliminates the possibility of trouble with contacts or filament bulbs.

The logic units are of the L.D.E.P. Digital System standard transistorized plug-in pattern, which have the advantage of ease of servicing coupled with high reliability.

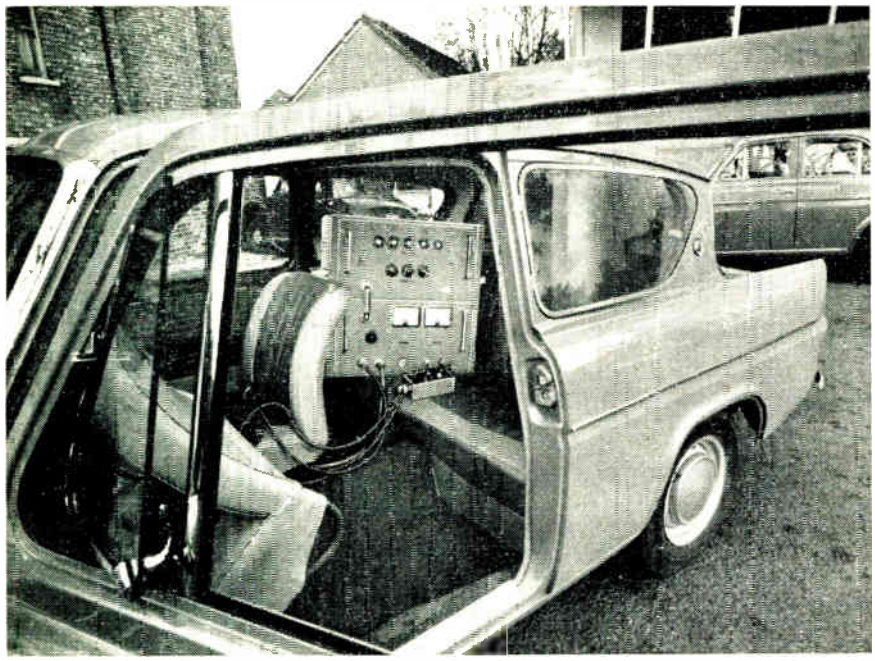
The digital system is not susceptible to drift. It can easily be adapted to work from a computer to ensure minimum wastage of steel in cutting to ordered lengths.

The automatic measuring stop is a fast working and accurate machine requiring a minimum of attention from an operator and it shows a considerable price advantage over other systems.

For further information circle 120 on Service Card



This shows the digital equipment controlling the automatic measuring stop for a hot saw



The control console in the back of a Ford Anglia about to undergo performance testing

ELECTRONIC CAR PERFORMANCE TESTER

LONDEX LTD. has developed an electronic 'stop watch' which enables the Ford Motor Co. to test the performance of cars when overtaking. It measures what is called 'exposure time', the critical period during which an overtaking car is passing another vehicle, allowing a safe distance before cutting in. One of the advantages of this equipment is that it is only necessary to use one car for the test.

The equipment consists of a console, which is basically a special electronic counter, a clip-on dashboard indicator and a pulse generator, driven by a trailing road-wheel. Vehicles are taken at random from the production line and are driven at a selected speed. A 'pass distance' appropriate to this speed is set on the equipment. The driver is given a visual signal from the dashboard indicator at the precise moment when he should accelerate hard to simulate overtaking conditions. When the 'pass distance' has been reached, he is given a signal to stop accelerating. The 'exposure time' is indicated on the console. Tests are carried out at varying speeds and the results compared with the manufacturer's designed performance figures as a routine product check.

'Exposure time' is measured by counting pulses obtained from a 1 kc/s crystal oscillator, which gives a reading accurate to ± 1 msec. The 'pass distance' is measured by counting the pulses generated by the trailing wheel-attachment. Each pulse represents a road distance of 1 in. A bridge network built into the equipment ensures that a test does not begin until the appropriate speed is reached.

For further information circle 34 on Service Card

The road-wheel attachment driving the generating unit produces one pulse for every inch travelled

This final part of the article discusses d.c. bias conditions and goes on to explain the action of tunnel-diode ring counters. It concludes with a description of a double-inductance multivibrator operating as a binary counter.

DUALITY AND TUNNEL DIODES

(Concluded from p. 393 of April issue)

By P. J. LANGLOIS, M.Sc.

IN the foregoing a.c. analyses of multivibrators, mention has been made of the d.c. conditions for astability. Bistable, monostable or astable circuits can be achieved using the same circuit configuration, but with different biasing. The essential features of d.c. bias conditions for each type of multivibrator will now be considered.

D.C. Bias Conditions

The general d.c. circuit for both single and double inductance is shown in Fig. 34. The *V–I* characteristic of this circuit is shown in Fig. 35, and demonstrates the effect of different symmetrical loads. In cases where the load resistance is greater than the negative resistance of the tunnel diode, there are three positive slopes where stable equilibrium can exist, shown as 'p', 'q', 'r', in Fig. 36. At slope 'p', the tunnel diodes are in the '0' condition; at slope 'q', one tunnel diode is in the '1' condition, and at slope 'r', both are in the '1' condition.

From the *V–I* characteristics shown, which are all derived using JK20A diodes as in Fig. 21, the d.c. state of either type of multivibrator can be derived using the loadline technique. Fig. 37 shows the loadline 'a' of a current generator in the single-inductance case as in Fig. 38, the loadline 'b' of a voltage as in the double-inductance case as in Fig. 39. The loadline 'c' is for a generator with an internal resistance R_g. The equivalent loaded current or voltage generator is shown

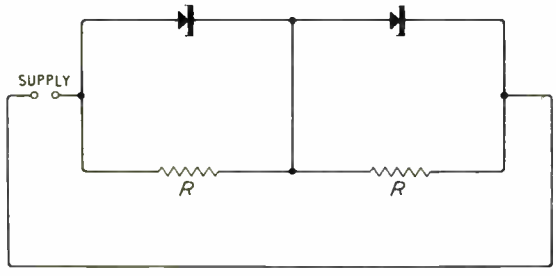


Fig. 34. General multivibrator d.c. circuit

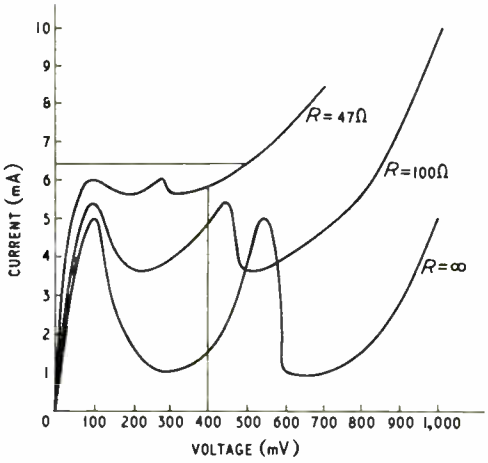


Fig. 35. Overall characteristic of circuit using JK20A tunnel diode

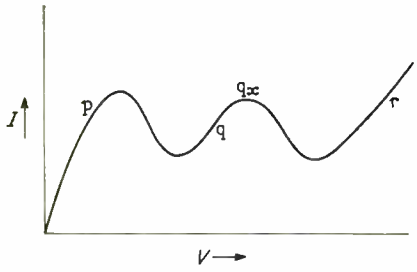


Fig. 36. Three positive slopes on overall d.c. characteristic of Fig. 34

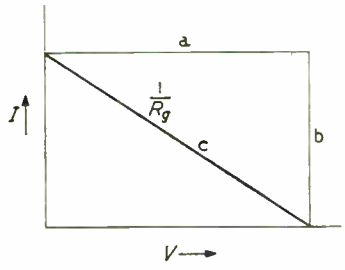


Fig. 37. *Loadlines of power supplies*

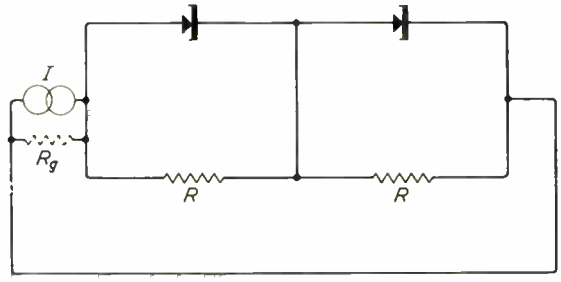


Fig. 38. *Current generator circuit*

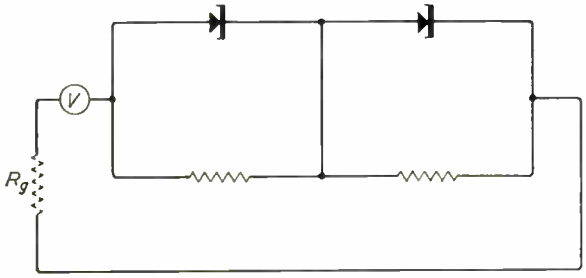


Fig. 39. *Voltage generator circuit*

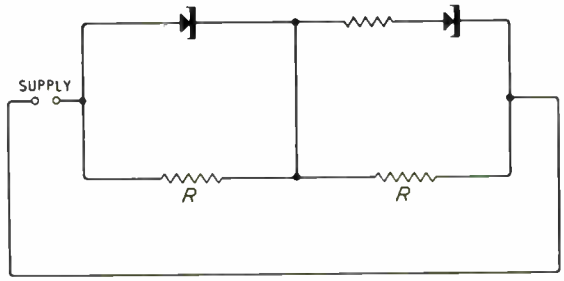


Fig. 40. *Monostable circuit using similar loads*

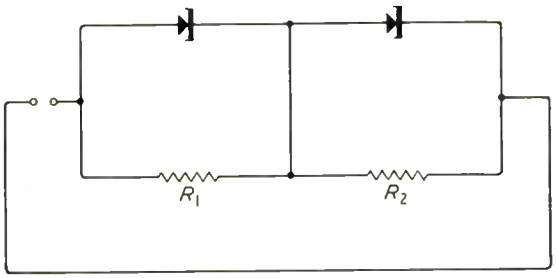


Fig. 41. *Monostable circuit using different loads* ($R_1 > R_2$)

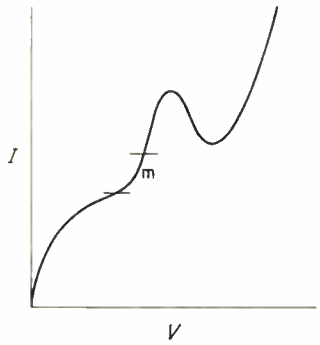


Fig. 42. *V: I characteristic of Fig. 40*

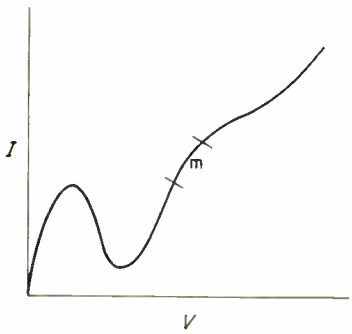


Fig. 43. *V: I characteristic of Fig. 41*

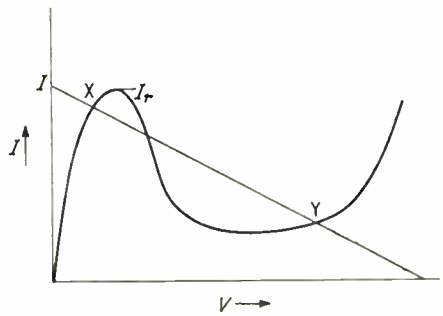


Fig. 45. *Loadline on tunnel diode characteristic*

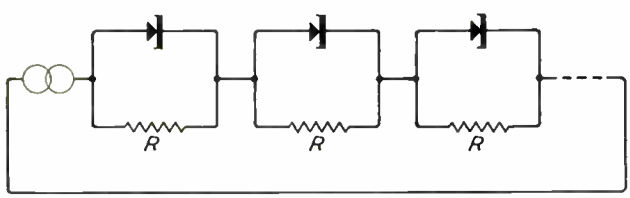


Fig. 44. *D.c. circuit of ring counter*

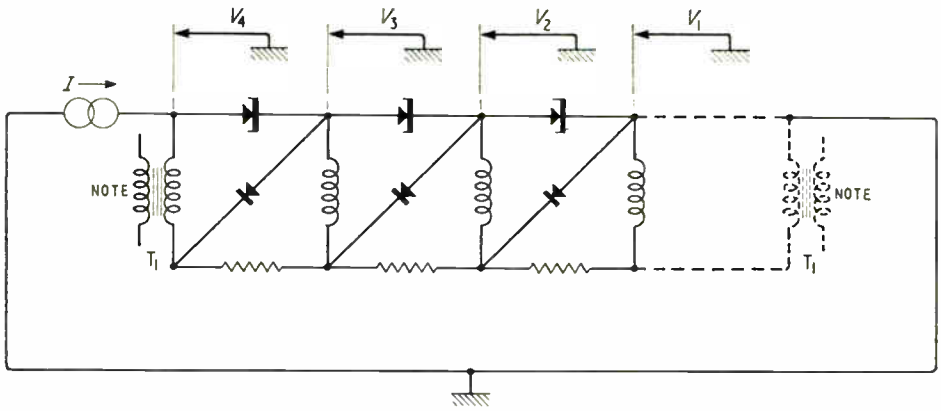


Fig. 46. Circuit of tunnel diode ring counter

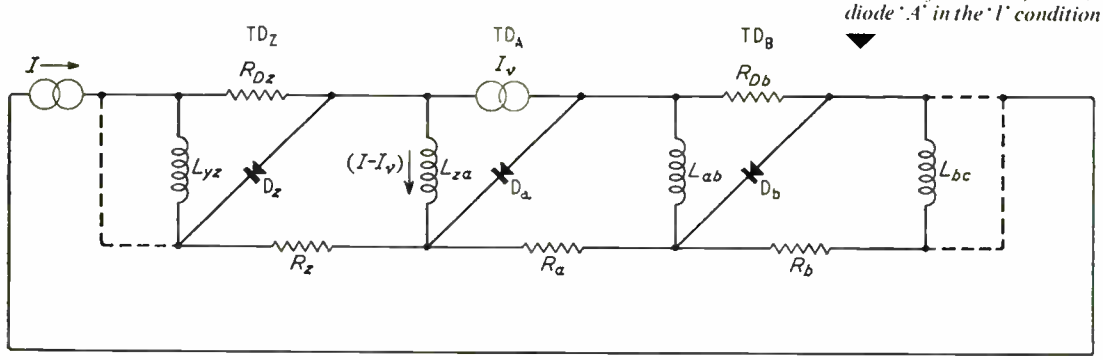


Fig. 47. D.c. equivalent circuit of counter; tunnel diode 'A' in the 'I' condition

by broken lines in Figs. 38 and 39 respectively. The loadlines can be arranged at will to cross any one, two, or three positive slopes, corresponding to one, two or three states of equilibrium.

For an astable multivibrator, the d.c. stable state must ensure that both can break down to the 'I' condition, if permitted by the reactive components; this means that the loadline must cross 'r' only in Fig. 36. The bistable multivibrator must have the tunnel diodes in opposite conditions. The loadline must therefore cross slope 'q', Fig. 36. It is preferable to have only one intersection (i.e., at 'q') but intersection at 'p' or 'r' is possible so long as the reactive components prevent operation at 'p' or 'r'. This is quite practicable.

In the quantitative analysis of the circuits under discussion, the appropriate voltage and current generators are assumed perfect, and the example test circuits have as near as possible perfect generators. But in many applications it is advantageous to have finite generator impedance as in Fig. 38. For example, certain bistable circuits theoretically operate with current generator supplies with the disadvantage of possible relaxation into a state where both are in the 'I' (r) or the '0' (p) condition. By judicious use of R_g, the loadline can be arranged to cut only the slope 'q', yet still operate in a similar way to the device using a perfect generator. This type of circuit can suffer disadvantages in its fast switching characteristics.

Monostable circuits require asymmetry to ensure that one of the tunnel diodes has only one stable state. There are two possible methods for obtaining monostability as demonstrated in Figs. 40 and 41. Their corresponding overall $V-I$ characteristics are shown in Figs. 42 and 43 respectively. In both cases TD_A will switch to the 'I' condition first, as the voltage is increased from zero. There is then an intermediate position where the tunnel diodes are in opposing conditions; this is equivalent to slope 'q', Fig. 36, and marked 'm' in Figs. 42 and 43. The loadline must intersect 'm' for monstable operation.

Tunnel Diode Ring Counter

The operation of the ring counter in Fig. 48 was described early in this article. Owing to practical difficulties and inaccuracies it is very difficult to obtain a precise design procedure. This section illustrates the guiding principles only for the design of Fig. 46 whose waveforms are shown in Fig. 56.

D.C. Bias Conditions

Fig. 44 shows the d.c. circuit of the ring counter. Each tunnel diode is loaded with its associated resistor R, and together can be regarded as one of a string of separate circuits fed by a current source as shown. For this operation, each tunnel diode must be bistable, and the loadline of each resistor must cross the tunnel-diode characteristic at two stable points X, Y as in Fig. 45. The load resistance must therefore have a value greater than the negative resistance of the tunnel diode.

A.C. Conditions

Consider a section of a ring counter as shown in the equivalent current of Fig. 47, where, with the d.c. bias applied, all except tunnel diode TD_A are in the '0' condition (R_D). The d.c. current distribution is as shown, assuming the equivalent circuit of Fig. 23. The current in L_{za} and L_{ab} is approximately $(I - I_v)$. All the ordinary diodes, D, are backed off. When the current supply is reduced to zero, due to a negative current pulse, the tunnel diode TD_A reverts to the '0' condition. Transient currents exist in the inductances which lead to the equivalent circuit of Fig. 48.

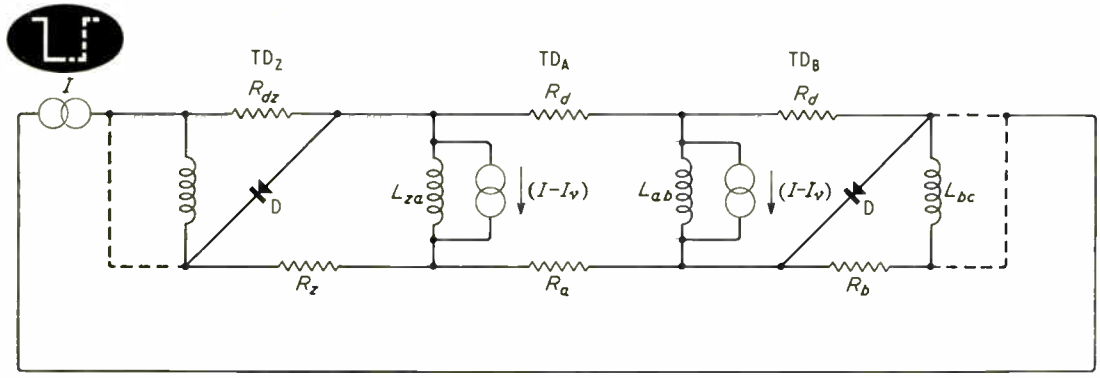


Fig. 48. Equivalent circuit of counter when negative pulse applied

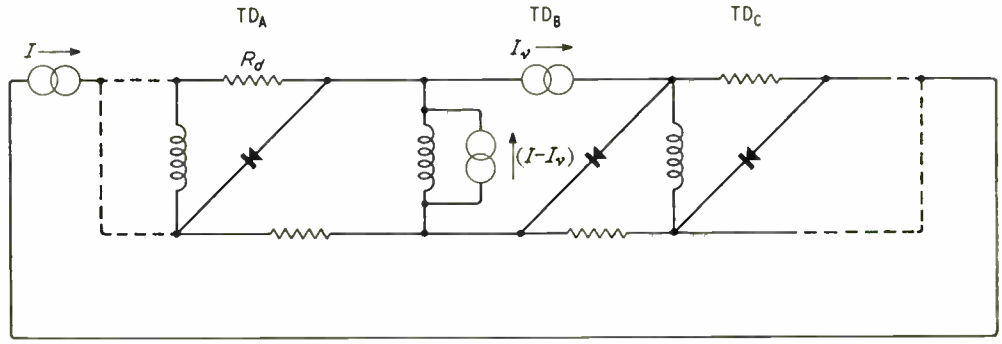


Fig. 49. Equivalent circuit of counter on resumption of d.c. current supply

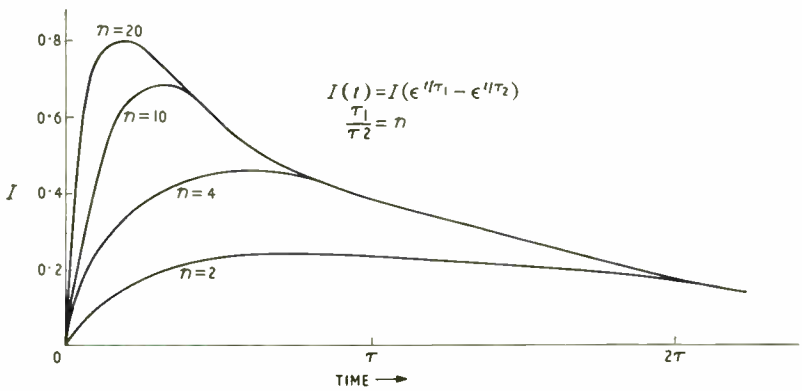


Fig. 50. Variation of net current through active tunnel diode in ring counter during the negative supply pulse. τ = circuit time constant

Assuming $R \gg R_D$ current due to L_{ab} circulates mainly through R_{Db} and D_b. If the ordinary diodes have a forward resistance of R_p, the current in tunnel diode TD_B due to L_{ab} decays exponentially with a time constant τ_1, where

$$\tau_1 = \frac{L}{R_D + R_p}$$

The current due to L_{za} flows in the diode D_b, opposing the current due to L_{ab}. Other diodes will be reversed-biased. The current due to L_{za} in tunnel diode TD_B decays with a time constant τ_2

$$\tau_2 = \frac{L}{R_D + R_p + R}$$

The net current due to circulating currents in L_{za} and L_{ab} is then

$$(I - I_v)(\epsilon^{-t/\tau_1} - \epsilon^{-t/\tau})$$

Now the aim is to have sufficient current flowing in R_{Db} at the end of the negative current pulse, so that the sum of the currents due to L_{za} and L_{ab} and the d.c. supply through tunnel diode TD_B is sufficient to switch it. The current due to L_{za} must therefore decay much more quickly than that due to L_{ab}. Fig. 50 shows the net current flowing through R_{Db} for different ratios of τ_1/τ_2, and gives some idea of the maximum current flow expected. Suppose the maximum current flow is

$$\gamma(I - I_v)$$

where $\gamma < 1$

For efficient storage of current during the negative pulse, γ tends towards 1.

