Wireless World

ELECTRONICS, RADIO, TELEVISION

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CONTENTS

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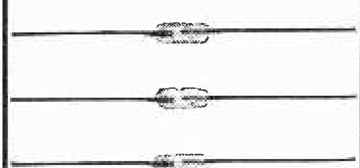
BA115-MULLARD SILICON DIODE

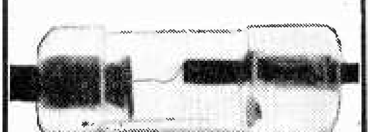
limits the visibility of white spot interference

A NEWLY-INTRODUCED DIODE—the Mullard gold-bonded silicon diode type BA115—will be encountered as an interference limiter in the latest television receivers.

Motor car ignition is probably the source of some of the most annoying television picture interference. When the signal transmission system uses positive modulation, as do BBC 1 and the ITA, any interference pulses can lead to a positive going component in the output of the video detector, which can easily exceed the normal signal level corresponding to peak white. Spots that are lighter than the whitest parts of the picture can therefore appear on the screen.



Actual size



Magnified 6 times

To reduce this irritating effect, a diode limiting circuit is often used which ensures that spikes above a predetermined level are removed before the signal reaches the picture tube. In such a circuit, the conditions imposed on the diode are particularly stringent, and the BA115 has been designed by Mullard to fulfil these special requirements:

- The maximum permissible reverse voltage of the diode must be high to withstand the high transient voltage; the BA115 is rated at 150V.
- The recovery time of the diode must be low to ensure a rapid response to the interference pulses; the BA115 has a forward recovery time of only 0·3 microseconds.
- The capacitance of the diode must be low to minimise its loading effect on the video amplifier; the signal capacitance of the BA115 is less than 5pF.
- A high reverse impedance at high temperatures is essential to minimise leakage currents; the leakage current of the BA115 is less than 20μA at an ambient temperature of 70°C when the reverse voltage is 100V.

The BA115 meets every demand made by an interference limiting circuit and is therefore making an important contribution to improved performance in the latest television receivers.

AD140—MULLARD OUTPUT TRANSISTOR

FOR CAR RADIOS

IN conjunction with a miniature driver transistor type OC82DM, the Mullard AD140 power transistor forms the audio package, type LCR2. This alloy-junction output transistor has a high current gain, and possesses good linearity and frequency characteristics.

The package forms a two-stage class A audio amplifier capable of delivering an output of 3W when driven directly from the detector of an all-transistor receiver. The sensitivity of the amplifier with respect to a 1kΩ source is typically 25mV for full output. The LCR2 is thus meeting the need for high audio gain in car radios, ensuring an excellent standard of performance while offering an economic design.

PCF 802 Line-Oscillator Triode-Pentode

FOR BBC 2 RECEIVERS

BBC 2 uses negative vision modulation, and dual-standard receivers have been produced in readiness for this employing line oscillators operating on the flywheel principle. The Mullard PCF802 triode-pentode was designed specifically for this type of circuit.

Mullard What's new in the new sets

In a typical mode of operation, the pentode section of the PCF802 will be used as a sine-wave oscillator whose frequency is controlled by the triode section of the valve functioning as a reactance valve. The d.c. frequency-control signal at the triode grid is obtained in a phase-frequency detector comparing the incoming synchronising pulses with pulses taken from the line output stage.

An attractive feature of this circuit is that only one switch is needed to change the frequency of the oscillator from that required for the 405-line standard—10·125kc/s—to that required for the 625-line standard—15·625kc/s.

Special attention has been paid in the development of the new valve to minimising hum and microphonic interference, which can be troublesome in this type of line-oscillator circuit. Furthermore, the amplification factor of the triode section of the valve is high, thus making the section particularly suitable for operation as a reactance valve.

9WW—099 FOR FURTHER DETAILS.

Wireless World

VOL 70 NO 6 JUNE 1964

I.E.A., R. & D., S. & E.

TO be "with it" and to hold one's own in the game of "one-upmanship" it is necessary to know all the current acronyms and abbreviations and if possible to have up one's sleeve a private collection with which to parry attack (which may explain the cryptic title of this month's comment).

I.E.A. has now been admitted into the language not only of this country, but of the world. It should, of course, be I.I.E.A., for the show is international, but "I.E.A." like "Phys. Soc." is likely to stick. This year the exhibition, with approximately 700 firms showing an estimated £22M worth of apparatus, is bigger than ever and will attract many overseas buyers, for it is now universally recognized as one of the three or four leading electronic shows in the world. It is for this reason that we have devoted a considerable portion of this issue to a preview for the benefit of those unable to attend.

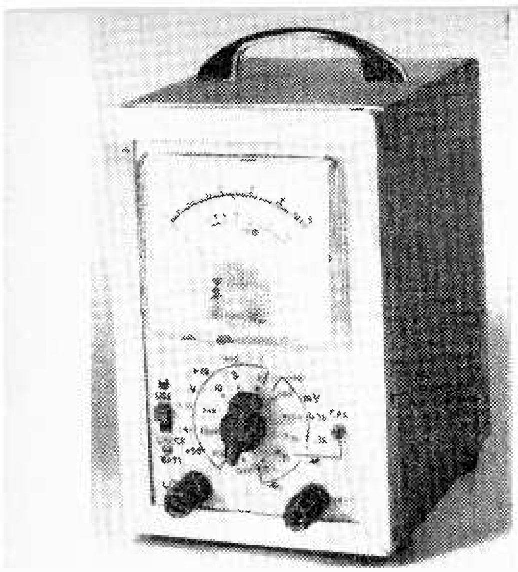
R. & D. to some people means something more than Research and Development. It has been current in America for quite some time and is now gaining currency in the U.K. While purporting to be a contemporary movement it seems to us to be our old friend applied research, and the distinction from pure research is the element of material gain which is added to the natural curiosity for new knowledge. There is still something unfinished about R. & D. which *The Times*, in choosing a title for its recent exhibition and conference at Olympia, has appreciated and remedied by extension to R.D.P. (Research, Development, Production). Recognizing the paramount importance of productivity, the exhibition showed how the methods of research and development should be channelled from the start of any new production to take into account the constraints of cost, reliability, ease of servicing, etc. as well as fitness for purpose. As a prelude to I.E.A. the R.D.P. exhibition was a fitting reminder of the way in which Science and Engineering combine to produce a saleable article.

S. and E, or rather S. *or* E., has been under discussion recently from another angle, namely the general preference shown by students for pure science rather than engineering as a course of study and later as a field for research. Apparently it is thought that science occupies a higher social status than engineering. As a corrective may we suggest that any fool can try something and write up the negative result in the jargon. He may even get a Ph.D. for it, but it takes a good man to produce work which will survive scrutiny at exhibitions like R.D.P. or I.E.A.

Playing on the Room

The announcement that the acoustics of the Royal Festival Hall have been changed by the introduction of active resonators operating at 3-c/s intervals up to 300c/s marks a further encroachment of electronics into the art of music making. Every musician—indeed every singer in his bath—knows that the room is an extension of his instrument or his vocal cavities. The joy of playing a fine violin resides not so much in its tone as in its "free playing" quality, which on analysis turns out to be the readiness with which it "speaks" or responds to the lightest touch of the bow. Stradivari had to achieve this by choice of wood and form. One wonders what he might have achieved had he been given modern electronic aids. Perhaps he would then have turned his attention to loudspeaker diaphragms. More certain is the fact that it is easier to play, as well as more pleasant to listen, in a reverberant environment than in, say, an echo-free test chamber, where even speech is hampered by a sense of claustrophobia (more accurately agoraphobia?).

Resonant absorbers have long been part of the stock-in-trade of broadcast studio designers who can level *down* the inequalities of the reverberation/frequency characteristic because they can also raise the whole response by amplification before broadcasting. But in a concert hall too much absorption makes both playing and listening hard work—too much like an open-air concert, in fact.



HIGH INPUT IMPEDANCE AND SENSITIVITY USING TRANSISTORS

Wireless World

A.C. MILLIVOLTMETER

WE have already described, in previous issues, an audio signal generator to provide test signals and an oscilloscope on which to observe the results of passing the signals through a piece of equipment under examination.

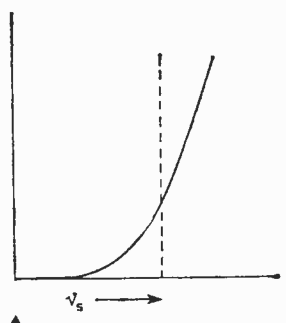
Oscilloscopes are all very well, but many measurements can be made under sine-wave conditions, and if one requires to know only, say, the gain or frequency response of the equipment, then an oscilloscope is unnecessarily complicated. For measurements such as this, the only requirements are a signal generator, which we already have, and an a.c. voltmeter.

To be capable of performing all the measurements needed on an audio amplifier or tape recorder, the voltmeter must have a high input impedance so that the circuit being measured is not appreciably shunted, a frequency response up to at least the frequency of a tape bias oscillator and a sensitivity sufficient to register the output of a microphone or pickup.

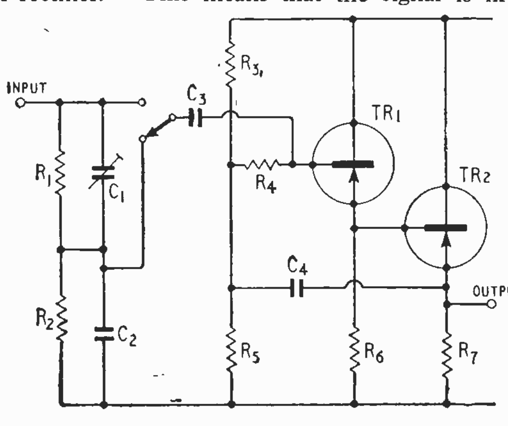
The instrument described here adequately fulfils these requirements, having an input impedance of 1 MΩ (10 MΩ on the higher voltage ranges), a frequency response which is virtually flat to well over 100 kc/s and sensitivity of 3 mV, full scale. The voltage scales are linear and a decibel scale is provided for convenience in plotting frequency response curves. A calibrating square wave, with a peak amplitude of 10 mV is available at the front panel to take account of any variations in amplifier gain, although this facility is not absolutely necessary and may be omitted if desired. The instrument costs about £12 to make.

Principle of Operation

The instrument is of the type known as an "amplifier-rectifier." This means that the signal is first



▲ *Fig. 1. Variation of diode current with voltage.*



► *Fig. 2. High input-impedance input stage.*

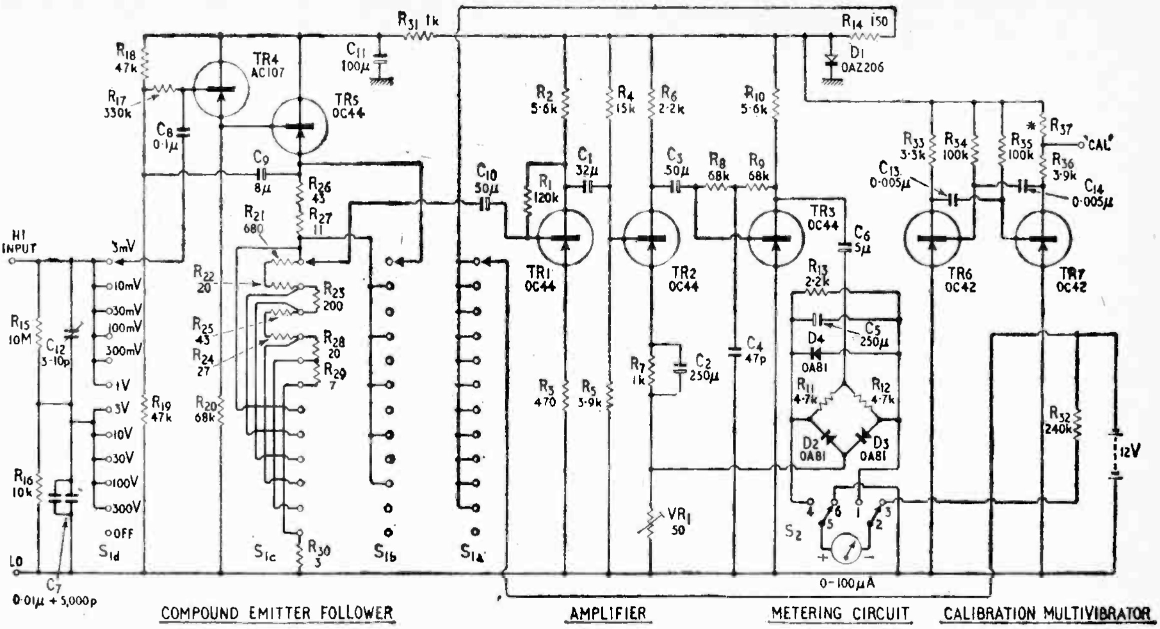


Fig. 3. Circuit diagram and (below) list of components of millivoltmeter.

Capacitors

C_1	32μF	Electrolytic	
C_2	250μF	,,	
C_3	50μF	,,	
C_4	47pF	±10% ceramic	
C_5	250μF	Electrolytic	
C_6	5μF	,,	
C_7	0.01μF	30V	Disc Ceramic in parallel with 5,000pF ±10% ceramic
C_8	0.1μF	350V	
C_9	8μF	Electrolytic	
C_{10}	50μF	,,	
C_{11}	100μF	,,	
C_{12}	3-10pF	Beehive Trimmer	
C_{13}	5000pF	±10% ceramic	
C_{14}	5000pF	,, ,,	

All electrolytics sub-miniature 15V, Radiospares.

Resistors

R_1	120kΩ	±10%	½W	
R_2	5.6kΩ	,,	,,	
R_3	470Ω	,,	,,	
R_4	15kΩ	,,	,,	
R_5	3.9kΩ	,,	,,	
R_6	2.2kΩ	,,	,,	
R_7	1kΩ	,,	,,	
R_8	68kΩ	,,	,,	
R_9	68kΩ	,,	,,	
R_{10}	5.6kΩ	,,	,,	
R_{11}	4.7kΩ	,,	,,	
R_{12}	4.7kΩ	,,	,,	
R_{13}	2.2kΩ	,,	,,	
R_{14}	150Ω	,,	,,	
R_{15}	10MΩ	±5%	½W Hystab	Radiospares
R_{16}	10kΩ	,,	,, ,,	Radiospares
R_{17}	330kΩ	±10%	,,	
R_{18}	47kΩ	,,	,,	
R_{19}	47kΩ	,,	,,	
R_{20}	68kΩ	,,	,,	
R_{21}	680Ω	±5%	½W Hystab	Radiospares
R_{22}	20Ω	,,	,, ,,	Radiospares
R_{23}	200Ω	,,	,, ,,	Radiospares
R_{24}	27Ω	,,	,, ,,	Radiospares
R_{25}	43Ω	,,	,, ,,	Radiospares
R_{26}	43Ω	,,	,, ,,	Radiospares
R_{27}	11Ω	,,	,, ,,	Radiospares
R_{28}	20Ω	,,	,, ,,	Radiospares
R_{29}	7Ω	wirewound, 16.8 inches of 36 s.w.g. **Eureka**		
R_{30}	3Ω	wirewound, 7.25 inches of 36 s.w.g. **Eureka**		
R_{31}	1kΩ	±10%	½W	
R_{32}	240kΩ	± 5%	½W Hystab	Radiospares
R_{33}	3.3kΩ	±10%	½W	
R_{34}	100kΩ	,,	,,	
R_{35}	100kΩ	,,	,,	
R_{36}	3.9kΩ	,,	,,	
R_{37}	10Ω	,,	in parallel with a resistor approx 100Ω to be chosen on calibration	
VR_1	50Ω	Preset control—Radiospares		

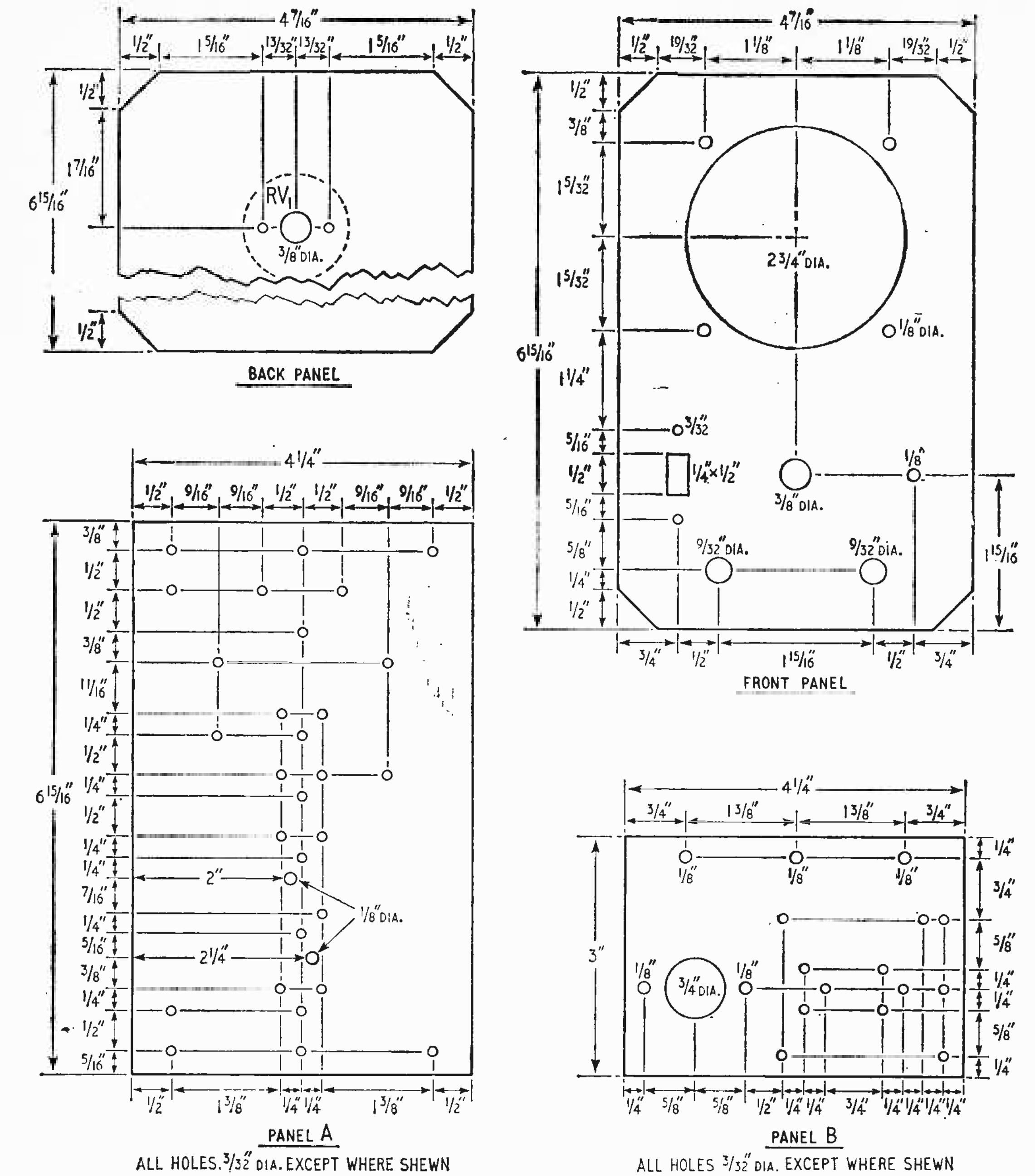
Semiconductors

3 × OA81 Diodes
1 × OAZ 206 Zener Diode
4 × OC44 Transistors
1 × AC107 Transistor
2 × OC42 Transistors

Miscellaneous

1/16 in thick paxolin sheet
½in Duralumin or aluminium angle
16 s.w.g. Aluminium sheet
Formica for front and rear panels
1 × Feedthrough bush
1 × 100μA Type MR65P Meter available from: G. W. Smith & Co. Ltd., 3-39 Lisle Street, London, W.C.2.
Miniature 3-pin socket and plug
2 × PP1, 6V batteries or equivalent
4 × Battery connecting clips
1 × Black terminal
1 × Red ,,
Small Turret Tags
1 × Miniature 2-pole 2-way slide switch
1 × Makaswitch standard shafting assembly
4 × 1 pole, 12-way Makaswitch wafers
6 × short Makaswitch spacers
2 × medium ,, ,,
2 × long ,, ,,
4 Rubber feet
1 Pointer knob

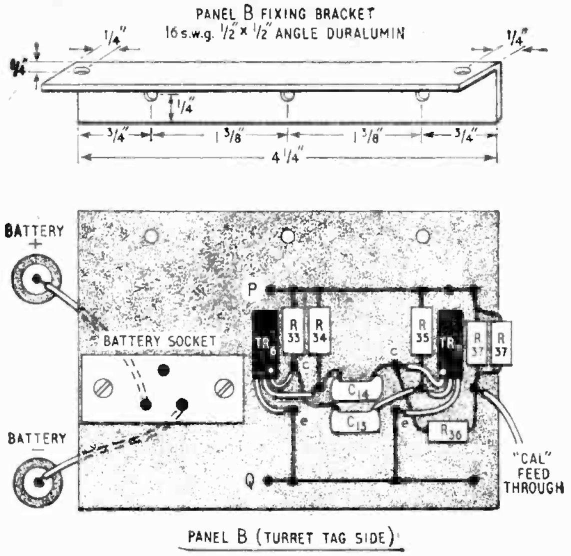
(Black terminal to Pointer knob: Radiospares)



Drilling diagram for component boards, front and rear panels. Boards are of paxolin and panels of 16 s.w.g. aluminium faced with Formica.

amplified before being applied to the rectifier which produces the direct metering current. The other type—the "rectifier-amplifier"—has several disadvantages, one of which renders it unsuitable for low-level measurements. The diode used to rectify the signal requires several hundred millivolts r.m.s. of a.c. applied across it before it begins to perform its rectifying function. Fig. 1 shows that the current through the diode increases very slowly at first, and only as the signal v_s reaches the dotted line does the curve become at all steep and linear. This type of voltmeter, therefore, is limited to measurements on signals greater than, say, 150 mV, and consists of the diode followed by a directly-coupled amplifier to increase the output of the diode sufficiently to operate the meter. The rectifier-amplifier type is used chiefly for relatively high level measurements at frequencies up to 1000 Mc/s or more.

On the other hand, the amplifier-rectifier type must possess an amplifier capable of handling the band of frequencies of interest, a problem which also imposes limitations of a different nature. The higher voltage across the diode gives greater linearity, which can be further improved by negative feedback. This

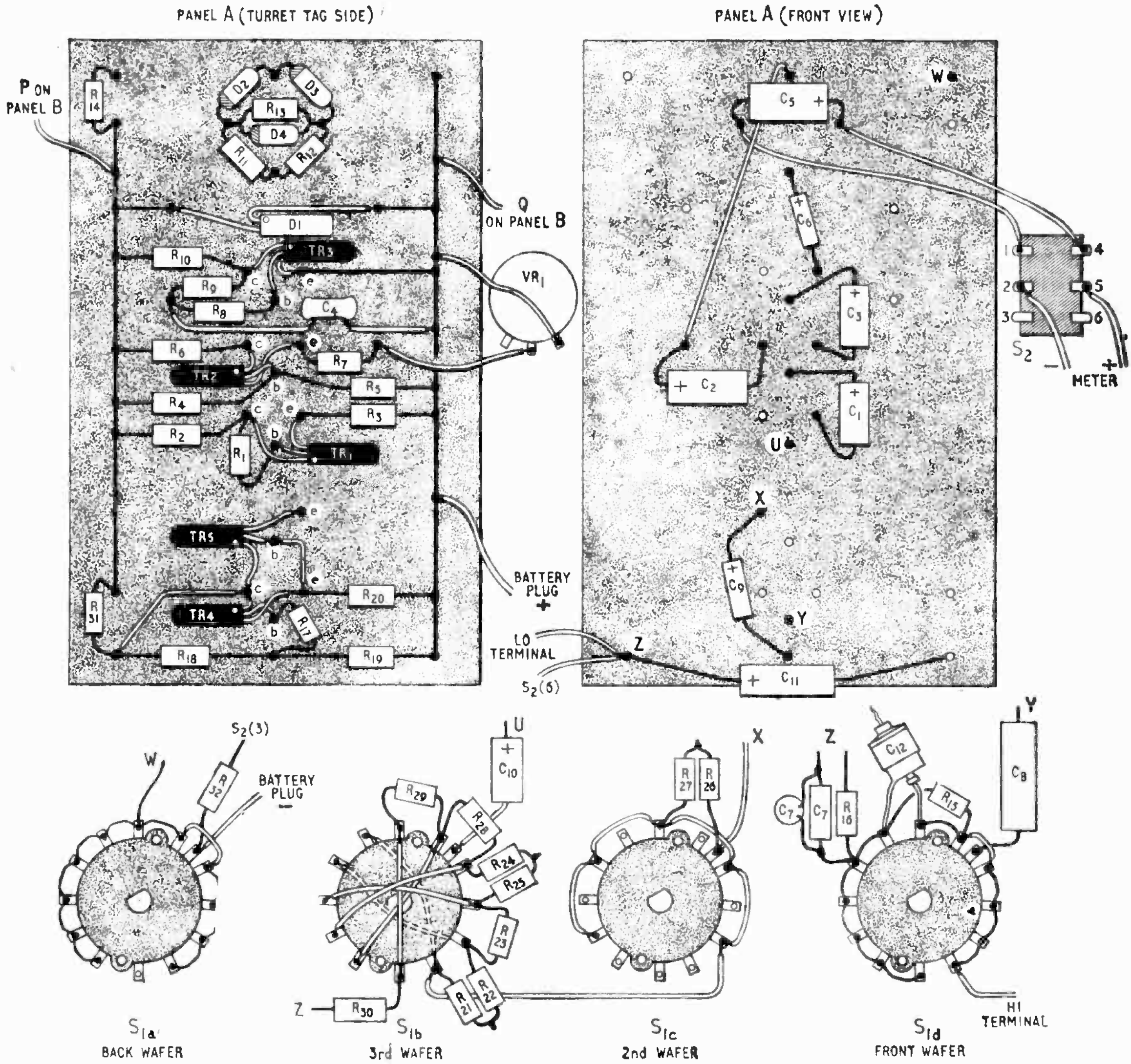


Layout of cal. oscillator board.

type is accordingly mainly used for low-level, relatively low-frequency work, although instruments have been designed which will measure 3mV at up to 50 Mc/s.

A point to remember about all instruments using moving-coil meters is that they respond to the average, or mean, value of the signal voltage. In a sine wave this differs from the r.m.s., or effective value by a factor of 1.11, but *only in a sinusoidal wave*. Most meters, ours included, are calibrated to read r.m.s. values, although responding to the average, because r.m.s. voltages are the ones we wish to know. This means that if the signal is not sinusoidal, the reading will be in error, unless square waves are

Wiring diagram and layout.



used, in which case peak, r.m.s. and average values are identical.

Input Stage

As mentioned previously, an important requirement of a millivoltmeter for many applications is that it should possess high input impedance. Unlike valves, transistors are not ideal voltage amplifiers. They are normally considered to be current-operated devices with low input resistance. Typically, a common-emitter transistor stage has an input resistance of about 1.5 kΩ, which is completely useless for voltage measurement unless the signal source impedance is less than about 70 Ω. To improve the situation, an emitter follower can be used to give an input impedance of $h_{fe}R_e$, where h_{fe} is the common-emitter current gain, otherwise known as α or β, and R_e is the emitter resistor. About 50 kΩ-100 kΩ can be obtained in this way, at the loss of all the gain, and even more improvement is obtained by a second emitter follower, the two being called a Darlington pair, shown in Fig. 2. An additional component, C_4, provides "bootstrap" feedback from Tr2 emitter to Tr1 base, with the result that, when the base end of R_4 is driven negative by the signal, the remote end is also driven negative by the emitter of Tr2 *via* C_4, so that the change of current through R_4 is reduced. R_4 therefore "looks" greater than it is, and is still sufficiently small to allow base current for Tr1 to flow. As any noise voltages generated by Tr1 are amplified and registered by the meter, a low-noise type—the AC107—is used. The voltage gain of the pair of transistors is very close to one and the input resistance is 1 MΩ.