The additional current above the d.c. bias, required to switch the tunnel diode over its peak current I_p, is approximately

$(I_p - I)$ (see Fig. 45).

Thus, to switch over tunnel diode TD_B

$$(I_p - I) < \gamma(I - I_v)$$

or

$$\frac{I}{I_p} > \frac{1 + (I_v/I_p)}{1 + \gamma} \qquad \text{(xviii)}$$

When the supply has reverted to its d.c. level, and switched tunnel diode TD_B, L_{bc} will charge to its d.c. value, and L_{ab} will

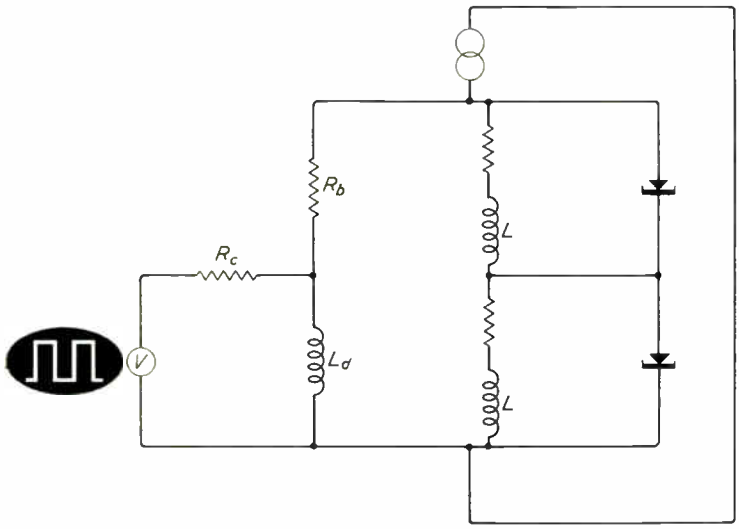
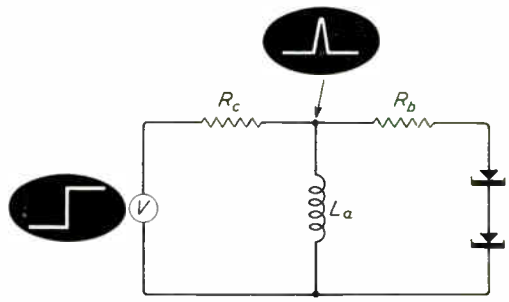


Fig. 51. Modified inductance bistable multivibrator

Fig. 52. Equivalent circuit during differentiation



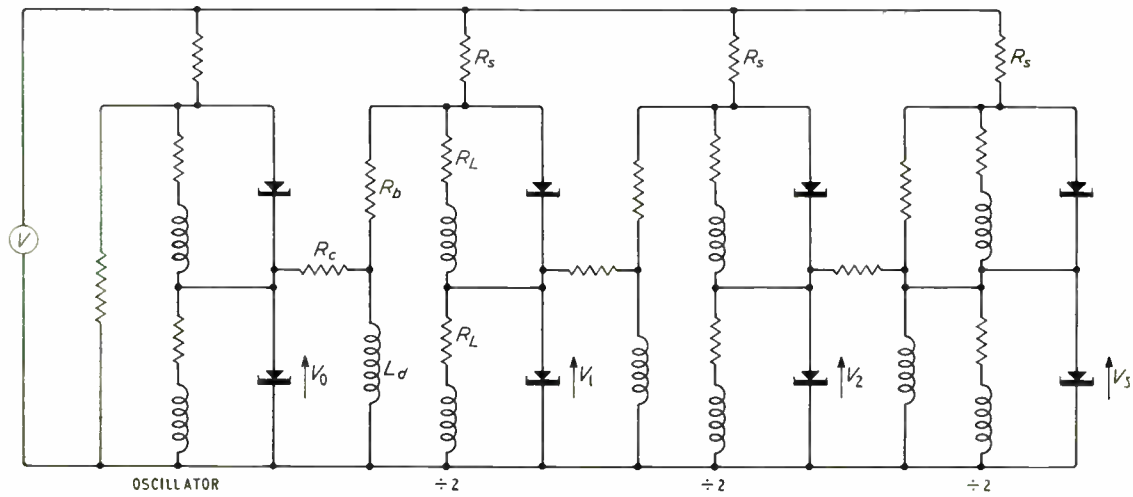


Fig. 53. Three-stage binary counter. $R_b \ll R_L$. $R_s \gg R_L$. $R_c \sim R_L$

discharge and charge in the opposite direction to its d.c. value. The equivalent circuit is shown in Fig. 49. These changes must be complete before the next negative current pulse appears. The current due to L_{ab} will discharge through diode D_a and load R_d with a time constant

$$\tau_3 = \frac{L}{R + R_p}$$

The inductance L_{bc} should in theory charge instantaneously, but due to excessive voltage across tunnel diode TD_B, the equivalent circuit using I_p is inaccurate, and will act more like the equivalent circuit in Fig. 22. This will slow up charging times, but the main charging delay is in τ_3.

Fig. 56 shows the waveforms of a ring counter running at 5 Mc/s, and its pulsed power supply, using the circuit of Fig. 46. Backward diodes, a degenerate form of tunnel diode, were used as the rectifier diodes.

Binary Counter using a Double-Inductance Multivibrator

The ring counter example demonstrates how the rectifier diodes are unsuited for unidirectional information flow in tunnel-diode circuits, mainly due to low working voltages. Some other form of unidirectional operation must be used. Fig. 36 shows the overall d.c. characteristic of the circuit of Fig. 34 discussed earlier. Now the loadline of the generator can be made to cut the slope 'q' at the point 'qx'. Suppose the loadline passes through 'qx' which is just below the peak threshold. If the effective power supply is increased instantaneously by a small amount, the load is shifted upwards so that both the tunnel diodes are temporarily in the 'l' condition. In either multivibrator, this would cause triggering action. If the effective power supply were to be reduced by the same small amount, the loadline would merely move down the slope 'q'. In this way, only positive pulses can be allowed to trigger a multivibrator.

Fig. 51 shows a coupling circuit and a modified form of double inductance multivibrator. The multivibrator is biased to the point 'qx' on the characteristic in Fig. 36. The voltage generator has been replaced by a current generator and a low value bypass resistor R_b. R_c is a resistor coupling the square-wave source V to the multivibrator circuit. An inductance L_d is used for differentiating the square-wave V.

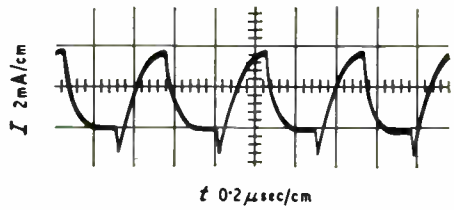


Fig. 54. Current in tunnel diode in single-inductance multivibrator

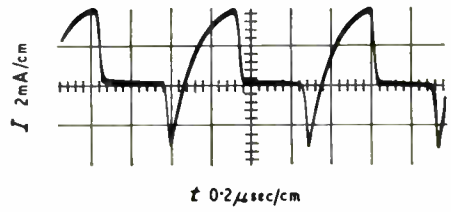


Fig. 55. Current in tunnel diode in double-inductance multivibrator

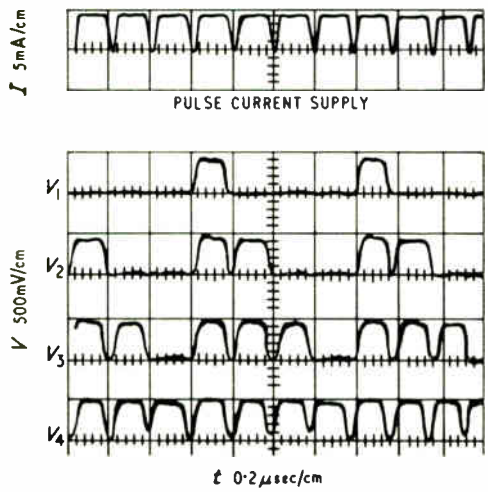


Fig. 56. Four-stage ring counter waveforms (see Fig. 46)

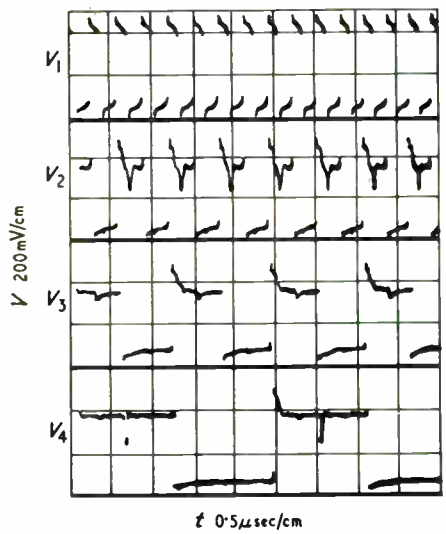


Fig. 57. Voltage waveforms of three-stage binary counter with 3 Mc/s input (see Fig. 53)

If L_d is much less than L, then the a.c. equivalent circuit during differentiation is as in Fig. 52 for positive pulses, and has an overall characteristic of form shown in Fig. 36. With suitable values of V and R_e, during differentiation, the tunnel diodes will both be in the 'l' condition, and the multivibrator will be triggered. By adjustment of 'qx' and R_e (and also V, if this is not fixed) the circuit can be arranged to trigger only on positive-going pulses.

A binary counter made of elements as in Fig. 51 is shown in Fig. 53. Waveforms of a three-stage binary are shown in Fig. 57. The counting rate shown is about 3 Mc/s to give a clear waveform, but a rate of 10 Mc/s has been attained.

Acknowledgments

Acknowledgment is made to Messrs. Standard Telephones and Cables Ltd. for permission to publish this paper.

The author wishes to thank Mr. A. D. Odell for his helpful comments and discussions and Messrs. J. Shaw and C. Hughes for their valuable assistance.

SOLID-STATE TOTALIZER

A completely solid-state totalizer designed to provide a highly reliable and accurate summation system for billing, data logging or telemetering in a wide variety of industries is now available from International General Electric overseas marketing division of U.S. General Electric.

The first of a range of GE called 'Pulscript' (*Pulse* Count, *R*ead, *I*ntegrate, *P*rint, *T*otalize), the new totalizer, type SST-1, is intended to link several measuring devices with associated recording or billing equipment. It is designed to meet the accuracy of electronic data loggers and digital computers with which it may be used.

Signals fed into the SST-1 originate with commercial contact-making devices, such as meters or production counters, that measure quantities like kilowatt-hours, cubic feet of gas, gallons of water, feet of wire, paper or steel. The SST-1 receives, integrates and transmits the total or net amount of like impulses generated by these devices to any one of a combination of the following: computer, data logger, telemetering equipment, printing demand meter, a mechanical-type totalizer, or another solid-state totalizer.

Depending upon the needs of the system, the SST-1 can count, add, subtract, or divide. The number of pulses it can deliver is restricted only by the end device used.

If an input-output ratio is employed—where a given number of input pulses equals one output pulse—the SST-1 can receive pulses several times faster than the outgoing pulse. A broad selection of input-output or 'divide by' radios is available, from 1 : 1 to 16 : 1.

The SST-1 will take from 3 to 16 channels and is compatible with all three-wire contact devices.

For further information circle 35 on Service Card

'SPECTOCOM' HEAD-UP DISPLAY

AN optical-electronic system designed to present flight information in the form of a light pattern within an aircraft pilot's normal 'head-up' field of vision has been demonstrated by Specto Avionics.

The illuminated display is presented via a cathode-ray tube on a part-silvered mirror and to the pilot appears superimposed on his view of the outside world, seen through the windscreen. The display is focused to appear at infinity so that there is no visual conflict between the display and the outside world.

The information that the pilot desires, such as flight director and command data or situation information together with an artificial horizon, can be selected by the operation of a rotary switch.

In addition, the pilot can adjust the brightness of the display to give the desired contrast with the view ahead. Thereafter, the same contrast is automatically maintained even when the brightness of the view changes.

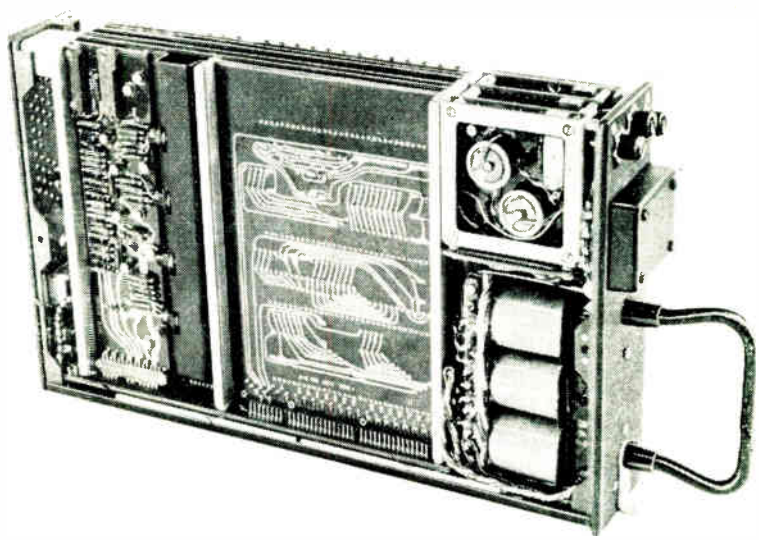
Since the display is achieved by digital techniques any type of image can be presented including bars or lines, circles, figures and letters. These may represent such information as altitude, roll, attitudes, airspeed, distance-to-go, etc. Providing there is a transducer available which gives an electrical output proportional to the parameter to be displayed, and there usually is, the waveform generator associated with the cathode-ray tube will convert this electrical signal into a form suitable for the head-up display.

The equipment is transistorized and in three units which together weigh 30½ lb.

For further information circle 36 on Service Card

An artist's impression of a typical head-up display

The pilot's display unit showing the reflector, lens and c.r.t. mount



This shows the transistorized waveform generator with the cover removed

EQUIPMENT review

1. Stable Oscillator

This oscillator, originally designed as the primary frequency control in a frequency synthesizer drive unit for the Marconi range of broadband linear amplifiers, gives an output of 5 Mc/s accurate to 3 parts in 10^8 from all causes, with a long term ageing rate of better than 5 parts in 10^8 per month, between the ambient temperature limits of −15 °C and +55 °C. At a constant ambient temperature the short term stability is as high as 1 part in 10^8. The power requirements are: 26·5 V d.c. ± 0·2 V at 100 mA after the initial warming-up period, although the starting current may rise to 500 mA.

The device consists of a silicon transistor crystal oscillator and associated buffer amplifier, enclosed in a miniature oven to form a complete plug-in sub-unit. This oven incorporates a proportional system of temperature control, using a thermistor as the temperature sensing element. This is coupled through a d.c. amplifier to a power transistor which directly controls the heater current, reducing it gradually as the oven approaches the working temperature. In this way, cyclic variations due to overshooting are completely eliminated. This control maintains the oven temperature very accurately at about 75 °C.

The entire system is contained in a cylindrical case 2·5 in. in diameter and 4·25 in. long. This size is increased by a fine tuning screw at the top, which adds 0·5 in. to the length. All connections are made through an octal type valve base in the lower end. —*Marconi's Wireless Telegraph Co. Ltd., Marconi House, Chelmsford, Essex.*

For further information circle 1 on Service Card

2. Automatic Earth Lead Tester

In addition to their standard portable earth lead tester, M. L. Aviation now offer a completely automatic, restricted current unit, which tests, under overload conditions, the continuity and current carrying capacity of the earth circuit on electrical tools, appliances and instruments. Based on the requirements of B.S. specification 2769, it will reject any unit which has an earth circuit resistance in excess of 0·25 Ω.

The most important feature of the tester is the limitation of the pulse current to a maximum of 32 A on dead short circuit, thereby preventing unnecessary damage to equipment with earth circuits of exceptionally low resistance. Pulse current through a 0·25 Ω circuit is 24 A.

The instrument is designed primarily for integration in production lines. The test sequence is initiated by a press button and thereafter is entirely automatic. An initial check for continuity is followed by a pulsed current for a duration of 5 sec which is again followed by a further continuity check. Satisfactory completion of these tests is indicated by a green lamp, after which the equipment under test can be operated. Failure of any part of the test sequence is indicated by an amber lamp and an interlock prevents the operation of the equipment. This interlock can be connected via the customer's own voltage selection panel to enable the operational test to be run on any selected voltage. Time cycle for the complete test sequence is 9 sec.

The complete tester is mounted on a standard 19-in. panel and is intended for operation from 200–240 V, 50–60 c/s mains.—*M. L. Aviation Co. Ltd., White Waltham, Maidenhead, Berks.*

For further information circle 2 on Service Card

3. Long-Life Digitizer

Designed originally to meet an Admiralty specification, the D.1 digitizer by Digitizer Techniques offers a number of advantages over flush bonded foil types.