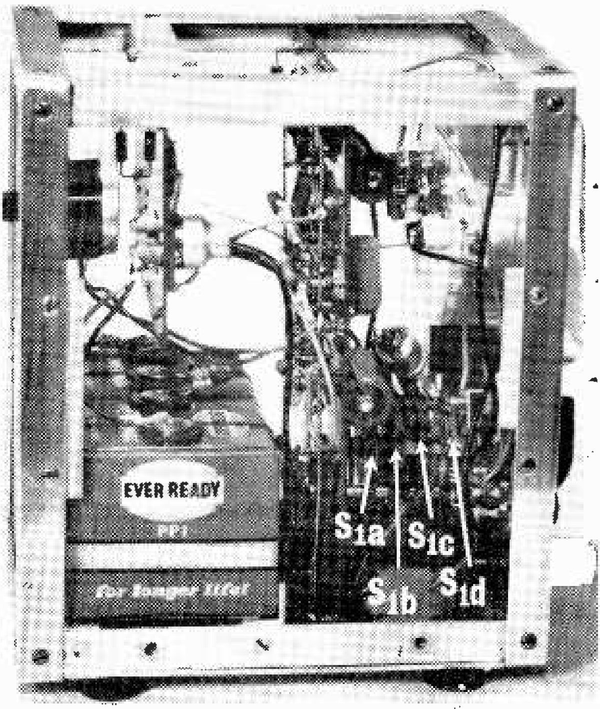
Attenuator

The attenuator is arranged to provide 3 mV to the main amplifier for full-scale deflection on each range. There are eleven ranges, and to frequency-compensate all eleven would involve more components than can reasonably be justified. The attenuator is, therefore, split into two parts. At the input is a 60 dB (1,000:1) voltage divider which gives two *groups* of ranges — 3 mV to 1 V and 3 V to 300 V. This divider is compensated by C_7 and C_{12} in Fig. 3 and, R_{13} being 10 MΩ, serves to increase the input impedance on the higher ranges.

The smaller steps, the individual ranges, are obtained from a divider in the emitter of Tr5. This chain has a total resistance of 1,000 Ω and is low enough in value not to need compensation for stray capacitance. As each range is ± 10 dB relative to the adjacent ones, odd values of resistor would normally have to be used in the chain to obtain the 3.16 : 1 steps. In this case, however, preferred values of close-tolerance, high-stability resistors were used, and a resistor switched in and out at the top of the chain by S_{1c} to make up the difference. S_{1d} is merely the battery on-off switch.

Amplifier

The main amplifier consists of three stages, with negative feedback to stabilize the gain and linearize the scale. In the absence of feedback, the diode characteristic would give a scale cramped at the bottom end and accuracy would suffer. An unfortunate by-product of the negative feedback is that the gain of the amplifier is reduced, but as distortion generated in the amplifier and metering circuit is reduced by roughly the same amount, it is considered worth while. We have about 20 dB of feedback, which means that the gain of the amplifier is reduced 20 dB or ten times, and the exact amount is made adjustable by VR_1 to set the gain. The third stage has a little frequency compensation applied to it by means of the 47 pF capacitor, C_1 in its bias network. Negative feedback is applied *via* the network from collector to base and is reduced at high frequencies.



Inside view of instrument.

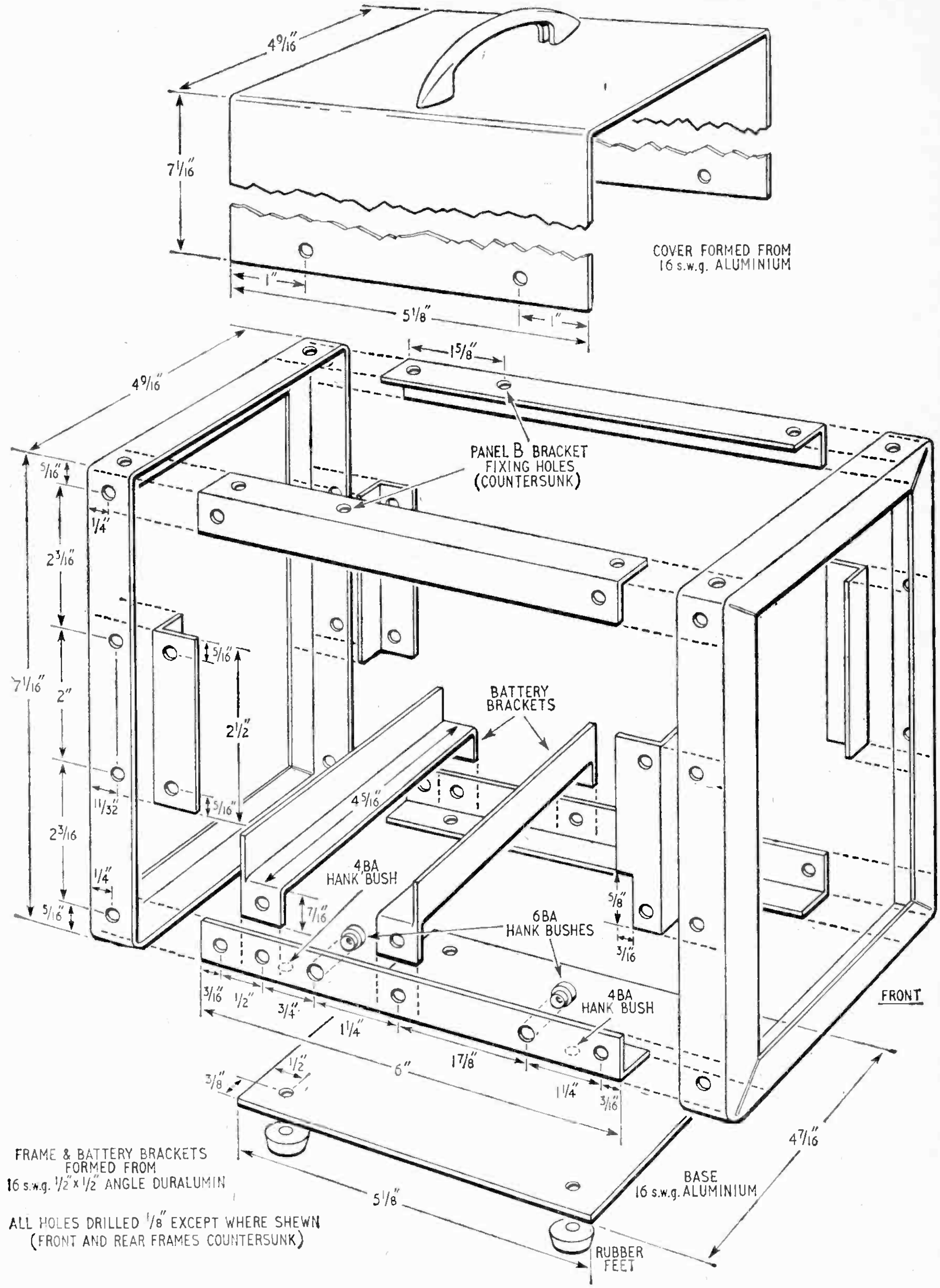
Metering

A half bridge is used as the rectifier, the "bottom" end being returned to the emitter of Tr2 to provide the negative feedback. The meter is protected against large accidental overloads by the diode across it, which conducts when a safe voltage is exceeded.

The meter is also used to check the battery voltage, this function being selected by S_2. The series resistor, R_{32}, is chosen to give a convenient scale reading with the meter used. With the specified meter, 240 kΩ gives a full-scale deflection of 20 V.

Calibration Oscillator

To make absolutely sure that the gain of the instrument has not changed, it is always a good thing to be able to check it against a stable signal, and we therefore provided a calibrating oscillator. It takes the form of a conventional collector-coupled astable multivibrator, using OC42 switching transistors and fed from the 8.2 V stabilized line. The 20 mV p.p. square wave produced at the junction of R_{36} and R_{37} is equivalent to a 10 mV r.m.s. sine wave, so that if



Assembly of case.

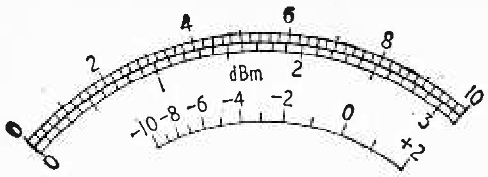


Fig. 4. Specimen meter dial shown actual size.

the "CAL" terminal is connected to the "HI" terminal when S_1 is switched to 10 mV, the "set gain" control, VR_1, can be adjusted to give full scale deflection and the gain is set.

Construction

The drawings should be self-explanatory, it only being necessary to remark (readers' letters in mind) that the circuit is entirely suitable for adaptation to printed circuitry. We have used our familiar tag-board method because we think it has the same advantages as printed boards, and is considerably less messy for the home constructor. The front panel can be lettered with Letraset (from drawing-office suppliers) by UNO stencil, or simply drawn by hand. A good method of finishing the metal cover is to put some light oil on it and rub it with steel wool, keeping the strokes in one direction. The result is a pleasant satin effect, and a coat of clear varnish protects it from finger marks.

Calibration

Three scales are used. The two voltage scales are calibrated 0-10 and 0-3.16, the ratio between them being −10 dB. The decibel scale is calibrated from −10 to +2 dB relative to 1 mW in 600 Ω, which corresponds to 0.775V.

To calibrate the three scales, it is only necessary to obtain full-scale deflection on the "10" scale. A mains transformer and potentiometer should be set to give 1, 10 or 100 V, this being measured with an ordinary testmeter. Apply this voltage to the millivoltmeter input, set to the appropriate range, and adjust RV_1 to obtain full-scale deflection. The gain is now set, and point "10" can be marked. The "10" scale should now be divided into equal divisions as in Fig. 4. The "3" and "dB" scales can be transferred from the "10" scale by means of Table 1 and Table 2. It is helpful if the three scales are marked in colours corresponding to the legend on the front panel.

R_{37}, the top arm of the multivibrator output divider, should be selected to give full-scale deflection when the "CAL" terminal is connected to the "HI" input, with the switch set to 10 mV.

The trimmer, C_{12} on the input attenuator must be set up to give a level response up to 200 kc/s. For this purpose, access to an oscillator is required, the reading at frequencies over about 10 kc/s being made equal to those at low frequency by means of the trimmer.

TABLE 1

"3"	"1"	"3"	"1"
0.1	0.32	1.7	5.38
0.2	0.63	1.8	5.69
0.3	0.95	1.9	6.01
0.4	1.26	2.0	6.32
0.5	1.58	2.1	6.64
0.6	1.90	2.2	6.96
0.7	2.21	2.3	7.27
0.8	2.53	2.4	7.59
0.9	2.85	2.5	7.91
1.0	3.16	2.6	8.22
1.1	3.48	2.7	8.54
1.2	3.80	2.8	8.85
1.3	4.11	2.9	9.17
1.4	4.43	3.0	9.49
1.5	4.74	3.1	9.80
1.6	5.06		

TABLE 2

"dB"	"1"	"dB"	"1"
+ 2	9.75	− 5	4.36
+ 1	8.69	− 6	3.88
0	7.75	− 7	3.46
− 1	6.90	− 8	3.08
− 2	6.15	− 9	2.75
− 3	5.48	−10	2.45
− 4	4.89		

SPECIFICATION

Volt ranges

3mV, 10mV, 30mV, 100mV, 300mV, 1V, 3V, 10V, 30V, 100V, 300V, f.s.d.
Decibel ranges −60 to +50, −10 to +2 on scale.

Accuracy

±5% of reading.

Response

±0.5dB from 20c/s to 200kc/s.
±3dB from 10c/s to 450kc/s.

Input Impedance

1MΩ+60pF at 3mV f.s.d.
1MΩ+40pF at 10mV f.s.d.
1MΩ+35pF at 30, 100, 300mV and 1V f.s.d.
10MΩ+18pF at greater than 3V f.s.d.

Noise level

40μV referred to input with input shorted.

JUNE CONFERENCES AND SHOWS

2-4 Philadelphia
Global Communications Symposium
(I.E.E.E., Box A, Lennox Hill Station, New York)

2-4 Los Angeles
National Telemetering Conference
(I.E.E.E., Box A, Lennox Hill Station, New York)

2-6 Budapest
Acoustics Conference
(Soc. for Optics-Acoustics, Szabadság tér 17, Budapest)

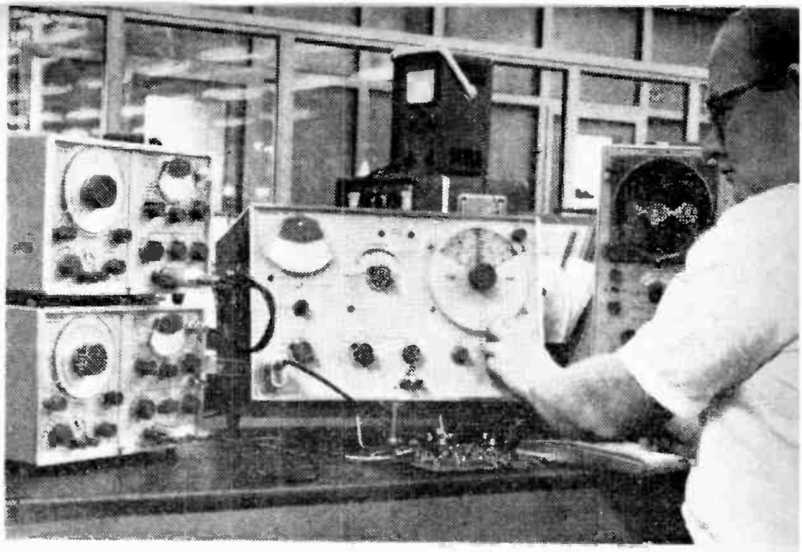
8-10 New York
Symposium on Quasi-optics
(Polytechnic Inst. of Brooklyn, New York)

15-16 Chicago
Conference on Broadcast & TV Receivers
(I.E.E.E., Box A, Lennox Hill Station, New York)

15-18 Coventry
Conference on Protection from Noise
(Society of Acoustic Technology, c/o Dr. P. Lord, College of Advanced Technology, Salford)

18-29 Rome
Electronics, TV, Radio & Cinematograph Fair
(A.N.I.E.E., via Donizetti 30, Milan)

23-25 Boulder
Precision Electromagnetic Measurements
(National Bureau of Standards, Boulder, Colorado)



BASIC METHODS OF MEASUREMENT AND THE COMPARATIVE MERITS OF THE SYSTEMS

Intermodulation Distortion Measurement

By D. E. O'N. WADDINGTON*, A.M.I.E.R.E.

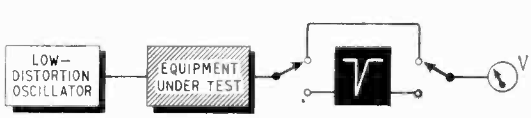
THE primary purpose of a distortion measurement is to assess the ability of an amplifier or other equipment to handle a signal. This statement may seem obvious but, what is not so obvious is that the method used should be adequate to provide a useful answer; useful in predicting performance under operational conditions or useful in indicating what steps should be taken to improve the performance. Two basic methods of distortion measurement are commonly used, viz., (i) single-signal harmonic distortion measurement and (ii) two-signal intermodulation distortion measurement.

Single-signal Method

This is the simplest method but it has an inherent difficulty in that a signal having a very low distortion content is a prime necessity. With modern test gear this is not insuperable but, if measurements of better than 0.1% distortion are to be made with any accuracy, it is generally necessary to use filters to " clean " the wave form.

Given a pure signal, there are two methods of measuring harmonic distortion. The first and simplest is to use a distortion factor meter (Fig. 1). This consists essentially of a tunable rejection filter followed by a voltmeter. Its mode of operation is as follows:—First the signal + distortion is measured. The stop filter is then switched into circuit and tuned so as to reject the fundamental. The residual signal which will consist of noise and harmonic components is then measured by the voltmeter. This measurement is then related to the first to give the percentage harmonic distortion. The main disadvantage of this method of measurement is that the distortion is measured as a single composite signal there being no differentiation between harmonic components. This defect may be overcome, however, by observing the residual signals on an oscilloscope when it is possible to assess their composition.

Fig. 1. Method of measuring harmonic distortion using a distortion factor meter.



More precise harmonic distortion measurements may be made by using a wave analyser to measure the individual harmonic components. The percentage harmonic distortion may be then calculated from the formula:—

$$\frac{\sqrt{E_2^2 + E_3^2 + \dots}}{E_1} \times 100$$

when E_1 is the amplitude of the fundamental component and E_2, E_3, etc. are the amplitudes of the harmonic components.

Two-signal Methods

There are two standard methods for making two-signal measurements, C.C.I.F. [1] and S.M.P.T.E.[2]. These methods frequently give widely differing results but each is very useful in its own field and it is often revealing to use both methods when assessing an equipment. The main advantage of two-signal methods is that there is no necessity for extreme purity of the test signals. A further advantage is that it more nearly simulates operating conditions.

C.C.I.F. In this system, two signals (" P " and " Q ") of equal amplitude but with a relatively small frequency difference are applied simultaneously to the equipment under test via a suitable combining network (Fig. 2). The resultant output is monitored

*Marconi Instruments Ltd.

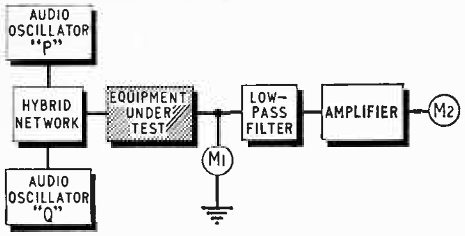


Fig. 2. C.C.I.F. system of intermodulation distortion measurement.

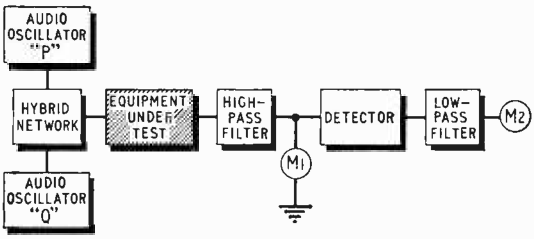


Fig. 3. In the S.M.P.T.E. system of measurement, the low-frequency signal has an amplitude four times that of the high-frequency signal.

by the peak-reading voltmeter M1 and then fed through a low-pass filter which rejects "P" and "Q". The even order inter-modulation products P−Q, 2(P−Q), 3(P−Q), etc. are passed by the filter and measured by the meter M2. The percentage intermodulation distortion is then given by the formula:—

$$\frac{\text{Intermodulation product amplitude}}{V_P + V_Q} \times 100$$

This method of measurement does not give any indication of the odd order intermodulation products (2P−Q), (3P−2Q), etc. These may best be measured by means of a wave analyser.

The most useful region of application for this system is at the upper end of the pass band of an amplifier where the frequency response is beginning to fall off. Here simple harmonic analysis tends to give erroneous results. The important precaution to observe in using this system is that the difference frequency chosen should be within the pass band of the equipment under test.

S.M.P.T.E. This system uses a high-frequency signal "P" and a low-frequency signal "Q", which has an amplitude four times that of "P". These signals are combined in a suitable hybrid network and applied to the equipment under test (Fig. 3). The output is fed through a high-pass filter which rejects the low-frequency signal "Q". The modulated high-frequency signal consisting of P (P + Q), (P−Q), (P + 2Q), (P−2Q) etc. is then detected and fed through a low-pass filter so as to select only the modulation products, which are then rectified and fed to the meter M2. The amplitude of this signal is then measured as a percentage of the high-frequency signal, thus giving the percentage intermodulation distortion. The main precaution to be observed in using this system of measurement is to ensure that the low-frequency signal is within the pass band of the equipment under test.

In common with the distortion factor meter this instrument gives no indication as to whether the distortion is due to odd or even order components in the transfer characteristic. Thus, while these methods may be sufficient for production line testing, design engineers will find that a wave analyser gives more revealing and hence, more useful results.

Theoretical Considerations

Many unconsidered claims are made for the advantages of intermodulation methods of testing, not the least of which is the "added sensitivity". An unthinking glance at the power series expansion of the transfer characteristic of an amplifier with two signals applied simultaneously is the main cause of this (see Appendix). At first sight the coefficient of the second order intermodulation component appears to be double the equivalent component for the second harmonic term. In point of fact it is, if the amplitudes of the signals "P" and "Q" are each the same as in the single signal case. In order to be fair to the equipment under test, however, it is essential to keep the peak-to-peak voltage applied the same as it would be with a single signal. The necessity for stressing this point is underlined by the current practice of quoting an amplifier specification in terms of harmonic distortion at a specific output power with a single signal applied, e.g. 10 watts at 0.1% distortion is a typical claim for a first-class audio amplifier. This claim may generally be substantiated at mid-band with a single signal. However, if two equal signals are applied and their level adjusted, so that the output is 10W, the distortion, both harmonic and intermodulation, is found to have increased considerably and the output waveform, viewed on an oscilloscope, shows that overloading is taking place. In fact the peak-to-peak voltage swing has increased by 41.4%. From this it is obvious that any system which is to give results directly comparable with those obtained by simple harmonic methods must ensure that the peak-to-peak voltage is the same so that the same portion of the transfer characteristic is explored in each case.

Having this criterion in mind it is now possible to assess the relative sensitivities of the simple harmonic measurement method and the two inter-

Table 1. Relative sensitivities of harmonic C.C.I.F. and S.M.P.T.E. measurements

	Harmonic	C.C.I.F.	S.M.P.T.E.
Applied signal	"P" amplitude 10 units	"P" amplitude 5 units "Q" amplitude 5 units	"P" amplitude 2 units "Q" amplitude 8 units
2nd order term	$\frac{1}{2}a_2P^2 = 50\,a_2$	$a_2PQ = 25\,a_2$	$a_2\,PQ = 16\,a_2$
3rd order term	$\frac{1}{4}a_3P^3 = 250\,a_3$	$\frac{3}{4}P^2Q = 93.75\,a_3$	$\frac{3}{4}PQ^2 = 96\,a_3$
4th order term	$\frac{1}{8}a_4P^4 = 1250\,a_4$	$\frac{3}{8}\,a_4P^2Q^2 = 234.4\,a_4$	$\frac{1}{2}a_4PQ^3 = 512\,a_4$
Proportionate measurement 2nd	5	2.5	8
3rd	25	9.375	48
4th	125	23.44	256

These results have been simplified so as to indicate clearly the proportionate sensitivities. A more precise evaluation of the coefficients should take the higher order contributions into account(3). (i.e., The second harmonic term is influenced by all even order terms and the 3rd harmonic by all odd order terms). However the additions due to these components do not affect the ratio appreciably.

modulation methods when using a wave analyser (Table 1). In each case the coefficient has been calculated by substituting suitable amplitude signals "P" and "Q" into the expression giving the frequency component being measured. These coefficients have then been referred to the composite signal level which may be applied to the wave analyser without introducing appreciable distortion. Thus in the case of harmonic distortion and of the C.C.I.F. system, the coefficient has been referred to 10 units. In the S.M.P.T.E. case, the coefficient has been referred to 2 units. This is permissible as the system used includes a band stop filter tuned to the low frequency signal "Q", thus ensuring that no intermodulation can take place in the wave analyser. From these figures it will be seen that the S.M.P.T.E. method is the most sensitive and the C.C.I.F. system the least.

Practical Results

Table 1 indicates that the results obtained by the three different methods should be directly comparable. A series of tests has been carried out to determine how nearly this is true in practice.

The first amplifier tested was a wide-band transistor amplifier in which careful attention had been given to the frequency/amplifier characteristic, but no emphasis at all placed on the distortion. The results are shown in Table 2. By multiplying the intermodulation distortion results with the ratio between the corresponding coefficients given in Table 1 to convert the results to those which would be obtained by simple harmonic analysis methods, it is seen that, within the limits of experimental error, Table 1 appears to be correct.

In view of the good correlation between theory and practice in the first test, a series of tests was made on an amplifier which was deliberately designed to have a poor inherent frequency characteristic similar to that of a cheap domestic radio receiver. In order to obtain reasonable results, the signal level was kept well below the overload point. The results of the tests are shown in Table 3. It is immediately apparent from these that the simple correlation between the three test methods no longer holds. Both intermodulation methods show more even-order distortion and less odd-order than would be expected. To a large extent this may be accounted for by recognising the fact that the frequency characteristic is non-linear and that therefore the coefficients a_1, a_2 etc. are frequency dependent. However, a full mathematical analysis to show that this is the case is both complex and tedious.

In an attempt to improve the distortion characteristic, 26dB of negative feedback was applied to the amplifier. The result was a reduction in both the harmonic distortion and even-order intermodulation products. The odd-order products increased so that they were in fact worse with feed-back than without.

In the hope that the readings taken in the last set of tests are peculiar to poor quality amplifiers, a proprietary 10W amplifier with a 0.1% distortion claim was tested. The results are shown in Table 4. It will be seen from these results that again there is no correlation at all between the measured results and the coefficients given in Table 1.

The study of the results obtained in the three series of measurements indicates that there is no simple rule for making distortion measurements.

Table 2. Measurements on a "flat" amplifier using the three methods

Harmonic method "P" = 1V	Fundamental freq.	2nd harmonic	3rd harmonic	4th harmonic
	1 kc/s	0.3%	0.1%	0.005%
	10 kc/s	0.25%	0.1%	0.005%
S.M.P.T.E. P = 0.2V at 10 kc/s Q = 0.8V at 1 kc/s	2nd order term at 9 kc/s $= 0.49\% \times \frac{5}{8} = 0.31\%$ 3rd order term at 8 kc/s $= 0.18\% \times \frac{25}{48} = 0.094\%$ 4th order term at 7 kc/s $= 0.12\% \times \frac{125}{256} = 0.0058\%$			
C.C.I.F. P = 0.5V at 10 kc/s Q = 0.5V at 9 kc/s	2nd order term at 1 kc/s $= 0.14\% \times \frac{5}{2.5} = 0.28\%$ 3rd order term at 8 kc/s $= 0.035\% \times \frac{25}{9.375} = 0.093\%$ 4th order term at 9 kc/s = too small to measure.			

Table 3. Measurements on a poor quality amplifier

Fundamental	2nd harmonic	3rd harmonic	4th harmonic
Harmonic method			
60 c/s	0.72%	0.65%	0.05%
1 kc/s	0.4%	0.08%	<0.01%
10 kc/s	1.7%	0.1%	<0.01%
S.M.P.T.E.	2nd order term	3rd order term	4th order term
60 c/s + 1 kc/s	2.8%	0.05%	0.005%
60 c/s + 10 kc/s	9.5%	0.1%	0.006%
1 kc/s + 10 kc/s	4%	0.025%	0.005%
C.C.I.F.			
1.1 kc/s + 900 c/s	1.1%	0.012%	0.009%
10.5 kc/s + 9.5 kc/s	6.5%	0.01%	0.01%

Table 4. Measurements on a "quality" amplifier

Fundamental	2nd harmonic	3rd harmonic	4th harmonic
Harmonic method			
60 c/s	0.4%	0.3%	0.1%
1 kc/s	0.1%	0.25%	0.04%
10 kc/s	0.45%	0.62%	0.08%
S.M.P.T.E.	2nd order term	3rd order term	4th order term
60 c/s + 1 kc/s	0.1%	0.45%	0.02%
60 c/s + 10 kc/s	0.25%	0.62%	0.005%
C.C.I.F.			
1.1 kc/s + 900 c/s	0.03%	0.12%	—
10.5 kc/s + 9.5 kc/s	0.07%	0.12%	—

Each case must be treated individually on its merits and one or more test methods applied. Simple harmonic measurements suffice in most cases but where a measurement is to be made either of extremely low distortion (e.g. less than 0.03%) or at the upper frequency limit of an amplifier, intermodulation methods are invaluable. The general rules for intermodulation measurement are:—

1. The peak-to-peak input voltage should be the same as that used for simple harmonic measurement.

2. All the frequencies involved in the measurement should be within the pass band of the equipment under test, e.g. there would be no point in measuring the intermodulation introduced by a tweeter loudspeaker using a signal of 60 c/s for the l.f. signal in an S.M.P.T.E. test.

3. The test signals should be combined in such a

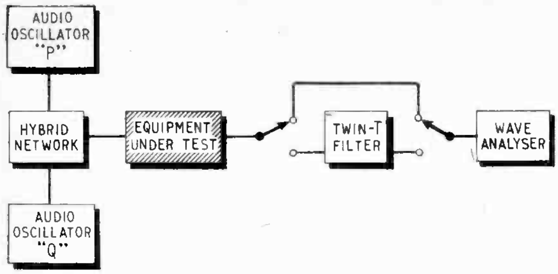


Fig. 4. Intermodulation test arrangement using a wave analyser.

manner that there is negligible inherent intermodulation.

4. If at all possible, one or both of the test signals should be excluded from active portions of the measuring equipment.

Test Equipment

The test arrangement used is shown in Fig. 4. As there is no need for extreme purity of the output from the signal generators " P " and " Q ", any suitable audio oscillators may be used, provided a simple resistive hybrid network is employed to combine the two signals. However, in the experiments described two Marconi Instruments audio frequency signal sources Type TF 2000 were used. With these oscillators the isolation within the intruments is sufficient to permit the outputs to be connected in parallel without introducing any measurable intermodulation. Thus it was possible to dispense with the hybrid network. The band stop filter was a simple RC twin-T network designed to have maximum rejection at 60 c/s which was the low frequency used in all the S.M.P.T.E. measurements. The wave analyser was a Marconi Instruments Type TF 2330. The selectivity of this instrument is such as to permit reasonably accurate measurements of 0.03% 60 c/s side bands, thus making these tests possible.

APPENDIX

The transfer function of an amplifier may be written as:—

$$V_{out} = a_1V + a_2V^2 + a_3V^3 \ldots\ldots\ldots\ldots a_nV^n$$

If a signal $V = P\sin pt$ is applied, the expression may be expanded as follows:—

$$\begin{aligned}V_{out} = {} & \tfrac{1}{2}a_2P^2 + \tfrac{3}{8}a_4P^4 \ldots\ldots\ldots\ldots \\ & + (a_1P + \tfrac{3}{4}a_3P^3 \ldots\ldots)\cos pt \text{ (FUNDAMENTAL)} \\ & + (\tfrac{1}{2}a_2P^2 + \tfrac{1}{2}a_4P^4 \ldots\ldots)\cos 2pt \text{ (2nd HARMONIC)} \\ & + (\tfrac{1}{4}a_3P^3 \ldots\ldots\ldots\ldots)\cos 3pt \text{ (3rd HARMONIC)} \\ & + (\tfrac{1}{8}a_4P^4 \ldots\ldots\ldots\ldots)\cos 4pt \text{ (4th HARMONIC)}\end{aligned}$$

If two signals $V_1 = (P\sin pt + Q\sin qt)$ are applied, the expression may be expanded as follows:—

$$\begin{aligned}V_{out} = {} & \tfrac{1}{2}a_2P^2 + \tfrac{1}{2}a_2Q^2 + \tfrac{3}{8}a_4P^4 + \tfrac{3}{8}a_4Q^4 + \tfrac{3}{4}a_4P^2Q^2 \\ & + (a_1P + \tfrac{3}{4}a_3P^3 + \tfrac{3}{2}a_3PQ^2 + \ldots)\cos pt \\ & + (a_1Q + \tfrac{3}{4}a_3Q^3 + \tfrac{3}{2}a_3P^2Q + \ldots)\cos qt \\ & + (\tfrac{1}{2}a_2P^2 + \tfrac{1}{2}a_4P^4 + \tfrac{3}{4}a_4P^2Q^2 \ldots\ldots)\cos 2pt \\ & + (\tfrac{1}{2}a_2Q^2 + \tfrac{1}{2}a_4P^4 + \tfrac{3}{4}a_4P^2Q^2 \ldots\ldots)\cos 2qt \\ & + (\tfrac{1}{4}a_3P^3 \ldots\ldots\ldots\ldots)\cos 3pt \\ & + (\tfrac{1}{4}a_3Q^3 \ldots\ldots\ldots\ldots)\cos 3qt \\ & + (\tfrac{1}{8}a_4P^4 \ldots\ldots\ldots\ldots)\cos 4pt \\ & + (\tfrac{1}{8}a_4Q^4 \ldots\ldots\ldots\ldots)\cos 4qt \\ & + (a_2PQ + \tfrac{3}{2}a_4P^3Q + \tfrac{3}{2}a_4PQ^3 \ldots\ldots)\cos (p+q)t \quad \text{(s)} \\ & + (a_2PQ + \tfrac{3}{2}a_4P^3Q + \tfrac{3}{2}a_4PQ^3 \ldots\ldots)\cos (p-q)t \quad \text{(c) (s)} \\ & + (\tfrac{3}{4}a_3P^2Q \ldots\ldots\ldots\ldots)\cos (2p+q)t \text{ (c)} \\ & + (\tfrac{3}{4}a_3P^2Q \ldots\ldots\ldots\ldots)\cos (2p-q)t \text{ (c)} \\ & + (\tfrac{3}{4}a_3PQ^2 \ldots\ldots\ldots\ldots)\cos (p+2q)t \text{ (s)} \\ & + (\tfrac{3}{4}a_3PQ^2 \ldots\ldots\ldots\ldots)\cos (p-2q)t \text{ (s)} \\ & + (\tfrac{3}{8}a_4P^2Q^2 \ldots\ldots\ldots\ldots)\cos 2(p+q)t \\ & + (\tfrac{3}{8}a_4P^2Q^2 \ldots\ldots\ldots\ldots)\cos 2(p-q)t \text{ (c)} \\ & + (\tfrac{1}{2}a_4P^3Q \ldots\ldots\ldots\ldots)\cos (3p+q)t \\ & + (\tfrac{1}{2}a_4P^3Q \ldots\ldots\ldots\ldots)\cos (3p-q)t \\ & + (\tfrac{1}{2}a_4PQ^3 \ldots\ldots\ldots\ldots)\cos (p+3q)t \text{ (s)} \\ & + (\tfrac{1}{2}a_4PQ^3 \ldots\ldots\ldots\ldots)\cos (p-3q)t \text{ (s)}\end{aligned}$$

(s) = Component measured by S.M.P.T.E. system.
(c) = Component measured by C.C.I.F. system.

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RADIO TRADERS' CONFERENCE

TOPICS discussed at this year's annual conference of the Radio and Television Retailers' Association ranged from the pros and cons of resale price maintenance to the technical problems of expanding the B.B.C.'s television services.

In a talk on the B.B.C.'s new television programme, Mr. Leonard Miall, the assistant controller of television programme services, spoke on the problems of creating BBC-2. To give some indication of the size of the task, Mr. Miall said the B.B.C. had to recruit and train 1,200 people for engineering duties. Re-equipping the studios and o.b. units was another major task and to date 91 extra television cameras and 500 television monitors have been installed for the new programme. Mr. L. W. Turner, head of the B.B.C.'s engineering information department, assisted Mr. Miall in answering delegates' questions, one of which was "When will Devon and Cornwall get colour television? "!

Mr. Miall said the postponement of colour television to 1967 has been a disappointment to the Corporation, especially when countries like Japan already have three colour services. However, the B.B.C. expected to be able to provide viewers in the present BBC-2 service area with colour during 1967 and, in other areas, colour television will arrive with the extension of BBC-2.

The fact that wired television relay systems are becoming popular and threaten the livelihood of dealers in areas where these systems are planned or are already in operation was among several interesting points raised at the conference. Mr. Michael Keegan, the Association's director, said that, with one exception, all the recent new town projects have accepted systems from the relay companies. The only solution he had to offer was that dealers should inform their local authorities that communal aerial systems are available and are equally competitive. After all, with the communal aerial system the viewer does have the opportunity of choosing any brand of receiver.

Sir Ian Orr-Ewing, M.P., was a guest speaker in the R.P.M. debate. After answering many varied questions Sir Ian said that he was confident that honest traders have nothing to fear from the R.P.M. Bill.

DOMESTIC RECEIVERS AND TAPE RECORDERS AT HANOVER FAIR

ALTHOUGH it is barely eight months since we last reported on developments in the west German radio industry the visit to last month's Hanover Fair was well worth while. Traditionally, the Fair marks the opening of the new season's sales campaigns, and most receiver manufacturers had on show their completed range of 1964/65 sets. New trends were to be seen in television, radio and tape recording, not only in styling but also in technical details.

Television:—The sales departments of most firms are making capital out of the increasing use of transistors in German sets today. Some have as many as 14 and few less than 5 in the front-end tuners and i.f. amplifiers. It is suggested that reliability is increased by as many times as there are transistors. However that may be, some of the associated circuits, particularly in the i.f. stages, are extremely interesting. Both Grundig and Imperial now use etched foil i.f. stages with unscreened printed flat spiral coils tuned, in the case of Imperial, by conventional screwed cylindrical ferrite cores, but in the Grundig sets by ferrite discs. The advantage of these is that it is possible to find only one maximum setting. The printed circuit board is a plug-in unit with edgewise contacts along the lower side.

In Graetz sets the line output stage is mounted on a plug-in printed board. A four-stage all-transistor i.f. amplifier is favoured by Graetz with two gain-controlled AF181s followed by two AF121s. All transistors are plug-in and easily replaceable and the wide-band coupling transformers are unusual in form, being toroidal-wound on ferrite cylinders.

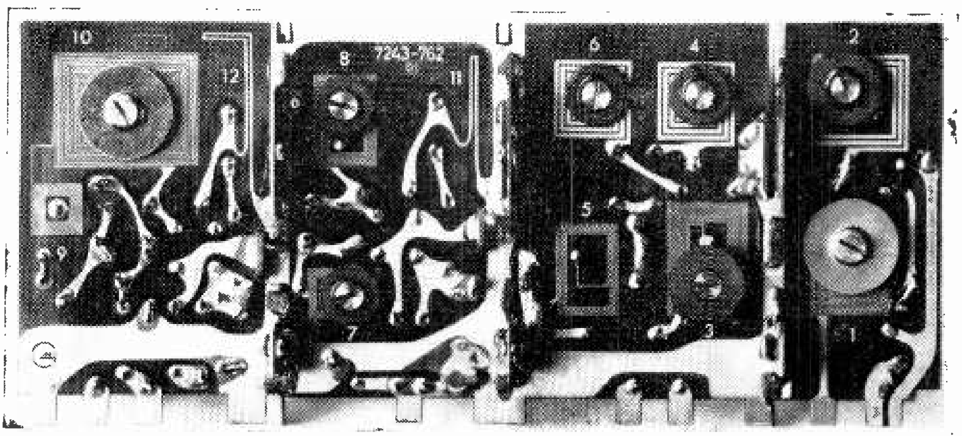
Single-knob tuning for both v.h.f. and u.h.f. with a continuous long scale and automatic waverange switching is a feature of the new Normende sets and in the capacitance-touch motor-controlled version ("Tippomatic") transistors are now used in the control circuits.

Blaupunkt, who came out with a long horizontal cabinet styling at the Berlin Show last autumn have carried the process a stage further in their "Bayreuth" television-stereo-radio-gramophone by providing an end compartment into which the television tube can be folded down and out of sight. A hinged flap gives a smooth table top to the stereo cabinet, outside viewing hours.

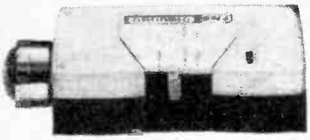
Radio:—Although medium-priced table-model sound broadcast receivers are still to be found in makers' ranges they are rapidly giving place to the general-purpose transistor portable which can be used as a home receiver and for picnics. Performance is being improved in two respects—quality of reproduction, and sensitivity. The Körting Type 25 064 for example has an unusually large loudspeaker and with 1.5W output stage gives "*Konzert*" performance. In this set there are parallel two-bar ferrite aerials in addition to a telescopic aerial for v.h.f. and press-button a.f.c. for final tuning when a station has been found. The Philips "Nicolette" has also been given a larger loudspeaker and the Normende "Globetrotter," Saba "Transeuropa Automatic" and Telefunken "Bajazzo TS" share in setting the trend not only in improved radio and audio performance, but in the rectilinear styling in black and chromium.

Stereo broadcasting is having a little more success in Germany than in the U.K. and several of the *Länder* broadcasting organizations are putting out regular if limited test transmissions. All leading manufacturers now market stereo adapters, and the aerial manufacturers have not been slow in producing the higher-gain Band II aerials which can also discriminate against possible multi-path propagation troubles.

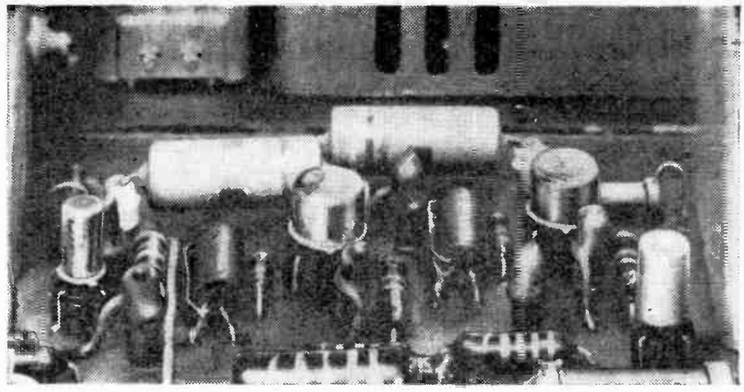
Tape Recorders:—A combined record player and medium-wave broadcast receiver little bigger than the normal car radio has been produced by Saba and is known as the "Sabamobil." When reception is noisy or the programme not to his taste the car driver can, single-handed, slip in a tape cassette and enjoy a programme of his own choice. Saba are producing their own recordings through the firm of



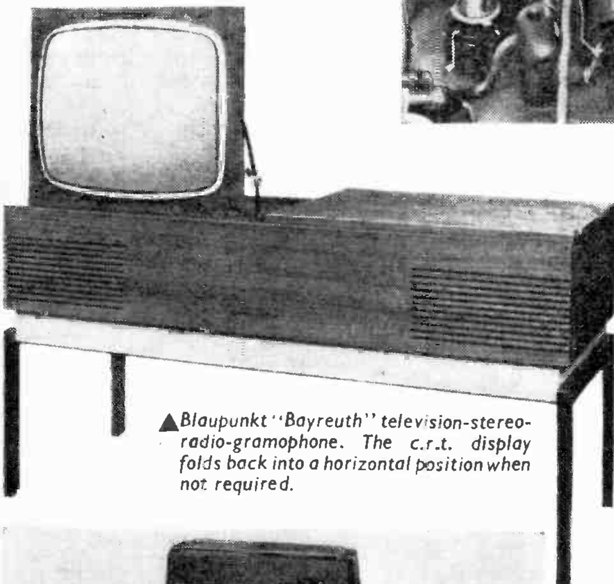
Printed i.f. amplifier (including coils) in the T400 series Grundig television receivers. The loops marked 11 and 12 are for neutralizing.



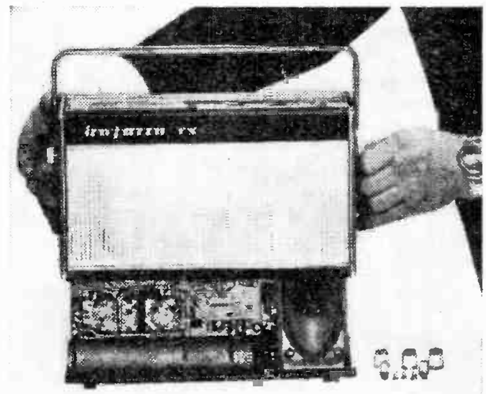
▲ Grundig Type EN3 "electronic notebook" measures $5\frac{1}{4} \times 2\frac{1}{2} \times 1\frac{1}{2}$in.



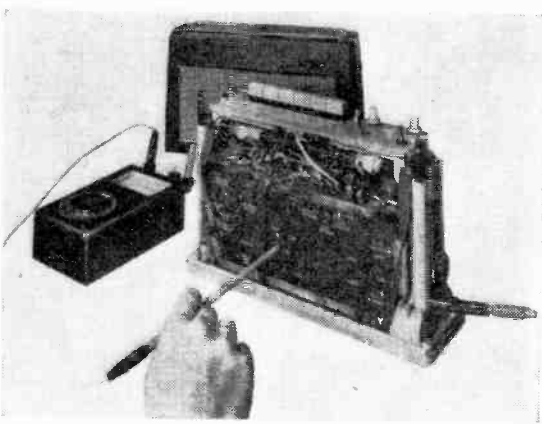
▲ Toroidal ferrite-cored transformers are used in Graetz wide-band television i.f. amplifiers.



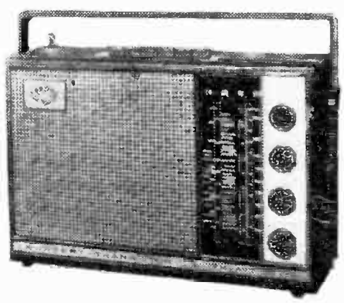
▲ Blaupunkt "Bayreuth" television-stereo-radio-gramophone. The c.r.t. display folds back into a horizontal position when not required.



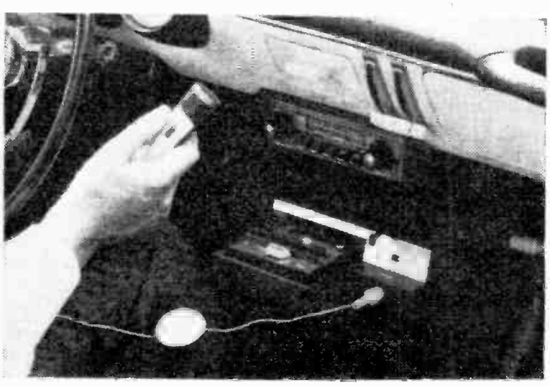
▲ Telefunken "Bajazzo TS" portable is designed for ease of servicing.



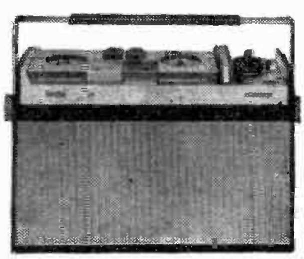
▲ Paper masks are provided for locating test points in Graetz printed circuit receivers (in this case the "Super Page").



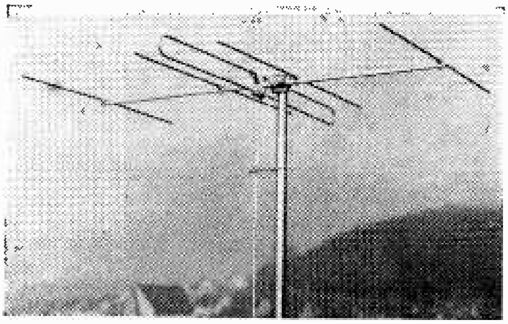
◄ Körting Type ZS 064 transistor portable with 1.5W output stage.



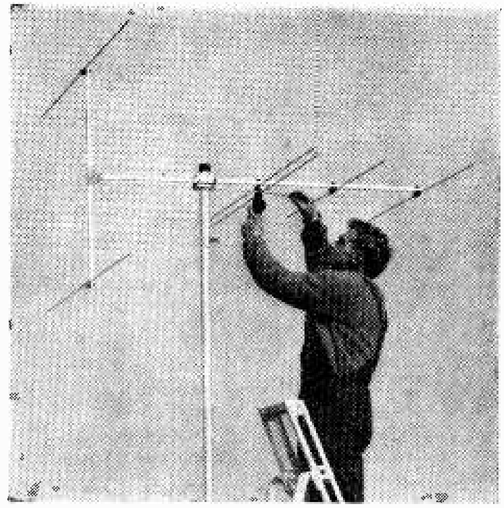
◄ Philips 3300 tape recorder in special mounting for car use.



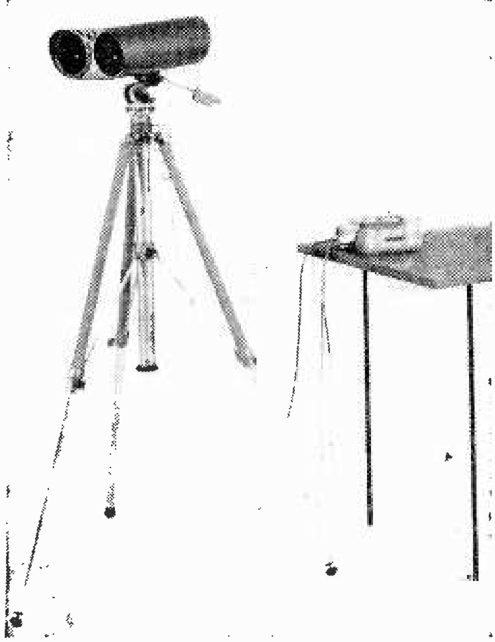
► "Sabamobil" combined medium-wave car radio and tape record player.



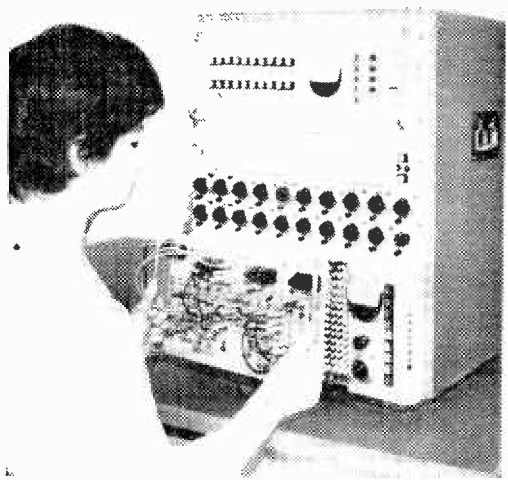
▲ *Bi-directional high-gain aerial (UKA Stereo 33) for Band II by Fuba.*



▲ *Siemens high-gain Band II aerial. Type SAA 164.*



▲ *Equipment by Grundig for talking along a light beam*



▲ *Telefunken Type RAT 740 analogue computer.*

Ariolo and the tapes on 7-cm spools are 170 metres in length and have four tracks giving a total playing time of 2 hours per cassette at a tape speed of 9.5 cm/sec ($3\frac{3}{4}$in/sec). Power output into the built-in loudspeaker is 3 watts, but 10 watts is available for use with an extension loudspeaker.

Philips, also, were featuring their Type 3300 pocket tape recorder in a special mounting for motorists which enables them to pull out or retract, with a lever action, a tray under the dashboard. The driver can record verbal notes or dictate letters as well as playing back recordings of his choice.

Most compact of all is the new Grundig "Electronic Notebook" (Type EN3) which is a complete battery-operated recorder (with playback) measuring $5\frac{1}{4}$in $\times$ $2\frac{1}{2}$ $\times$ $1\frac{1}{2}$ and weighing only $13\frac{1}{2}$oz. The moving coil microphone serves also as a playback loudspeaker. Playing time is about 45 minutes and erasure is by permanent magnet; there is no h.f. bias. The $4\frac{1}{2}$ volt batteries last about 15 hours.

Also remarkably compact for its type is the new automatic telephone answering machine developed by Graetz. Measuring only 7in $\times$ $3\frac{1}{2}$ $\times$ $10\frac{1}{2}$in it gives a preliminary announcement of 12 seconds and then permits the caller a 30 second message.

Styling in tape recorders, like that of portables is acquiring the "technical look" i.e. the appearance of a measuring instrument rather than a piece of weekend luggage. Notable examples are the Telefunken "100" series and the Uher "4000 Report-S."

In conclusion we have space to mention two eye-catching electronic demonstrations.

One is the Grundig light-beam communication system in which a light bulb is modulated directly by a.f. between 300 and 2800 c/s and the received signal is converted by a photodiode and amplified.

The other is the Telefunken RAT 740 analogue computer which was demonstrated in process of solving a problem in the springing of an automobile. To show that the capacity of the machine was not overtaxed by this exercise, the remaining functions were used to draw-in on the face of the c.r.t. the outline of a Volkswagen, which duly responded to simulated road shocks.

I.E.A. EXHIBITION GUIDE

THE fifth in the series of Instruments, Electronics & Automation Exhibitions opens at Olympia, London, on May 25th for six days. Sponsored by five industrial associations* it will be by far the largest in the series and has attracted well over 600 firms, about a fifth of them from overseas.

The interests of the exhibitors are very diverse—from raw materials to elaborate automation systems—and the large majority of them produce equipment which falls within the purview of *Wireless World*.

It will be obvious, therefore, that it is impossible to deal adequately in a few pages with so vast a display of products many of which are being seen for the first time at a public exhibition in this country. However, in the following pages we have endeavoured to give readers a brief preview of the exhibition compiled from information which manufacturers were invited to send. Not all exhibitors responded to the invitation and some who did were showing equipment on the fringe of *W.W.* interests.

Many of the exhibitors listed below are sharing stands. It has been necessary, therefore, to group them together stand-by-stand. To facilitate the finding of references in this preview we have included in the list of exhibitors the name, in square brackets, under which the report on the stand is listed. Where we have thought it might be useful we have appended a number for use on the reply card by professional readers requiring further information on manufacturers' exhibits. We hope to publish a further report in the next issue after members of *Wireless World* staff have visited the stands.

* British Electrical & Allied Manufacturers' Association, British Industrial Measuring & Control Apparatus Manufacturers' Association, Electronic Engineering Association, Radio & Electronic Component Manufacturers' Federation and the Scientific Instrument Manufacturers' Association.

LIST OF EXHIBITORS

Exhibitor	Stand No.
A.D.S. Relays	E259
A.E.I.	G78
A.E.P.-International	N431
A.K. Fans	N169
AMF	G396
A.P.T. Electronic Indus.	G385
Acbars	N184
Accles & Pollock	E523
Ad. Auriema	N422
Addo	N157
Advance Electronics	E286
Advanced Products Co.	G12
Air Control Installations	E292
Aircraft-Marine Products	N203
Airflow Developments	G354
Airmec	G74
Allspeeds	N425
Alma Components	G377
Alston Capacitors [Alma]	G377
American S.T. Wires [S.A.S.C.O.]	E566
Ampex Great Britain	G64
Amphenol-Borg	G18
Analytical Measurements	E257
Ancillary Developments	E525
Anderton Springs	N209
Anglo-German Translation	G130
Arclex	G12
Aric	E287
Arrow Electric Switches	G112
Asch Equipment Co.	N438
Ashcroft Dewrance Inst. Co.	E542
Assoc. Automation [Elliott]	E255 & G50
Associated Iliffe Press	N408
Assoc. des Ouvriers en Inst. [Lyons]	G117
Astralux Dynamics	E517
Ateliers de Construction [Solartron]	G77
Atkins, Robertson & Whiteford [Scott]	G121
Aumann K.G. [Cole Electronics]	N409
Austen Pumps	G110A
Automat Precision Eng. AG	N438
Autronic Developments	N195
Aveley Electric	E265
Avery, W. & T.	G48
Avo	N176
BEME Telecoms. [Derritron]	N429
B.F.I. Electronics	G61
BICC-Burndy	N175
B.I. Callender's Cables	N175
B. & K. Laboratories	G85
B. & R. Relays	G88
Bailey Meters & Controls	G46
Baird-Atomic [Wood]	G131
Bakelite	E521
Baldwin Inst. Co. [Elliott]	E255 & G50
Balzers High Vacuum	N403
Barden Corp.	E272
Barr & Stroud	E536
Bay & Co.	E508
Bay State Electronics [A.E.P.]	N431
Beckman Instruments	G47
Bedco	G22A
Belclere Co.	G375
Belix Co.	E530
Bell & Howell	N437
Belling & Lee	G54
Bellingham & Stanley	N167
Bendix Electronics	N205
Benson-Lehner	E526A
Bernstein-Werk. [D.T.V.]	N197
Beulah Electronics [D.T.V.]	N197
Blakeborough, J. & Sons	N199
Bogen, W. [Cole Electronics]	N409
Bourns Inc. [Painton]	E261
Bowmar Instrument	G391
Bradley, G. & E. [Lucas]	G72
Bran & Leubbe (G.B.)	E275
Brayhead [Ancillary Dev.]	E525
Bribond Printed Circuits	G384
Brimar Indust. Valves	G27
Bristols Inst. Co.[Elliott]	E255 & G50
Britimpex	E560
British Aircraft Corp.	G98
British Drug Houses	E520
British Electric Resistance Co.	E251
British Ermeto Corp.	G125
British Iron & Steel Res.	N440
British Physical Labs.	N156
British Rototherm Co.	G373
Brown, Neville, & Co.	N414
Brown, S. G.	N170
Brush Clevite Co.	E289
Bryans	G106
Budgen Instruments	E276
Budenberg Gauge Co.	E266
Bulgin, A. F. & Co.	G83
Burgess Products Co.	G89
Bush Beach & Segner Bayley	G383
C. & N. (Electrical)	E522
C.R.E.I. (London)	E506
C.T. (London)	E501
C. Z. Scientific Inst.	N182
Cambion Electronic Prod.	E545
Cannon Electric (G.B.)	N413
Carr Fastener Co.	N190
Cathodeon Crystals [Pye]	E270
Celdis	G86
Censor Patent [Joseph Electronics]	N402
Central Dynamics [A.E.P.]	N431
Chatillon & Sons Inc.	N438
Ciba (A.R.L.)	E293
Clare, C.P. [Elliott]	E255 & G50
Clarke, H. & Co.	G90
Cobham, Alan, Engineering	G99
Cohu Electronics [Solartron]	G77
Cole, R. H., Electronics	N409
Colliery Guardian Co.	G382
Colvern	G356
Combustion Instruments	G368
Comoy, H., & Co.	E534
Compagnie des Compteurs	E544
Computer Controls Ltd	N193
Connollys (Blackley)	E262
Constructions Radioelectriques et Electroniques [Lyons]	G117
Continental Connectors	N208
Contraves A.G.	N193
Cossor Group	G30
Costruzione Radioelettriche [Lyons]	G117
Coulter Electronics	N417
Counting Instruments	E252
Cressall Manufacturing Co.	N196
Crompton Parkinson	G22
Crosby Valve & Eng. Co.	N151
Crossley, Henry	G12
Croven [A.E.P.]	N431
Croydon Precision Inst. Co.	G367
Cryotronics Inc.	N195
Cybernetic Developments [A.P.T.]	G385
D.E.V. Engineering	N161
D.S.I.R.	G40
D.T.V. Group	N197
Dage (Great Britain)	E501
Data Recording Instrument Co.	E512
Dawe Instruments	N423
Davis Emergency Equip.	N438
Day, J. & Co.	G11
Day, P. G. [Kerry's]	N160
Daystrom Inc. [Solartron]	G77
Daystrom	G391A
De La Rue Frigistor	N428
Defense Electronics [A.E.P.]	N431
Degenhardt & Co.	E551
Degussa Hanau	G383
Delta Controls	E274
Delviljem (London)	G108
Demornay-Bonardi Corp.	E501
Den Norske Hoyttalerfabrikk [DNH]	G128
Derritron Group	N429
Deuta-Werke	E513
Devar Controls [Elliott]	E255 & G50
Devices Sales	G96
Digital Equipment Corp.	G398
Digital Measurements	E562
Diodes Inc.	E501
Dobbie McInnes	N198
Drayton Controls	G49
Du Pont Co.	E553
Dubilier Condenser Co.	G25
Dürrwächter - Doduco - K.G. [Joseph Electronics]	N402
E-A Tech. Services [Elliott]	E255 & G50
EFEN Elektrotechnische	E267
ERG Elektro-Röhren	E267
Eberle & Co.	E267
Ediswan Industrial Tubes	G27
Ekco Electronics	G71
Elcom (Northampton)	N426
Electrical Develop. Assoc.	N187
Electrical Remote Control Co.	G93
Electrical Times	E295
Electro Mech. Res. [Solartron]	G77
Electro Mechanisms	N400
Electroflo Meters [Elliott]	E255 & G50
Electrolube	N207
Electronic Associates	N177
Electronic Instruments	G355
Electronic Machine Co.	N152
Electronics & Automation [Palmer]	G353
Electrons Inc. [Lyons]	G117
Electrosil	E557
Electrothermal Engineering	G87
Electrovac [Joseph Electronics]	N402
Electroweighers (Birmingham)	N168
Elesta Electronics	E564
Elga Products	E509
Elliott Group	E255 & G50
Emeco Electronics [Palmer]	G353
Engelhard Industries	E278
English Electric Co.	G69
English Electric Valve Co.	G62
English Numbering Machines	G35
Entech	G399
Epsylon Industries	G26
Erg Industrial Corp.	G374
Ericsson [Plessey]	G68
Erie Resistor	G350
Ether	G51
Europa Engineering Co.	E558
Evans Electroselenium	G17
Evershed & Vignoles	G53