The rotor comprises a number of phosphor-bronze rings segmented on their periphery and electrically connected. The complete rotor assembly takes the form of a hollow cylinder closed at each end and mounted on a stainless steel shaft. Insulation between individual segments is effected by means of epoxy resin of similar wear characteristics to that of the phosphor bronze rings. The contacts mounted in the casing take the form of beryllium copper spring strips, the

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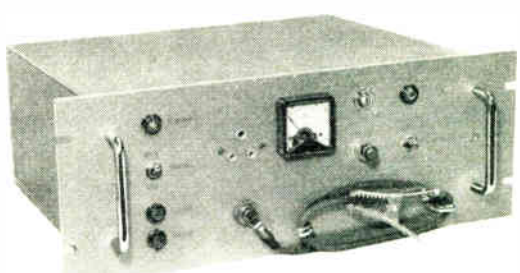

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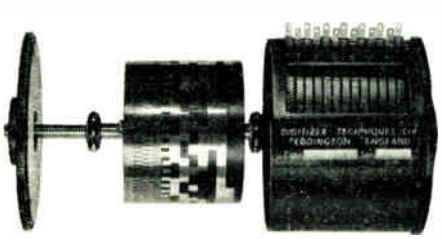

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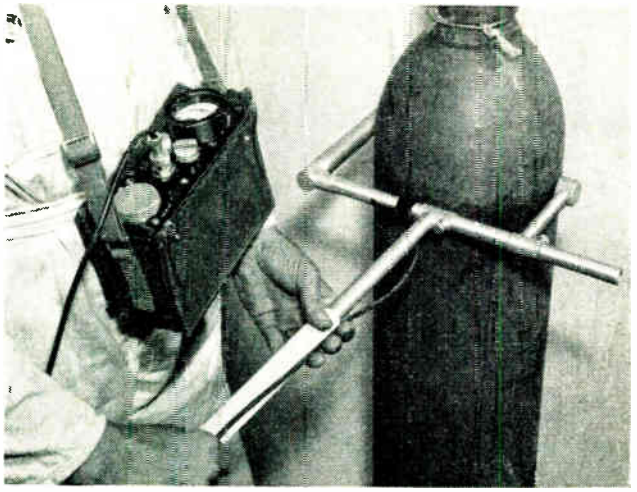

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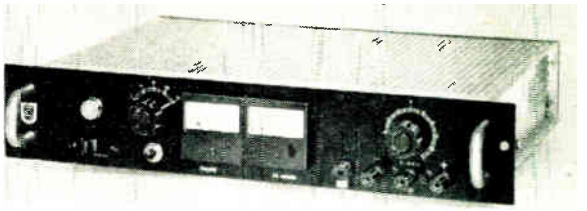

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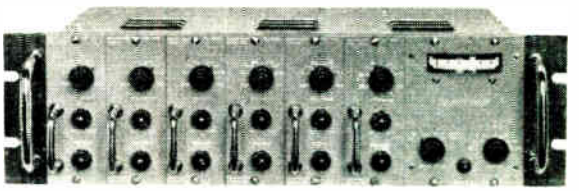

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contact areas of which are suitably contoured and which can easily be replaced.

This form of construction allows special codings to be incorporated without the penalty of high tooling costs and the substantial segments give the D.1 digitizer a long working life. The illustration shows the unit with the rotor removed from the casing.—*Digitizer Techniques Ltd., Watts Lane, Teddington, Middlesex.*

For further information circle 3 on Service Card

4. Transistorized Portable Tachometer

E. K. Electronics are producing a relatively inexpensive transistorized portable tachometer suitable for garage and general industrial use.

The circuit consists of a monostable pair preceded by a high-gain two-stage amplifier which is fed by a shaping network and twin-screened input for transducer operation. Vehicle checks are carried out via a single socket, the unit being switched on by the action of plugging in the jack.

A feature of this instrument is its high accuracy: —± 2% f.s.d. on all five ranges, covering 2,500 to 250,000 r.p.m. The dimensions are 7 by 5 by 3½ in. and the weight is 4½ lb. Price: £23 19s., including magnetic transducer and 12 V battery.—*E. K. Electronics (Industrial Amplifiers) Ltd., Brotherton, Knottingley, Yorks.*

For further information circle 4 on Service Card

5. Level Gauge

A portable, battery-powered gauge, using a radioisotope, has been developed by Panax for the determination of fluid levels in sealed pipes or cylinders. It has proved to be particularly suitable for assessing the contents of liquid CO_2 fire extinguishers, although any liquid, or gas that liquefies under pressure, can be measured in this way. The device does not come into contact with the fluid at any time. Cylinders or pipes up to 10 in. in diameter can be accommodated by the standard probe. Other probes can be supplied for larger containers.

The isotope, caesium 137, has a useful life of 30 years and at the strength employed it is completely harmless to personnel. This exempts the gauge from the provisions of the Special Regulations for Factories (Ionizing Radiations), 1961.

The instrument, known as the level gauge type TM64L, is in two parts: a lightweight two-armed probe containing the radioactive source in one arm and a geiger counter in the other, and an indicator unit. The indicator shows the radiation strength which is heavily reduced by the presence of fluid between the source and the detector. Using this method the level can be found very quickly and to within ¼ in.—*Panax Equipment Ltd., Holmethorpe Industrial Estate, Redhill, Surrey.*

For further information circle 5 on Service Card

6. Stabilizer Unit

The first of a Philips range of stabilized power-supply units has been announced. Intended for use with transistorized equipment, it has a maximum output current rating of 1 A and the voltage is continuously adjustable over five ranges from 0 to 35 V.

With line voltage variations of 10%, the maximum change in output is well within 0·1%. Hum is less than 1 mV and output resistance is 0·02 Ω. A recovery time of 0·1 msec is quoted, with a step load variation from no load to full load or vice versa. Output is floating and either positive or negative may be connected to the earth terminal provided.

The unit is fitted with separate voltage and current output meters, and relay overload protection. The type number is PE 4805/00.—*Research and Control Instruments Ltd., Instrument House, 207 King's Cross Road, London, W.C.1.*

For further information circle 6 on Service Card

7. Six-Channel Converter

The six-channel frequency/d.c. converter recently introduced by Meter-Flow works with a wide range of free impeller type flowmeters and may also be used as a tachometer in conjunction with a magnetic pick-up.

The converter units are transistorized, and each channel is totally isolated, having three ranges, 0·5, 1, and 2 kc/s, with two outputs to each range of 0-1 V, 1 mA and 0-100 mV. Both channels have individual gain control. Each unit is also fitted with a crystal-stabilized oscillator which can be switched into any of the channels in order to check the calibration, the oscillator frequencies being 500 and 1,000 c/s.

The equipment is housed in a standard 19 in. rack and is 5¼ in. deep. The input connections are by means of individual plugs and sockets, while

EQUIPMENT

review

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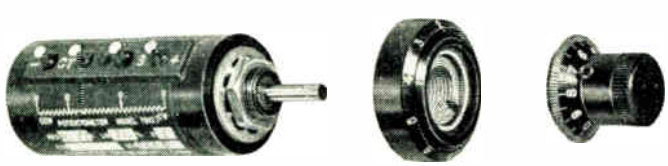

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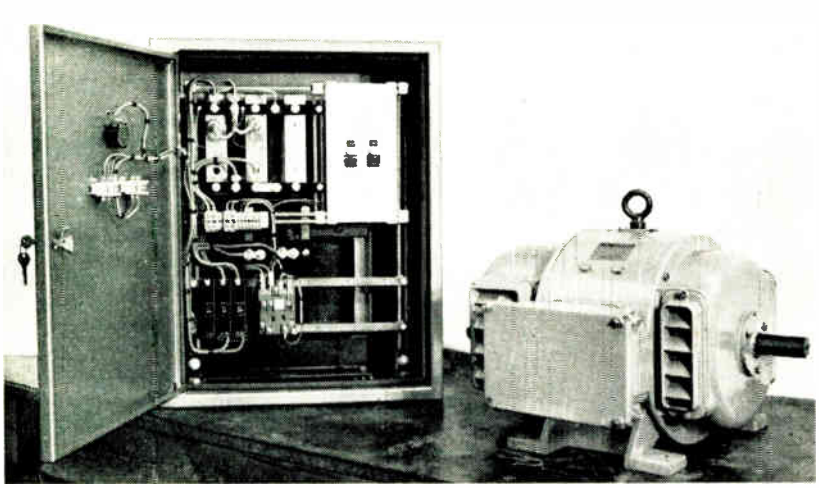


both outputs are taken through two 12-channel plug and socket connections. — *Meter-Flow Ltd., North Feltham Trading Estate, Feltham, Middlesex.*

For further information circle 7 on Service Card

8. Medium Power Tetrode

The 4CX350A is the latest addition to the Eimac family of medium power tetrodes. It has improved performance characteristics compared to the 4X150 and 4CX250 types and is meant to supersede these in most new equipment designs.

The 4CX350A has increased cathode area and higher amplification factor which result in higher mutual conductance and an improved figure of merit. It has an anode dissipation of 350 watts. Heater voltage is 6·3; a 26·5 V version, the 4CX350F, is also available.—*Walmore Electronics Ltd., 11-15 Betterton Street, Drury Lane, London, W.C.2.*

For further information circle 8 on Service Card

9. Plug-in Standard Module Unit

Keyswitch Relays have announced the P33 plug-in standard module unit. This unit is the P33 plug-in component carrying not a relay but instead, either a circuit mounting board or a mounting bracket. This will enable engineers to put circuits and small components into plug-in form with a minimum expenditure of time and effort. It will also provide a ready made module for the design of equipment where circuits are duplicated many times over.

In the event of circuit failure in a standard plug-in system, the status quo can of course be restored by a simple 'replace and repair later' technique. — *Keyswitch Relays Ltd., 120-132 Cricklewood Lane, London, N.W.2.*

For further information circle 9 on Service Card

10. F.M./A.M. Signal Generator

The Advance signal generator type SG63D provides frequency or amplitude modulated signals over a continually variable frequency range from 4·0 to 230 Mc/s. The instrument has been designed primarily for use by radio and television service engineers, but its performance makes it suitable for development work in an electronics laboratory or in the field.

A directly calibrated frequency dial, with slow-motion drive, provides a tuning accuracy of ±1% and an internal oscillator provides spot calibration checks at 5 Mc/s intervals to an accuracy of 0·03%. The output

signal can be frequency modulated internally at fixed frequency and deviation, or at the supply frequency with variable deviation of 0 to ±200 kc/s. External modulating signals may also be used. Amplitude modulation is achieved internally to a depth of 30% at 1,000 c/s.

The output level is continuously variable from 1 μV to 100 mV. R.F. leakage is kept to a low level by triple screening of the oscillator circuits.—*Advance Components Ltd., Roebuck Road, Hainault, Ilford, Essex.*

For further information circle 10 on Service Card

11. Kilo-Dial Analogue Indicator

The series 400 10-turn Kilo-Dial by Kynmore Engineering is an analogue indicator, 1 in. deep by 1 in. diameter, with standard versions suitable for 0·25, 0·125 and 0·0935 in. diameter shafts. (The series 500 single-turn dials match the series 400 in appearance and dimensions.)

Shaft extension beyond the face of the panel should be between 0·6 and 0·8 in. Bushing extension of the potentiometer etc. beyond the face of the panel should not exceed 0·3 in. for all models. A shaft lock can be supplied if required.

The illustration shows a fitting for a $\frac{7}{8}$ in. diameter, 10-turn potentiometer. —*Kynmore Engineering Co. Ltd., 19 Buckingham Street, London, W.C.2.*

For further information circle 11 on Service Card

12. The 'Staticontroller'

AMECO have introduced a range of moderately priced variable speed drives from 1 to 10 h.p. designed to give stepless speed control against constant torque. They may also be used to solve any control problem requiring a variable d.c. output.

One or two phases of a standard 3-phase supply are fed to a double-wound transformer via a push-button controlled contactor and two h.r.c. fuses. The secondary of this transformer feeds two full-wave rectifier bridges, one composed of silicon diodes, the other of s.c.rs. From the silicon diode bridge is obtained the fixed voltage d.c. supply for the motor field, while the s.c.r. bridge supplies the variable d.c. voltage for the motor armature. Control of the s.c.r. bridge is by a pulse firing circuit arranged on a plug-in board using the armature feedback voltage as a reference to give accurate control of the output voltage.

The output from the 'Staticontroller' is suitable for the control of a standard 110 V, separately excited, shunt wound d.c. motor. Regulation will be dependent largely on the motor used but should be in the order of ±2½% using the armature feedback system. This can be considerably improved by the use of a tacho-generator feedback system. The illustration shows a 5 h.p. 1,500/150 r.p.m. drive unit.—*Albert Mann Engineering Co. Ltd., Basildon, Essex.*

For further information circle 12 on Service Card

13. Carbon Pile Voltage Regulators

With the announcement that the 1,000 W type NR4/4/2 voltage regulator is now in production, Newton Brothers (Derby) Ltd., are able to offer a complete range of automatic carbon pile voltage regulators. This range, which covers pile dissipations up to 1,000 W, is suitable for generators and alternators up to 20 MW and larger.

With these regulators a speed of response of 80/120 msec with full stabilization can be obtained, together with a regulation of ±2%. Where closer tolerance than this is required, a transistorized amplifier can be added, giving a regulation of ±0·5%. —*Newton Brothers (Derby) Ltd. Alfreton Road, Derby.*

For further information circle 13 on Service Card

14. Miniature D.C. Power Supply

Lan-Elec have announced the first of a range of miniature d.c. power supply units.

These units have been designed for industrial and educational applications and are fully transistorized. A feature of the unit is its small size (4¾ by 3⅝ by 2¼ in.) in relation to its output (continuously variable from 7·5 to 12 V at 0·5 A). The manufacturers state that two units may be connected in series to give an output of 15 to 24 V at 0·5 A. The input is suitable for 200 to 250 V, 50 to 400 c/s.

Stability is said to be 1,000 : 1 for variations of ±10% and output resistance not more than 60 mΩ. The price is £18.—*Lan-Elec Ltd., 97 Farnham Road, Slough, Bucks.*

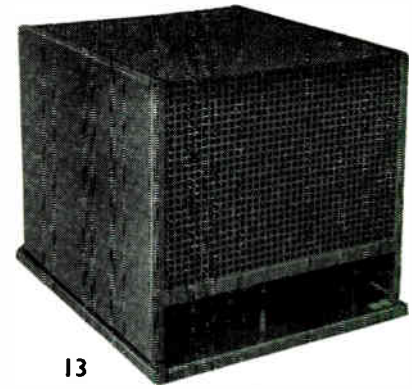
For further information circle 14 on Service Card

15. High Vacuum Units

Bir-Vac have announced a comprehensive range of high vacuum equipment under the name 'Torr Plan'.

The instrumented pumping unit, available in six sizes, provides pumping speeds ranging from 7 to 900 litres/sec (baffled). Control can be automatic, semi-automatic or manual, and the ultimate vacuum is better than 10^{-5} torr.

Extra self-contained assemblies



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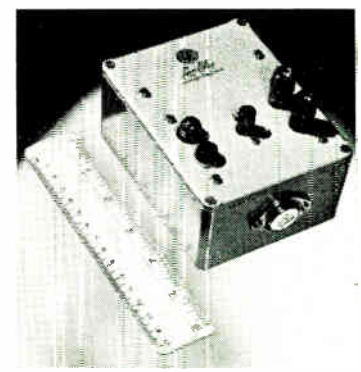

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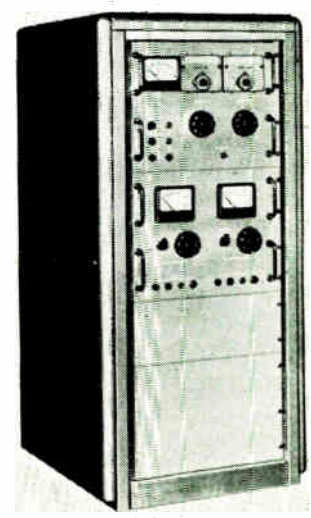
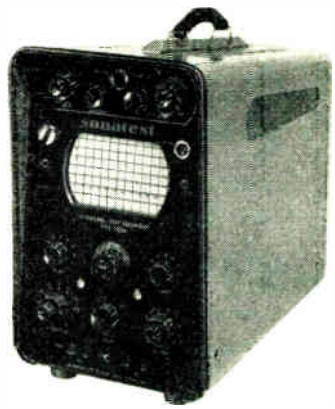


allow the equipment to be readily converted from one role to another: an evaporation unit, for example, can become a straightforward pumping set, a vacuum furnace or an electron beam unit within a matter of minutes.

The photograph shows a standard pumping unit to which has been added a stainless steel chamber, an electron gun, a power supply console and other equipment needed for electron beam work. — *Bir-Vac Ltd., Swindon Road, Cheltenham, Glos*

For further information circle 15 on Service Card

EQUIPMENT review



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16. Ultrasonic Flaw Detector

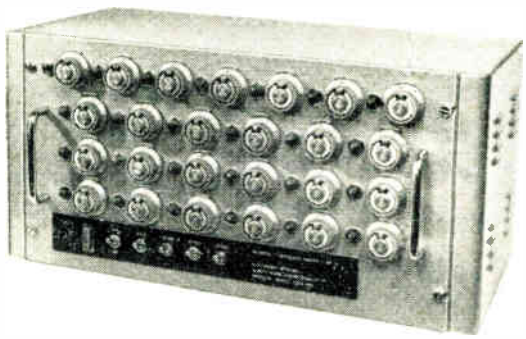
An improved version of the Sonatest TE/2 ultrasonic flaw detector has been announced which combines in one compact unit cathode-ray tube indication and an automatic flaw alarm monitor.

When the instrument is used in the conventional manner, echoes are observed on its five-inch diameter flat-faced cathode-ray tube. When used for repetitive or automatic testing, however, advantage may be taken of the built-in transistorized flaw monitor. With the controls correctly pre-set, the presence of a flaw is indicated by the illumination of a signal lamp at the top of the panel and, if required, by an external alarm.

Accurate thickness measurements may be made with the aid of the monitor: the thickness is read directly from a scale which is calibrated in 0·001-in. divisions. A further important innovation is a weld zone marker which makes for easier and more accurate location of defects.

The gain of 1,000,000 and bandwidth of 1 to 15 Mc/s, in conjunction with special probes, enables micro-cracking and small inclusions to be located. Price of the TE/2A is £750.—*Research and Control Instruments Ltd., Instrument House, 207 King's Cross Road, London, W.C.1.*

For further information circle 16 on Service Card



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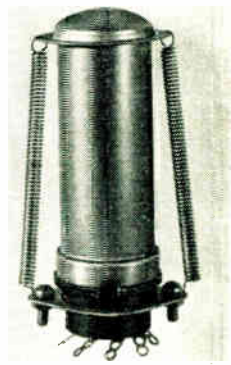

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17. Process Controller

Albert Mann has produced a versatile process control system intended to bridge the gap between conventional relay control schemes and complex programming which calls for computer techniques.

This controller can be actuated by any logic signal however derived, and the basic units can be engineered for up to 49 sequenced steps with up to 5 outputs per step. Each step is capable of switching ½ A at 250 V a.c. or 10 mA at 300 V d.c. Units may be combined to give multiplication or addition functions.

The timed steps are integral, with continuous adjustment in the ranges ½ sec to 60 sec per step and ½ min to 60 min per step; these times can be extended if required. Each step has an indicator light to show when it is in operation.

Switching can be provided to stop the sequence at any given point and restart from that point, and/or reset to step 1 from any position. Units are available using either continuous charging rate capacitor control (uniselector operated), or digital static switching devices. — *Albert Mann Engineering Co. Ltd., Basildon Industrial Estate, Essex.*

For further information circle 17 on Service Card

18. Relay Retainer

Electrothermal Engineering have added a new item to their range of valve and component retainers.

Type VRA 59 comprises a metal cap, shaped to fit the domed top of many British and American valve based, canned relays having diameters not exceeding $1\frac{3}{32}$ in. The cap is tensioned by springs of various lengths to suit different seated heights.—*Electrothermal Engineering Ltd., 270 Neville Road, London, E.7.*

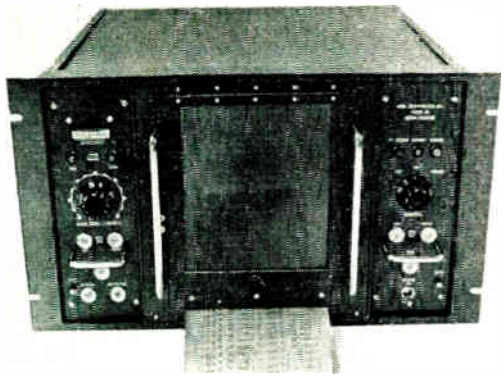
For further information circle 18 on Service Card

19. High Speed Digital Printer

The 500 series DEAN (Digital Electronic Alpha-Numerical) printers by Hull Instruments are high speed digital readout devices which combine rapid printout with serial character input making them useful in many areas of data processing.

The printout rate, of more than 9,000 lines per minute, is compatible with many computer processing rates, thus removing the need for intermediate buffer storage. Printout cycle in the read—compute—print sequence is substantially reduced, thereby allowing more computation time.

The DEAN printers use a digital generator to form and position characters on the face of a cathode-ray tube. The c.r.t. image is projected on to photo-sensitive paper with a fibre



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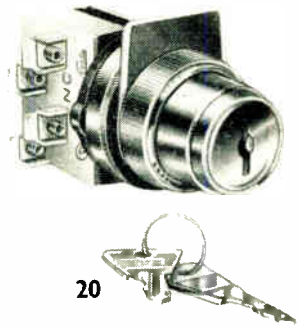

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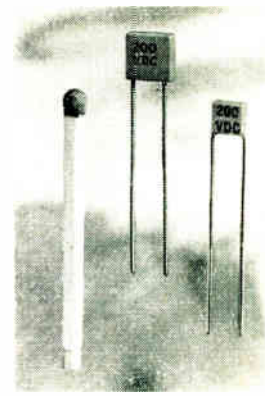

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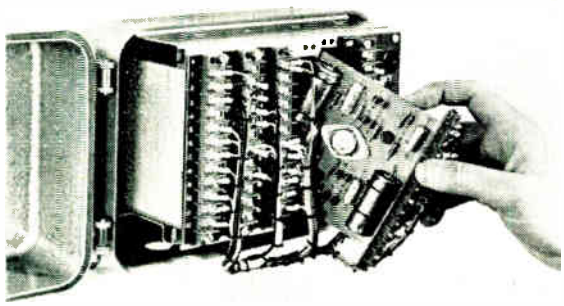

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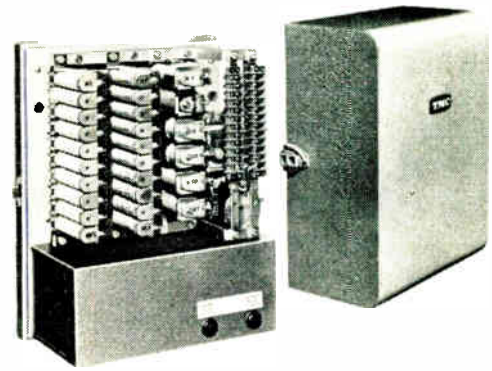

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optic bundle. After the paper is exposed it moves over a heated platen, where it is developed and fixed. Forty-four columns can be printed on the 6 in. paper width.

The basic cost of the printer is £7,590, excluding import duty; delivery 12 weeks.—*Scientific Furnishings Ltd., Poynton, Cheshire.*

For further information circle 19 on Service Card

20. Key Pushbutton Switch

Introduced by Shawford Control Gear is a 'Cema' pushbutton incorporating an internal lock that enables the switch to be secured in either the pushed or the released position. The unit comprises a chromium plated actuator operating on a single-, 2-, 3- or 4-pole contact block.

The key (a duplicate is provided) can be withdrawn in the pushed or released positions, or both, in accordance with users' requirements.—*Shawford Control Gear Co. Ltd., 715 Tudor Estate, Abbey Road, Park Royal, London, N.W.10.*

For further information circle 20 on Service Card

21. Microminiature Ceramic Capacitor

Vitramon is now marketing the range of 'VK' ceramic capacitors which utilize a closely controlled barium titanate dielectric. Temperature characteristics, voltage coefficient and ageing properties hold the capacitance change under all rated conditions to less than +25% to −40%.

'VK' capacitors are available from stock at preferred values from 10 pF to 0·01 μF (with ±10% tolerance). 200 V d.c.wkg., and are suitable for use up to 125 °C. These units are supplied with radial leads spaced at 0·2 in. for printed circuit applications. Standard dimensions are 0·3 by 0·3 by 0·1 in.; for capacitance values less than 1,000 pF, a smaller case size of 0·2 by 0·2 by 0·1 in. is offered. — *Vitramon Laboratories Ltd., 45 Holloway Lane, Harmondsworth, Middlesex.*

For further information circle 21 on Service Card

22. New D.C. Amplifier

Eversheds and Vignoles announce the introduction of the series 500 d.c. amplifier for use in a wide variety of roles, particularly in the process-control field.

Solid-state circuits are used throughout for reliability and minimum maintenance, the circuits being grouped on to easily-replaceable printed-circuit boards. Other points of interest: high open-loop gain ensures that substitution can be made of the amplifier or any of its boards without re-setting the feedback circuits; overall gain and individual gains are fully stabilized; standby mains or d.c. supplies can be used without regulation.

Output current is 0 to 10 mA into a 2-kΩ maximum load and the input voltage for 10 mA output is 1 mV. Linearity error is less than 0·1%.—*Eversheds and Vignoles Ltd., Acton Lane, Chiswick, London W.4.*

For further information circle 22 on Service Card

23. 10-Line Automatic Exchange

A compact, self-contained 10-line private automatic exchange designed to provide comprehensive intercommunication facilities for the smaller

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review

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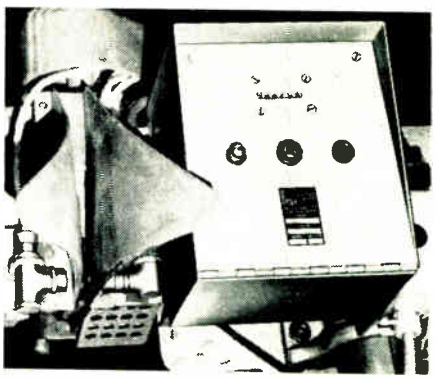

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industrial and commercial organization has been introduced by T.M.C.

The basic equipment, which has a built-in power pack for 200 to 250 V or 100 to 125 V, 50 or 60 c/s mains, is supplied in a wall-mounting metal case measuring only 14 by 10 by 7 in. Features include single digit dialling, secrecy of conversation, transistorized ringing and tone unit, and a facility for one master extension to make preference calls.

Normal telephone instruments with dials are used and only two line wires are required from the exchange to each extension telephone. The equipment is designed to work with a maximum loop resistance of 650 Ω and, if necessary, may be operated directly from a 50-V d.c. supply, the maximum current being approximately 350 mA. The total weight of the exchange unit is approximately 37 lb. — *Telephone Manufacturing Co. Ltd. (Telephone Equipment Division), Martell Road, West Dulwich, London, S.E.*21.

For further information circle 23 on Service Card

24. Blue-White Light Stroboscope

A blue-white light stroboscope has been introduced by Dukes & Briggs, which provides an output of variable frequency which is amplified to give pulses of several kilovolts to trigger off the flash tube. The flash tube is a 'U' shaped source giving a brilliant blue-white xenon flash.

The entire unit is compact and portable so that it may be held in the hand close to any part of a machine which is being examined. Its range is from 600 to 7,200 flashes per minute and the supply source required is 25 W, 110/250 V, 50–60 c/s. The overall size is only 14½ by 8 by 8½ in. and the total weight 8 lb. Price £45. —*Dukes and Briggs Ltd., Approach Road, Urmston, Manchester.*

For further information circle 24 on Service Card

25. Rugged Tape Recorder

The Specto Avionics contra-rotating-flywheel tape recorder has been designed to withstand very high impact forces and to operate accurately in any position or sequence of positions.

Speed variations due to environmental changes are reduced by the use of high speed motors and special gear boxes to drive both flywheel and tape; those due to gyroscopic forces are minimized by using a contra-rotating flywheel.

The normal spool will accommodate 2,400 ft of 1-mm base tape, which will play for 6 hr at a tape speed of 1⅛ in./sec. To keep the deck area to a minimum (8 × 9 in.) the two spools are placed one above the other on a concentric shaft system; ½-in. tape with a 8-track head is normally used, but other widths and track capabilities can be accommodated with little modification. Power requirements are normally 200 V, 400 c/s, 3-phase; 40 W. The operating temperature range is −55 to +100 °C.

By the use of a system of plug-in units the standard model can use either pulse code modulation or pulse ratio modulation or both at the same time, thus catering for 7 signals at 1 kc/s up to 112 signals at 6 c/s per in./sec of tape speed.—*Specto Avionics Ltd., Hanworth Air Park, Feltham, Middlesex.*

For further information circle 25 on Service Card

26. Photo-Electric Control

Herga Electric announce the 578 Mk 2 photo-electric control, which is supplied complete with miniature lamp source and receiver unit for £9 15s. The circuit permits light or darkness energization locking facilities and arrangements for multiple cell operation. The control box measures approximately 5¼ × 6 × 5⅛ in.

For simple ON/OFF applications 2 changeover contacts rated at 6 A 415 V a.c. are available. The unit operates from a 240 V a.c. supply and full isolation of all components is provided. The miniature lamp source and receiver are suitable for an

approximate throw of 5 ft in average ambient daylight and the response time is better than 140 msec. For a longer throw a more powerful lamp unit and head are available.

The illustration shows a lamp source and receiver with a typical Mk I control unit including a batch counter with internal manual reset and time delay, fitted to a machine. — *Herga Electric Ltd., Wallingford Road, Uxbridge, Middlesex.*

For further information circle 26 on Service Card

27. Silicon Rectifiers

Sarkes Tarzian series B hermetically-sealed silicon rectifiers have a 1·6-A basic rating and provide 3·2 A in full-wave single-phase, 4 A in three-phase, and 8 A in six-phase connections; 100 to 600 V recurrent peak reverse voltage.

Pigtail lead mounting simplifies connection in any configuration and full rating is achieved without external cooling. Use of cooling fins, if desired, can extend the current range considerably. Type B silicon rectifiers can be connected to cooling fins by drilling holes to accept the body and clamping with an internal tooth fastener.—*Ad. Auriema Ltd.*, 414 *Chiswick High Road, London, W.4.*

For further information circle 27 on Service Card

28. Pigmy Lampholder

Arcolectric have announced the B.C. signal lampholder type S.L.100 designed to accept 15 watt pigmy lamps in voltages from 260 V down to 25 V.

The lens is shallow and its appearance blends well with modern panel layouts. Concentric rings on the inside help to ensure that a good signal is obtained through a full 180°. The polycarbonate lens is virtually unbreakable and will resist temperatures as high as 140 °C without discoloration or distortion. Colours available are red, green, amber and blue; an opal lens can also be supplied.

Several different types of holder are available: the standard version (illustrated) is in brass and porcelain. List price 21s; separate lenses 2s 3d each. — *Arcolectric Switches Ltd., Central Avenue, West Molesey, Surrey.*

For further information circle 28 on Service Card

29. Paper Punch Drive Unit

The latest addition to the range of digital equipment produced and marketed by Digital Measurements is the DM5021 punch drive unit, designed for maximum flexibility of codes and input sources.

The DM5021 is used to couple data sources, such as digital voltmeters, counters, computer registers, etc., to almost any type of sychronous or non-synchronous, high or low speed, paper tape punch.

By adopting modular construction, any decade group may be equipped to handle codes other than decimal; i.e., radix less than 10. Matrix boards wired to any specified code are incorporated to order, and blank boards are available for adaptation by the user to meet alternative code requirements.

An important feature of the instrument is the word length (up to 16 characters per word cycle) and the facility with which word length and format can be changed by means of a built-in patch board. Character punching speed is limited only by the type of paper punch used, e.g. 110 characters/sec with Teletype BRPE110 or 33 characters/sec with Creed 25. — *Digital Measurements Ltd., 25 Salisbury Grove, Mytchett, Aldershot, Hants.*

For further information circle 29 on Service Card

30. Improved Rectifier Stacks

The range of medium power silicon rectifier stacks made by International Rectifier has been re-designed. The new stacks, which consist of 'top-hat' rectifiers SD or SD/A mounted on copper cooling fins, have been made smaller by incorporating tinned terminations on the fins themselves, instead of using separate terminal plates.

At the same time, a new method has been developed for mounting the diodes which enables the fins to be mounted closer together.

The stacks are available in half-wave single-phase bridge and three-phase bridge assemblies. They are rated from 2 to 5·6 A, 100 to 1,000 V p.i., and have dimensions ranging from 2 by 2 by 2 in. to 2 by 2 by 4·6 in., including fixing brackets. — *International Rectifier Company (Great Britain) Ltd., Hurst Green, Oxted, Surrey.*

For further information circle 30 on Service Card

31. Isolated Sockets

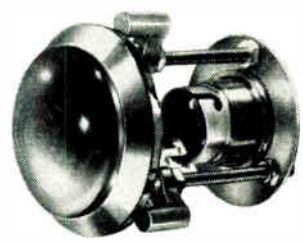
The Sealectoboard cordless programming system is based on a 2-plane ¼-in. matrix pin-board with continuous socket strips on each plane.

Some circuit arrangements however are prone to output-to-input feedback, but this can now be eliminated by the substitution, on the lower plane of the Sealectoboard, of a single isolated socket for the socket strips, thus enabling series diodes to be interposed at each matrix point.

Mounting of the diodes is facilitated by the provision of turret lugs at each end of the rows of isolated sockets, between each pair of which a heavy gauge wire bus-bar can be run.

In applications where there are no feedback problems, the use of isolated sockets and turret lugs can provide greater flexibility.—*Sealectro Corporation, Hersham Factory Estate, Walton-on-Thames, Surrey.*

For further information circle 31 on Service Card



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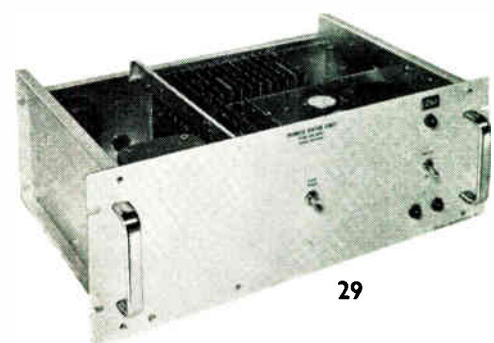

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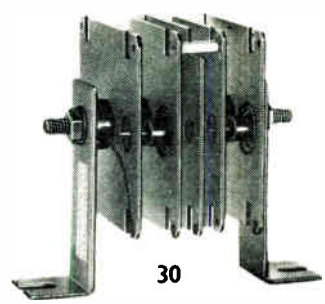

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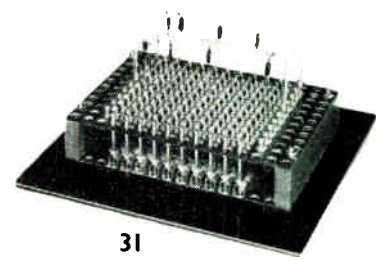

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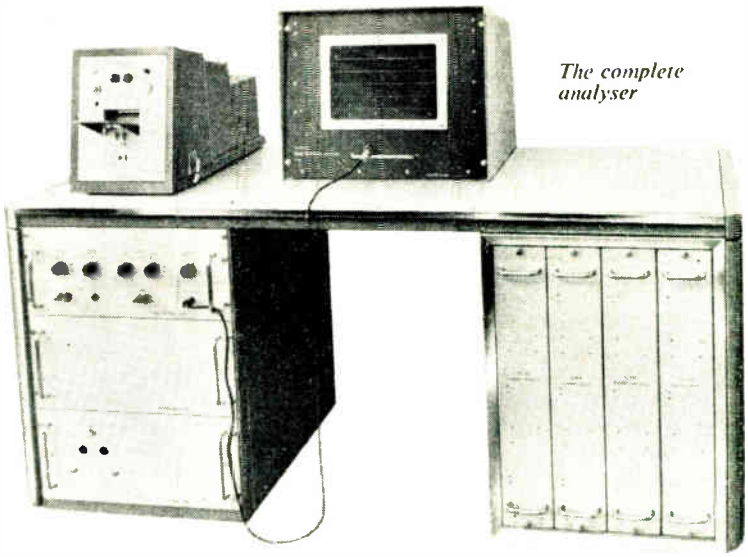
AUTOMATIC NOISE SPECTRUM ANALYSER



The complete analyser

A DEMONSTRATION of the automatic noise spectrum analyser PZ1128 was recently given at the Farnborough headquarters of The Solartron Electronic Group Ltd.

The instrument has been designed to analyse complex noise signals and to present a visual display of the component signal frequencies and their amplitudes. The display takes the form of a histogram or frequency spectrum presented on a cathode-ray tube. On command, the equipment will print out the display in a bar-graph form on a card. Fig. 1 is a reproduction of one of the cards. The frequency range of the instrument is 1 c/s to 10 kc/s.

The design approach of the analyser is the classic one of providing a parallel bank of filters, in this case 35 in number, each of which is followed by a linear rectifier of wide dynamic range. The rectifiers have two outputs of different storage time-constants. One set of 35 outputs is scanned at the rate of 2,000 channels per second to drive the c.r.t. display, and the other set is scanned at about 50 channels per second, under the control of the printer.

These high and low-speed commutated outputs are fed to logarithmic amplifiers, having a dynamic range of about 50 dB. The output of the amplifier in the high speed circuit is compared with a signal proportional to the vertical deflection current of the c.r.t., and when they are equal the c.r.t. beam current is switched; thus a line is drawn whose length is proportional to the logarithm of the input signal.

The output of each stage of the low-speed logarithmic amplifiers is applied to a series of comparators having bias levels graded in steps of 2 dB. The outputs of these comparators operate the printer type hammers to print a line composed of up to 20 dashes each of length equivalent to a 2 dB increase in signal. Stepping of the low-speed commutator is synchronized with the movement of the card under the type hammers so that the print-out consists of 35 parallel lines each of length proportional to the logarithm of amplitude in the corresponding channel. The presentation is therefore similar to that of the c.r.t. display except for the 2-dB quantization of signal strength.

The averaging time constants at the detector outputs are 2 sec for all channels in the case of the low-speed output, and $0.36/f_0$ sec for the high-speed output, where f_0 is the channel centre frequency. This latter time-constant has been chosen to give a sufficiently 'smooth' visual display.

The continuous visual display is presented on a 17-in. rectangular c.r.t. The permanent record is made on demand via a push-button either singly or continuously at the alternative rates of 30, 10 or 3 per minute.

For further information circle 37 on Service Card

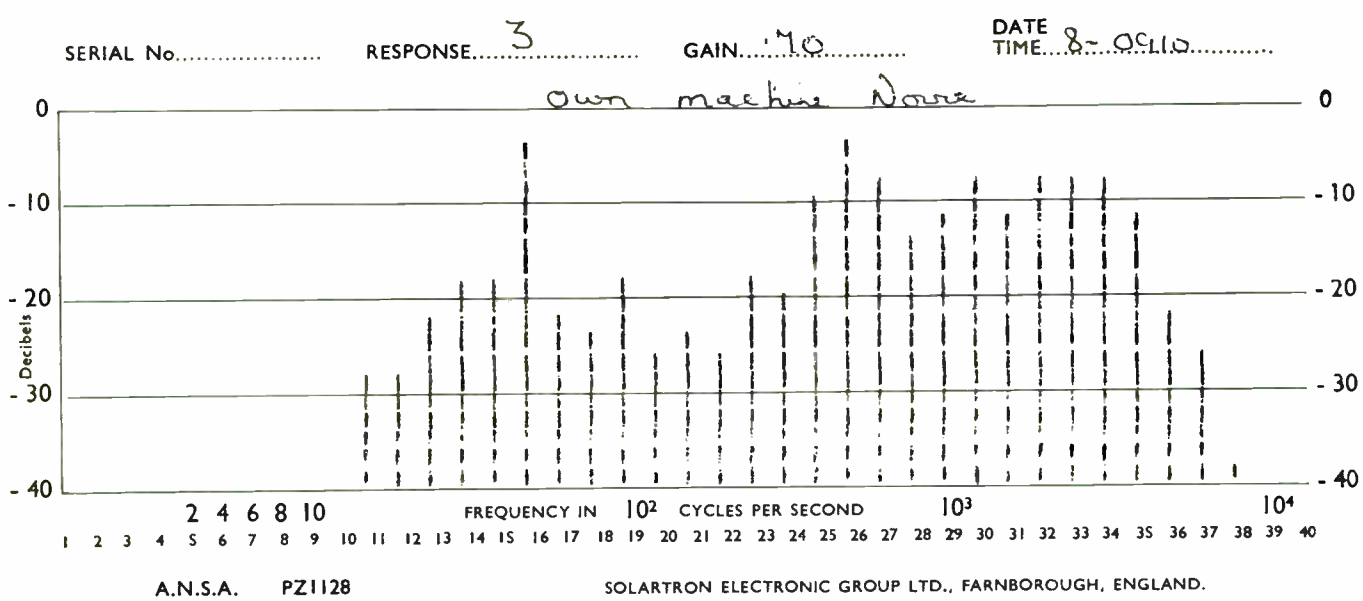


Fig. 1. A reproduction of an actual bar-graph

By H. J. GOLDSMID, B.Sc., Ph.D., F.Inst.P.*

Thermoelectric and Thermomagnetic Cooling

Although the Peltier effect has been known a long time, it is only recently that materials have been developed which have enabled it to be of practical use. The article discusses the requirements and considers the possibilities of another effect—the little-known Ettingshausen effect.

HISTORICALLY, the development of thermoelectric cooling from an obscure and rather unimportant phenomenon to a practical method of refrigeration is primarily the story of advances in thermoelectric materials. Similarly, the more novel concept of using the transverse thermomagnetic effects in direct energy conversion awaits improvements in materials for its full realization. Most of this article will, therefore, be devoted to a discussion of the materials which have been used, and are likely to be used, in thermoelectric and thermomagnetic cooling, although some of the applications of thermoelectric cooling which are both possible and practicable at the present time will also be described.