Exhibitor	Stand No.
Fabrique Maret	E561
Facit	G393
Fairchild Publications	N420
Fairey Engineering	E281
Faraday Electronic Inst. [Beckman]	G47
Farnell Instruments	E524
Farris Engineering [Elliott]	E255 & G50
Feinmechanik und Optik	G95
Ferranti	G79
Fielden Electronics	G38
Fieldtech [Bendix]	N205
Filhol, J. P.	G101
Fischer & Porter	E254
Fleming Instruments	G371
Flexonics [Electro Mech.]	N400
Formica	E555
Foster Instrument Co.	N159
Fox, P. X. [General Controls]	G116
Foxboro-Yoxall	G56
Frako GmbH	E267
Friden	E285
Furzehill Labs.	N206
G.E.C. (Electronics)	G70
G.E.C. (Telecommunications) [M-O Valve]	E288
G.K.N. Screws & Fasteners	E282
G.P.O.	G357
General Applied Science Labs. [A.E.P.]	N431
General Controls	G116
General Radio Co. [Lyons]	G117
Glass Developments [Ultrasonoscope]	E518
Gloster Equipment	G55
Gloucester Controls	N436
Goodmans Industries	G107
Gordon & Co. [Elliott]	E255 & G50
Gordon Valves [Elliott]	E255 & G50
Graphic Instruments	E276
Graviner Manufacturing Co	N211
Greibech Insts. Corp [Lyons]	G117
Gresham Lion Electronics	N424
Gudenbrod Bros. Silk Co.	G12
H.C.D. Research	E505
H.V.L. S.A.	G359
Haddon & Stokes [G.K.N.]	E282
Haefner & Krullmann [Cole Electronics]	N409
Hahn Magnet	E267
Hallam, Sleigh & Cheston	G28
Hallikainen Instruments [Elliott]	E255 & G50
Hamilton (Instrumentation)	E561
Harris Plating Works	E258
Harwin Engineers	G91
Hassett & Harper	N191
Hatfield Instruments	N210
Hawker Siddeley Dynamics	G390
Hawksley & Sons [Beckman]	G47
Headland Engineering Dev.	G351
Hellermann Equipment	E548
Hendrey Relays	G378
Hengstler, J., Co.	E514
Henley Inc.	E501
Henry & Thomas	G360
Hewlett-Packard	N174
Hexcel Products Inc.	G12
Heywood & Co.	E532
Highland Electronics	G127
Hirschmann, Richard	E267
Hirst Electronic	E503
Hivac	N171
Hoffmann	E516
Honeywell Controls	N188
Horizon House Inc.	G397
Hughes International	G366
Hunt, A. H.	G31
Hunt & Mitton	G15
I.E.C. (Electronics)	N438
Ide, T. & W.	G119
Ilford	E284
Imhof	G379
Impectron [Ad. Auriema]	N422
Industrial Pyrometer Co.	N443
Infotronics Corp. [Techmation]	N432
Instron	E263
Instruments & Communications [Techmation]	N432
International Electro-Comp.	E501
International Electronics	E552
International Engineering	N438
International Res. & Dev.	N441

Exhibitor	Stand No.
International Systems Control [G.E.C.]	G70
Ireland Industrial Dev.	N442
Isora Illuminating Ceilings [Electro Mechanisms]	N400
Japan Electron Optics Lab.	G108
Jautz, Karl, GmbH	E267
Jenaer Glaswerk Schott & Gen.	N427
Jennings Radio Mfg. Corp.	G359A
Joclin Manufacturing Co.	G12
Johnson, Matthey & Co.	N433
Joseph Electronics	N402
K.D.G. Instruments	E264
K. & N. Electronics	E539
KOVO	E269
Kappa Electronics	G369
Kent, George	G39
Kent Mouldings [S.T.C.]	G66
Kerry's (Ultrasonics)	N160
Ketay [Plessey]	G68
Keyswitch Relays	E547
Kings Electronics [S.A.S.C.O.]	E566
Knott Elektronik [A.E.P.]	N431
Kuhnke, H.	E515
Kumag A.G. [Cole Electronics]	N409
Kynmore Engineering Co.	N193
L.P.S. Electrical [Day]	G11
Laboratoire Electro-Acoustique [Furzehill]	N206
Laboratoire Industriel d' Electronique Belin [Solartron]	G77
Laboratoires de Physique Applique [Solartron]	G77
Laboratory for Electronics [Scott]	G121
Lancashire Dynamo	G122
Landis & Gyr	E531
Langendorf Watch Co.	E561
Lectropon	G60
Leeds Meter Co.	N181
Leeds & Northrup	N162
Leesona Holt	E554
Leevers-Rich Equipment	E541
Levell Electronics	E268
Leybold-Elliott [Elliott-Automation]	E255 & G50
Linvar	G20
Lippke, Paul, K.G.	E275
Livingston Laboratories	G84
Lloyd & Hillman	G401
Lloyds Bank	E256
Londex [Elliott-Automation]	E255 & G50
London Elect. Wire Co. & Smiths	N410
Lucas, Joseph	G72
Lufthansa German Airlines	G350A
Lund Bros. & Co.	E565
Lyons, Claude	G117
M.B. Metals	G394
M.C.P. Electronics [Reliance Controls]	N404
M.E.L. Equipment Co.	G82 & G114
M-O Valve Co.	E288
Magnetic Devices	N164
Magnetic & Electrical Alloys [Telcon]	N183
Maier, Karl	E267
Malaker Laboratories Inc.	N195
Mallory Batteries	G58
Manigley Fréres	E561
Marconi [English Electric]	G69
Marconi Instruments	N189
Markovits, I.	G21
Marrison & Catherall	G372
Martin-Ivo	G129
Mason, E. N., & Sons	G395
Mawdsley's	G361
Mazda Equipment Sales Dept.	G27
McMichael [G.E.C.]	G70
McMurdo Instrument Co.	G103
Measuring Instruments [Pullin]	G44
Mec-Test	N166
Medintron	G360
Mercantile Credit Co.	E502
Metal Detection	N168
Meterflow [S.E. Labs.]	G63
Metrimpex	E526
Microcell	G94
Micronia Amplifier [Lyons]	G117
Microponent Development	N434
MicroTek Instruments [Techmation]	N432

Exhibitor	Stand No.
Microtube S.A.	E561
Midland Bank	N200
Millivac Instruments [Lyons]	G117
Milton Ross Co.	E563
Mine Safety Appliances Co.	G92
Miniature Bearings	N438
Miniature Electronic Comps.	G43
Mining & Chemical Prods. [Reliance Controls]	N404
Ministry of Aviation	N172
Ministry of Defence	N172
Model & Prototype Systems	N213
Moore, Reed & Co.	E519
Morgan Bros.	N163
Morganite Resistors	N185
Motorola Semiconductor Prods.	G86
Muirhead & Co.	G32
Mullard	G37
Murex	N406
N S F	N407
Nalder Bros. & Thompson	E253
Negretti & Zambra	G73
Neoflex	E267
New Western (Engineering)	G73
Newmark, Louis [McMurdo]	G103
Newmarket Transistors [Pye]	E270
Newport Instruments	N195
Non-Linear Systems [A.E.P.]	N431
Norgren, C.A.	N192
Nuclear Enterprises (G.B.)	E250
Oliver Pell Control	G386
O.M.I Instruments [Palmer]	G353
Optical Works	G14
P & H Engineering Co.	E260
P.S.B. Instruments	N415
Pacific Semiconductors [Reliance Controls]	N404
Packard Instruments	N430
Painton & Co.	E261
Palatine [Elliott-Automation]	E255 & G50
Pall Corp.	G12
Pall (U.K.)	G401
Palmer, G.A. Stanley	G353
Panax [Electronic Machine]	N152
Paramatic Engineering	G100
Parechoc S.A.	E561
Parkinson Cowan Measurement	G29
Parmeko	G42
Payne & Griffiths	N212
Pedoka	N439
Pergamon Press	G352
Perkin-Elmer	N401
Philbrick Res. Inc. [A.E.P.]	N431
Phoenix Telephones	N444
Photoelectronics Holdings	G59
Pignone Sud S.p.A.	G389
Plannair	N418
Platon, G.A.	G13
Plessey Co.	G68
Polaron Instruments	G108
Potter Instrument Co.	N432A
Printed Circuits [LEWCOS]	N410
Publishers' Association	E550
Pullin, R. B., & Co.	G44
Pulsonic [Derritron]	N429
Pye Group	E270
Pyro-Werk GmbH	E556
Quentin & Cie [Solartron]	G77
RCA Great Britain	G364
Raaco	E510
Racal Instruments	N173
Radiatron	E511
Radionic Products [S.A.S.C.O.]	E566
Rank Organisation	G45
Rathdown Industries	E543
Record Electrical Co.	E500
Recording Instruments Group	E276
Reliance Controls	N404
Reliance Cords & Cables	N180
Reliance Gear Co.	N419
Research Controls Inc. [Platon]	G13

Exhibitor	Stand No.
Reslosound [Derritron]	N429
Reuter-Stokes Electronic Components [A.E.P.]	N431
Rivlin Instruments	N153
Roband Electronics	N186
Robinson, F. C., & Partners [Hunt]	G31
Rochar Electronique [Solartron]	G77
Rose Bros. (Gainsborough)	G12
Ross, Courtney & Co.	N405
Rotameter Manfg. [Elliott]	E255 & G50
Rotax [Lucas]	G72
Rotron Controls [Elliott]	E255 & G50
Roulements Miniatures S.A.	N438
Royal Worcester	G362
Royce Electric Furnaces	E291
Royston Instruments	G10
Rustrak Instruments	E290
S.E. Laboratories (Engineering)	G63
SESCO [Reliance Controls]	N404
SFIM [Electro Mechanisms]	N400
SGS-Fairchild	N412
Salford [M-O Valve]	E288
Salter & Co.	E296
Sanders Group	G388
Sangamo Weston	G75
Scama	E549
Schaevitz Eng. [Electro Mechanisms]	N400
Schlumberger [Solartron]	G77
Schnorr, Adolf, K.G.	N438
Schnyder-Liechti, S.A.	E561
Scott, James	G121
Sealectro Corp. [Elga]	E509
Self Organizing Systems [S.A.S.C.O.]	E566
Semiconductors [Plessey]	G68
Semikron M.B.H. [H.C.D. Research]	E505
Service Electric Co.	G19
Servo Consultants	E538
Seton Creaghe Engineering	N438
Sferax S.A.	N438
Shandon Scientific Co.	G392
Shaw Publishing Co.	N445
Siemens & Halske [Cole Electronics]	N409
Sierex	E535
Sifam Electrical Instrument Co.	N420
Simplifix Couplings	G125
Singer Co. [Electro Mechanisms]	N400
Sirco Controls	G97
S. London Electrical Equip.	G115
Smith, S., & Sons (England)	N202
Société Analac [Lyons]	G117
Société d'Electronique Materiel Automatique Controle [Solartron]	G77
Société d'Instrumentation Schlumberger [Solartron]	G77
Solartron Electronic Group	G77
Sorensen-Ardag	E501
Southern Instruments	G49
Sovirel	N150
Spear Engineering Co.	G370
Sperry Gyroscope Co.	E273
Spirol Pins	E561
Standard Telephones & Cables	G66
Stanton Instruments	G105
Steatite Insulations	G104
Stewart Aeronautical Supply Co.	E566
Stratton & Co.	E279
Studer S.A.	E561
Superior Electric Nederland	G126
Swartwout [Elliott-Automation]	E255&G50
Swiss Jewel Co.	G12
Swiss Instruments & Comps.	G400
Sylvania International	N411
Sylvania-Thorn	G27
Symonds Engineering Co.	G12
Symonds, R. H.	G12
Synchronome Co.	E264
System Computers	N441
TRG Inc [Lyons]	G117
TRW Semiconductors [Reliance Controls]	N404

Exhibitor	Stand No.
Tannoy Products	E527
Taylor Instrument Co.	G65
Techmation	N432
Techna (Sales)	G363
Technivision Group	G387
Technograph & Telegraph	N155
Tectonic	N421
Teddington Aircraft Controls	E546
Tektronix U.K.	G67
Telcon Metals	N183
Teledictor	G111
Telefunken [Britimpex]	E560
Telegraph Condenser Co.	G36
Telehoist [Wayne Kerr]	G34
Telektron (Great Britain)	E528
Telephone Manufacturing Co.	G81
Telequipment	G109
Temco [Telcon Metals]	N183
Texas Instruments	G52
Thermal Syndicate	G358
Thermionic Products [Airmec]	G74
Thompson, J. Langham [Ether]	G51
Thorn-AEI Radio Valves & Tubes	G27
Thorn Electronics	G118& E271
Tinsley & Co.	N158
Tintometer	G110
Tiro-Clas S.A.	E513
Tolana S.A. [Solartron]	G77
Toolpro [Telcon Metals]	N183
Topper Cases	G24
Tothill Press	G120
Transitron Electronic	N179
Trumeter Co.	E294
Turbo-Werk Köln	G399
Turner Electrical Inst.	G23
Turton Bros. & Matthews	G41
20th Century Electronics	G380
Tylors	N161
U.S. Business Inform. Center	E507
Ultra Electronics	G80
Ultrasonoscope Co.	E518
Uni-Tubes [Smiths]	N202
Union Carbide	N435
Union Optical Co. of Japan	G108
United Electric Controls [A.E.P.]	N431
United Trade Press	G376
Vactite Wire Co. [LEWCOS]	N410
Vactric Control Equipment	N178
Vacwell Eng. [Electronic Machine]	N152
Varad Inc. [Lyons]	G117
Varian Associates	N154
Veeco Instruments	E504
Veeder-Root	G16
Venner Electronics	G76
Vero Electronics	E529
Victoreen Instrument [A.E.P.]	N431
Vidor Corp. [A.E.P.]	N431
Visual Engineers	G73
Wandleside Cable Works	E559
Watch Stones	E561
Waters Manufacturing Inc.	N438
Waycom	E537
Wayne Kerr Labs.	G34
Weber [Cole Electronics]	N409
Welmec Corp.	G123
Welwyn Electric	G365
West Instrument	E290
Westinghouse Brake & Signal Co	N165
Westminster Bank	E283
Westool	N194
Whiteley Electrical Radio Co.	N201
Williams & James (Engineers)	E280
Wire Products & Machine Designs	G113
Wireless World	N408
Witte & Sutor [Joseph Electronics]	N402
Woden Transformer Co.	E277
Wood, Hugh, & Son	G131
X-Lon Products	N416
Yellow Springs Inst. [S.A.S.C.O.]	E566
Zeal, G. H.	E533
Zenith Electric [Lyons]	G117

PREVIEW OF I.E.A. EXHIBITS

A.D.S. RELAYS

Their complete range of relays is being shown this year. In addition to the Post Office 3000 and 600 types, a selection of miniature units—some measuring as little as ⅞ in cube—are on display.

9WW 301 for further details

A.E.I.

A large selection of products from Associated Electrical Industries electronics group are featured. A.E.I.'s closed-circuit television system (which can be run off two 12V car batteries), a range of silicon and germanium rectifier diodes, a high-speed motor uniselector and a representative range of relays are included in the display. The radio component department's display includes transistor mounting pads and holders, coaxial attenuator plugs, printed circuit connectors, and a new 5mm plug and socket system.

9WW 302 for further details

A.E.P.

A.E.P.-International Ltd. are showing a selection of products from a number of overseas companies, including a pulse height analysing computer from the American Victoreen Instrument Company, a sweep signal generator from the Bay State Electronics Corp., a large-screen oscilloscope—with plug-in units—from Knott Elektronik and statistical digital voltmeters from Non-Linear Systems.

9WW 303 for further details

A.K. FANS

In addition to the Airmax range of fans manufactured by A.K. Fans Ltd., a selection of fans made by the Rotron Manufacturing Corporation are on show. Other exhibits include forced convection heat sinks and sub-miniature Minicube blowers.

9WW 304 for further details

A.M.P.

"Circuitip" terminals, printed circuit edge connectors, test probe receptacles, re-usable component jacks, plugs and sockets, modular connectors and neon pilot indicators are among this year's exhibits.

9WW 305 for further details

A.P.T.

The data processing division of A.P.T. Electronic Industries Ltd. is showing a range of plug-in electronic drive and logic circuits which it has designed for coupling paper tape and card readers to electric typewriters. Other exhibits include a selection of power supplies, heat sinks and blower units. Language laboratory equipment from Cybernetic Developments Ltd. is also being shown.

9WW 306 for further details

AD. AURIEMA and IMPECTRON

The two companies on this stand represent well over 50 overseas manufacturers. Components, laboratory equipment and domestic radio equipment can be seen.

9WW 307 for further details

ADVANCE

Advance Electronics Ltd. (until recently Advance Components) is showing items from its range of instruments, including the SC1 20 kc/s counter, PG54 transistor pulse generator, SG21 v.h.f. square-wave generator, and the OS41 single-beam oscilloscope. The bandwidth of this scope is d.c. to 22 Mc/s, with a maximum sensitivity of 50 mV/cm (or 5 mV/cm from 10 c/s to 18 Mc/s using the switchable pre-amplifier).

9WW 308 for further details

AIR CONTROL INSTALLATIONS

A selection of axial and centrifugal blowers, with impellers ranging from 1½ to 8in in diameter, are shown together with a number of miniature filters. Arrangements can be made with the manufacturers to borrow these units on free loan for development purposes.

9WW 309 for further details

AIRFLOW DEVELOPMENTS

Among the air and gas flow test equipment on show is a transistorized anemometer.

9WW 310 for further details

AIRMEC

The full range of Airmec instrumentation is shown. This includes voltmeters, signal generators and the recently introduced u.h.f. instrumentation. Thermionic Products is sharing the stand and is showing a new range of magnetic, tape-recording equipment, which includes a 7-track analogue recorder, an 8-track digital recorder and tape-transport mechanisms. Other equipments demonstrated are a speaking clock, standard tape transport operating from a 24 V direct supply with an inverter and a standard Series IV communications recorder.

9WW 311 for further details

ALMA

Alma Components Ltd. are showing a comprehensive selection of their resistors, including their new ranges of precision metal film resistors. Alma are also showing a range of dry reed and mercury wetted relays. Other exhibits include a selection of capacitors from Alston Capacitors Ltd. In addition to the established type approved CMM1-G and CMM3-Y silvered mica capacitors, a new range is being shown for the first time.

9WW 312 for further details

AMPHENOL-BORG

Amphenol-Borg (Electronics) Ltd. are displaying a variety of connectors, and crimp contact demonstrations are being given daily. A full range of potentiometers are also being shown.

9WW 313 for further details

ANCILLARY DEVELOPMENTS

Ancillary Developments, exhibiting for the first time, are showing flux-

sensitive heads for data-recording applications, precision gear heads and clutch-brake mechanisms, miniature trimmers, differential potentiometers, sub-miniature variable resistors and servo potentiometers.
9WW 314 for further details

ARROW ELECTRIC SWITCHES
Sub-miniature as well as the standard range of Arrow switches are being displayed. A small relay with open and closed circuit combinations up to 8 poles rated at 10 amps at 250 V a.c. is also shown.
9WW 315 for further details

AVELEY ELECTRIC
Equipment manufactured by Rohde and Schwarz, Fairchild International, Brush Instruments, Norda, North Atlantic, Stoddart, and Scientific Atlanta is displayed. The range includes oscilloscopes, impedance-measuring instruments, coaxial connectors and semiconductor testers with digital readout.
9WW 316 for further details

AVO
A comprehensive selection of "Avo-Meters," including the Mk. 3 version of the Model 8, valve characteristic meters and transistor analysers are being shown with a selection of nucleonic instruments. A new oscilloscope camera, which is a joint product of Avo and the Beattie-Coleman Inc. of California, is also exhibited.
9WW 317 for further details

B.I.C.C.
British Insulated Callender's Cables Ltd. are showing a comprehensive range of cables and accessories. A substantial proportion of the display is devoted to exhibits of B.I.C.C.-Burndy Ltd., which include a variety of connectors. Most of these employ compression jointing techniques.
9WW 318 for further details

B.I.S.R.A.
The British Iron and Steel Research Association is demonstrating an inductive loop data transmission system as applied to an overhead crane. It is also showing several items of automation equipment and instrumentation relative to the iron and steel industries.

B & K LABORATORIES
Components and instruments with applications in all engineering fields are shown. Ultrasonic systems, high-voltage components, welding-control apparatus and general electronic instrumentation are being demonstrated.
9WW 319 for further details

B & R RELAYS
In addition to their own range of electro-mechanical relays and allied equipment, B & R Relays Ltd. are also showing Siemens & Halske miniature relays, Adlake mercury wetted and mercury displacement relays and Benedikt & Jäger contactors. B & R are showing a miniature 3-pole changeover plug-in relay and a transistor timing unit for the first time at this year's show.
9WW 320 for further details

BAKELITE
Two recently introduced grades of glass laminates, one based on melamine resin, the other on epoxide glass, are being shown with the more conventional laminates based on paper, wood, fabric and asbestos. One of the principal exhibits is a borrowed computer unit, incorporating printed circuitry based on copper-clad Bakelite laminations.
9WW 321 for further details

BARDEN
In addition to showing a selection of precision ball bearings, the Barden Corporation (U.K.) Ltd. is exhibiting a bearing torque testing instrument and a Smoothrator; an electronic instrument used to check performance qualities of oil lubricated ball bearings, by revealing their vibrational characteristics.
9WW 322 for further details

BARR & STROUD
The principal electronic exhibit is a transistor image-orthicon television camera similar to the ones used in the periscope television systems installed at the Winfrith reactor station. Other exhibits include a Morse automatic keying device, standard ruby, neodymium and gas lasers as well as a variety of mirrors, crystals and other components. Optical components are also being shown.
9WW 323 for further details

BECKMAN INSTRUMENTS
A number of new products are being displayed. These include a pH meter designed primarily for research work, a range of British manufactured pH electrodes and a radioactivity counting system. The Helipot Division are demonstrating their Hall-effect voltage generators. In addition to the new equipments the established range of Beckman analytical and electronic components will be shown.
9WW 324 for further details

BELLING-LEE
Among the selection of components from a range of over 1,000 are several new items including the one-hole-fixing series of Securex miniature circuit breakers, a new-style flexible terminal block with stainless steel pressure pads to accommodate a wide range of wire gauges, and a range of pattern 15(B.N.C.) connectors. The Prestincert system of component mounting is featured.
9WW 325 for further details

BENDIX
As well as U.K.-manufactured products Bendix are showing equipment from their parent and associated companies. Among the new items are a rotary pulse generator for deriving pulses from a rotating shaft, a digital integrator, a tester for measuring the leakage and gain characteristics of both p-n-p and n-p-n transistors and a digital voltmeter measuring 100 μV to 1,000 V d.c. in five ranges.
9WW 326 for further details

BENSON-LEHNER
A variety of digital shaft coders are being shown. Other exhibits include an incremental plotter, which is on show for the first time, and an electroplotter, a machine which can produce "report-quality" graphs rapidly and accurately from computer-generated output data.
9WW 327 for further details

BERCO
The British Electric Resistance Company is showing its range of Bercotrol solid-state automatic control units. These units, which have ratings from 3 to 39A a.c., operate from 250-volt single-phase a.c. mains supplies and will provide either d.c. or a.c. outputs. "CVS" (continuous voltage stabilizers) and regulating transformers are also being shown.
9WW 328 for further details

BRIBOND PRINTED CIRCUITS
A comprehensive selection of printed circuit boards in current use, including examples of precious metal plating and roller tin coating, are being shown. Their latest roller tin coating machine, the Brilite, is also displayed along with samples of their specialized lines, which include thermocouples, flexible circuits and cableforms.
9WW 329 for further details

BRITISH PHYSICAL LABS
The major exhibit is the multi-stage component testing machine, Model A III, which is being demonstrated testing various parameters of metallized plastic-foil capacitors, at the rate of 3,500 per hour. B.P.L.'s new deviation voltmeter, Model DM164-L, and their transistor voltmeter, can also be seen.
9WW 330 for further details

BRITIMPEX
Telefunken's U.K. distributors, Britimpex Ltd., are showing a wide selection of Telefunken products. These range from film resistors and polystyrene capacitors to miniature thyratrons and other special purpose valves. Among the other exhibits are transistor u.h.f. tuners, cathode ray tubes and several new v.h.f./u.h.f. semiconductor devices, including some in planar, epitaxial and mesa design.
9WW 331 for further details

BROWN
The recently introduced "Diplomat" lightweight headset, using ceramic transducers and having a frequency response of 20-17,500 c/s, is among the headphones shown. These "Diplomat" phones are used in the "Personal Auditorium" unit providing individual adjustment for each earpiece.
9WW 332 for further details

BRUSH
Brush Clevite Co., formerly Brush Crystal Co., is exhibiting several

new ranges of planar Zener diodes, power rectifiers and silicon epitaxial planar transistors for the first time. The planar Zener diodes are claimed to offer lower temperature coefficients and operate at different spot voltages than the conventional Zener.
9WW 333 for further details

BRYANS
The high sensitivity plotting table Model 20170, the portable plotter 22016, digital data translator 20017/F, the "Digitima" digital clock 20128 and an automatic symbol writer are among this year's display. Other exhibits include a function generator fitted to an x-y plotter and a selection of pressure control and calibration equipment.
9WW 334 for further details

BULGIN
Among the new components being shown are an addition to the series of momentary action s.p. push-button switches, a new range of s.p. moulded panel-mounting switches, several new signal lamps, and a variety of control knobs. Bulgin are also showing a representative selection of their standard range of products.
9WW 335 for further details

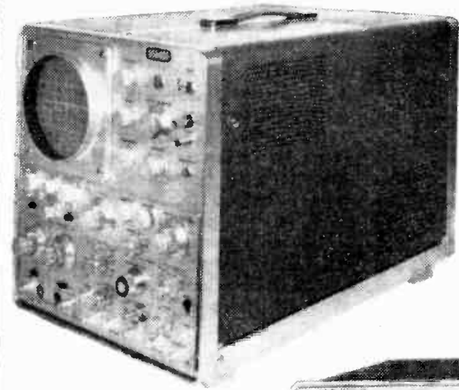
C. & N.
The 7383 simulator for the functional testing of time-sequenced electro-mechanical control equipment is on show with other examples of the company's products including a transistor h.f. communications receiver.
9WW 336 for further details

C.R.E.I.
Examples of new lesson material C.R.E.I. (London) has produced for its 1964 Home Study Programme are being shown. Programmes include electronic engineering technology, automation, space data systems and spacecraft tracking and control.
9WW 337 for further details

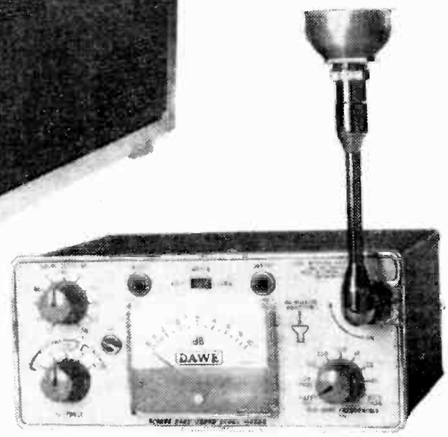
CIBA (A.R.L.)
Examples of the many uses of Araldite epoxy resins are being shown, including those for potting electronic components and circuits. A section of the stand has been devoted to Araldite moulding powders and their use in the manufacture of miniature transformers, multi-point connectors and other components.
9WW 338 for further details

CARR FASTENER
Only a small selection of the company's 5,000 or more components is being shown, including the "Cinch" Greenline range of moulded-edge connectors, micro and slide switches, indicator lights, plugs and sockets, etc.
9WW 339 for further details

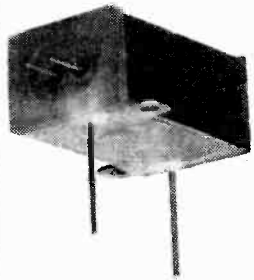
COLE (R.H.) ELECTRONICS
Telecommunications test gear, precision laboratory instruments, and a wide range of components and accessories from the German company Siemens & Halske are being shown.