Jean Peltier, a French watchmaker, was the first person to draw attention to the reversible heating and cooling effects when an electric current crosses the junction between two similar metals. His observations of 1834, and Thomas Seebeck's earlier discovery of the production of an e.m.f. on heating a junction, were related to one another by Lord Kelvin's thermodynamic theory of 1857. Although we shall be dealing with the *Peltier* cooling effect, reference will be made almost invariably to the *Seebeck* coefficient of a thermocouple or a thermoelectric material. A reminder of Kelvin's first law is thus not out of place.

The differential Seebeck coefficient at a junction between conductors a and b is defined as:

$$\alpha_{ab} = V/\Delta T$$

where V is the open-circuit voltage and ΔT the temperature difference between the junctions. The differential Peltier coefficient is:

$$\pi_{ab} = q/I$$

where q is the rate of reversible heat generation at one junction and I is the current. Kelvin's law states that:

$$\pi_{ab} = \alpha_{ab} T$$

where T is the absolute temperature. If the conductor b is a metal whose thermoelectric coefficients are zero, then π and α are the absolute Peltier and Seebeck coefficients of conductor a.

The theory of thermoelectric generators and refrigerators was given by the German scientist Altenkirch in 1910 and 1911. Qualitatively, besides a high Seebeck or Peltier coefficient, a good thermoelectric material should have a high electrical conductivity to minimize the Joule heating effect and a low thermal conductivity to minimize irreversible heat transfer between the source of heat and the sink. Although Altenkirch's theory has been established for so many years it is only since the 1950s that practical thermoelectric refrigerators have been built. This corresponds to the replacement of the traditional metallic and semi-metallic thermocouples with semiconductor thermocouples. It is noteworthy that the new art of thermomagnetic cooling is

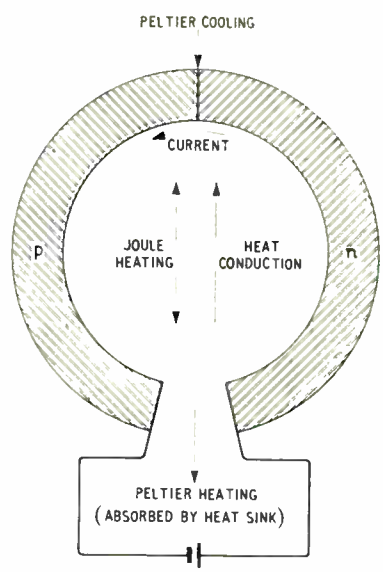


Fig. 1. A simple thermoelectric refrigerator

* Hirst Research Centre of The General Electric Co. Ltd., England.

GLOSSARY OF SEMICONDUCTOR TERMINOLOGY

Fermi Level. The *Fermi level* is the level of energy at which an electronic state has equal chances of being occupied or empty.

Energy Bands. At the absolute zero of temperature some of the allowed bands of energy in a semiconductor are completely full while the remainder are empty. The highest full band is the *valence band* and the lowest empty band is the *conduction band*.

Energy Gap. The *energy gap* is the band of forbidden energy between the valence and conduction bands. If the energy gap just falls to zero the material is a *semi-metal* rather than a semiconductor.

Multi-valley Bands. In a *single-valley band* the extreme energy occurs when the momentum of the charge carriers is zero. In a *multi-valley band* the energy extrema are found when the momentum has equal values in a number of different directions determined by the crystal symmetry.

Holes. The empty energy-states in a nearly-full valence band act like positively charged carriers and are called *holes*. In a *mixed semiconductor* there are appreciable numbers of both electrons and holes. In an *intrinsic semiconductor* there are equal numbers of each.

Mobility. The mobility of a charge carrier is the speed at which it drifts in unit electric field.

Effective Mass. Because of their interaction with the lattice, electrons and holes behave as if their masses were different from the mass of a free electron. When calculating the energy distribution of the carriers one must use the *density-of-states effective mass* instead of the free-electron mass. When considering scattering of the carriers it is the *inertial effective mass* that is important. Simple relations exist between the two effective masses.

likely to make use of semi-metals rather than semiconductors as will be shown later.

Thermoelectric Figure of Merit

It is not worth reproducing the details of the calculation of the coefficient of performance (c.o.p.) of a thermoelectric refrigerator in terms of the thermocouple parameters (the interested reader may refer to one of the textbooks in the bibliography). The model for such a calculation is shown in Fig. 1. The Peltier cooling effect is opposed by heat conduction through the arms of the couple and by Joule heating, half of which goes to each junction. Lateral heat transfer is neglected. For a given pair of materials, which should have positive and negative absolute Seebeck coefficients respectively, there will be an optimum relation between the dimensions of the arms and an optimum current for either maximum cooling power or c.o.p. There is scope for altering the cooling power per couple by increasing or decreasing the ratio of length to cross-section area (with corresponding changes in the optimum current) but for the moment let us merely consider the maximum reduction of temperature that can be achieved. At a certain current, the difference between the Peltier cooling (which is directly proportional to the current) and the Joule heating (which varies as the square of the current) reaches its maximum value; this difference is exactly balanced by heat conduction when the temperature of the cold junction has fallen to its lowest possible value. The simplest equation which describes this situation is:

$$\Delta T_{max} = \tfrac{1}{2} Z T_c^2$$

where T_c is the absolute cold-junction temperature and

$$Z = \frac{(\alpha_p - \alpha_n)^2}{\{(\kappa_p/\sigma_p)^{\frac{1}{2}} - (\kappa_n/\sigma_n)^{\frac{1}{2}}\}^2}$$

where κ is thermal conductivity and σ is electrical conductivity and the subscripts p and n refer to the two branches. Z is known as the figure of merit of the thermocouple and is measured in deg^{-1}.

Prior to the use of semiconductor thermocouples the best value of Z for metal thermocouples lay around $0{\cdot}25 \times 10^{-3}\ \text{deg}^{-1}$. Then if T_c were 273 °K, ΔT_{max} was less than 10 °C. The first thermocouples between p-type and n-type Bi_2Te_3 made in 1955 had Z of about $1 \times 10^{-3}\ \text{deg}^{-1}$ with ΔT_{max} equal to about 40 °C. Anticipating the subsequent discussion, present day thermocouples have a value of Z of more than $3 \times 10^{-3}\ \text{deg}^{-1}$. Thus if $T_c = 273$ °K, $\Delta T_{max} > 110$ °C. It is possible, in principle at least, to maintain the cold junctions below freezing point when using a boiling-water heat sink.

Incidentally, except when designing a cooling unit, it is rare to use the *thermocouple* figure of merit Z as we have defined it. It is much more usual to deal with a figure of merit z for a *single material*:—

$$z = \alpha^2 \sigma / \kappa.$$

The thermocouple Z is approximately equal to the mean value of z for the two branches in all practical cases.

Thermoelectric Materials

Most metals have Seebeck coefficients of the order of 1 to 10 μV/°C while, according to the Wiedemann-Franz law, the ratio of the electrical conductivity σ to the thermal conductivity κ has the value of $4 \times 10^7/T$ practical e.m.u. Thus if T is of the order of 300 °K, z for a metal is about 10^{-7} to $10^{-5}\ \text{deg}^{-1}$. Even if α rises to about 70 μV/°C as in a semi-metal like Bi the value of z reaches no more than about $5 \times 10^{-4}\ \text{deg}^{-1}$. The simple electron theory of metals, in fact, shows that z could not exceed such a value as this, though the same conclusion would not necessarily apply for a metal with a complex band structure. If metals, then, do not look promising, do semiconductors look any better? Certainly experimental Seebeck coefficients well in excess of 1 mV/°C have been reported for some semiconductors; against this we must set the fact that ratio σ/κ is invariably worse than the value given by the Wiedemann-Franz law for metals. This is due to the fact that, in semiconductors, most of the heat conduction is due to the lattice vibrations which, of course, cannot conduct electricity.

Consider the energy diagram for the junction between a

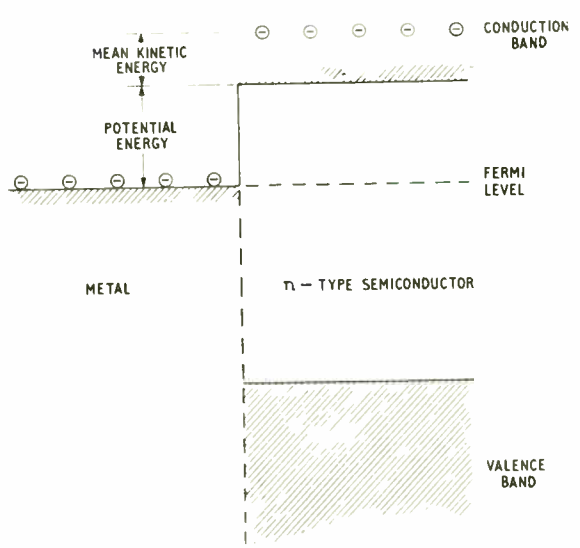


Fig. 2. Energy diagram for a junction between a metal and an n-type semiconductor

metal and an n-type semiconductor shown in Fig. 2. The following would be equally applicable to a p-type semiconductor junction with the exception that the sign of the Seebeck coefficient would then be positive instead of negative. Here it is supposed that the valence band is completely full and does not contribute to the transport effects. The Peltier effect arises from the fact that an electron passing from the metal to the semiconductor has to cool its surroundings in order to gain enough energy to move in the conduction band. The required kinetic energy is of the order of $2kT$ per electron where k is Boltzmann's constant; the potential energy depends on the position of the Fermi level. Obviously, the larger the potential energy the larger the Peltier and Seebeck coefficients. On the other hand, the larger the potential energy the lower the carrier concentration and the lower the electrical conductivity. Of course, a fall in the electrical conductivity reduces the electronic part of the thermal conductivity, but in most semiconductors the lattice vibrations provide the major contribution to the conduction of heat; thus an increase of potential energy lowers the ratio σ/κ.

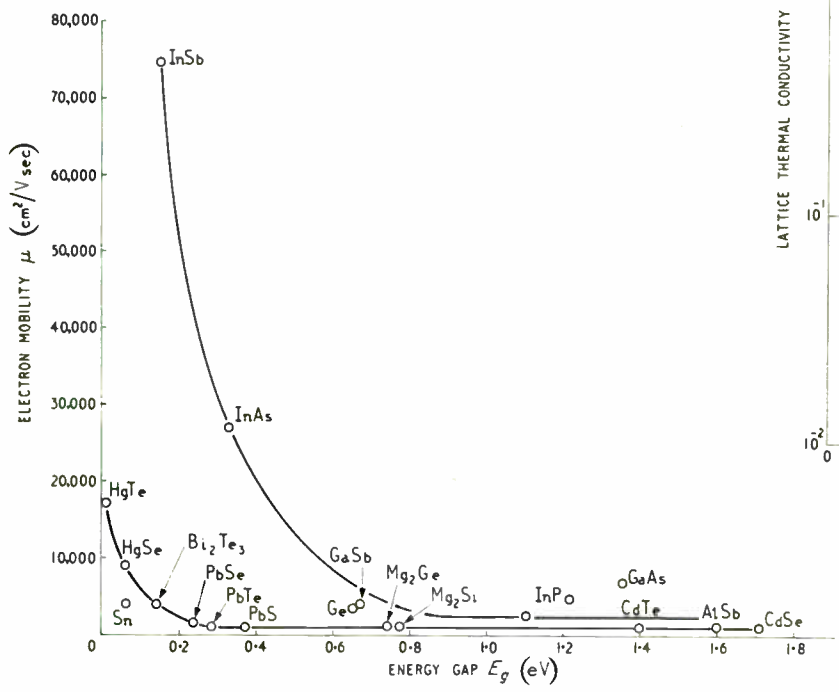
It is useful to express the quantities, α, σ and κ as functions of the potential energy η since the Fermi level can in general be changed at will by doping with certain impurities. In this way we obtain an expression for the figure of merit in terms of η and certain fundamental semiconductor parameters; z is a function of η and $\mu m^{*3/2}/\kappa_L$ where μ is the carrier mobility, κ_L is the lattice thermal conductivity and m^* is the density-of-states effective mass of the charge carriers. The expression for z tells us two things. First, more or less independently of the particular values of μ, m^* and κ_L, the potential energy η should have an optimum value close to zero. This in turn implies that the Seebeck coefficient should be adjusted, by doping, so as to be about $\pm 200\,\mu V/^\circ C$. Secondly, the semiconductor should have a high mobility, a high density-of-states effective mass and a low lattice thermal conductivity, so that the factor $\mu m^{*3/2}/\kappa_L$ is as high as possible.

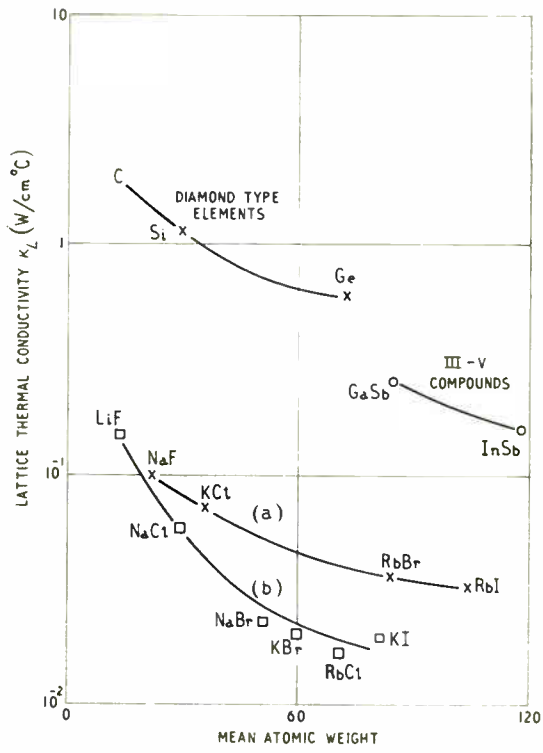
The three important parameters are not independent of one another. Thus a high effective mass implies a low mobility. Similarly a semiconductor which has a high mobility usually also has a high thermal conductivity. There are, however, two ways in which we can obtain a favourable combination of parameters. First, by choosing materials of high atomic weight we tend to reduce the lattice thermal conductivity as shown in Fig. 3. Moreover semiconductors of high atomic weight tend to have a small energy gap and, associated with this, a high mobility as shown in Fig. 4. Secondly, if the semiconductor has a complex multi-valley band structure one can obtain a relatively high *density-of-states* effective mass with a relatively low *inertial* mass, the latter mass having the primary effect on the mobility.

Thus our ideal material would seem to be a semiconductor of high atomic weight with a multi-valley band structure doped to yield a Seebeck coefficient of $\pm 200\,\mu V/^\circ C$. Multi-valley bands seem to be more common among the non-cubic crystal classes.

There is one difficulty that becomes apparent when we try to make use of the heaviest semiconductors. They sometimes have so small an energy gap that it is impossible to avoid simultaneous conduction by holes and electrons. Mixed or intrinsic conduction is to be avoided since the partial Seebeck coefficients of the electrons and holes are of opposite sign so that the overall Seebeck coefficient is low. Moreover, the electronic thermal conductivity is exceptionally high in a mixed semiconductor since the electron-hole pairs can transport their ionization energy as well as their kinetic energy. It is difficult to see how one can make use of a semiconductor with an energy gap of much less than about $4kT$, that is, about 0·1 eV near room temperature.

Having found a useful semiconducting compound, is there any way in which it can be improved still further? Abram Ioffe, who until his death in 1960 was the world's leading authority on thermoelectricity, put forward the rather surprising hypothesis that the formation of an alloy or solid solution between two isomorphous semiconductors might





Above: Fig. 3. Lattice thermal conductivity against mean atomic weight

Left: Fig. 4. Variation of mobility with energy gap

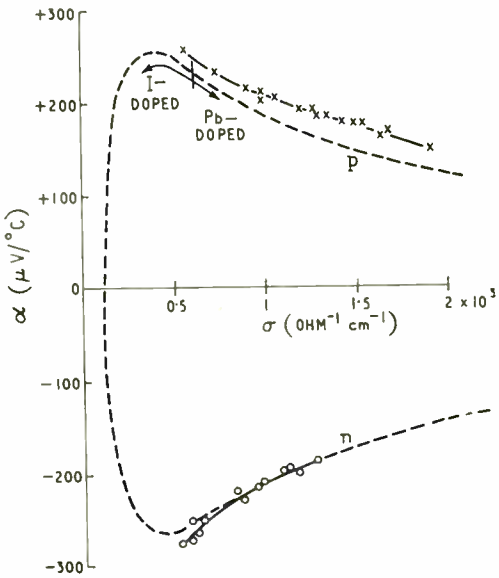


Fig. 5. Seebeck coefficient against electrical conductivity for Bi_2Te_3 and its alloys at room temperature

– – – – – – – – Bi_2Te_3
X————X $(Bi\text{-}Sb)_2Te_3$ *(p-type)*
O————O $Bi_2(Se\text{-}Te)_3$ *(n-type)*

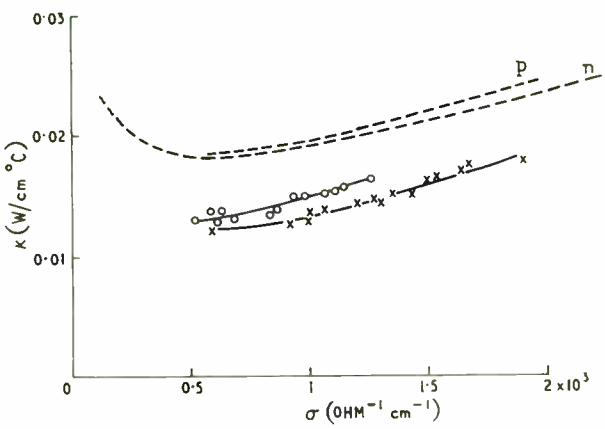


Fig. 6. Thermal conductivity against electrical conductivity for Bi_2Te_3 and its alloys

– – – – – – – – Bi_2Te_3
X————X $(Bi\text{-}Sb)_2Te_3$ *(p-type)*
O————O $Bi_2(Se\text{-}Te)_3$ *(n-type)*

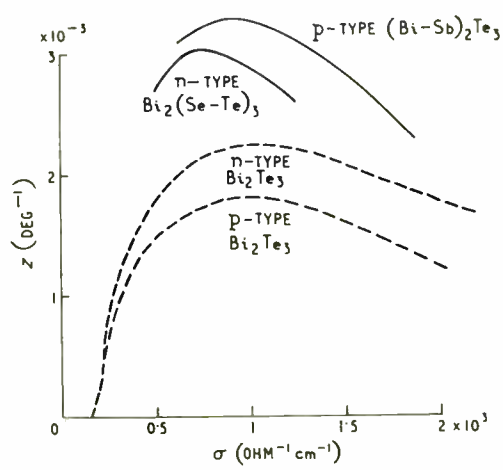


Fig. 7. Figure of merit against electrical conductivity for Bi_2Te_3 and its alloys

lower the lattice thermal conductivity without reducing the carrier mobility.

Let us now see how our principles work out in practice. The best semiconducting compound in the room temperature region is Bi_2Te_3. It was first studied on the basis of the high atomic weight criterion. It is an anisotropic material (having a layer structure like mica) with 6- and 3-valley conduction and valence bands respectively. Its energy gap is about 0·15 eV. Fig. 5 (dotted curve) shows a plot of Seebeck coefficient against electrical conductivity. The undoped compound is p-type due to lack of stoichiometry; Pb and I act as acceptor and donor impurities respectively. Note that in the one-carrier region (to the right) the Seebeck coefficient falls as the electrical conductivity rises. Note also that both the Seebeck coefficient and the electrical conductivity are low in the region of mixed conduction (on the left). The solid curves refer to alloys of Bi_2Te_3 with Sb_2Te_3 and Bi_2Se_3: they confirm one part of Ioffe's hypothesis since a lower carrier mobility would normally imply a lower electrical conductivity for a given Seebeck coefficient.

Fig. 6 shows the thermal conductivity plotted against the electrical conductivity. As expected, the thermal conductivity rises with electrical conductivity in the one-carrier region on the right. The sharp increase on the left of the diagram corresponds to the transport of ionization energy in the mixed conduction region already mentioned. The solid curves are the results for the alloys of Bi_2Te_3 with Sb_2Te_3 and Bi_2Se_3. The overall downward shift of these curves compared with those for Bi_2Te_3 illustrates the reduction in lattice thermal conductivity on alloying.

Fig. 7 shows the figure of merit plotted against electrical conductivity. The optimum electrical conductivity of about 1,000 $ohm^{-1}cm^{-1}$ in all cases corresponds to a Seebeck coefficient near to $\pm$ 200 μV/°C. For Bi_2Te_3 the values of z are about 2×10^{-3} deg^{-1} while for the alloys z is 3 or $3{\cdot}3 \times 10^{-3}$ deg^{-1}.

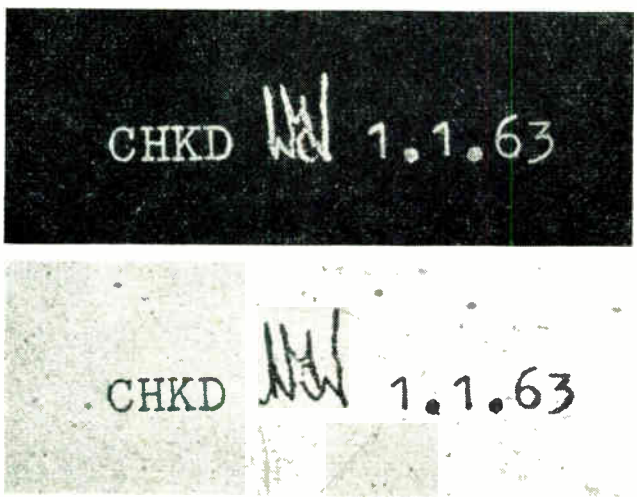
These are not the highest values of z that have been achieved. For the n-type semiconducting alloys of Bi and Sb (with about 10% Sb) a value of z equal to 5×10^{-3} deg^{-1} has been reached by Wolfe and Smith but only at liquid nitrogen temperature. Bi-Sb alloys satisfy all our criteria for a good thermoelectric material at room temperature with the exception of a sufficiently large energy gap. The largest gap in the alloy system is about 0·016 eV; i.e., less than 1 kT at room temperature. Even at liquid nitrogen temperature, 77 °K, a Seebeck coefficient of no more than $-$ 130 μV/°C can be reached before mixed conduction sets in. If the energy gap were larger z would be appreciably greater than even 5×10^{-3} deg^{-1} at liquid nitrogen temperature. It is primarily for this reason that the application of a transverse magnetic field (of about 500 Oe), which increases the Seebeck coefficient (by up to 100% in higher fields) leads to a rise in z to about 9×10^{-3} deg^{-1} in spite of some deterioration in the ratio σ/κ due to magneto-resistance. A figure of merit of 3×10^{-3} deg^{-1} for a Bi-Sb alloy at room temperature has also been achieved but it was neccessary to apply a field of 17,000 Oe to reach it.

(To be continued)

ELECTROLYTIC MARKING

AS a means of identifying metal components, imprinting inspectors' symbols and applying designations and trademarks, electrolytic etch-marking has many advantages over other methods. The result is permanent, without the work-hardening and stress-raising effects of mechanical stamps, yet is much more quickly achieved than by spark-etching. Stencils are very easily prepared either by typing, handwriting or die stamping, while most elaborate and detailed patterns can be prepared economically by photographic techniques. Marking takes only a few seconds, even for complicated marks, and the depth of penetration can be closely controlled. Finally, little skill is required to produce perfect results.

Already in wide use as a workshop technique, electrolytic marking in the field is now made possible by a new transistorized unit, the type BT400 produced by Electromark (GB) Ltd. The unit, complete with batteries and all accessories, weighs about 4 lb and is housed in a camera-sized carrying case. It uses a transistorized oscillator to convert the output of two bell-type dry cells, or of a re-chargeable accumulator, into alternating current at about 9·5 V, 200 mA. Although d.c. output is also available, a.c. etching is the more versatile, producing on most metals a permanent dark mark composed of re-deposited metallic oxides. Current is applied to the work by a plug-in marker and earthing clip; the marker electrode is fitted with an absorbent pad moistened with electrolyte from a small ampoule carried in the case. The a.c./d.c. switch is the only control, the oscillator being switched on automatically by a jack-plug on the marker cable.



Electromarked specimens: d.c. etch on stainless steel (top) and a.c. mark on brass (bottom). The 'checked' sign and date are typed on the stencil; each inspector adds his own initials with a ball-point pen

In operation, the stencil is simply applied to the work and the moistened marker placed on the stencil for a few seconds. Results are consistently maintained over a large number of marks, from one stencil. New stencils can be prepared in the field, using a ball-point pen, as easily as writing on a piece of paper.

The new marker, the first portable unit of its kind, is expected to appeal to those responsible for inspection and overhaul of equipment in the field, such as aircraft and other transport operators, roving inspectors on production line work, and others for whom it may be inconvenient to take the work to power-operated bench marking units.

For further information circle 38 on Service Card

For work which cannot be taken to a bench-type marking unit, such as marking jet sizes on a modified carburettor, the portable Electromark type BT400 provides an ideal solution

Here the BT400 is being used for the permanent marking of components on a production line

Personal and Company News

Advance Components Ltd. have acquired Pentechnique Ltd. of Cheltenham, specialists in electronic measurement, counting and control techniques. The company's name will be changed to Advance Controls Ltd. and its board will comprise E. A. J. Miles, managing director, A. W. Piercey, A.M.Brit.I.R.E., and E. G. Wakeling, A.M.I.E.E.

Standard Telephones & Cables Ltd. have acquired the whole of the issued share capital of Robert Maclaren & Co. Ltd., manufacturers of temperature control equipment.

Communication Systems International Ltd. is a new company in the Plessey group formed to control its interests in the rental and sale of telephone systems. It has an operating capital of £2 million. A. E. Underwood is chairman, W. A. Travers is managing director, and G. D. Christie, E. H. Ousten and E. H. Townsend are directors.

Lord Chandos is to retire from Associated Electrical Industries Ltd. at the end of the year. He will be succeeded as chairman by **C. R. Wheeler.**

G. & E. Bradley Ltd. have appointed industrial distributors for Lucas silicon power rectifiers and transistors. They are: Hardman & Co. Ltd., Hardale House, Baillie Street, Rochdale, Lancs.; Gothic Electrical Supplies Ltd., Gothic House, Henrietta Street, Birmingham 19; and Cables & Components Ltd., 304 Northfield Avenue, Ealing, London W.5.

Osram (G.E.C.) Ltd. announce board changes. L. A. Mills becomes assistant managing director, D. L. Tabraham becomes assistant managing director (lighting) and P. R. Sansom sales director.

Dr. Stanley Gill of Ferranti Ltd. has been appointed to a newly-created part-time chair at the Manchester College of Science and Technology as Professor of Computation.

The **Scientific Instrument Association of Great Britain Ltd.** has set up a Medical Instruments Group to provide a forum for the discussion of problems about the application of instrumentation and equipment systems in medicine, health and hygiene.

G. N. Petty has been appointed deputy managing director, and P. I. Marshall financial director, of **E.M.I. Electronics Ltd.**

Simmonds Relays Ltd. have been appointed sole distributors for the United Kingdom and Eire for the photo-electric control equipment manufactured by Violux-Electronik of Berlin.

Captain Charles F. Booth, C.B.E., M.I.E.E., deputy engineer-in-chief of the Post Office, retired on 31st March.

W. H. Lidstone, engineer-in-charge at Bush House of the B.B.C.'s external services retired on 10th April. He is succeeded by **R. H. Bullen.**

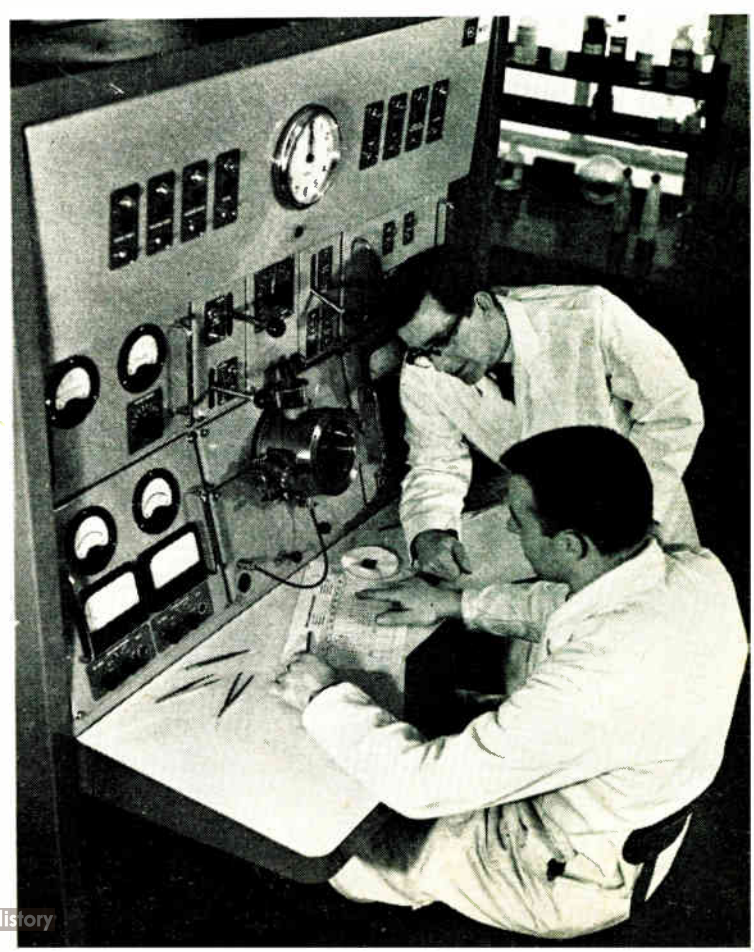
The association between the **Miles Group** of companies and **Intertechnique** of Paris has recently become closer and agreement has been reached on reciprocal manufacturing arrangements.

Ownership of the Univac computer centre in Manchester has been transferred to an independent company, **Manchester Computer Centre Ltd.**

Bendix Ericsson U.K. Ltd., of New Basford, Nottingham, have become agents of and distributors for M. C. Jones Electronic Co. Inc., of Bristol, Connecticut, U.S.A.

Consolidated Electrodynamics Corporation (U.K.) Ltd. has become the Consolidated Electrodynamics Division of **Bell & Howell Ltd.** The head office is unchanged at 14 Commercial Road, Woking, Surrey, and the factory is still at 25 Salisbury Grove, Mytchett, Nr. Aldershot, Hants.

An A.E.I. mass spectograph has been installed at the research laboratories of B.I.C.C. It enables impurities in metals to be detected and estimated down to one ten millionth of one per cent



The picture shows solder being refined at the works of Enthoven Solders Ltd. Crude metals are fused in a 70-ton pot. Impurities are removed by fluxes and other chemical additives which are mixed with the solder by a motor-driven paddle. The whole operation can take as long as five days

British Relay Wireless & Television Ltd. and **British Home Entertainment Ltd.** have reached an agreement on joint participation in a Pay-TV experiment. British Relay's subsidiary Toll TV Ltd. is to be reformed.

Electronics & Automation (London) Ltd., Maxwell House, Arundel Street, London W.C.2, have been appointed sole export agents for France and Italy for the electronic equipment manufactured by James Scott (Electronic Engineering) Ltd., Glasgow.

A. B. Vickery has resigned from his position as managing director of **Brookhirst Igranic.**

F. W. Hardstone, former deputy chief general manager of Westminster Bank Ltd., has joined the board of directors of **Ferranti Ltd.**

Aveley Electric Ltd. have transferred to a new building at South Ockendon, Essex (telephone: South Ockendon 3444). Their previous building is now occupied by their subsidiary, Avel Products Ltd.

R. H. Hill, secretary of **British Insulated Callender's Construction Co. Ltd.,** has been appointed a director.

Eversbed & Vignoles Ltd. are represented in Wales by K. Z. Baldy, Hillside, Heol Hir, Cardiff.

Hughes International (U.K.) Ltd. have been appointed sales distributors for Fansteel tantalum capacitors in the United Kingdom and Eire.

Armstrong Whitworth Equipment, the Gloucester unit of Whitworth Gloster Aircraft Ltd., is changing its name to Whitworth Gloster Equipment.

Carr Fastener Co. Ltd. have a northern sales office at Crossford Court, Dane Road, Sale, Cheshire (Telephone: Sale 4213).

British Central Electrical Co. Ltd. have moved to 16–26 Banner Street, London, E.C.1.

F. G. Flower becomes the new standards co-ordinator of **I.B.M. United Kingdom Ltd.**

Sales Organisers Ltd., 6–8 Old Bond Street, London, W.1, announce that they are the sole concessionaires for all equipment manufactured by Tudor Electronics Ltd.

Takbro Industrial Ltd., 85 Regent Street, Leamington Spa, Warwickshire (Telephone: Leamington Spa 21488) is a company formed to market solderless terminals manufactured in Japan.

Eastern Aero Electrical Services Ltd. has been appointed an authorized industrial distributor for International Rectifier Co. Ltd. Middlesex, Buckinghamshire and Oxfordshire will be served by the London Airport branch (Telephone Skyport 1314), while East Anglia is served from Colchester (Telephone: Colchester 6173). **Direct T.V. Replacements Ltd.** is an authorized distributor for London and Kent (Telephone: Tideway 6666).

Epsylon Industries Ltd. have opened a branch office at 68 Grosvenor Street, Manchester 1.

F. J. Wood has been appointed general manager of **Vidor Ltd.**

G. H. Bloore Ltd., Honeypot Lane, Stanmore, Middlesex, have been appointed sole distributors for England of Polypenco plastics.

A. E. Trehearn, sales executive of the Dubilier Condenser Co. Ltd., has died after a short illness.

E. Gibbs, a senior development engineer of **Telequipment Ltd.,** has been transferred to the technical sales staff.

Interplas 63

The International Plastics Exhibition is being held at Olympia, London, from 12th to 22nd June, except Sunday. It will be open from 10 a.m. until 6 p.m. daily, except on the 19th and 20th when it will close at 8 p.m.

The Canadian Westinghouse WQ4A harmonic filter is intended to prevent harmonic radiation from high-power c.w. transmitters. It is designed for the 4,400 to 5,000 Mc/s band and gives 2nd-harmonic attenuation of more than 30 dB for a fundamental loss of under 0·2 dB

For further information circle 39 on Service Card

Rank-Westrex Agreement

The Rank Organization and the Westrex Company Ltd., a Division of Litton Industries Inc., announce that they have reached agreement under which the Rank Kalee Division of the Rank Organization will be granted the sole agency for the United Kingdom and many territories overseas (excluding Eire) for the sale of sound recording and reproducing equipment manufactured by Westrex.

It is also announced that the service facilities provided by Rank Kalee and Westrex for maintaining sound and projection equipment in well over 2,000 cinemas in the U.K. have been amalgamated and are operated by Westrex at Cricklewood, London.

EMIHUS

A new Anglo-American military electronics company, EMIHUS Ltd., has been formed. It is owned equally by Electric & Musical Industries Ltd. and Hughes Aircraft Co. of California. It is British based with offices in Blyth Road, Hayes, Middlesex, and the day-to-day management is being conducted by E.M.I. Electronics Ltd. The two parent companies each have four members on the board of directors.

The chairman and managing director is P. A. Allaway and Air Vice-Marshal W. E. Oulton, who is director of military electronics in E.M.I. Electronics Ltd., is on the board and also acts as general manager. General Clarence A. Shoop heads the Hughes team of directors.

The new company will handle certain types of Hughes equipment, which will be manufactured by E.M.I. Electronics Ltd. The apparatus will include digital computers, airborne radar, digital test equipment, airborne instrumentation and airborne navigation and control systems.

The formation of the company does not affect work carried out directly for the British Government by other E.M.I. companies. The new company is concerned only when it is desirable to bring the combined resources of E.M.I. and Hughes Aircraft to bear upon a project.

Cambridge University Computer

An Elliott 405 computer has been presented to the Engineering Laboratory of Cambridge University by the National Research Development Corporation and Associated Electrical Industries (Woolwich) Ltd. It is to be used for research on automatic control. The computer is one which has been used for some years by N.R.D.C. and A.E.I. for studying the applications of a computer to production control, and this work has now been completed.

Linear Accelerator

The Department of Scientific and Industrial Research has approved a grant of a million pounds for the provision of a linear electron accelerator for Glasgow University. The accelerator is to be used for investigations into photo-problems in nuclear physics. It will be at East Kilbride adjacent to the Scottish Universities' Reactor Centre.

1962 BEAMA Annual Report

The recently-published 1962 annual report of the British Electrical and Allied Manufacturers' Association states that the output of the industry is now about £1,700 million a year. In 1962, exports reached a new record of £332·6 million—an increase of £14 million or 4·4%, on the figures for 1961.

Electrical and allied products now represent 10·4% of all manufactured goods exported from Britain.

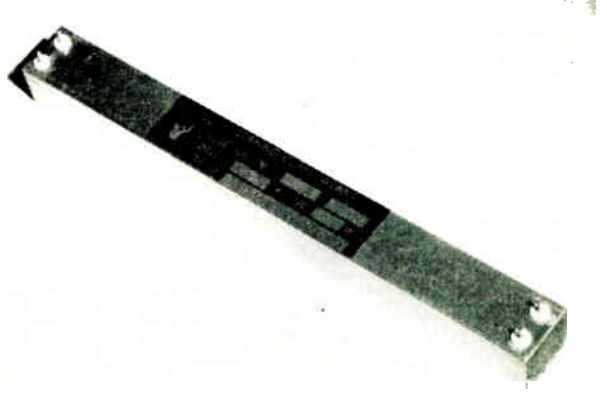
Automation in Road Planning

An integrated data processing service for the civil engineering and construction industries is being provided by Computaquants Ltd. of London in collaboration with Nordisk ADB of Sweden and C.E.I.R. (U.K.) Ltd. The system is based on the integration of aerial survey, photogrammetry and computer techniques.

7th International Instrument Show

The 7th International Instrument Show is to be held by B. & K. Laboratories Ltd. at their London offices at 4 Tilney Street, Park Lane, London, W.1, from 27th to 31st May. The times of admittance are 10.30 a.m. to 6.30 p.m. except Wednesday when the exhibition is open until 9 p.m. Tickets are available at no charge on application to B. & K. Laboratories.

As in previous years, the show will include exhibits from the latest ranges of some of the leading overseas manufacturers of electronic equipment.



Inexpensive delay line for operation at 4·43 Mc/s and giving a delay of 63·8 μsec. The model illustrated is made by Corning Glass Works and is suitable for the Secam colour television system. At present the price is $50 in 1,000 lots, but it is envisaged that if Secam were adopted in Europe the production would be so large that the price would be $5 only

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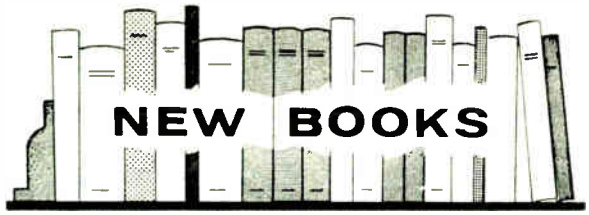

The Case Against the Nuclear Atom

By DEWEY B. LARSON. Pp. 139 + viii. North Pacific Publishers, P.O. Box 5044, Portland 13, Oregon, U.S.A. Price $4.50.

The author of this book believes that current atomic theory is all wrong. He goes back to Rutherford who directed alpha particles against a thin metal plate and found that most of the particles passed through the plate. He admits that Rutherford's explanation that most of the mass of the atom is concentrated in a very small volume, and that most of the region which the atom occupies in the solid state is empty space, is consistent with the observed facts. He maintains, however, that alternative explanations have never been considered and he rejects Rutherford's. In his view the atom has neither nucleus nor electrons but is solid entity, small compared with the volume which it is considered to occupy.

The existence of the electron as a particle outside the atom is admitted, as is also the neutrino. No coherent alternative to current atomic theory is advanced, however, and the book is completely non-mathematical. The criticism is almost entirely destructive.

The average reader will feel considerable sympathy with the author about his dislike of many of the concepts of atomic physics, for they are undoubtedly hard to grasp, and the book is certainly an interesting one to read, even if it is not convincing. There is indeed much to be said for the author's contention that from time to time experts should review critically the foundations of their subject.

Analogue Computing at Ultra-High Speed

By DONALD M. MACKAY, B.Sc., Ph.D., and MICHAEL E. FISHER, B.Sc., Ph.D. Pp. 395 + xv. Chapman & Hall Ltd., 37 Essex Street, London, W.C.2. Price 65s.