Cossor CD100 solid-state modular oscilloscope.



An octave band sound level meter from Dawe Instruments Ltd.



Miniature reed relay (AB1434) of E.R.G. Industrial Corp.

A coil-winding machine from Aumann, a riveting press from Kumag and a wire stripper from Fuchs are among the other exhibits.
9WW 340 for further details

COLVERN
A comprehensive selection of wire-wound potentiometers and variable resistors is being shown. A new 10-turn helical potentiometer with an integral watch face dial is included in the display.
9WW 341 for further details

COMBUSTION INSTRUMENTS
An electrical servo-operated micro-balance, designed for weighing objects down to a microgram, is being shown. No special vibration-free or temperature-controlled enclosure is needed with this instrument.
9WW 342 for further details

CONSOLIDATED ELECTRODYNAMICS
The main feature of the display is an advanced recording oscillograph Type 5-133. A direct-writing instrument, it can record 36 or 52 channels on the 12-in, light-sensitive paper. Chemical processing is not required. Many other facilities are provided.
9WW 343 for further details

COSSOR
The instrument, industrial control and telecommunication divisions are represented. Consequently oscilloscopes, pulse generators, v.h.f. radio-telephone equipment and motor-control equipment are demonstrated. The versatility of the Model CD100 oscilloscope series will be shown with plug-in units which include single and dual-trace wideband amplifiers, differential amplifier, sweep units and $x-y$ plotter unit.
9WW 344 for further details

COULTER
Particle counting and sizing instruments are a speciality of this company which is showing several new models.
9WW 345 for further details

CRESSAL
The Cressal Manufacturing Company is exhibiting a range of resistors and control equipment. Fixed and pre-set resistors, sliding and toroidal rheostats—with ratings up to 1,000 watts—are being shown with a selection of their Torovolt auto and double wound variable transformers. The Cressal system of electromagnetic screening using expanded metal mesh and specially designed filter units is also shown.
9WW 346 for further details

CROMPTON PARKINSON
Self-contained wattmeters, frequency indicators, static transducers and expanded-scale d.c. voltmeters are among the instruments being shown. Other interesting exhibits include pivotless movements in circular scale switchboard instruments, circular scale ohmmeters in desk stands for school bench use, and a new form of internal illumination for 2½in and 3½in instruments.
9WW 347 for further details

CROPICO
The Croydon Precision Instrument Company is showing a selection of

precision measuring instruments. Preferred value resistance boxes, Wheatstone bridges and insulation test sets are included in the display.
9WW 348 for further details

D.N.H.
A wide range of D.N.H. loudspeakers made by the Norwegian firm of Den Norske Høyttalerfabrikk is being shown by their U.K. representative Douglas A. Lyons & Associates. They are designed primarily for industrial and public address systems.
9WW 349 for further details

D.S.I.R.
Instruments developed by the D.S.I.R. or associated industrial research organizations are exhibited. The Electrical Research Assoc. is showing an instrument for calibrating any discharge detector which observes individual discharges using detection frequencies up to 2 Mc/s. The Motor Industry Research Assoc. has developed a torque measuring device employing f.m. telemetry. Semiconductor strain gauges are used in the small, easily handled tension meter devised by the Wool Industry Research Assoc.

D.T.V. GROUP
A low-priced transistorized closed-circuit television system, built to industrial standards, is featured together with the Beukit "do-it-yourself" television camera kit. A selection of the American EICO instrument kits are also being shown. These can be supplied ready-made.
9WW 350 for further details

DATA RECORDING
The Data Recording Instrument Company is exhibiting a number of new products from the range of magnetic recording equipment it manufactures for use in instrumentation, data processing and communications.
9WW 351 for further details

DAWE INSTRUMENTS
Five new instruments are being shown for the first time. These are: a transistor battery-operated sound level meter, an octave-band sound level meter, a vibration meter, an a.f. analyser with a frequency coverage of 2c/s-20kc/s, and a variable bandwidth filter.
9WW 352 for further details

DAY, J. & CO.
A comprehensive range of p.v.c. and polythene wires and cables are being shown. Many new types of subminiature and multicore cables are included in the display. Screened wires are also featured.
9WW 353 for further details

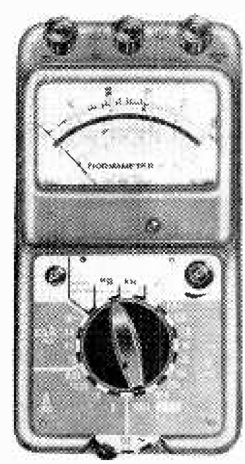
DAYSTROM
Subminiature potentiometers for computer and missile applications, servo components, resistors and bi-metal thermometers are among this year's exhibits. The Heathkit ranges of domestic and amateur radio equipment, audio equipment and test instruments are also being shown.
9WW 354 for further details

DERRITRON
The Derritron Group of companies is showing a wide variety of products this year ranging from Reslosound microphones and Chapman audio equipment to laboratory measuring instruments. A digital Wheatstone bridge and several potentiometers, decade boxes and voltmeters are included in the instrument display. Pulsonic welding and ultrasonic cleaning equipment is also being shown.
9WW 355 for further details

DIGITAL MEASUREMENTS
A comprehensive range of digital measuring equipment is exhibited. This includes digital voltmeters, multi-channel, digital-data recording systems with alarm-level monitoring, optical shaft encoders and precision a.c. dividers, etc. New accessories developed for the established equipments are also shown.
9WW 356 for further details

DOBBIE McINNES
Two twin-channel Graphispot recorders, the GRS and the GRD, are latest additions to the range of industrial and laboratory galvanometer recorders being displayed this year. Another instrument to be shown for the first time is the "D-Mac" limpet logger, a self-contained instrument used for sampling and recording data, at pre-set intervals, on magnetic tape
9WW 357 for further details

▲ *The EICO 955 "in-circuit" bridge-type capacitor tester can be seen on the D.T.V. Group stand.*



▲ *Multirange meter Type 685-T shown by Cropico.*

DUBILIER
Capacitors, resistors and suppression devices are being shown by the Dubilier Condenser Company. Products of interest include delay and pulse-forming networks, and a range of interference suppressors.
9WW 358 for further details

E.E.L.
Evans Electroselenium Ltd. is showing a selection from its range of E.E.L. photo-electric equipment for use in medical and industrial laboratories. A wide range of microammeters and galvanometer units are also displayed.
9WW 359 for further details

E.E. VALVE CO.
The English Electric Valve Company is showing a selection of the valves and tubes it manufactures for the electronics industry. The display includes high-power klystron amplifiers, storage tubes and television tubes as well as transmitting and receiving valves, travelling wave tubes, backward wave oscillators, etc. An entirely new series of high-voltage vacuum variable capacitors for 75A operation are also featured.
9WW 360 for further details

E.N.M.
English Numbering Machines Ltd. are exhibiting their wide range of mechanical and electro-mechanical counting devices and systems with indicating or print-out facilities.
9WW 361 for further details

E.R.G. INDUSTRIAL CORP.
A variety of chokes, transformers, resistors and dry reed relays are included in this year's display. The precision wire-wound resistors (to DEF 5113) are singled out as of special interest.
9WW 362 for further details

EKCO
Both the aviation and instrumentation divisions of Ekco are showing equipment including a radar speed meter for measuring the speed of moving vehicles and a miniature tuning fork, measuring $3 \times 2 \times \frac{7}{8}$in and available in a range of frequencies from 400c/s to 2.4kc/s. Dynatron equipment is also on show.
9WW 363 for further details

ELCOM
Elcom (Northampton) Ltd. are displaying their new range of sound mixing equipment and associated components, which include switches, plugs and sockets, printed circuit connectors, faders and attenuators. Complete mixing desks, ranging from four-channel transportable units to multi-channel consols are being shown.
9WW 364 for further details

ELECTRO MECHANISMS
A wide range of vibration transducers for flight-test instrumentation and ground-vibration analysis are shown and, in addition, the associated electronic equipment is demonstrated. Other exhibits include strain gauges, displacement transducers and a range of Japanese precision, wire-wound potentiometers.
9WW 365 for further details

ELECTROLUBE
The full range of Electrolube lubricants and greases are being shown together with examples of the components on which they are used.
9WW 366 for further details

ELECTRONIC MACHINE
Industrial electronic control equipment utilizing various types of capacity, photo electric and ultrasonic sensing devices is shown by Electronic Machine Control Ltd. And an extensive range of nucleonic instruments and equipment is being demonstrated by Panax Equipment Ltd. The other company in the Electronic Machine group, Vacwell Engineering, is showing specially manufactured equipment for setting up semiconductor production lines and full range testing of production batches of semiconductor devices.
9WW 367 for further details

ELECTROSIL
"Lo-cap" capacitors, with glass dielectric and fused into a glass monolithic unit in a range of 0.1 to 10pF, are featured together with a variety of resistors. Corning glass memories and thin film resistor networks are also to be seen.
9WW 368 for further details

ELECTROTHERMAL
The electronic division of Electrothermal Engineering Ltd. is showing a selection of moulded precision resistors, which the company introduced last year under the trade name Precistor. A selection of laboratory and industrial heating equipment, scientific instruments and control equipment is being shown by the company's heating division.
9WW 369 for further details

ELESTA ELECTRONICS
Included in the exhibits of this Swiss company are photoelectric devices, relays and electronic counters. Some of the cold cathode tubes they manufacture for stabilization, relay and counter applications are also being shown.
9WW 370 for further details

ELGA PRODUCTS
A new water-purification plant is introduced by Elga. Capable of being tailored to customer requirements, the basic system consists of the de-ionizer, control equipment (with quality monitor) and the distribution tank. An example of the scheme is that of the water requirement in a c.r.t. plant. Twenty-two "draw-off" points are provided, the system having a 500 gall/hr flowrate.

Sealectro Corporation is sharing this stand and are showing their vast range of Teflon-bodied terminals, coaxial cables and switches.
9WW 371 for further details

ELLIOTT-AUTOMATION
Products from more than 40 companies and divisions in the group are on show and it seems invidious to highlight any items. However, dominating their stand G50 is the display of the ARCH family of computing systems. There is also a demonstration of data transmission, examples of miniature logic elements, servo components, ultrasonic cleaning tanks, and digital recording and control systems. On stand E255 will be found a wide range of communications test instruments, precision microwave components and measuring instruments including some from Elliott's W. German associates Spinner and Wandel & Golterman.
9WW 372 for further details

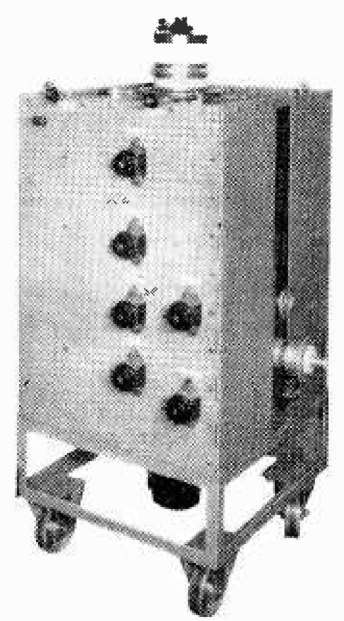
ENGELHARD
Engelhard Industries Ltd., who refine and fabricate precious metals, are showing a selection of their products. Thermocouples and measuring resistance wires are included along with a comprehensive display of hot-bonded bimetal rivets, which the company has introduced to counter the rising cost of silver.
9WW 373 for further details

ENGLISH ELECTRIC
Products from the Industrial Actuator Division, the Metal Industries Division, the Small Machines Division and the Fractional Horsepower Motor Division of the English Electric Company are shown. Demonstrations of telemetry, process control and marine watch-keeping systems are presented by English Electric-Leo Computers. This company also shows a number of photoelectric cells and infra-red detectors that were developed mainly for measurement applications in the steel industry.

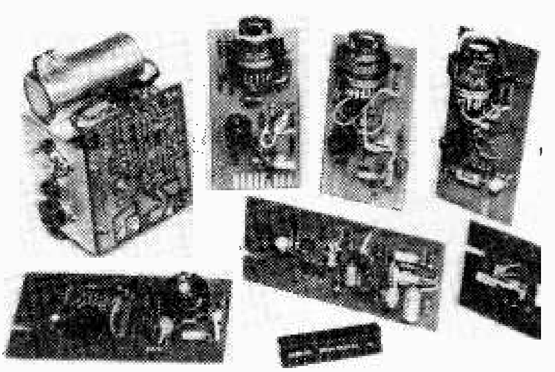
The principal demonstration in the Marconi Company's section of the stand is that of an ultra high-speed computer which performs over 30×10^6 orders per minute. Other demonstrations include "Autospec" error-correction equipment and closed-circuit television. Specialized components are also shown.
9WW 374 for further details

EPSYLON
Epsylon Industries are showing samples of magnetic recording equipment. The display includes four magnetic recorders introduced this year, their Series 111 lapped recording heads and their range of resistor

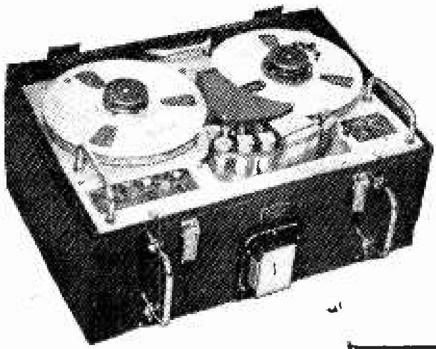
(*Continued on page* 285)



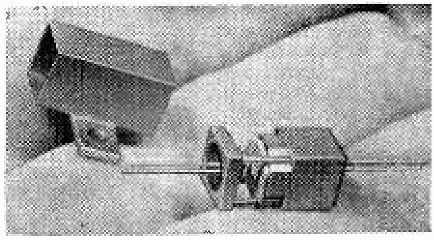
This 25kW power klystron (K377) from the English Electric Co. is to be used in the new BBC-2 television transmitters.



These Panax sub-assemblies are being shown on the Electronic Machine stand.



Epsylon MR1080 magnetic recorder for up to 16 channels.



This miniature relay from G.E.C. (Telecommunications) can be seen on the M-O Valve stand.

silicon transistor logic units ("Sylogs"). Closed-circuit television is also featured.

9WW 375 for further details

ERIE RESISTOR

Miniature tantalum capacitors suitable for working voltages of 6, 10, 15, 20, 35 and 50V (d.c.) are introduced. The capacitance range is 0.33 to 330μF. The established component lines are also shown. The miniature suppression filters demonstrated offer an attenuation of radio interference over a range of 150 kc/s to 1000 Mc/s.

9WW 376 for further details

ETHER

A thermocouple thermostat, a potentiometric indicating temperature controller, a precision 10-turn potentiometer, and a minature semiconductor strain gauge are among the exhibits to be seen for the first time. There are several working demonstrations incorporating temperature instruments, power supplies, solenoid valves, Haydon timers and transducers, etc.

9WW 377 for further details

EVERSHED

A series of solid-state circuit modules for on-line analogue computing are being demonstrated to show their use in industrial process control. Other exhibits include a selection of items from Evershed's range of instrumentation and control systems.

9WW 378 for further details

FACIT

Facit Aktiebolaget Atvidabergs Industrier of Stockholm, Sweden, are featuring three of their products at this year's show: the PE 1000 high-speed paper tape reader; the PE 1500 high-speed paper tape punch; and the Carousel magnetic tape memory. Both the tape reader and the tape punch are suitable for 5-, 6-, 7- or 8-track tape operation.

9WW 379 for further details

FAIREY GROUP

Companies within the Fairey Group are exhibiting a wide range of products. These include direct power converters, glove boxes and nuclear-control systems (all by the nuclear division), hydraulic devices and vibrators.

9WW 380 for further details

FARNELL

Several stabilized voltage supply units are being shown, including a number of new types, one of which, in addition to supplying an accurate voltage source, can be used to measure a voltage within the range 0-100 V at high accuracy. Farnell Instruments Ltd. are also showing a new low-priced sine and square wave oscillator, covering the frequency range 1 c/s to 100 kc/s.

9WW 381 for further details

FIELDEN

Fielden Electronics Ltd. are showing a wide selection of process control equipment. Other exhibits include a potentiometric pyrometer for use with thermocouples, a range of Bikini precision temperature controllers, and a low frequency alarm for use on 50 c/s and other supplies.

9WW 382 for further details

FILHOL

The exhibits include industrial jewel bearings, meter pivots, pins and sockets for multi-pin plugs and gramophone styli. The instrument parts supplied by this company are machined in many materials. Normally a 0.002in tolerance is maintained but, if required, the parts can be machined to within 0.0002in.

9WW 383 for further details

FORMICA

The full range of paper and glass-based, copper-clad laminates is displayed together with examples of printed circuitry constructed on typical laminates. Another display is devoted to the use of paper-fabric and glass-based industrial laminates. Engraved and printed signs (on Formica) are also shown.

9WW 384 for further details

FOSTER

A selection of temperature measuring and controlling equipment is being shown by the Foster Instrument Company. The display includes electrical resistance thermometers, thermo-electric, optical and radiational pyrometers.

9WW 385 for further details

FOXBORO-YOXALL

In addition to recent developments in the gas chromatography fields, the company's range of pneumatic and electronic analogue computers are shown. Other exhibits include flow meters and electronic and pneumatic force and motion balance transmitters.

9WW 386 for further details

FRIDEN

A desk-sized computer specially designed for applications which require high-speed computation as well as descriptive alphabetical information is shown. Other exhibits include a telephone data transmitting system, with complementary receiving equipment, and several calculators capable of automatic extraction of square roots and of automatic squaring.

9WW 387 for further details

G.E.C. ELECTRONICS

Data transmission equipment for sending information at 100 characters a second over telephone lines and incorporating error detection facilities is displayed. There are also four additions to the company's range of remote control and indication equipment. Also featured is the Lancon v.h.f. transceiver produced originally for the Lancashire Constabulary.

9WW 388 for further details

G.K.N.

The main feature of this stand is the range of G.K.N. Phillips "Pozidriv" recess screws. The advantages of the new shape (recess) are clearly shown by a colour film. Other products include weld bolts, crinkle washers and plastic mouldings.

9WW 389 for further details

G.P.O.

The data transmission service provided by the General Post Office is featured.

GENERAL CONTROLS

A complete range of precision wire-wound potentiometers and associated components are on display. Digital turns counters, indicating dials, precision turned knobs, locking control knobs, spindle locks and flush locks are also being shown.

9WW 390 for further details

GOODMANS

Loudspeakers from 2½in to 12in diameter for domestic applications are being shown, with a selection of speaker enclosures. Goodmans Industries Ltd. are also showing a range of speakers for public address applications.

9WW 391 for further details

H.C.D. RESEARCH

Several frequency standards, one of which has an accuracy of better than one part in ten to the tenth per day, and precision oscillators are being shown. Other exhibits include ranges of selenium rectifiers, silicon diodes and encapsulated bridge rectifiers from their German associates Semikron.

9WW 392 for further details

H.V.L.

The Syntec 150 multi-channel pulse height analyser from Linear Alpha Inc. and the Model 400 channel height pulse analyser from Radiation Counter Laboratories Inc. are being displayed. H.V.L. Ltd. are also showing the Stabimat digital drift stabilizer and a selection of scintillation crystals from the Kyoto Electronics Manufacturing Company, of Japan.

9WW 393 for further details

HATFIELD

Hatfield Instruments and Balun Ltd. are showing their standard range of instruments, which includes an r.f. bridge, a selection of a.c. power supply units, and an a.c. clip-on milliammeter. Hatfield are also showing a range of transmission test equipment manufactured to designs of the G.E.C. Telecommunications Division. An industrial television camera manufactured by A.C.E.C. (Ateliers de Constructions Electriques de Charleroi) of Belgium, is also being shown.

9WW 394 for further details

HAWKER SIDDELEY

The industrial electronics division of Hawker Siddeley Dynamics Ltd. are showing the data handling equipment which forms the basis of their electronic control and telemetry systems. They also have a display showing the manufacturing techniques they use in the encapsulation of equipment.

9WW 395 for further details

HENDREY RELAYS

In addition to a comprehensive display of industrial and aircraft relays, complete systems for fire-prevention control and examples of special scientific equipment are shown.

9WW 396 for further details

HENGSTLER

A panel of electromagnetic counters provides an eye-catching display. The demonstration is programmed to show typical examples of the predetermining and indicating properties of the F043 and FA043 series of counters.

9WW 397 for further details

HEWLETT-PACKARD

A broadband frequency synthesizer (0.01 c/s-50 Mc/s), which employs a 1 Mc/s internal standard having a stability of ± 3 parts in 10^9 per day, a digital voltmeter and sweep oscillators for the 1-4 Gc/s range are among the new equipment being shown.

9WW 398 for further details

HIGHLAND ELECTRONICS

A range of miniature push-button switches, miniature rotary switches and specials, including spring-return, unidirectional and concentric, are being shown. Other exhibits include miniature balanced armature microphones and miniature alarms.

9WW 399 for further details

HOFFMANN

This Dutch company, which has now formed a British subsidiary—J. H. Hoffmann (G.B.) Ltd., specializes in the production of chart paper.

9WW 400 for further details

HIRST ELECTRONIC

The company's products to be seen include stabilized power supplies, and a display of encapsulated assemblies. As agents for Hughes Aircraft Co., of California, they are showing their micro-welding head with capacitor discharge power pack.

9WW 401 for further details

HIVAC

Recent additions to the company's range of thermionic and electronic devices being shown include the XN3 digital display indicator and dry reed relay inserts. They are also showing their range of subminiature valves.

9WW 402 for further details

HONEYWELL

Items making their debut at the show include an on-line mass flow computer for measuring the flow rate of gases or liquids, an f.m. recorder/reproducer for the medical, scientific and industrial fields, and a 24-channel Visicorder oscillograph.

9WW 403 for further details

HUGHES INTERNATIONAL

Instruments and components are featured in this display. The components include a great variety of semiconductor devices and thermionic valves. The instruments include digital voltmeters, oscilloscopes and lasers. Welding equipment is also shown.

9WW 404 for further details

HUNT

All types of miniature and standard capacitors for electrical and electronic applications are being shown. Metalized film, metalized paper and film, and special printed circuit capacitors are included in the display.

9WW 405 for further details

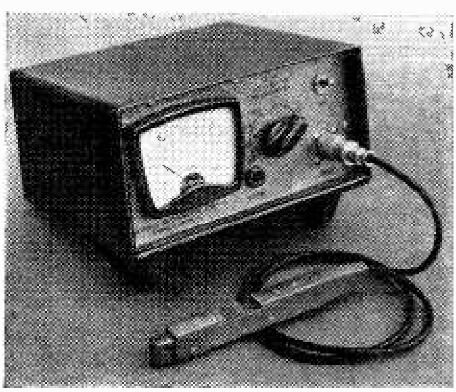
IMHOF

A selection from their extensive range of instruments and equipment racks, cases, consoles and accessories are on display.

9WW 406 for further details

INSTRON

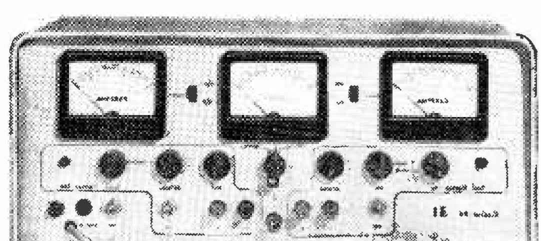
Instruments manufactured in the United States for testing materials



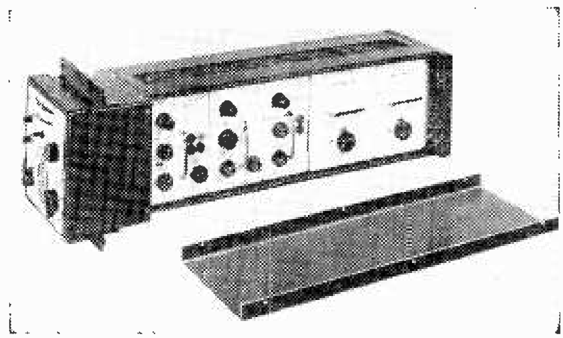
▲ *20c/s to 2Mc/s a.c. clip-on milliammeter, which measures current from 1mA to 10A, can be seen on the Hatfield Instruments stand.*

▲ *One of several dry-reed relays (Type XS4) shown by Hivac.*

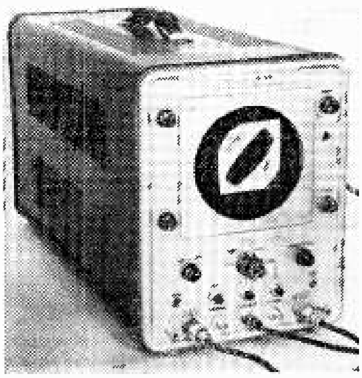
Bench power unit having two outputs of 0-50V at 2A ▼ *(International Electronics).*



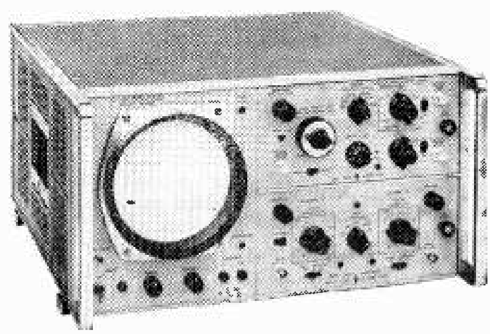
Mass flow computer introduced by Honeywell Controls.



Proportional, integral and derivative control in process control loops is provided by this instrument of Lancashire Dynamo.



Hughes 203 Tono-corder for the display of graphical data on a 5in storage tube.



Hewlett-Packard 140A oscilloscope with 5in c.r. tube and X & Y plug-in units.

are being shown. These include tensile testing machines, an optical extensometer and an environmental chamber.

9WW 407 for further details

INTERNATIONAL ELECTRONICS

Three bench power units, using the switch inductor method of stabilization, are introduced at the show, together with a digital voltmeter with four ranges giving four-digit readings up to 1, 10, 100, and 1,000 V.

9WW 408 for further details

IRELAND INDUSTRIAL DEV.

Information on the facilities offered to companies manufacturing in Ireland is provided by the Industrial Development Authority.

9WW 409 for further details

JENNINGS RADIO

This American company is featuring vacuum capacitors, vacuum power switches, and transfer and coaxial relays in vacua.

9WW 410 for further details

JOHNSON, MATTHEY

Several new developments are shown, of these the range of base- and noble-metal potentiometer wires are given prominence, as are the "Silver Star" capacitors and silver anodes. Other products on show include thermocouples, high-purity metal alloys and permanent-magnet material.

9WW 411 for further details

JOSEPH ELECTRONICS

The stand is divided into 4 sections, each part being allocated to the products of the companies represented by Joseph Electronics. The firms are Censor (Liechtenstein), Dürrwächter-Doduco-K.G. (W. Germany), Electrovac (Austria) and Witte and Sutor (W. Germany). The products on show range from components to measuring instruments and production machines.

9WW 412 for further details

KAPPA ELECTRONICS

Moisture meters, cold-cathode industrial control equipment, solid-state control devices, pressure switches and an oven are demonstrated. The oven utilizes a low-voltage magnetron producing 1 kW of microwave energy and the equipment is characterized by a simple push-button control system.

9WW 413 for further details

KERRY'S

Ultrasonic cleaning equipment, ranging from small bench units to multiple-tank cleaners, is being shown by Kerry's (Ultrasonics) Ltd. Other exhibits include ultrasonic drills, ultrasonic dip-tinning equipment and capacitor discharge stud welding equipment.

9WW 414 for further details

KEYSWITCH RELAYS

A complete range of Keyswitch type 3000 and 600 Post Office relays, and their latest P33 transistorized models, are on display. Other products on show include their low-cost Omron series of relays and their MH series of sub-miniature relays.

9WW 415 for further details

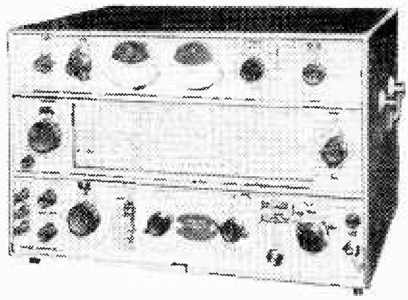
KOVO

A range of measuring instruments manufactured by TESLA and biological microscopes from Meopta Instruments are being shown on the stand of KOVO—the Foreign Trade Corporation of Czechoslovakia. A 3Mc/s millivoltmeter, precision capacitance bridge, "Q" meter suitable for operation up to 300Mc/s, a 1Mc/s universal counter, an a.m./f.m. signal generator and a stabilized power supply unit are included in the display.

9WW 416 for further details

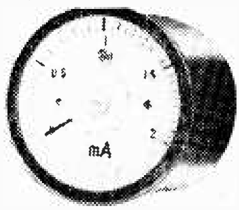
LANCASHIRE DYNAMO

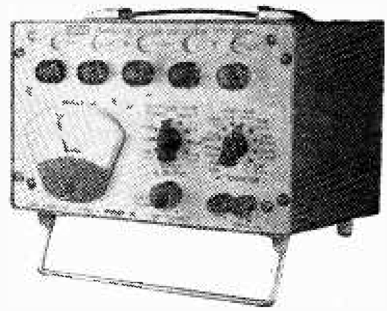
Controllers, recorders and photoelectric equipment are being shown. Among the controllers is a small



▲ *Solid-state signal generator (TF2002) covering 10kc/s to 72Mc/s in eight bands (Marconi Instruments).*

Nalder long-scale (240°) pointer meter. ▼





▲ *Levell transistor decade oscillator Type TG66A.*

temperature control unit (TCT1) employing a printed-circuit transistor amplifier and a three-term controller (3TC1) providing proportional, integral and derivative control in process control loops.

9WW 417 for further details

LECTROPON

Lectropon Ltd., which was formed last year to represent American and French countries in the U.K., is showing a selection of tuning forks manufactured by Time and Frequency of Batavia, Illinois. These tuning fork oscillators are claimed to have long term accuracies ranging from 50 parts in 10^6 to 1 part in 10^7, without the use of ovens.

9WW 418 for further details

LEEDS & NORTHRUP

A feature of this year's display is the Speedomax Type W potentiometric recorder which, with a calibrated chart width of 10in, is only 15in wide and 12in high. Other equipment on display includes several portable potentiometers, a Mueller bridge, a stabilized d.c. indicating amplifier and a bench type pH indicator.

9WW 419 for further details

LEEVERS-RICH

Equipment being shown for the first time by Leevers-Rich includes a new version of their 16 mm sprocketed magnetic film recorder, a servo-controlled transcription machine for automatically copying synchronous tape recordings to magnetic film tracks, and a closed loop deck for $\frac{1}{2}$ in or 1 in tapes and speeds of from $1\frac{7}{8}$ to 60 in/sec.

9WW 420 for further details

LEVELL

The transistor decade oscillator type TG66A and the universal counter timer type TM51B are the two latest instruments in the range manufactured by Levell Electronics Ltd. Other transistor instruments on show include several r.c. oscillators and a.c. voltmeters, and an a.c. amplifier which can be used to increase the sensitivity of an oscilloscope by 10 or 100 times.

9WW 421 for further details

LEWCOS

London Electric Wire Co. & Smiths are exhibiting their comprehensive range of insulated wires and strips, some of which are self-fluxing. Other exhibits include nickel-chrome and cupro-nickel resistance wires from the Vactite Wire Company, and a selection of printed circuit boards and cable forms from Printed Circuits Ltd. The latter company is also showing printed potentiometers and resistance units.

9WW 422 for further details

LINVAR

General purpose, instrument and oscilloscope trolleys are being shown along with samples of the racks, cabinets and cases, Linvar manufacture for the electronics industry.

9WW 423 for further details

LYONS, CLAUDE

In addition to showing their own a.c. automatic voltage stabilizers and high-current stabilized d.c. power supplies Claude Lyons are exhibiting instruments by seven American, three French and one Italian firm for which they are agents. The newly formed General Radio Company (U.K.) is sharing this stand and is showing several new instruments including the 1162A decade frequency synthesizer, the 1900A wave analyser and a tone-burst generator Type 1396A.

9WW 424 for further details

LUCAS

The products of four companies in the group are shown on this stand. Bradley's are showing, in addition to their range of lasers and established instruments two new calibrators, Types 125(a.c.) and 126(d.c.), providing a stabilized voltage supply. Rotax include a range of photo-electric shaft-angle encoders with accuracies up to five seconds of arc. Additions have been made to the range of Lucas power silicon transistors, and Joseph Lucas (Batteries) are showing a new range of lightweight silver oxide/zince cells and batteries.

9WW 425 for further details

M-E-C

Miniature Electronic Components Ltd. are showing a variety of wire-wound resistors and potentiometers with a range of miniature toggie switches, whose overall diameter is less than $\frac{1}{4}$in and which project only $\frac{3}{4}$in behind a standard instrument panel.

9WW 426 for further details

M.E.L. EQUIPMENT

The M.E.L. Equipment Company, a new company formed from Mullard Equipment Ltd. and Research & Control Instruments Ltd., is showing a selection of its telecommunication equipment, closed-circuit television and ultrasonic equipment, and a selection of electronic sub-assemblies.

9WW 427 for further details

M-O VALVE CO.

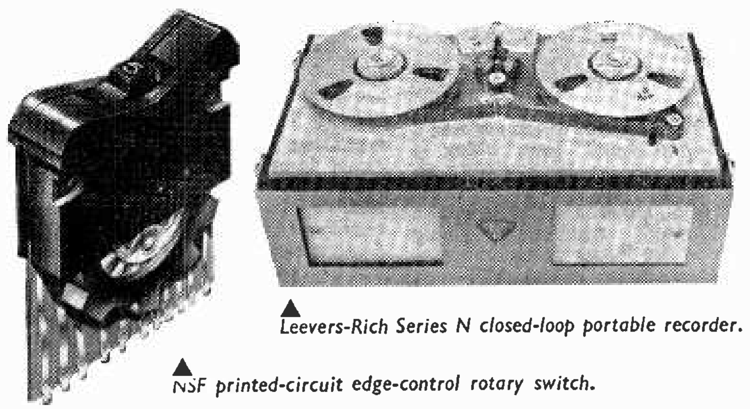
Among the many new devices being shown is a packaged semiconductor microwave generator for the 12-15 Gc/s band which has a power output of some 15 mW. Additions to the M-O range of c.r.ts is the rectangular screen 700E which has a display area of 45 × 24 mm and is primarily intended for the display of digital information. New valves include the E3008 directly-heated disc-seal triode. The extensive range of instruments and components displayed on this stand by Salford Electrical Instruments includes quartz crystal controlled transistor oscillators, capacitors and magnetic materials. The components group of G.E.C. (Telecommunications) is showing and demonstrating a wide range of electromechanical equipment suitable for use in data handling, remote control and electronic control systems. Of especial interest is a new relay with a volume less than 0.04 cu in and with a mechanical life expectancy of 50 million operations.

9WW 428 for further details

MAGNETIC DEVICES

A selection of relays, which the company manufactures for the electrical and electronic industries is being shown along with a selection of solenoids and sequence timers. Several coaxial and multiway connectors are also on display.

9WW 429 for further details



▲ Leevers-Rich Series N closed-loop portable recorder.

▲ NSF printed-circuit edge-control rotary switch.

MALLORY BATTERIES
Mercury, manganese alkaline and silver oxide cells are being shown in a number of different circuit applications.
9WW 430 for further details

MARCONI INSTRUMENTS
The full range of telecommunication measurement equipment is shown. However, particular prominence will be given to the "2000" range of modular instrumentation. Two new instruments are introduced at the exhibition, these are the solid-state, 10 kc/s to 72 Mc/s signal generator Type TF2002 and the transistor counter Type TF2401.
9WW 431 for further details

MARRISON & CATHERALL
A representative selection of the permanent magnets and "C" cores the company manufactures is being shown. Other exhibits include the results of a design study Marrison & Catherall has recently completed on magnets for use with reed switches and mass spectrometers.
9WW 432 for further details

MARTIN-IVO
Irion & Vosseler of West Germany, represented by Martin-Ivo, are showing for the first time in this country their comprehensive range of mechanical and electrical counters. Included in this is a complete series of totalizing and predetermining units with push-button and/or electric reset facilities.
9WW 433 for further details

McMURDO
The McMurdo Instrument Company is showing a selection of valve-holders, plugs and sockets, and ancillary items. Others exhibits include a miniature electrocardiograph, logic blocks and timing devices from Louis Newmark Ltd.
9WW 434 for further details

MEASURING INSTRUMENTS (PULLIN)
A selection of miniature and hermetically sealed voltmeters and ammeters are being shown. The new "Slimline" range of panel mounting instruments is included in the display.
9WW 435 for further details

MEC-TEST
Two types of heavy-duty proximity switches, known as Proximitron Type C, are featured. The inductive type detects ferrous and non-ferrous metal at distances of up to 1½ inches and can count up to 10,000 per minute. The ultrasonic type, counting up to 200,000 per minute, is actuated by the breaking of an ultrasonic beam.
9WW 436 for further details

MICROPONENT DEVELOPMENT
Varied examples of the company's photo-etching process are being shown. By this means small quantities of complex flat metal parts can be produced cheaper than by conventional presswork.
9WW 437 for further details

MOORE, REED & CO
Various types of synchros are being shown. The display includes control transmitters, transformers and differential transmitters, torque transmitters and receivers, resolvers, and phase angle generators. A wide variety of encoders are also on display.
9WW 438 for further details

MORGANITE RESISTORS
This year's display features a precision metal-film resistor, known as the Filmet, and a high-value glass-enclosed resistor known as the Megistor. Also exhibited is a wide range of ceramic and carbon composition resistors and potentiometers together with a variety of switches for light current applications.
9WW 439 for further details

MUIRHEAD
Several new products are being exhibited at this year's show for the first time. These include a transistor wave analyser covering the frequency range 3c/s to 30kc/s, a crystal calibrator, a resistor tolerance indicator with a sensitivity of $\pm 0.001\%$, and a five-decade Kelvin-Varley divider, which, while providing a constant load resistance, is accurate to $\pm 0.01\%$ down to a ratio of 1:100. Examples of their synchros and servo systems are also displayed.
9WW 440 for further details

MUREX
A number of instruments containing Murex sintered magnets and "Sincomax" magnets are being shown along with a new sintered magnet alloy, E.H.C., which is claimed to have the highest coercive force of all commercially available aluminium-nickel-cobalt-iron magnet alloys. They are also showing a range of tungsten, molybdenum, tantalum, niobium and zirconium products.
9WW 441 for further details

NSF
A printed circuit 10-position edge control rotary switch is introduced by NSF who are also showing their full range of "Oak" and "Cutler-Hammer" switches. Among other items of interest are Holzer timers, which are now manufactured under license by NSF, and the NSF/Union range of miniature hermetically sealed relays.
9WW 442 for further details

NALDER & THOMPSON
Long-scale pointer meters in small sizes (2½ × 4 in) are shown. These have low-inertia movements for use under conditions of vibration and shock.
9WW 443 for further details

NUCLEAR ENTERPRISES
This U.K. associate company of the Canadian organization of the same name is showing nucleonic instruments and radiation detectors.
9WW 444 for further details

OLIVER PELL CONTROL
Beside the standard range of a.c. and d.c. solenoids, motors and coils, the new, improved Varley range of miniature, plug-in relays is shown. New features of this last component include glass-filled, nylon bobbins, all-silver contacts gold-flashed and relay covers manufactured from transparent, non-gassing polycarbonate material.
9WW 445 for further details

P & H ENGINEERING
Samples of the standard instrument cubicles, cases, cabinets and consoles manufactured by this firm are being shown.
9WW 446 for further details

P.S.B. INSTRUMENTS
A strain and stress measuring bridge and a number of slow-run actuators are the latest products to join the P.S.B. range of educational and industrial instruments being shown this year. A wide range of gears and gear boxes for use with small synchronous motors for timers, chart drives, etc., are also on display.
9WW 447 for further details

PACKARD
Packard Instrument Ltd. is showing a selection of spectrometers and scintillation detectors. Other exhibits include spectrometer systems for medical, chemical, and industrial research applications, and a number of systems for gas chromatography.
9WW 448 for further details

PAINTON
Production models of a new wire-wound trimmer potentiometer are being shown. This is a version of the Painton Flatpot series and is only $\frac{5}{16}$in sq and $\frac{3}{4}$in long. It is available with standard ohmic values from 10Ω to 10kΩ. Gold flashed terminals designed to be used as printed circuit pins or as solder spills are also being shown.
9WW 449 for further details

PALMER, G. A. STANLEY
The exhibits include rechargeable batteries, high-stability, carbon-film, metal-film and wire-wound resistors, capacitors, switches and hardware such as valve holders, knobs, plugs and sockets.
9WW 450 for further details

PARAMATIC
A digital follower, for continuous monitoring of machine tools, is being shown by the machine tool control manufacturers Paramatic Engineering Ltd. Other exhibits include an electro-mechanical braking device suitable for high-speed operation and an electro-mechanical measuring unit with an accuracy of 0.0005 in over a 6 in range.
9WW 451 for further details

PERKIN-ELMER
A comprehensive range of instruments covering the fields of spectroscopy from the ultraviolet to the infrared can be examined. Also, equipment with applications in the fields of atomic absorption, gas chromatography and nuclear magnetic resonance is shown.
9WW 452 for further details

PHOTOELECTRONICS
Photoelectric and electronic aids to automation are featured in this year's show. This includes a 6-amp solid-state switch for controlling solenoids at high speed, a photoelectric infrared burglar alarm and long-life indicator lamps.
9WW 453 for further details

PLANNAIR
The Plannette range of axial flow blowers is being shown at this year's show. Two new models, one with a 10 in diameter and the other with a 12 in diameter, have been added to their range.
9WW 454 for further details

PLATON
Flowmeters in a variety of types and sizes are shown together with accessories, including a photo-transistor alarm device.
9WW 455 for further details

PLESSEY
The Plessey Company is showing a wide range of components this year. New components include a range of sub-miniature micro switches, miniature 3-pole two-way slider switches, illuminated push-button switches, high-stability tantalum electrolytic capacitors and two new types of potentiometers. Other exhibits include 50 c/s and 400 c/s servo units from Ketay, electro-luminescence devices and photo-resistors from Ericsson Telephones, and a selection of products from Semiconductors Ltd.
9WW 456 for further details

POTTER
Three magnetic tape machines and a new "Quick-Lock" hub, which is claimed to cut the loading time on computer tape systems by an average of 80%, are among the American manufactured equipment being shown by the Potter Instrument Co.
9WW 457 for further details

PYE
Six companies in the Pye group are sharing the stand on which will be found laboratory instruments, including the new pH meter (Model 79) made by W. G. Pye, the range of transistors and "packaged circuits" produced by Newmarket Transistors and crystals and crystal ovens of Cathodeon. Medical equipment, including a cardiac pacemaker and a speech aid for the rehabilitation of laryngectomy patients, is shown by Pye Laboratories. Vibration test equipment (Pye-Ling) and a wide range of switches and control equipment by Pye Switches are also shown.
9WW 458 for further details

R.C.A. GREAT BRITAIN
Of particular interest among the semiconductors on show is the TA2307 silicon transistor which has an output of over 3 W at 400 Mc/s. Also on show are vision tape recorders, a television film projector and distance measuring equipment.
9WW 459 for further details

RAACO
A comprehensive selection from the large range of Danish-manufactured industrial storage cabinets is on display.
9WW 460 for further details

RACAL
Several examples of Racal communication equipment are being shown, including their latest transistor h.f. receiver, the RA. 217. Among the instruments featured are the type SA.535 transistor universal counter/timer, four digital frequency meters—two of which are portable instruments—and two frequency standards.
9WW 461 for further details

RANK CINTEL
The 18920/1 transistor power pack introduced by Rank Cintel is designed to deliver 6 to 30 volts at up to 500 mA. A 9 in Matricon alphanumerical display tube is among several new c.r.ts and photoelectric cells. Latest in the family of Systron counter timers is Model 1014, an h.f. counter.
9WW 462 for further details

RECORD
The Record Electrical Company are exhibiting a number of electrical measuring instruments, the latest of which is a 4 in graphic recorder.
9WW 463 for further details

RELIANCE CONTROLS
Reliance Controls Ltd. are showing their wide range of fixed and continuously variable potentiometers. Both wire-wound and helical types are included.
9WW 464 for further details

RELIANCE GEAR
Apart from gears, the exhibits and demonstrations include magnetic clutches, bevel mitre boxes, speed reducers and limit stops. One of the demonstrations consists of a new heavy-duty, shaft angle encoder having 1,000 counts per revolution and capable of operating at 300,000 counts per minute.
9WW 465 for further details

ROBAND
A range of four oscilloscopes, each based on the Roband "5" series of interchangeable plug-in units, is introduced. Also shown is a range of data handling equipment, including digital voltmeters and remote read-out units, and a selection of stabilized power supplies.
9WW 466 for further details

ROSS, COURTNEY
Insulated and non-insulated "Sta-Kon" terminals are being shown with associated hand and power installing tools. Other exhibits include "Kent" strip terminals and automatic machines, "Ty-Rap" nylon cable straps and ties together with installing tools, and "Oddie" fasteners.
9WW 467 for further details

ROYAL WORCESTER
Royal Worcester Industrial Ceramics Ltd. are showing their full range of ceramic/metal terminals, bushings and stand-off insulators, and wafer-thin substrates. They are also showing examples of components manufactured to customers' requirements.
9WW 468 for further details

ROYCE ELECTRONIC FURNACES
The main exhibit consists of a furnace used for diffusion processes (transistor manufacture). S.c.r. temperature-control units are utilized and a uniformity of $\pm 1°C$ is guaranteed in the high-temperature zones.
9WW 469 for further details

S.E. LABORATORIES
The full range of equipment manufactured by S.E. Laboratories and its subsidiary company Meter-Flow is being shown. This includes galvanometer recorders, transducers, demodulators, strain-gauge amplifiers, oscillators and flowmeters.
9WW 470 for further details

SGS-FAIRCHILD
More than half of this stand is devoted to integrated silicon microcircuits. There will be found additions to the family of epitaxial micrologic circuits and a flip-flop, designated the μL916, which is a complete storage element in a single chip of silicon. Also being shown is a family of seven milliwatt micrologic circuits with a power dissipation of 2 mW/node. Several new

transistors, including the 2N3014 and 2N3137 n-p-n silicon planar types, are to be seen.

9WW 471 for further details

S.T.C.

In the field of micro-electronics S.T.C. is featuring the "Ministac" system of modular circuit construction and showing examples of integrated and thin-film circuits. Among the semiconductor devices shown is an epitaxial planar switch, a new 5-amp silicon avalanche rectifier and "Silring" silicon rectifier stacks. New valves include the LS950 travelling wave amplifier and an L-band klystron. Magnetic materials and a wide variety of components are also included.

9WW 472 for further details

SALTER, GEO.

George Salter & Co. Ltd. are exhibiting a selection of circlips, fasteners and springs they have produced for the instrument and electronic industries.

9WW 473 for further details

SANDERS

A representative selection of equipment from W. H. Sanders (Electronics) Ltd. is being shown. This ranges from precision gears and gear boxes to microwave and industrial control equipment. A number of kits the company produces for educational purposes are also featured.

9WW 474 for further details

SANGAMO WESTON

A selection of instruments, ranging from laboratory standards to miniature panel instruments, are being shown. Another exhibit is the Sangamo magnetic tape instrumentation system.

9WW 475 for further details

SASCO

Products of four American manufacturers—Yellow Springs Instruments, Self Organizing Systems, Kings Electronic Co. and American Super-Temperature Wires—are shown, together with information on the products of nearly 30 other companies for which SASCO are agents.

9WW 476 for further details

SCAMA

Examples of Scama annunciators, including remote relay annunciator components and accessories are on display. The Series 700 solid-state annunciator is being shown for the first time.

9WW 477 for further details

SCOTT

A new data logging system is introduced by James Scott (Electronic Engineering) of Glasgow, who are also showing a travelling wave tube power supply unit, an e.h.t. power unit and an aerial radiation pattern recorder.

9WW 478 for further details

SERVICE ELECTRONIC CO.

Various types of industrial fans, blowers and electric syrens are being displayed. Included in the display is a flat axial-flow fan with a flange-to-flange measurement of only 1⅝in and a free air displacement capacity of 95 cu ft-min.

9WW 479 for further details

SERVO CONSULTANTS

The waveform generator Type 130 and the electro-hydraulic vibration table Type 175 are among the pieces of equipment featured this year. The generator produces cyclic voltage waveforms of any shape by means of pattern discs.

9WW 480 for further details

SLEE

The South London Electrical Equipment Company are exhibiting their micro welding machine, which will weld wires and tapes, down to 6 microns thickness, to metallized laminated surfaces, to micro circuits on glass substrates and to semiconductor surfaces.

9WW 481 for further details

SMITHS

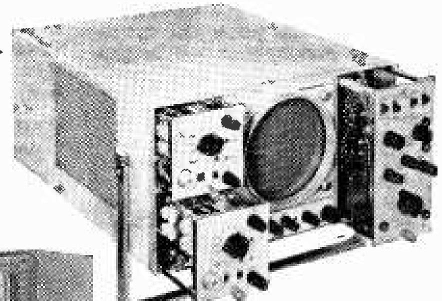
Five divisions of the Smiths organization are participating although most of the equipment shown and all the new items are from the Industrial Division. The equipment on show for the first time in the U.K. includes an electronic tachometer, solid-state temperature controllers, new pen recorders with transistor amplifiers and attenuators, two slidewire potentiometric recorders and Motorola telemetry equipment.

9WW 482 for further details

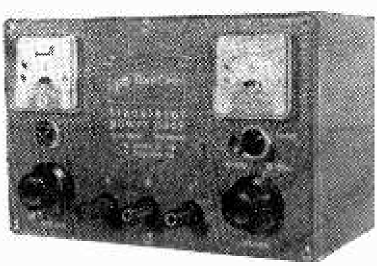
SOLARTRON

Several new Solartron instruments are being shown for the first time. Among these is a 5-in double-beam oscilloscope with plug-in X and Y amplifiers and an integrating digital

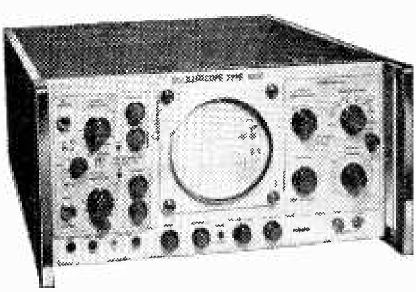
Solartron CD140 with 5in double-gun c.r.t. and plug-in X and Y units. ▶



Transistor power pack (18920/1) to deliver 6-30V at up to 500mA (Rank Cintel). ▼



This portable power-crimping tool is being shown by the Plessey Company. ▶



▶ *One of the series of Roband oscilloscopes (RO50).*

voltmeter. A selection of their current instruments is also being shown. In addition to their own equipment, products from overseas companies—who they are connected with—are being displayed. An a.c./d.c. digital voltmeter from Rochar Electronique is included in this section.

9WW 483 for further details

SPERRY
More than a hundred electrical servo components are on show along with several systems Sperry have introduced for industrial control applications. Among the working demonstrations is one showing Sperry's data transmission and logging equipment. Another shows a new solid-state digital system capable of handling from six to many thousands of parameters.

9WW 484 for further details

STEATITE
A selection of the miniature and subminiature ceramic components manufactured by Steatite Insulations Ltd. is being shown. A wide range of ceramic capacitors is also being exhibited.

9WW 485 for further details

STRATTON
Several Eddystone receivers are on show this year together with a range of panoramic display units. These units, which are suitable for use with the Eddystone range of receivers and some others, provide a visual display of any received signal and are intended for both operational and laboratory applications.

9WW 486 for further details

T.C.C.
New ranges of plain and etched tantalum foil tubular capacitors, plug-in plastic-case electrolytics for printed circuits, monolithic ceramic capacitors, "Hikonol" energy storage capacitors for laser applications and subminiature electrolytics for potted assemblies are among the components selected for exhibition. A display of T.C.C.-Sprague components is also included.

9WW 487 for further details

T.M.C.
In addition to showing a selection of their own capacitors, the Telephone Manufacturing Company is showing capacitors produced by Pirelli Applicazioni Elettroniche of Italy and the General Instrument Corporation of the U.S.A. Other exhibits include a variety of push-button and lever keys, Carpenter polarized relays, read-out counters and solid-state circuit elements. Data transmission equipment is also being shown.

9WW 488 for further details

TANNOY
Examples from the wide range of equipment available for public address, sound reinforcement, and audio systems for particular circumstances—flameproof, inductive loop, etc.—are on show. Tannoy are also showing transducers for environmental vibration testing.

9WW 489 for further details

TAYLOR INSTRUMENT
Taylor Instrument Companies (Europe) Ltd., formerly Taylor Controls Ltd., are showing a selection of the electronic and pneumatic instruments they manufacture for the process industries.

9WW 490 for further details

TECHMATION
As agents for the Infotronics Corp., of America, this company is showing their new automatic electronic digital integrators. They are also showing equipment manufactured by Micro-Tek Instruments of the U.S.A.

9WW 491 for further details

TECHNA (SALES)
A range of E-T-A miniature circuit breakers for single and three phase use with ratings from 50 mA to 30 A are featured.

9WW 492 for further details

TECHNOGRAPH
Technograph & Telegraph Ltd.—a new company resulting from the merging of the printed circuit division of the Telegraph Condenser Company with Technograph Electronic Products Ltd.—are showing circuits made by a new process which, they claim, are cheaper to make than those using standard etched foil techniques. A complete range of etched foil processed circuits are also exhibited.

9WW 493 for further details

TEDDINGTON
Teddington Aircraft Controls Ltd. are exhibiting a representative selection of their precision logging and monitoring instruments. These consist of potentiometric pressure transducers and miniature potentiometers.

9WW 494 for further details

TEKTRONIX
The type 647, d.c. to 50 Mc/s, oscilloscope is one of the latest instruments to be added to the Tektronix range of oscilloscopes. A selection from their current range of instruments, many of which are of modular construction, is being shown along with their auxiliary instruments and accessories. The sensitivity of the type 647 is 10 mV per cm.