There are three parts to this book. The first is introductory and deals with the instrumental requirements for high-speed analogue computation. The second covers the elements of a computer from linear computing units, such as adders and integrators, to power supplies and overall performance. The third and largest part deals with applications; that is, it describes the kinds of equations with which a computer can deal and how the apparatus is set up to simulate the equations.

The treatment is thorough and is by no means unduly mathematical. The book is certainly a very useful addition to the literature on analogue computers.

Introduction to Radar Systems

By MERRILL I. SKOLNIK. Pp. 648 + ix. McGraw-Hill Publishing Co. Ltd., 95 Farringdon Street, London E.C.4. Price £5 12s. 6d.

The subject of this book is radar systems engineering. Circuit techniques are not treated and there is hardly a circuit diagram in the book. The starting point is a discussion of the nature of radar and this is followed by a chapter on the radar equation. Then come descriptions of the various type of radar, viz., c.w., f.m., m.t.i., pulse, followed by tracking methods. Then come chapters on transmitters, aerial, receivers, noise, extracting information from radar signals, propagation, clutter, weather and interference. Systems engineering and design form the virtual end of the main subject matter, but there is a final chapter on radar detection of extra terrestrial objects.

Nonlinear and Parametric Phenomena in Radio Engineering

By A. A. KHARKEVICH. Pp. 192 + xvi. John F. Rider Publisher Inc., 116 West 14th Street, New York 11. Price $6.50.

This book is a translation from the Russian. It starts by considering nonlinear circuits and fundamental nonlinear processes. Chapter 2 covers the generation of oscillations, and chapter 3 deals with the response of nonlinear systems to external signals. The fourth and final chapter is on parametric phenomena. Free use is made of the simpler kinds of mathematics, but there is a great deal of descriptive matter as well, and the book is not a difficult one, certainly not as difficult as the nature of the subject would lead one to expect.

Television Simplified

By MILTON S. KIVER. 6th Edition. Pp. 637 + vii. D. Van Nostrand Co. Ltd., 358 Kensington High Street, London, W.14. Price 63s.

This is an American book and deals only with American television practice. It gives a good account of that in a non-mathematical way and provides a very useful introduction to the subject.

Leybold Vakuum-Taschenbuch

By K. DIELS and R. JAECKEL. Pp. 366 + xii. Springer-Verlag, Heidelberger Platz 3, Berlin-Wilmersdorf. Price DM 56.

Einführung in die Theorie geregelter Gleichstromantriebe

By H. BÜHLER. Pp. 453. Birkhäuser Verlag, Basel, Switzerland. Price SF 58·00.

Variable Resistors and Potentiometers

By G. W. A. DUMMER, M.B.E., M.I.E.E. Pp. 228 + xi. Sir Isaac Pitman & Sons Ltd., Parker Street, Kingsway, London, W.C.2. Price 45s.

This is the second edition of volume two of the Radio and Electronic Components series. More data on commercial types of variable resistor has been included, new types have been added and a new method of summarizing the choice of variable resistors available has been devised.

Radio-Television-Electronics Dictionary

By The National Radio Institute Teaching Staff. Pp. 190. John F. Rider Publisher Inc., 116 West 14th Street, New York 11, U.S.A. Price $3.50.

Halbleiterbauelemente: Vol. I, Halbleiter und Halbleiterdioden

By WALTER GUGGENBÜHL, MAX. J. O. STRUTT and WILLY WUNDERLIN. Pp. 255. Birkhäuser Verlag, Basel, Switzerland. Price SF38.50.

High Fidelity Home Music Systems

By WILLIAM R. WELLMAN. 2nd Edition. Pp. 241 + vi. D. Van Nostrand Co. Ltd., 358 Kensington High Street, London, W.14. Price 51s.

The book carries the sub-title 'Their Selection, Assembly, and Installation'. It is almost entirely descriptive and the author's aim appears to be to give guidance to people with little technical knowledge who wish to assemble a high-

fidelity system from commercially-manufactured units, such as, tuners, amplifiers, loudspeakers, etc. The only constructional information included is on loudspeaker enclosures.

Trägerfrequenz-Nachrichtenübertragung über Hochspannungsleitungen
By HEINRICH-KARL PODSZECK. Pp. 191 + viii. Springer Verlag, Heidelberger Platz 3, Berlin-Wilmersdorf. Price DM36.

Physics and Chemistry of Electronic Technology
By HARRY L. VAN VELZER, Ph.D. Pp. 372 + xii. McGraw-Hill Publishing Co. Ltd., 95 Farringdon Street, London, E.C.4. Price 77s. 6d.

Eléments de Commutation Générale
By ANDRÉ BLANCHARD. Pp. 384. Editions Eyrolles, 61 Boulevard Saint-Germain, Paris Ve. Price NF65.70.

Techniques of Public Relations
By MIKE WILLIAMS-THOMPSON. Pp. 20. Breams Printing and Publishing Co. Ltd., Mitcham, Surrey. Price 2s. 6d.

Manufacturers' Literature

Acromag Plug-in Magnetic Amplifiers. This 4-page leaflet describes the Acromag range of precision plug-in magnetic amplifiers introduced to the British market by Electro Methods. Included is the Acrostat pre-amplifier capable of handling an input of 1 μW from thermocouples, strain gauges, Hall devices, etc.
Electro Methods Ltd., Industrial Control Division, Caxton Way, Stevenage, Herts.

For further information circle 41 on Service Card

Voltage Stabilizers. Claude Lyons series TS automatic voltage stabilizers are described in detail in this 5-page illustrated catalogue. Power ratings range from 1 to 360 kVA.
Claude Lyons Ltd., Valley Works, Hoddesdon, Herts.

For further information circle 42 on Service Card

Duo-Pulse Generator. General details of a transistorized portable double-pulse generator are outlined in a single-sheet leaflet. The pulse outputs from this unit are independently variable in height, width and separation.
Digitizer Techniques Ltd., Watts Lane, Teddington, Middlesex.

For further information circle 43 on Service Card

Krohn-Hite Electronic Instruments. An illustrated 6-page fold-out catalogue providing specifications of Krohn-Hite power supply units, oscillators, filters and amplifiers.
Systems Engineering Services Ltd., 34 Bloomsbury Street, London, W.C.1.

For further information circle 44 on Service Card

Functions of Electrolube. In this 20-page booklet the properties of Electrolube electrical and mechanical lubricants are clearly described with the aid of illustrations.
Electrolube Ltd., Oxford Avenue, Slough, Bucks.

For further information circle 45 on Service Card

Single-Crystal Materials and Components. This 4-page illustrated leaflet gives details of Mervyn's facilities in the field of single-crystal materials; products mentioned include a wide range of laser and quantum electronic crystals.
Mervyn Instruments Ltd., St. John's, Woking, Surrey.

For further information circle 46 on Service Card

High Temperature Wires and Cables. A 4-page leaflet to facilitate selection of wires and cables by American Super-Temperature Wires, Inc. The selector chart provided covers materials with operating temperatures ranging from 130 °F to 1,000 °F.
Stewart Aeronautical Supply Co. Ltd., Adastral House, Nutfield, Redhill, Surrey.

For further information circle 47 on Service Card

8-mm Band 'Hybrid Tee' Element. This single-sheet leaflet gives brief data on a Philips measuring element which can be used as an 8-mm band microwave bridge; four waveguide sections constitute the branches of the bridge.
Research and Control Instruments Ltd., Instrument House, 207 King's Cross Road, London, W.C.1.

For further information circle 48 on Service Card

Muirhead Standard Cells. A 4-page leaflet presents in concise form the full range of Muirhead standard and reference cells with a brief description of each.
Muirhead and Co. Ltd., Beckenham, Kent.

For further information circle 49 on Service Card

Semiconductor Encapsulation Guide. This wall chart lists on one side 180 different Mullard semiconductor devices and covers 18 types of encapsulation of which dimensions and drawings are given on the reverse.
Mullard Ltd., Industrial Semiconductor Division, Mullard House, Torrington Place, London, W.C.1.

For further information circle 50 on Service Card

Subminiature Trimming Potentiometers. A technical data sheet on Daystrom 318 series Squaretrim potentiometers provides complete specifications covering these subminiature 1 W trimmers in a range from 10 Ω to 65 kΩ.
Weston-Instruments & Electronics Division, 614 Frelinghuysen Avenue, Newark 14, New Jersey, U.S.A.

For further information circle 51 on Service Card

Temperature Measurement and Control. This 18-page booklet describes the full range of Fielden 'Bikini' transistorized temperature instruments. In addition to technical information details are given of the economic advantages of temperature control and its application in various industries.
Fielden Electronics Ltd., Wythenshawe, Manchester 22.

For further information circle 52 on Service Card

Twin-Lamp Placard Lights. This 4-page catalogue presents detailed information on Dialco rectangular indicator lights. Actual-size illustrations are shown in two colours to facilitate the choice of placard light and legend presentation.
Dialight Corporation, 60 Stewart Avenue, Brooklyn 37, New York, U.S.A.

For further information circle 53 on Service Card

16 mm Rank Documentary Films. This illustrated 40-page sponsored film catalogue covers a wide diversity of subject matter and includes eight films on electronic computers, two of which deal with basic principles as opposed to industrial applications.
Rank Film Library, 1 Aintree Road, Perivale, Greenford, Middlesex.

For further information circle 54 on Service Card

Light-Beam Oscillographs. A 4-page, 3-colour, brochure describes the Brush series 2300 8- or 16-channel oscillographs and discusses the advantages offered by an incandescent light source. Also described are d.c. galvo amplifiers that extend the range of the oscillograph.
Brush Instruments, 37th and Perkins, Cleveland 14, Ohio, U.S.A.

For further information circle 55 on Service Card

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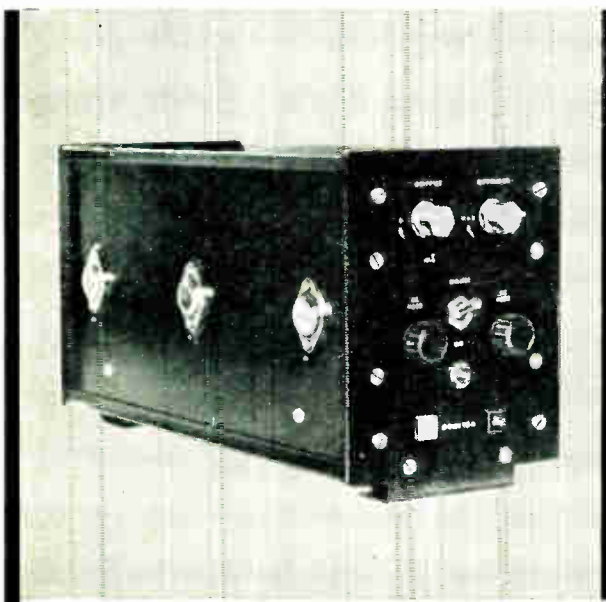

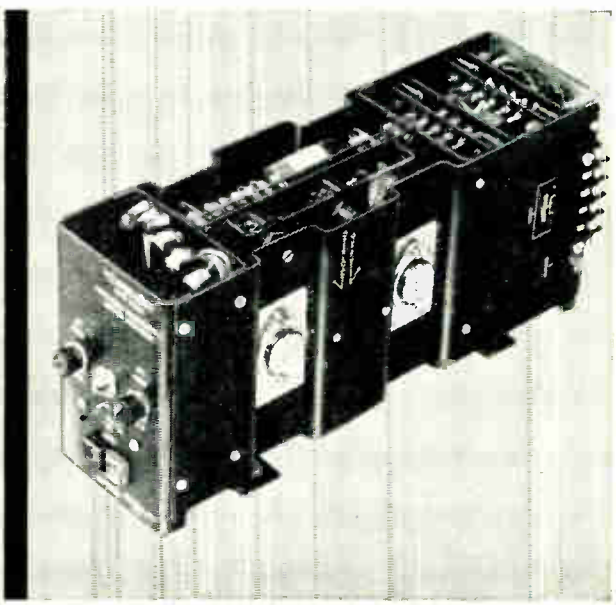

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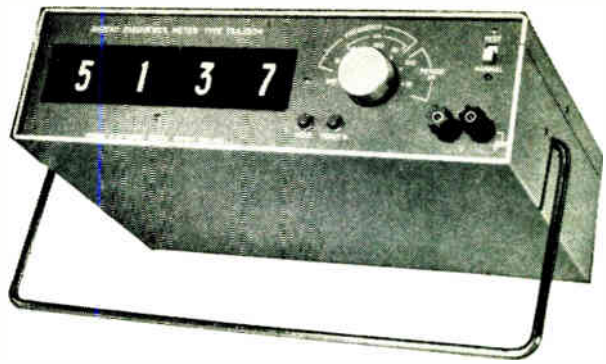

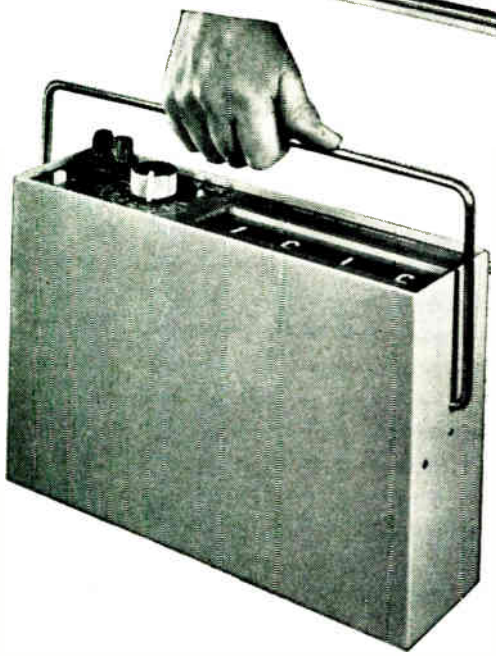

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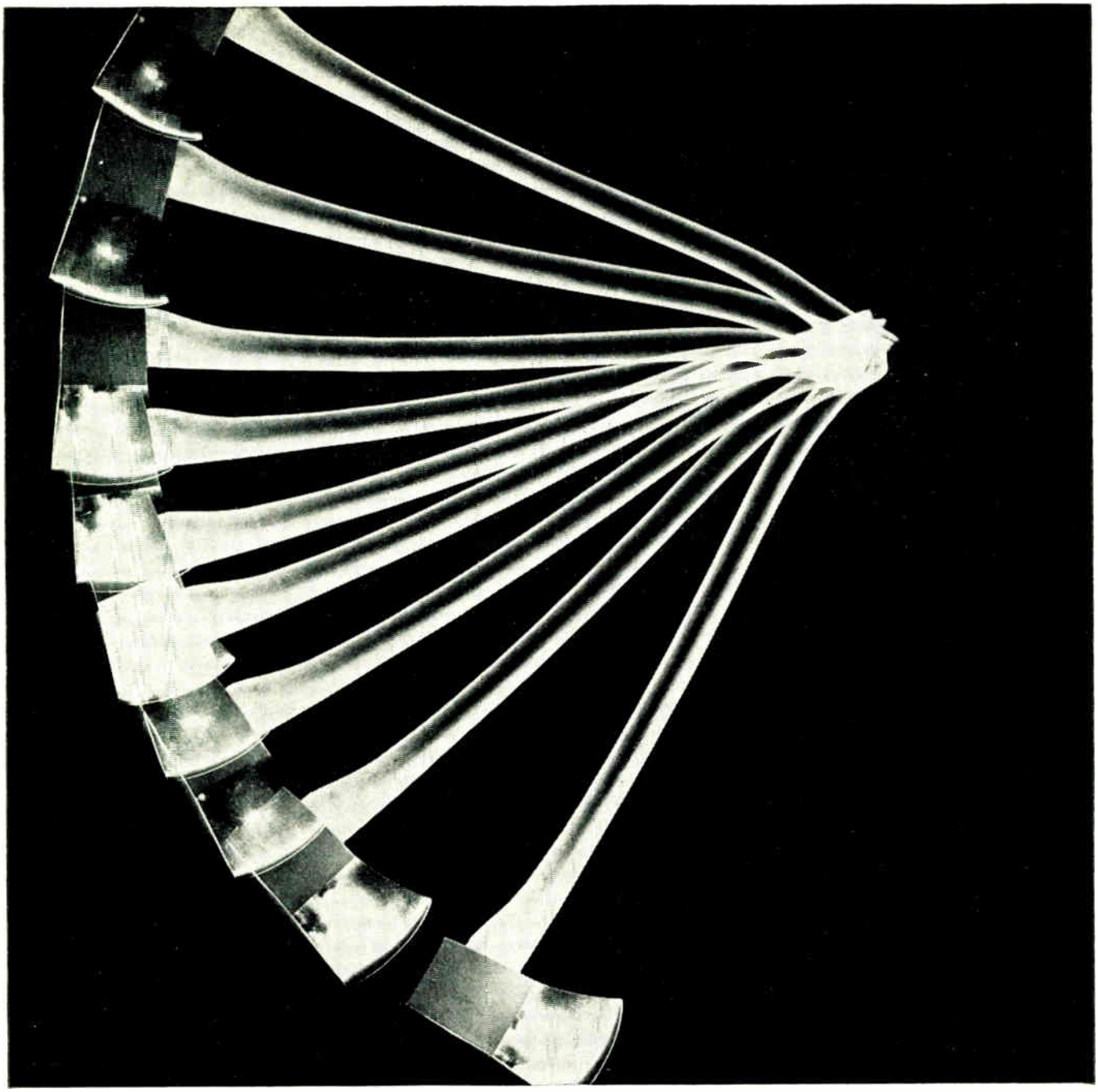

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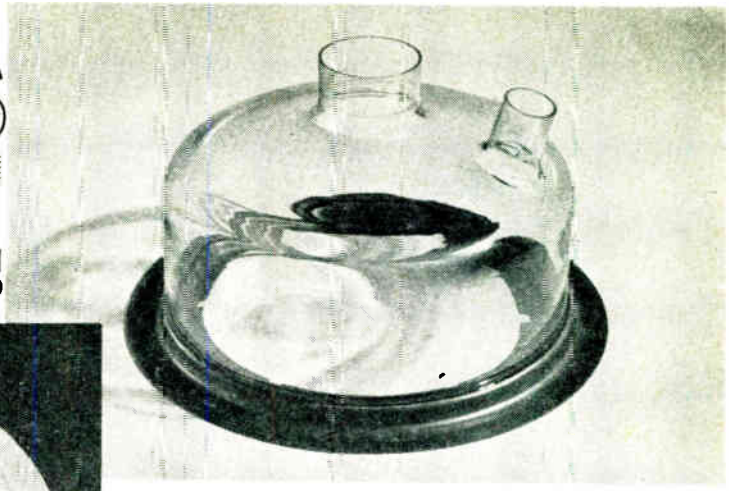

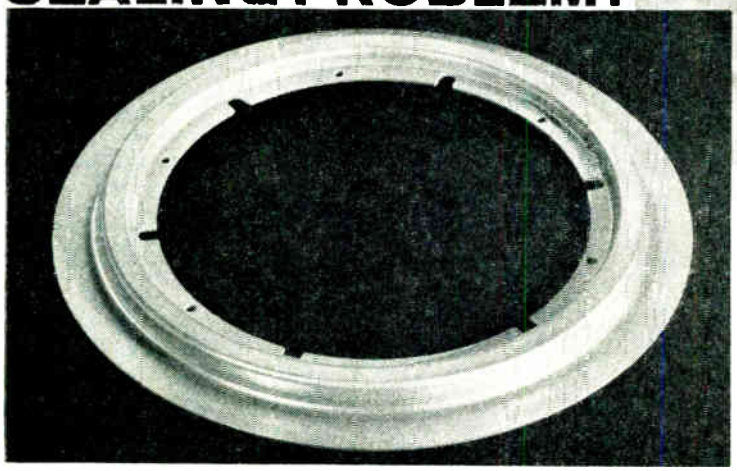

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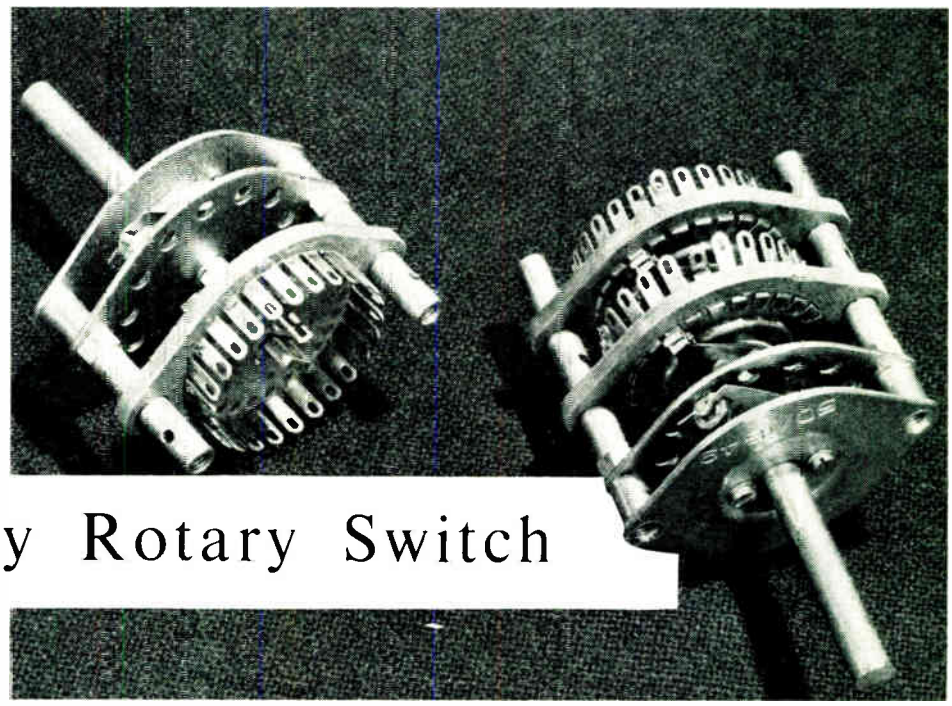

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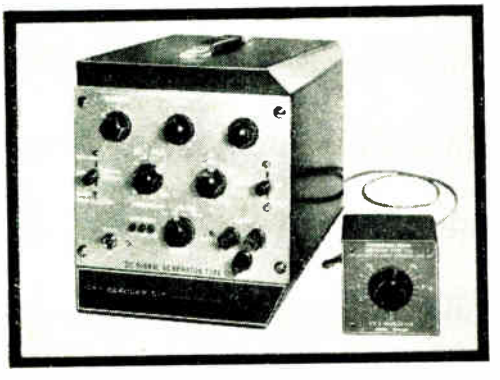

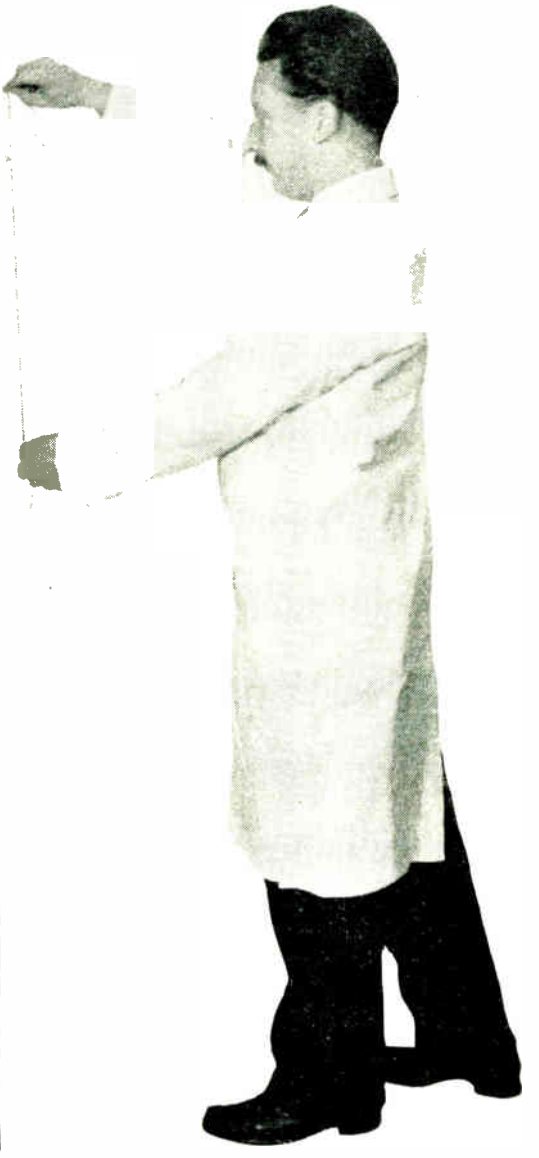

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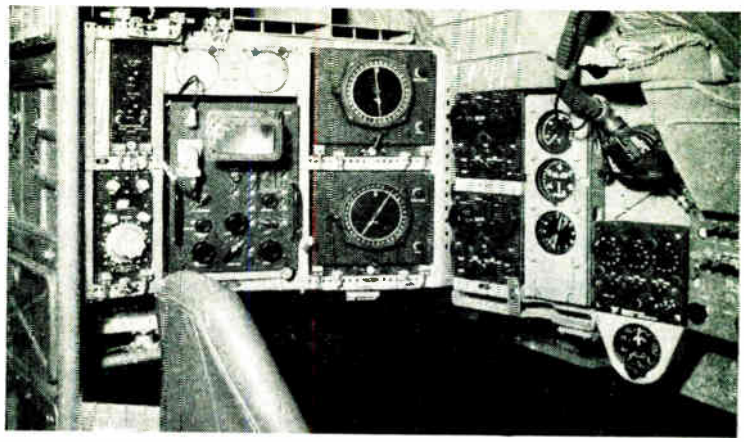

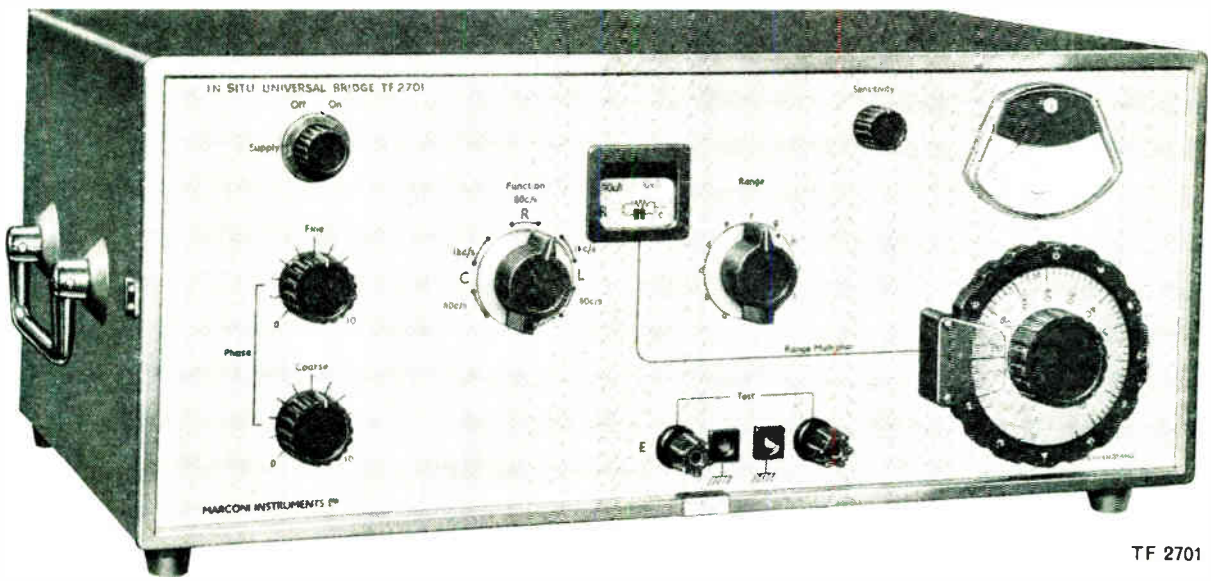

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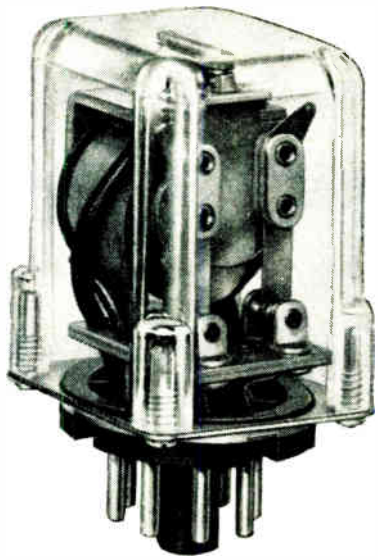

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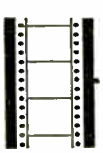

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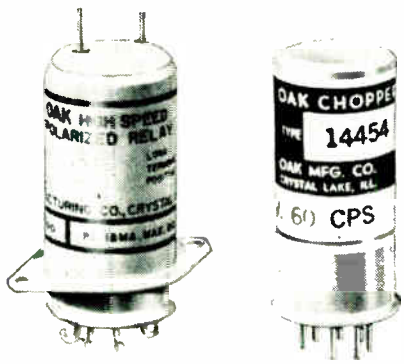

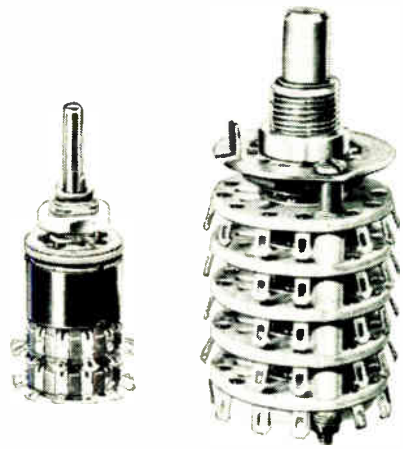

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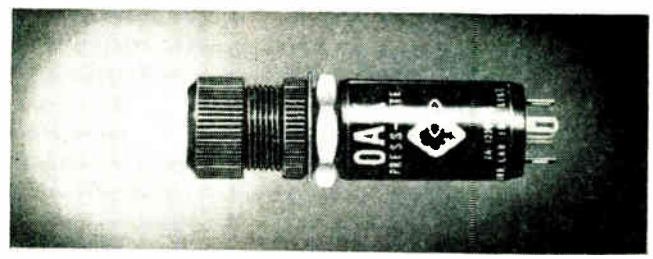

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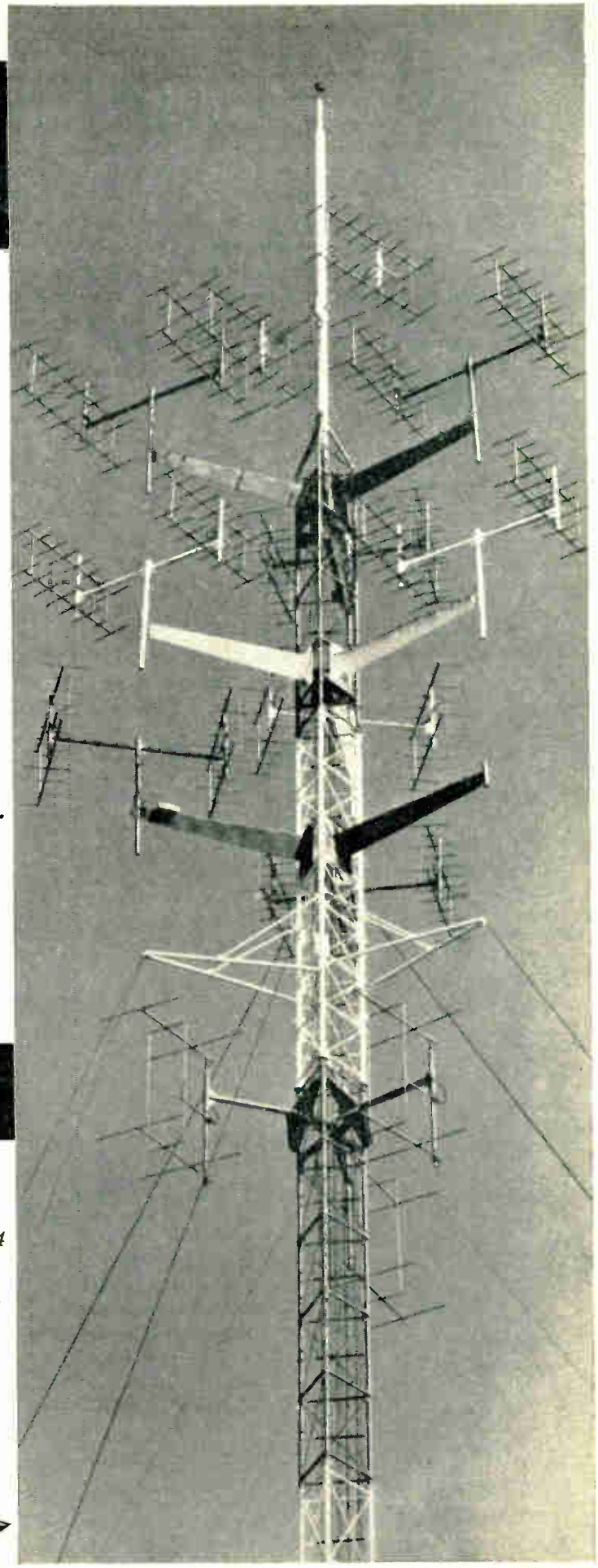

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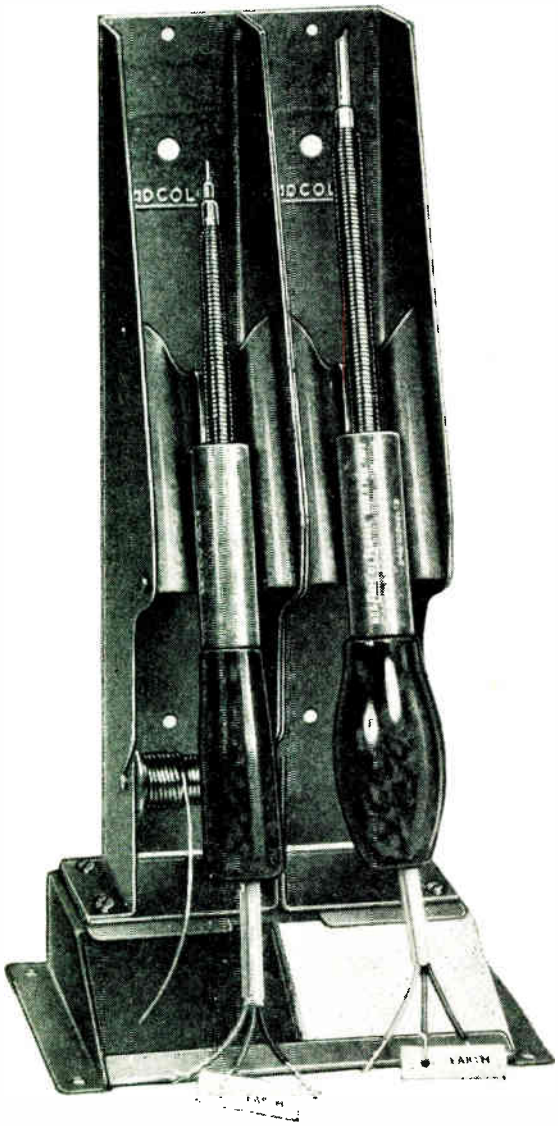

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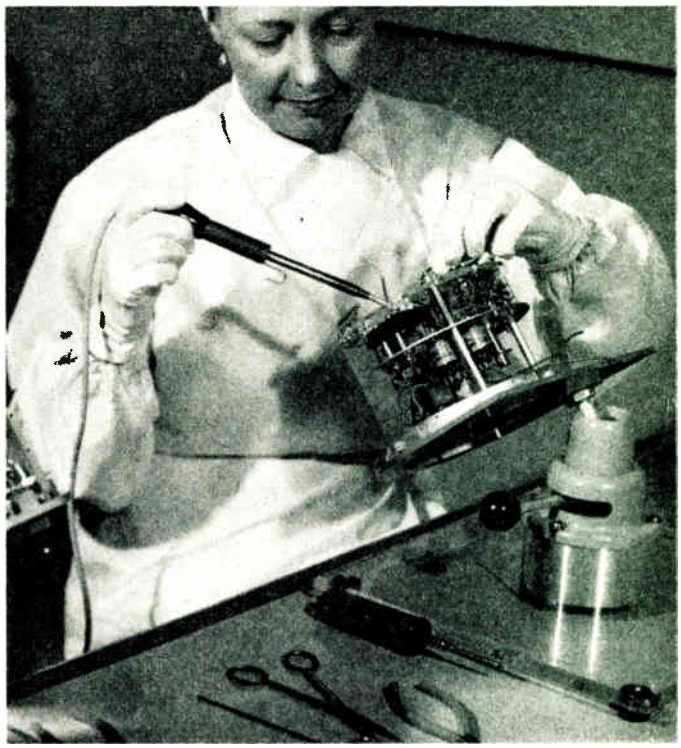

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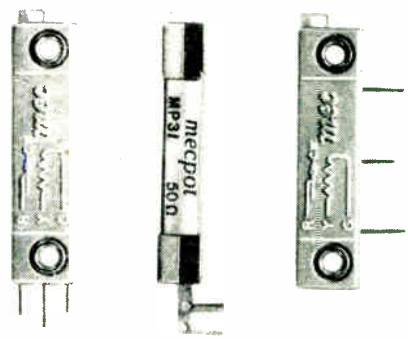

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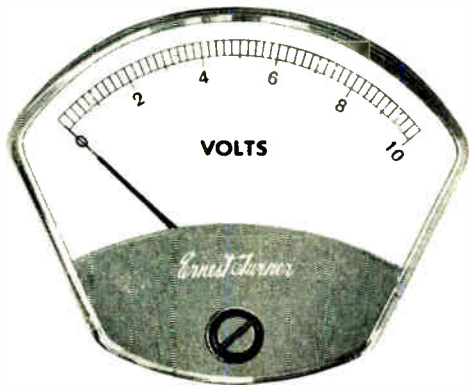

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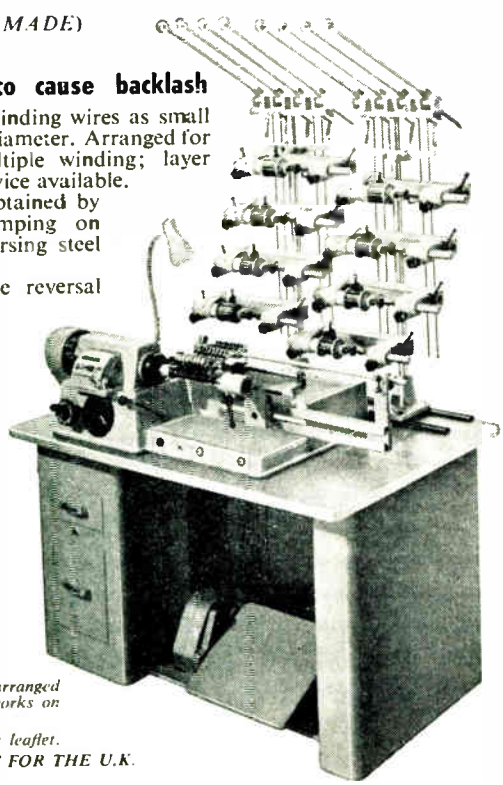

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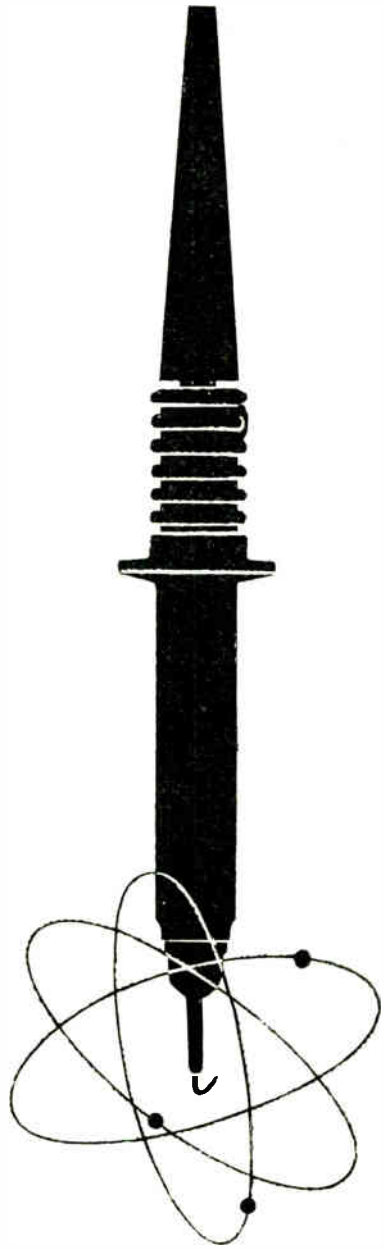

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