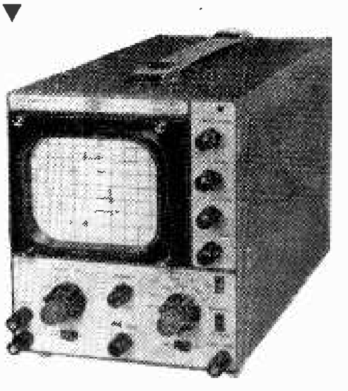
9WW 495 for further details

TELCON METALS
Glass sealing alloys with a super-fine finish and a wide range of thermostatic bimetals are included in this year's display. Other exhibits include a range of transformer, transductor and choke laminations from Magnetic and Electrical Alloys Ltd., a range of "C" type cores from Telcon-

(*Continued on page* 293)

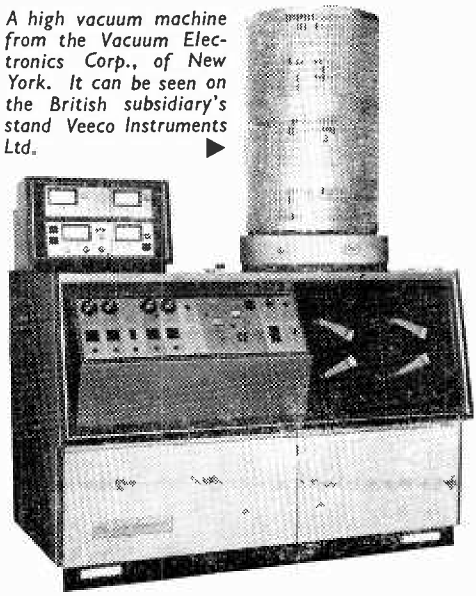
▲ *Some of the industrial cathode ray tubes being shown by Thorn-A.E.I. Radio Valves & Tubes Ltd.*

Telequipment Type S51A oscilloscope with calibrated sweep speeds from 100msec to 1μsec per cm. ▼

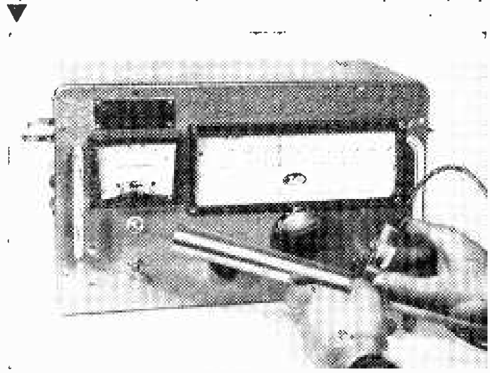


Single gun electrical storage tube from 20th Century Electronics. ◀

A high vacuum machine from the Vacuum Electronics Corp., of New York. It can be seen on the British subsidiary's stand Veeco Instruments Ltd. ▶



A film thickness meter from the Ultrasonoscope Company. ▼



Magnetic Cores Ltd. and a selection of resistance wires from Temco Ltd.
9WW 496 for further details

TELEDICTOR
A selection of s.c.r. power supply units, with outputs of up to 100 amps at 250 volts, are being shown. A series of electronic timers and a number of transformers are included among the other exhibits.
9WW 497 for further details

TELEQUIPMENT
The full range of oscilloscopes is both shown and demonstrated. The new instruments include the Type S51A, which has a 5in, flat-face tube and calibrated sweep speeds from 100msec/cm to 1μsec/cm and the Type S51E which is an oscilloscope specifically designed for educational use.
9WW 498 for further details

THERMAL SYNDICATE
Examples of pure fused quartz and silica, and of high temperature refractories, are being shown. These include "Spectrosil," a high-purity silica, with high transmittance in the ultraviolet region.
9WW 499 for further details

THORN
The Thornvision closed-circuit television equipment forms the major part of a display of control equipment from Thorn Electronics Ltd. Thorn's special products division is showing a wide range of exhibits in the components field, including electroluminescent lamps.
9WW 500 for further details

THORN-A.E.I.
Thorn-A.E.I. Radio Valves and Tubes Ltd. are exhibiting a wide range of valves and cathode ray tubes under their brand names Brimar, Mazda and Ediswan (export). The recently formed industrial cathode ray tube division is showing several new tubes, including a camera viewfinder tube of extremely compact dimensions and two p.p.i. tubes for transistor radar applications.
9WW 501 for further details

TINSLEY
Precision components and laboratory measuring instruments are being shown. An interesting exhibit is a six-figure low resistance potentiometer, known as the Stabaumatic Type 5545, reading from zero volts to 1.51110 V.
9WW 502 for further details

TOPPER CASES
A variety of cases, including some for scientific instruments and radio equipment, in leather, plastics, covered board, etc., is shown.
9WW 503 for further details

TRANSITRON
A new version of the Transwitch—an s.c.r. device which can be turned "off" at the gate—with a current rating of 5 amps and a bilateral switching diode, which will replace two s.c.rs in certain full-wave phase controlled applications, are featured this year. Other exhibits include many examples of their semiconductors, integrated circuits and special encapsulations.
9WW 504 for further details

TRUMETER
A selection of electrical and mechanical counters is being shown. The "Excelsior" digital control "brick" is included in the display.
9WW 505 for further details

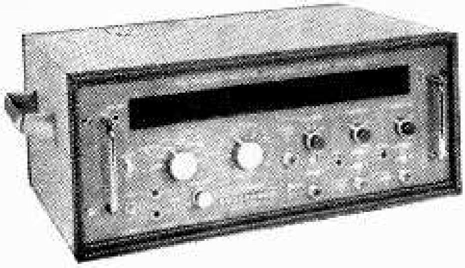
TURTON BROS. & MATTHEWS
A comprehensive selection of permanent magnets is being displayed. Magnets with brazed polepieces, for various instrument applications, and magnets for use in reed relays are among those in the display.
9WW 506 for further details

20TH CENTURY
Cathode ray tubes, storage tubes and photomultipliers are on show this year. A fully automatic mass spectrometer leak detection equipment, for individually leak-testing small sealed components, is among the other exhibits on display.
9WW 507 for further details

ULTRA
The four divisions of the company—Control and Instrumentation, Automated Business Systems, Special Products, and Telecommunications—are all participating on this stand. The display includes industrial control systems, ultrasonic equipment (including the recently introduced aid for the blind), communication sets and audio equipment.
9WW 508 for further details

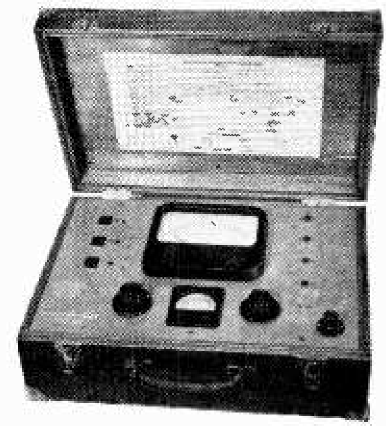
ULTRASONOSCOPE
Ultrasonic testing instruments with a varied selection of probes are being shown this year. The Ultrasonoscope dual-channel alarm units and surface film thickness meters are included among the other exhibits.
9WW 509 for further details

UNION CARBIDE
Solid tantalum capacitors, barium getters, semiconductor silicon, silicon monoxide and a range of industrial crystal products including synthetic gems for masers and lasers are shown.
9WW 510 for further details



▲ *Venner TSA3338 time/frequency measuring instrument.*

Carpenter-type relay test set (Whiteley). ▶



VACTRIC
A.C. and d.c. servo motors, a.c. tachogenerators, servo gearheads, rotary sampling switches and bread-board components are included in this year's display. A range of Ugon subminiature relays is being shown, and also the new Vacsyn slow-speed (60 r.p.m. at 50 c/s) synchronous motor.
9WW 511 for further details

VEECO INSTRUMENTS
Two ionization gauge control instruments, the RGLL-6 and the RGS-6, and a high vacuum machine are being shown. These products are manufactured by the parent company, the Vacuum-Electronics Corporation of New York.
9WW 512 for further details

VEEDER-ROOT
Electronic, electrical and mechanical counters including one remotely driven by a stepping motor and programmed by a solid-state circuit, are being displayed.
9WW 513 for further details

VENNER ELECTRONICS
A pre-production model of the TSA 3338 time/frequency measuring instrument is on show. It has an 8-digit in-line projection display and can be used to measure direct frequency up to 50 Mc/s and time in units of 0.1μsec. Among other instruments, for industry and research, being shown this year is the Type TSA 648 variable rise time pulse generator. Another is the TSA 65 transistorized digital printer.
9WW 514 for further details

WANDLESIDE
Equipment wires with and without screening are being shown. Other exhibits include p.t.f.e. multicore instrumentation cables, flame-resistant cables for continuous operation at 260°C, or at 1,100°C for five minutes, and a selection of r.f. coaxial cables.
9WW 515 for further details

WAYCOM
The Wima range of polyester, paper and low-voltage electrolytic capacitors made by Wilhelm Westermann, of West Germany; Piher carbon film resistors from Spain; Fujisoku subminiature switches from Japan; and S.E.C.M.E. switches and connectors made in France are being displayed.
9WW 516 for further details

WAYNE KERR
A number of new bridges, including the "Autobalance" and the recently introduced "Midge" types are on display. Also on show is a comprehensive display of instrumentation for the accurate measurement of displacement and vibration, the generation of audio, video and pulse signals, and the analysis and equalization of control systems. The "Digitec" series of voltmeters is also featured.
9WW 517 for further details

WELMEC
The Welmec Corporation Ltd. is showing a selection of products of the West German companies which it represents. These include: xenon, mercury and spectral lamps from Osram G.m.b.H.; and electrical components, portable electric tools and a sheet metal shear machine—with a cutting capacity in mild steel of 14 gauge—from A.E.G.
9WW 518 for further details

WELWYN ELECTRIC
Two new ranges of insulated metal film resistors and a new range of vitreous enamelled wire-wound resistors have been added to Welwyn's comprehensive display of resistors. Examples of their film networks and micro-electronic assemblies are also being shown.
9WW 519 for further details

WESTOOL
Electric and electronic control equipment and components are featured at this year's show. This includes a wide variety of a.c. and d.c. solenoids, chokes and transformers. The Sonac range of ultrasonic sensing and switching equipment is also being shown.
9WW 520 for further details

WHITELEY
Instruments on show include a variety of Post Office test sets, cable location equipment, variable r.f. attenuators, variable decade boxes and a test set for checking Carpenter relays. Encapsulated audio amplifiers, oscillators and transformers, the Whiteley range of loudspeakers and amplifiers and the radio sonde are also exhibited.
9WW 521 for further details

WIRE PRODUCTS
As suppliers of "components of components" Wire Products & Machine Design are displaying an extensive range of pins, wires, rivets, printed circuit connectors and glass-to-metal seals.
9WW 522 for further details

WODEN
The Woden Transformer Company is displaying a comprehensive range of torque motors, transformers and chokes, and a wide variety of patch-boards, card readers and wire contact relays.
9WW 523 for further details

WOOD, HUGH, & SON
A selection of transistor test equipment, for measuring d.c. parameters of n-p-n and p-n-p devices on a "go"-"no-go" basis, is included in the variety of Baird-Atomic products being shown. This includes a full range of nuclear equipment for medical, biological and industrial applications.
9WW 524 for further details

ZEAL
Among the many types of thermometers made by these specialists are included miniature sensing elements based on thermistors.
9WW 525 for further details

LETTERS TO THE EDITOR

The Editor does not necessarily endorse opinions expressed by his correspondents

Thévenin and Norton

WITH reference to Fig. 4 in " Cathode Ray's " interesting paper on the Thévenin and Norton theorems (January 1964 issue), the very correct statement is made that $r_a i_a^2$ differs from the anode dissipation $\tilde{P}_a$ (the internal power loss) when the tube is in operation. This does not, however, rule out the calculation of $\tilde{P}_a$ with the aid of the equivalent a.c. generator, provided that the plate dissipation P_a without signal is known to us, and provided that we do not fail to acknowledge that there must exist an input signal power $\mu v_g i_a$ to the equivalent generator, which power can only come from P_a. Thus the impossible relation and the true relation become

$$\tilde{P}_a = r_a i_a^2 \text{ (false)}, \quad \tilde{P}_a = r_a i_a^2 - \mu v_g i_a + P_a \text{ (true)}.$$

The author derived this formula in 1944.[1]

" Cathode Ray " brings out some interesting aspects of Thévenin's and Norton's theorems, and I should like to take the opportunity to bring out some of the thoughts prevailing on this side of the Atlantic, and also to bring out some of the limitations of the theorems in the calculations of tube and transistor networks.[2] Although Thévenin's theorem originally was stated for d.c., we boldly go ahead today and use it in the periodic steady state, with sinor variables, and in transient calculations, with phasor variables. Further, Thévenin's sources were independent, but a large number of the sources we encounter today in tube and transistor networks are dependent. The theorem formulation gives us no clue to the treatment of any kind of dependent sources. Accordingly, errors often result when students attempt to apply this theorem and the related Norton theorem. One rather common error is that students occasionally list r_a of a tube amplifier as the output resistance. When the source μv_g is dependent, meaning that it is a function of a current or voltage somewhere else in the system, r_a is not the output resistance. Following the classical theorem formulation, we would " passivate " the network by eliminating all sources to obtain the series resistance in the equivalent, but with dependent sources present we cannot do this and then enter the open circuit output voltage in series to complete the equivalent generator. (The equivalent only becomes correct if we enter a modified form of the open circuit voltage.) Many students are at a loss when trying to apply the theorems to rather common tube and transistor networks, and clearly a " modified " theorem is badly needed; one that is valid under all conditions. The author has formulated such a theorem, intended to replace the Thévenin and Norton theorems in the analysis of tube and transistor networks, but before we discuss this new theorem, let us take a look at a simple application example.

The network in Fig. 1(a) may represent a part of a tube or transistor amplifier network, and is symbolic for the way in which a dependent source enters in, although the dependent source may not appear precisely in this fashion. Except for the dependent current source kI_1, the network is in principle the same as that shown by " Cathode Ray " in his Fig. 2(a). Apparently, we cannot open the function source in a formal application of Thévenin's theorem to obtain the equivalent in Fig. 1(b). We can open the source kI_1 and obtain R as equivalent generator resistance, but the voltage source required in series then differs from that prescribed by the Thévenin theorem. The student ultimately finds ways to determine the equivalent network in Fig. 1(b), but he is not securing the result by a direct application of the Thévenin theorem. As an example, he may write $E^* = V_{open}$, and then make use of the Applied Source Method to determine R^* (applying a measurement voltage to the terminals in Fig. 1(a) with $E_1 = 0$). As another alternative, he may determine the short-circuit current and then apply Ohm's law, thus obtaining $R^* = V_{open}/I_{short}$. But this is a more elaborate procedure then to have available a theorem that gives R^* merely upon inspection of the network.

E^* and R^* in the equivalent network in Fig. 1(b) are as follows

$$V_{open} = E^* = \frac{(1 + k)\, R_2 E_1}{R_1 + (1 + k)R_2} \quad \ldots \quad \ldots \quad (1)$$

$$R_{out} = R^* = \frac{R_1 R_2}{R_1 + (1 + k)R_2} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

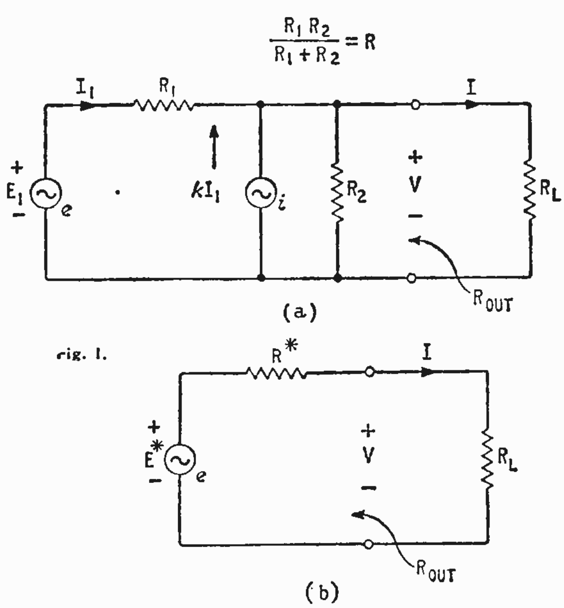


Fig. 1.

[1]H. E. Stockman " The Validity of the Equivalent Plate-Circuit Theorem for Power Calculations," *Proc. I.R.E.*, Vol. 32, No. 6, June 1944.

[2]The history of Norton's contribution to " Norton's theorem " is as follows.

The first statement of the theorem pertains to a patent communication of November 3, 1926 (unpublished). It reads " It is ordinarily easier, however, to make use of a simple theorem which can readily be proved that the effect of a constant voltage E in series with an impedance Z and the network is the same as a current I = E/Z into a parallel combination of the network and the impedance Z." The first published statement of the theorem appeared in the first edition of professor W. L. Everitt's book on network theory, which must have been published in the late 1920's or early 1930's. Professor Everitt visited Bell Telephone Laboratories and talked with R. V. L. Hartley. Mr. Hartley mentioned the theorem, and gave Norton the credit for originating it. (Personal correspondence with E. L. Norton, April 24, 1963).

It is apparent from this that both the Thévenin theorem and the Norton theorem were originated for *independent sources* only. It is therefore logical that the theorems fail when applied to dependent sources, and that a new theorem is needed to handle dependent (and independent) sources.

The conventional Thévenin theorem gives (1) but not (2), so when we talk about a modification of the theorem, we are merely talking about some new way of obtaining (2). The theorem to be described provides precisely this, and it does so in an exceedingly simple and direct fashion. The theorem is equally valid for impedance and admittance; both here referred to by means of the term immittance. Further, this immittance may be a complex quantity, such as $j\omega L$ in periodic steady-state problems, or a Laplace Transform, such as sL in problems on transients. It is a foregone conclusion that the transfer function we are using truly represents the network under discussion, and as an example here R_{out} could not very well be obtained from a current ratio transfer function, leaving the input open. The new theorem has the following formulation:

A linear network with any arrangement of dependent and independent sources may with reference to a specified port be represented by an equivalent generator with an immittance equal to the denominator of vanishing load immittance in the selected transfer function, and with the open port voltage in series or the closed port current in parallel.

We note that this theorem replaces both Thévenin's and Norton's theorems. The port mentioned in the theorem is the selected or observed terminal pair. Usually, the driving generator, which may be a signal generator in the laboratory occupies the other port in the typical two-port configuration of a tube or transistor amplifier. Applying the new theorem to the network used as an example in Fig. 1(a) we probably already have the transfer function in (1) available in its complete form, which is

$$\frac{V}{E_1} = \frac{(1+k)\,R_2\,R_L}{R_1\,R_2 + [R_1+R_2\,(1+k)]\,R_L} \quad \cdots \quad (3)$$

Inspecting the denominator, we produce R_L as a single term and let it vanish, following the theorem formulation. The result is $R_{out} = R^*$ as given by (2). This method is much faster than the Applied Source Method, and very often R^* is determined in the matter of seconds. Since this theorem holds for all kinds of sources, it makes the Thévenin and Norton theorems superfluous. While these theorems employ a briefer transfer function, they require inspection of the network to determine the combination resistance, but nevertheless fail to handle dependent sources. The new theorem extends the transfer function to the load, but no inspection of a known network diagram is required since the transfer function denominator gives the generator immittance, and dependent sources are handled just as easily as independent sources.

If the output immittance only is of interest, the theorem shrinks to the following form:

The output immittance is the denominator of the selected transfer function as the load immittance vanishes.[3]

This practical theorem is becoming known in the U.S.A. under the name the "Denominator Output Immittance Theorem," and the time-saving feature of this theorem shall now be demonstrated by means of three typical transistor transfer functions:

$$\frac{I_2}{I_1} = \frac{-z_{21}}{z_{22} + Z_L} \quad \text{yields directly } Z_{out} = z_{22},$$

$$\frac{V_2}{V_1} = \frac{-h_{21}}{\Delta h + h_{11}Y_L} \quad \text{yields directly } Y_{out} = \frac{\Delta h}{h_{11}},$$

$$\frac{I_2}{I_1} = \frac{-1}{a_{12} + a_{11}Z_L} \quad \text{yields directly } Z_{out} = \frac{a_{12}}{a_{11}}.$$

It is hoped that this discussion of Thévenin's and Norton's theorems may serve as a useful extension to "Cathode Ray's" timely paper and that it will illuminate the limitations of the classical theorem formulations.

Lowell, Mass., U.S.A. H. E. STOCKMAN
Lowell Technological Institute.

H. E. Stockman "Three Output Immittance Theorems," *Electronic Industries*, January, 1958.

Automatic Error Correction

THE article by Mr. P. R. Keller in the February and March issues gives a concise description of error-correcting codes and the Marconi "Autospec" system.

It seems probable that regeneration of the received signal is inherent in the "Autospec" equipment. This being so, improvement, due solely to use of the error-correcting code, is not apparent and a fairer comparison would be of a regenerated teleprinter copy and the "Autospec" copy. Perhaps Mr. Keller could provide some figures.

In Fig. 3 almost 100% of the checkable corruptions are due to extra Z elements whereas at least 90% of the checkable corruptions in Fig. 4 are due to extra A elements (assuming that an A.T. & E. coder was used for the tests shown in Fig. 4). Is this due to the controller test conditions or was a bias control overlooked?

Winchester R. A. JUBB

The author replies:

As Mr. Jubb surmises, regeneration is included in the "Autospec" equipment which has a margin of not less than ± 45% against distortion of the received signal. The margin of a teleprinter would be of the order of ± 30% to ± 42% dependent on adjustment, and may, or may not, be balanced. Some improvement might be due to this factor alone, but this is small in comparison with the improvements resulting from (a) the use of synchronous as opposed to start-stop working, and (b) the use of the error-correcting code.

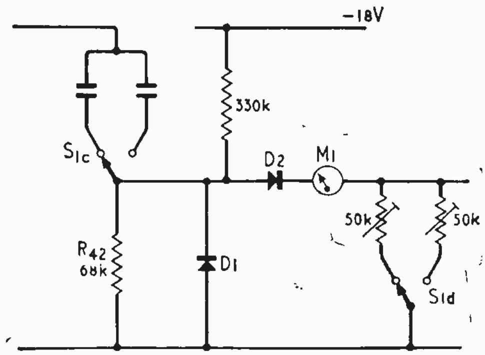
The order of improvement resulting from these causes is indicated in Table IV (p. 121, March issue), which relates to basic element error rates.

The arrangements for the tests shown in Figs. 3 and 4 were typical of practical cases, and, as Mr. Jubb points out, there was imbalance between A element errors and Z element errors (in opposite senses in the two tests). This may be due to a number of causes including bias distortion in the signal output from the radio receiver tone detector, and differential positive and negative margin in the teleprinters. However, as mentioned above, the improvement is more a function of a basic element error rate than of whether this error rate is due to bias distortion, noise, or other factors. Noise was the dominant factor in determining the error rate at the levels used in these tests, while bias distortion and margin asymmetry accounted for the errors affecting predominantly A or Z elements. P. R. KELLER

Frequency Meter

A RECENT requirement for a frequency meter prompted me to make up the frequency-measuring section of the *Wireless World* Audio Signal Generator. Using a 100 μA meter (the only one available) I found a maximum error of about 10% due to the blip where the positive pulse is clipped by the diode. This was corrected by biasing the diode with a 330 kΩ resistor to the negative supply and the resulting zero error is corrected mechanically at the meter.

To prevent a permanent zero error when the meter is



switched off, with the temptation to anyone to correct it, the 330 kΩ bias resistor is connected direct to the battery negative. This gives a permanent drain of about 50 μA which should not appreciably affect the life of the battery.

The instrument now gives good linearity over the required range of 5 c/s to 5 kc/s and a 50 μF capacitor across the meter reduces flutter at low frequencies. The modified discriminator circuit is shown in the accompanying figure.

Leigh-on-Sea. C. J. MILLS

Loudspeaker Polarity

DURING the course of recent experiments I have come across a phenomenon which, for lack of any previous reference, I propose to call the "Wooller effect." It started when I was observing oscillograms of various instruments and noted that while strings looked symmetrical, brass and woodwind were definitely unsymmetrical, being characterized mainly by a large repetitive peak in one direction only. This, I reasoned, must correspond to either a pressure or a rarefaction wave—probably the former. And so the question arose —"Would the instrument sound different if it were reproduced with loudspeaker phasing such that these peaks caused a rarefaction wave?" So, together with some very sceptical friends, who have subsequently agreed to endorse by findings, I tried a listening test. Reversing the phase of both speakers (to avoid any argument about relative phasing for stereo) we found that on brass especially there was a distinct difference in the "life" of the performance. The phasing which corresponded to the most realistic performance was not the same for all records, thus showing that the effect was not caused by non-linearity in the reproducing system, and also that there is no standardization among manufacturers concerning which direction of stylus movement corresponds to an increase of pressure at the microphone. Both mono and stereo records were tried with similar results.

Auckland, New Zealand. A. M. WOOLLER, A. THORLEY, J. T. BOYS

BOOKS RECEIVED

Mathematical Techniques in Electronics and Engineering Analysis, by J. W. Head, M.A. (Cantab), F. Inst. P., A.M.I.E.E. Based on a series of articles published in *Electronic and Radio Engineer* (now *Industrial Electronics*) this book is a self-contained guide to the use of algebra, the differential and integral calculus, trigonometry, operational calculus, matrices, etc. in the solution of engineering problems, particularly those encountered in light-current electrical engineering. Pp. 263. Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1. Price 45s.

Propagation of Radio Waves at Frequencies below 300 kc/s, edited by W. T. Blackband. Proceedings of the 7th meeting of AGARD Ionospheric Research Committee, Munich, 1962, comprising a total of 32 papers grouped under the heading: the lower ionosphere; D-layer irregularities; the lower ionosphere and low-frequency propagation; oblique incidence measurements; radio noise below 300 kc/s; v.l.f. propagation; e.l.f. propagation; earth resonance. Pp. 478. Pergamon Press Ltd. Headington Hill Hall, Oxford. Price £7.

Transistor Circuits for Magnetic Recording, by N. M. Haynes. Deals with the fundamentals of transistor theory and (largely on a qualitative basis) with the elements of recording and playback circuits. One chapter includes the circuit diagrams (with values) of a number of commercial recorders. There are useful chapters on f.m. and digital recording. Pp. 384. Howard W. Sams & Co. Inc., Indianapolis 6, Indiana, U.S.A. Price $9.95.

Schaltungstechnik der Loewe Opta Fernsehempfänger, by Ing. F. Möhring. Thorough analysis (in German) of one firm's television receiver circuits, profusely illustrated by photographs of waveforms and corresponding picture characteristics. Gives a close insight into the performance of all stages of the television receiver and a general indication of Continental receiver practice. Pp. 442. Loewe Opta A. G., Industriestrasse, Kronach, Germany. Price DM 4.50.

Understanding Television, by J. R. Davies. Based on a series of articles in *The Radio Constructor* this book describes in detail the elements of a television receiver. Essential differences between the 405- and 625-line standards are dealt with throughout the book and there is a chapter at the end on colour (including N.T.S.C., SECAM and PAL) and an appendix on u.h.f. tuners. Pp. 504. Data Publications Ltd., 57, Maida Vale, London, W.9. Price 37s 6d.

Colour Television Explained, by W. A. Holm. Extends the author's earlier work on "How Television Works" and gives a clear and succinct description of fundamental colour theory and of the N.T.S.C. colour television system (both transmission and reception). Pp. 110. Philips Technical Library, Cleaver-Hume Press Ltd., 10-15 St. Martins Street, London, W.C.2. Price 20s.

Properties and Applications of Transistors by J. P. Vasseur, D. es S. Based on a series of lectures on transistor theory and practice to colleagues in the Compagnie Générale de Télégraphie Sans Fils (C.S.F.) this book constitutes a useful cross-reference on all matters relating to design. The two-port (four pole) network approach, necessary to differentiate between transistor and valve action, is clearly and fully presented. Pp. 434. Pergamon Press Ltd., Headington Hill Hall, Oxford. Price £5.

Diodes and Transistors, by G. Fontaine. English translation from the French of a treatise published in 1961 in the Philips Technical Library gives a clear exposition of the physics of semiconductors and the general theory of diodes and transistors. The book is non-mathematical but is liberally illustrated with line diagrams in which the use of three colours materially aids comprehension. Pp. 470. Cleaver Hume Press Ltd., 10-15 St. Martin's Street, London, W.C.2. Price 55s.

Filters, A Handbook on Theory and Practice, by the staff of White Electromagnetics Inc. A collection of design data and graphs covering low-, high- and band-pass passive filters with maximally flat (Butterworth) or equal-ripple (Tchebycheff) responses over a frequency range from 30 c/s to 500 Mc/s. A useful practical guide for designers. Pp. 279. White Electromagnetics, Inc., 670 Lopstrand Lane, Southlawn Industrial Park, Rockville, Maryland, U.S.A. Price $11.75.

Proceedings of Symposium on Extended Range V.H.F. Air/Ground Communications held at the Royal Geographical Society, May 1963 describes the equipment in aircraft and on the ground, records the results of trials and the discussion for criteria for presenting and assessing the performance of extended-range v.h.f. facilities. Pp. 162. The Engineering Division, International Aeradio Ltd., Hayes Road, Southall, Middlesex. Price £2.

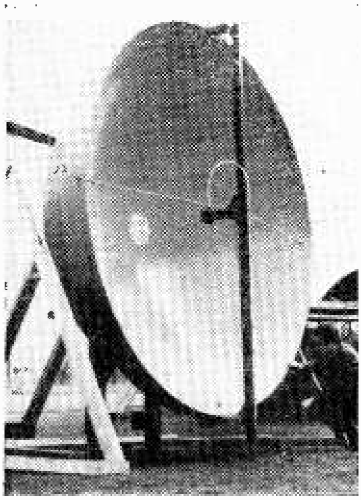
RECENT TECHNICAL DEVELOPMENTS

Metal-Oxide Transistor

A new type of field-effect transistor was described at a recent I.E.E. Colloquium. In this device, conduction is by means of charged carriers induced in the surface of a semiconductor by an electrostatic field. The field is applied by imposing a voltage to an evaporated aluminium film which is insulated from the silicon by a layer of silicon dioxide. The conduction path is between two diffused areas in the silicon. An input impedance of $10^{13}\Omega$ in parallel with 2-5pF is obtained, the g_m lying between 1 and 5mA/V.

Glass Fibre Microwave Aerial

The extreme accuracy of surface contour required for optimum performance in a dish aerial is difficult to obtain with normal methods of sheet-metal fabrication. A considerable degree of simplification and gain in strength/weight ratio has been achieved by the Marconi Company in a new method of construction, using glass fibre and "CRYSTIC" polyester resin, manufactured by Scott Bader and Co., Wollaston, Wellingborough, Northants. The necessary degree of surface finish is obtained by stretching steel wire mesh over an epoxide-coated concrete former. Glass fibre is laid over the mesh, and the whole impregnated by resin, which completely encloses the steel mesh. Further layers are bonded on, steel anchoring plates being let in during construction. The main features of these dishes are their accuracy (±0.03in on the true profile), high stiffness/weight ratio and comparative immunity to climatic extremes. At 7000 Mc/s, the aerials possess a gain over an isotropic radiator of over 44dB, the beamwidth being 0.9 degrees at −3dB.



Marconi 10ft diameter glass-fibre aerial. Centre-feeding can be used, but front-fed type is shown here.

Sensitive Storage Camera Tube

In the fields of astronomy and space research, there has been considerable need for a television camera to detect and store very faint images. Long exposures to light or other radiation can then be made, the image being stored and transmitted to base by a slow read-out. R. S. Filby *et al* described, in the issue of *Nature* for February 22, 1964, a tube which is sensitive, can store an image for several hours, and which does not exhibit the "lag" which is a common failing of tubes with larger target capacities and photoconductive layers. The novel feature of the tube is the construction of the target, which consists of a thin layer (500Å) of aluminium oxide supporting the signal plate of aluminium. On the side of the signal plate remote from the photocathode is a spongy layer of potassium chloride of a density about 3 per cent of that of the solid and about 10 micrometres thick. Electrons penetrate the spongy layer, building up a positive charge by transmission secondary emission; the secondary electrons are collected by a mesh a short distance from the target. The large thickness of the spongy layer gives a low capacitance and avoids lag. The positive charge image, which is about 10 times that of the image orthicon, is read out by a low-velocity beam and the signal obtained from the conducting signal plate.

Transistor Assembly

A new technique of assembling transistors has been developed by S.T.C. Conventionally, the semiconductor wafer is first welded to the sealed lead assembly, followed by separate, intricate operations to connect the electrodes to the lead-out wires by very thin contact wires. In the new process, the silicon planar epitaxial structure has been modified to enable contact to be made with collector, base and emitter from one side of the wafer. A metal flash, followed by a coating of solder, is applied to each contact area and the completed wafer is dropped, contacts downwards, on to the lead-out wires. A brief heat treatment forms the three welds and the transistor is complete, except for encapsulation. The first type to be made by this process is the BSY95 switching transistor.

The S.T.C. BSY95 made by the new process.

C.R.T. for Character Generator

Alphanumeric characters used in displays of navigational and tabular information are usually generated by tracing them out dot by dot or by segments. To obtain greater brightness or speed, it is necessary to illuminate each element of the character at the same time. The Matricon, on which a paper was presented at a recent I.E.E. Colloquium, is a device intended to produce a speed × brightness factor of about 20 times greater than in the normal method. A quarter-inch square cathode has a parallel control electrode a short distance away, at or slightly above cathode potential. The control electrode is perforated with a 7×5 matrix of holes, and the beam is split into 35 parallel rays. These may pass through an insulating plate with 35 holes in it containing metal tubes, leads being taken from each tube to pins at the tube base. Positive or negative voltages on the pins pass or reject the rays, and characters are formed.

WORLD OF WIRELESS

Local Broadcasting

IT will be recalled that the Pilkington Committee recommended that a system of local sound broadcasting should be introduced in this country under the B.B.C's control. The Government has said that before deciding it wished to take cognizance of public reaction, but the fact is that the public has had no experience of local broadcasting, for all the pilot schemes tried by the B.B.C. have been on closed circuit.

The B.B.C's Director of Sound Broadcasting, Frank Gillard, recently stated in an interview that "what the B.B.C. would very much like to do now—as the next step—is to introduce a system of, say, half a dozen stations, on the air, in different centres, well chosen, in different parts of the country, and to run those stations for, say, a year, or even two years, experimentally, to see first of all whether the people who lived in those communities welcomed local broadcasting, and secondly, whether our ideas on the sort of programmes we should like to put on the local stations are worth while. I think it's a service which we certainly ought to introduce in this country, and one which would prove to be extremely valuable."

Television Award

THE first presentation of the Geoffrey Parr Award was made by Mrs. F. E. Parr, widow of "G.P.", at the annual dinner of the Television Society on 8th May. It was received by Peter Rainger on behalf, as he said, of his team in the B.B.C. Designs Department in recognition of their work on the electronic standards converter described in our October 1963 issue. No camera or display tubes are used in the new system which depends on electronic analysis of the 625-line picture and its re-synthesis at 405 lines.

The award, which has been introduced to commemorate the work of the late Geoffrey Parr who was secretary of the Society for many years, is to be presented annually "for an outstanding contribution to television engineering or an associated science". When receiving the award Mr. Rainger made special reference to the work of L. G. Davis and G. A. Hunt who are members of the team.

Hong Kong, which has had a wired television service operated by Rediffusion since 1957, is now to have a commercial television broadcasting station. The new service will operate on 625 lines and will provide both English and Chinese language programmes.

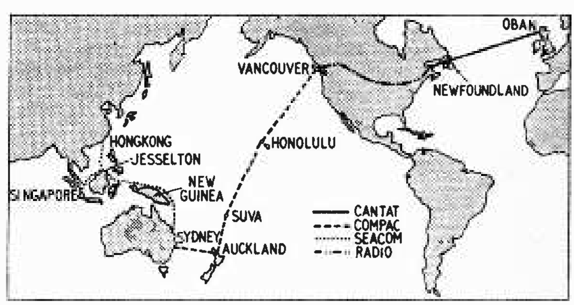
R.E.C.M.F. Officers.—The 1964/65 council of the Radio and Electronic Component Manufacturers' Federation consists of the following representatives of member firms:—R. Arbib (Multicore), C.M. Benham (Painton), E. E. Bivand (S.T.C.), S. H. Brewell (Hunt), N. D. Bryce (Belling & Lee), R. A. Bulgin (Bulgin & Co.), R. F. Collinson (Colvern), B. E. G. Harris (Bakelite), F. W. Irons (McMurdo Instrument), Dr. F. E. Jones (Mullard), E. G. Lennard (Cosmocord), Dr. G. A. V. Sowter (Telcon Metals), J. D. Sutton (Parmeko), and J. Thomson (Morganite Resistors). At the first meeting of the council Mr. Thomson was re-elected chairman, Mr. Brewell was elected deputy chairman, and Dr. Jones and Dr. Sowter vice-chairmen. Mr. A. F. Bulgin is continuing as president of the Federation, with K. G. Smith (N.S.F.) and E. E. Webster (Plessey) as vice-presidents.

Colour Transmissions.—The 625-line u.h.f. field trials of N.T.S.C. colour television from the Crystal Palace station on Channel 33 (the BBC-2 channel for the London area) are being transmitted for two half-hour periods daily. The times are as follows: Mondays, Thursdays and Fridays 12.0 to 12.30 p.m. and 4.30 to 5.0 p.m.; Tuesdays and Wednesdays 4.30 to 5.0 p.m. and 11.0 to 11.30 p.m. All the transmissions are asynchronous.

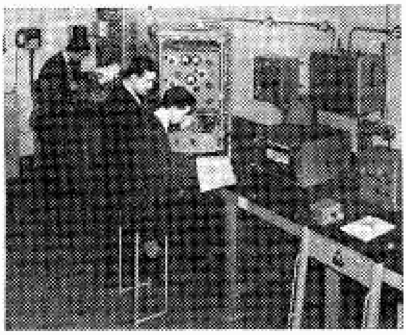
Extension of Test Transmissions.—The trade test transmissions from the BBC-2 London station will be extended during the next few months to assist the radio trade with the installation of aerials and receivers. The new schedule is: 9.30 a.m. to 1.0 p.m. and 2.0 p.m. to 6.0 p.m. Mondays to Saturdays inclusive. The material transmitted will consist of test card with tone or recorded music.

B.E.A.M.A. Electronics Board.—In accordance with its new divisional structure, the British Electrical & Allied Manufacturers' Association announces the formation of the electronics division, the constituent parts of which are the industrial electronic equipment section, the semiconductor devices section and the X-ray apparatus section. The electronics board has been reconstituted under the chairmanship of G. S. C. Lucas (A.E.I.), and the other members are: W. Gregson (Ferranti); R. J. Clayton (G.E.C. Electronics); John Collins (English Electric); G. E. C. Fairbanks (Elliott-Automation); W. Padley (Metal Industries); L. E. Thompson (Westinghouse); A. J. Minns (Watson & Sons Electro-Medical) and D. Edmundson (A.E.I.).

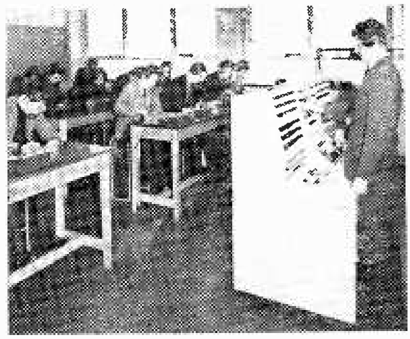
Arabian Station.—Nearing completion at Salt Pans, near Aden, is a new £250,000 wireless receiving station which is being built by Cable & Wireless (Mid East) Ltd. It will work as a sister station to the nearby transmitting station at Hiswa equipped with 28 transmitters, and will provide direct telephone and telegraph links with the U.K., Africa and the East as well as serving as a relay centre on the London-Far East routes. It will also provide a ship-shore service.



Canada's *microwave network linking the Canadian Transatlantic telephone cable (Cantat) with the Commonwealth Trans-Pacific telephone cable (Compac) was officially opened on 11th May, by the Canadian Minister of Transport. This project, which links Montreal on the east coast with Vancouver on the west, has been built jointly by Canadian Pacific and Canadian National Telecommunications at a cost of $41M (about £14.6M). It is Canada's second radio link between the east and west coast cities and will ultimately provide eight radio channels, each of which can carry 600 telephone circuits. Some 130 stations are used in the 3,282-mile radio path.*



Aberdeen's *new £1.5M Technical College provides places for some 3,500 students in forty different professions. In the electrical engineering department is a section providing instruction for prospective marine radio officers. On the left students are receiving instruction in servicing and on the right students are receiving Morse under simulated sea-going conditions. Marconi Marine equipment is used.*



The B.B.C.'s new television and v.h.f. sound relay station at Ward of Bressay, near Lerwick, to be known as the **Shetland Transmitting Station,** was brought into service on 15th April. Television transmissions are radiated in Channel 3 with vertical polarization, and the three sound programmes are radiated with horizontal polarization, on the following frequencies: 88.3, 90.5 and 92.7 Mc/s. A receiving station has been built at Fitful Head to pick up the programmes from the B.B.C.'s Orkney transmitting station. The television programme is then fed over a microwave link to the transmitting station at Ward of Bressay; the three sound programmes are carried by Post Office line. This new station brings B.B.C. television and the v.h.f. sound programmes within reach of about 17,000 people in the Shetlands for the first time.

Sydney, Australia, is to have its third commercial television station next year in addition to the station operated by the national Australian Broadcasting Commission. All Australia's existing 42 stations operate in the v.h.f. band. There are now nearly two million television licences in the country which represents a set for every six people.

Broadcast Receiving Licences.—There was an increase of 95,848 combined television and sound licences in the U.K. during the first quarter of this year. The end-of-March figures were:—sound only 2,999,348 (including 576,621 for sets fitted in cars) and combined TV/sound 12,885,331; making an overall total of 15,884,679.

Eavesdropping.—New regulations proposed by the American Federal Communications Commission would ban the use of transmitting equipment for the purpose of recording or overhearing private conversations. According to our New York contemporary, *Radio-Electronics*, this apparently late action has been necessitated by the advent of miniature battery-operated transmitters, smaller than a pack of cards.

Band V—The German Post Office has announced that frequencies between 790 and 860 Mc/s, which are within the television Band V, will be used for other services—mainly for "fixed" stations.

OUR COVER

In the centre of a selection of equipment to be seen at the I.E.A. Exhibition is a Via-Vac combined sputtering and evaporation unit used for the production of thin film circuits at an S.T.C. factory. The remaining photographs have also been used in illustrating our preview.

Northern Ireland is to have its on Radio, TV and Electronics Exhibition. It is being sponsored by the Northern Ireland Radio Retailers' Association and will be held in the King's Hall, Balmoral, Belfast, from 14th-21st October.

European V.H.F. Sound Broadcasting.—Nearly 2,300 transmitters, of which over 1,250 are in Italy, are listed in the latest edition (No. 9) of the "List of v.h.f. sound broadcasting stations" in the European area issued by the European Broadcasting Union. The country with the next highest number of transmitters is West Germany with 194. The 78-page geographical list giving the location and operating characteristics of the stations costs 100 Belgian francs and this includes six bi-monthly amendments.

A symposium on **sonic investigations** of internal damping in solids will be held in the Physics Department of Imperial College, London, from 5th-7th August. It is being organized by the Acoustics Group of the Institute of Physics & Physical Society.

Reliability—A three-day course on the principles of electronic equipment reliability will be held at the Borough Polytechnic, London, S.E.1, from Tuesday, 23rd June (Fee £6).

An international conference on **Magnetic Recording** is to be held at the Institution of Electrical Engineers, Savoy Place, London, W.C.2, from 6th to 10th July. The conference has been divided into six categories to cover audio, video, digital and analogue techniques, recording media, and general problems. The meeting is sponsored by the I.E.E., the I.E.R.E. and the I.E.E.E. and a technical exhibition is being held during the conference.

"Thames Navigational Service."—The Gas Accumulator Company (U.K.) Ltd., ask us to supplement the information given on p. 218 of the May issue about their tide recorders at Shivering Sands Fort. The battery-operated transistor transmitter linking the recorder at the Fort with Southend Pier was provided by Microwave Associates Ltd., and the links with Southend and Tilbury to Gravesend by Pye Telecommunications Ltd.

A new 28-frame colour filmstrip entitled **"A.M. Receivers"** is now available from the Mullard Educational Service distributors, Unicorn Head Visual Aids Ltd., 42 Westminster Palace Gardens, London, S.W.1. The strip briefly describes tuned radio-frequency and super-regenerative receivers, and covers in some detail the r.f. and i.f. stages of the superhet receiver. It concludes with a number of practical receiver circuits. Price 25s per strip, including comprehensive teaching notes.

PERSONALITIES

Sir Harold Bishop, C.B.E., B.Sc. (Eng.), who retired from the post of Director of Engineering, B.B.C., last year, has joined the board of the International Research and Development Company of Newcastle-upon-Tyne. Sir Harold is deputy chairman of the Telegraph Condenser Company and a consultant to the British Insulated Callender's Cables group of companies.

A. J. King, M.Sc.Tech., D.Sc., M.I.E.E., F.Inst.P., who recently became consultant on acoustics to the Research Laboratory of the A.E.I. Power Group, has been appointed a part-time reader in applied acoustics at the College of Science and Technology, Manchester. Dr. King began work on acoustics in the Research Department of the Metropolitan-Vickers Electrical Company in 1926 and has been in charge of the Acoustics Laboratory at Manchester since 1928.

Leonard G. Dive, A.M.I.E.E., A.M.I.E.R.E., senior assistant in the B.B.C's Engineering Information Department for the past ten years, is going to New York as senior engineer in the Corporation's United States office in succession to **D. A. V. Williams,** B.A., A.M.I.E.E., who has completed his two-year tour of duty. Mr. Dive joined the B.B.C. 20 years ago as a maintenance engineer at the Tatsfield Receiving and Measurement Station. In 1945 he became station instructor for both Tatsfield and the Monitoring Station at Caversham Park, near Reading. In 1947 he was appointed lecturer in the Engineering Training Department at Wood Norton, Worcs., where from 1951-54 he was deputy senior lecturer.

L. G. Dive

W. Proctor Wilson, C.B.E., B.Sc.(Eng.), F.C.G.I., M.I.E.E., head of the B.B.C's Research Department since 1950, is retiring at the end of July. After working with the Western Electric Company (now S.T.C.), Mr. Wilson joined the B.B.C. in 1927. Three years later he left to join Marconi's but returned in 1933 to rejoin the Research Department. Throughout the war he served in the Signals Branch of the R.A.F., first as an assistant air attaché in Paris and later (1941-45) as chief engineer of No. 60 (Signals) Group with the rank of group captain. He returned to the B.B.C. in 1945 as assistant head of the Research Department.

W. Proctor Wilson

G. G. Gouriet, M.I.E.E., who left the B.B.C. in 1958 to join the board of Wayne Kerr Laboratories as technical director, is returning to the Corporation to become head of the Research Department in succession to Mr. Wilson. Mr. Gouriet, who is 46, joined the B.B.C. in 1937 and after five years in the Operations and Maintenance Department transferred to the Research Department where he was head of the television group when he left. Although he has specialized in television research and more especially colour systems, Mr. Gouriet's interests include information theory, and measurement and control problems.

G. G. Gouriet

P. A. C. Morris, B.Sc., A.M.I.E.E., has joined Granger Associates Ltd., of Weybridge, the recently formed British subsidiary of the Californian company of the same name which manufactures oblique incidence sounders, log periodic aerials and other specialized communications equipment. Mr. Morris, who has frequently contributed to *Wireless World* on h.f. propagation, is a graduate of Leeds University (1953) and served his apprenticeship with Edison Swan before joining Cable & Wireless in 1957. For the past five years he has been in charge of the radio propagation section of the engineer-in-chief's department. Mr. Morris has, for some time, represented C. & W. on study groups of the C.C.I.R. concerned with ionospheric and tropospheric propagation.

P. A. C. Morris

R. J. F. Keir, O.B.E., B.Sc., A.M.I.E.E., has recently returned to Singapore for a second tour of duty as resident engineer of the B.B.C's Far Eastern Station at Tebrau. He returned to this country in 1961 after spending nearly five years in the Far East and for the past three years has been engineer-in-charge of the short-wave transmitting station at Skelton, Cumberland, where **T. E. Lowry** is, for the present, acting e.-in-c.

John R. Trost, B.Sc., A.M.I.E.E., who since 1958 has been leading a team engaged in the design and development of radar projects at the Gt. Baddow Research Laboratories

John R. Trost

of the Marconi Company, has been appointed deputy technical manager of the Marconi International Marine Company. He succeeds **G. N. Bowling,** who recently left to become managing director of Brookdeal Electronics. Mr. Trost joined Marconi's in 1944 as a design engineer after studying at the Brighton Technical College.

Tom Goddard, an employee of Standard Telephones and Cables Ltd. at Harlow, Essex, has received a cheque for £625, as an award under the company's employee suggestion scheme. Mr. Goddard, who has been with the company for 28 years, received his award for suggesting a modification to a manufacturing procedure in the quartz crystal division. He has had six other suggestions accepted, one of which won him £100.

Fellowship of the Television Society, which is conferred on those who have "achieved eminence or made outstanding contributions to the science, technology or art of television," has been awarded to **S. N. Watson,** M.I.E.E., head of the B.B.C's Designs Department, **P. A. T. Bevan,** C.B.E., B.Sc., M.I.E.E., chief engineer of I.T.A., and **W. E. Turk,** A.M.I.E.E., manager of the photoelectric tube division of the English Electric Valve Company. Mr. Watson has been with the B.B.C. since 1933 and joined the Designs Department in 1947. Mr. Bevan was in industry prior to joining the B.B.C. in 1934 and was senior planning engineer when he left in 1954 to become the first chief engineer of I.T.A. Mr. Turk joined the E.M.I. Research Laboratories in 1936 where he stayed until 1953 when he joined the E.E. Valve Company. He has been in charge of the photoelectric tube division for seven years.

R. H. Wood, M.V.O., the B.B.C.'s engineer-in-charge of outside broadcasts (sound), London, has retired after over 40 years' service. Mr. Wood joined the B.B.C. in 1923 as a maintenance engineer at Manchester and became e.-in-c. there the following year, before moving to Chelmsford to take up the post of assistant e.-in-c. of the team working on the experimental transmitter 5XX. In 1925, Mr. Wood was appointed assistant e.-in-c. London outside broadcasts; he has been e.-in-c. since 1935. Mr. Wood was made a member of Royal Victorian Order in 1946 by King George VI in recognition of his services to the Royal Family over many years in connection with Royal broadcasts.

P. E. Leventhall, B.Sc.(Hons.), M.I.E.R.E., who joined the Cossor Group nine months ago as v.h.f. group leader, has been appointed chief engineer of the Cossor Communications Company. Prior to

P. E. Leventhall

joining Cossor's he was, for five years, with the Rank-Bush-Murphy organization where he was chief engineer of the radiotelephone division.

R. G. Robertshaw, who joined the G.E.C. research laboratories as a technical assistant in 1940, has been appointed technical manager of the M-O Valve Company. In recent years he has specialized in the research and development aspects of special magnetrons, travelling wave tubes and other microwave devices at the Hirst Research Centre, Wembley. **E. Kettlewell,** who also comes from the Hirst Research Centre, has been appointed the M-O Valve Company's development manager. Mr. Kettlewell joined the scientific staff of the G.E.C. research laboratories in 1936 and spent four years on the development of high pressure mercury lamps before turning his attention to radar systems. In 1943 he transferred to the microwave valve group.

D. W. Heightman, M.I.E.R.E., who has been connected with Goodmans Industries Ltd. for several years and a director of the company for the past two, has been appointed joint managing director with **M. H. C. Lewis.** Mr. Heightman resigned from Denco (Clacton) Ltd., a company which he formed before the war, to become chief television engineer of English Electric's Liverpool works in 1951. Five years later, Mr. Heightman joined Radio Rentals Ltd. as chief engineer and was appointed to the board, as technical director, in 1960. He relinquished this post in 1962.

K. E. Owens recently joined the board of Livingston Laboratories Ltd. and has been appointed general manager of their establishment at Camden Road, London, N.W.1. Mr. Owens was formerly manager of the Broadcast and Recording Equipment Division of E.M.I. Ltd.

OUR AUTHORS

R. H. Bradsell, joint author of the article describing a u.h.f. test oscillator in this issue, has worked in the Standards Division of the National Physical Laboratory since 1949. He did the early research on a photoelectric micrometer microscope which was subsequently developed and went into commercial production. More recently he has been interested in the velocity of light as a basis for a length standard and in the use of microwave techniques to produce an electronic measuring device for geodetic distances. His collaborator, **M. Grimshaw,** joined the Standards Division from college in 1962 and has been working in the field of length measurement and moiré fringe techniques and has worked with his co-author on u.h.f. semiconductor devices.

A. T. Bayliss, who has been senior lecturer in radio communication at the College of Technology, Oxford, for the past 17 years, writes in this issue on the tunnel diode as a frequency divider. He received his technical training at the college where he now teaches and during the war served as a signals/radar officer in the R.A.F.

OBITUARY

T. P. Lynott, A.M.I.E.E., chief engineer of Gardners Transformers Ltd., of Christchurch, died on 2nd May, aged 49. Mr. Lynott joined Gardners as chief engineer in 1957, having previously been for ten years at A.E.R.E., Harwell, where he was head of the transformer section in the Electronics Division. He was at one time in the directorate of instrument production in the Ministry of Supply.

Tunnel Diode Frequency Divider

RELIABLE OPERATION AT HIGH DIVISION RATIOS

By A. T. BAYLISS, A.M.I.E.E.

MULTIVIBRATORS using either valves or transistors have been widely used as frequency dividers, but the maximum reliable frequency division does not exceed a factor of ten in these circuits.

The precision with which a tunnel diode multivibrator can be synchronized allows much higher division ratios to be achieved.

A consideration of the basic action of the tunnel diode multivibrator will indicate how this precision is obtained. Consider the circuit of Fig. 1. The tunnel diode is biased into its astable region on the negative-resistance portion of the characteristic shown at (1) in Fig. 2. The slope of the load line (1) is the resistance of the source plus the resistance of the inductance L. Any random fluctuation of current will produce an e.m.f. in the inductance which will carry the circuit into a semi-stable state and a relaxation oscillation occurs. Commencing at

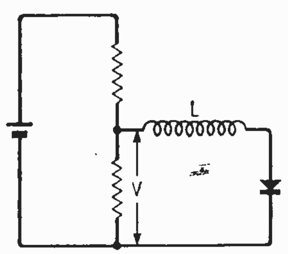


Fig. 1. Elements of tunnel diode oscillator circuit.

point A with voltage rising towards V, the current will tend to decrease as the negative resistance region is entered. The inductance will, however, maintain the current through the diode nearly constant and an e.m.f. E_L is induced which transfers the load line to B. This e.m.f. now falls at a rate decided by the time constant of the circuit L/R_{eq} where R_{eq} is the source resistance, the coil resistance and the forward resistance of the diode from C to B. With this decaying e.m.f. point C is reached where current starts to rise. Again an e.m.f. is induced which transfers the load line to D, again holding the diode current nearly constant. The current in the tunnel diode rises to A at a rate dependent on the time constant of the circuit, and the cycle of events is repeated. The voltage waveform across the diode is shown in Fig. 3.

Positive going pulses are now introduced across the tunnel diode via C and R to synchronize the multivibrator as in Fig. 4.

The slope resistance of the diode from D to E, Fig. 2, is very low compared with the resistance R, so that the synchronizing pulses occurring during this time interval when the current is rising from D to E are almost entirely suppressed. Between E and A the incremental resistance sharply rises

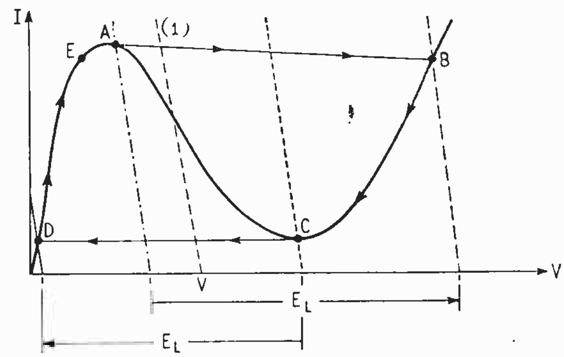


Fig. 2. Locus of operating point in circuit of Fig. 1.

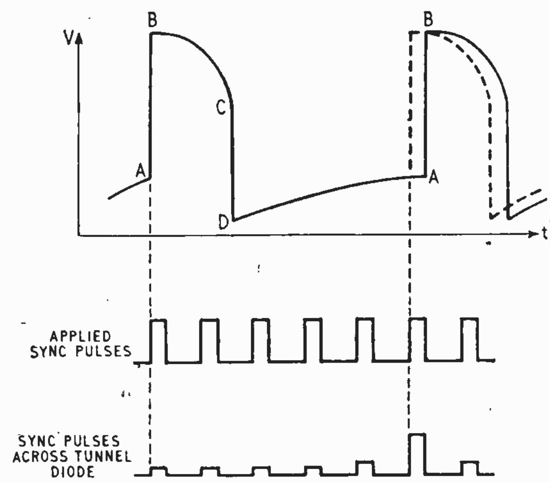


Fig. 3. Operation as frequency divider, showing division by 5.

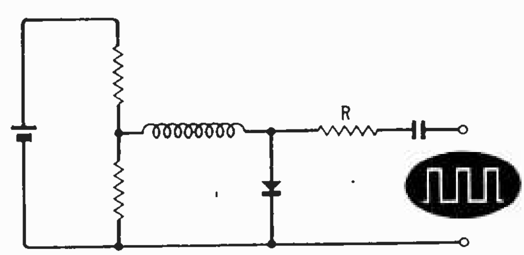


Fig. 4. Method of introduction of sync. pulses. R is large compared with initial slope resistance of tunnel diode.

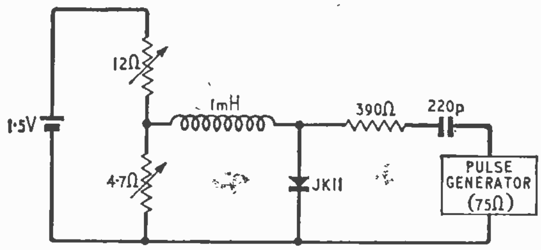


Fig. 5. Circuit used to measure divider performance.

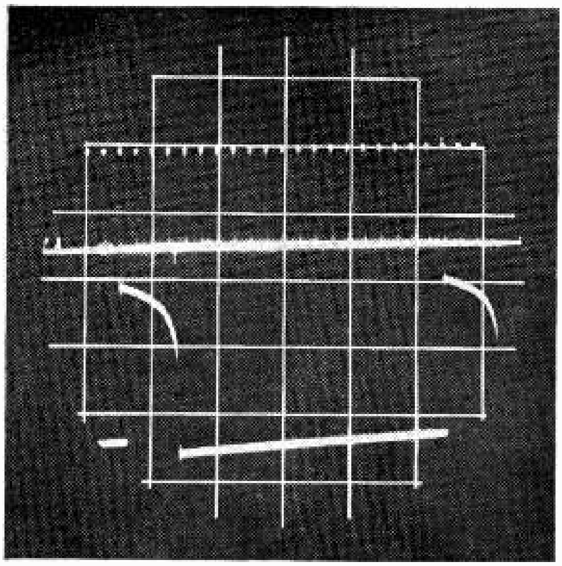


Fig. 6. Division ratio of 20 : 1 from circuit of Fig. 5.

allowing a positive pulse to lock the multivibrator before the critical point at A is reached. The dotted wave form in Fig. 3 shows the triggering of the divider by every fifth sync. pulse. Synchronizing pulses occurring during a time interval from B to C are likewise suppressed. The suppression of the unwanted synchronizing pulses is shown.

A practical circuit (Fig. 5) using an S.T.C. JK11 germanium tunnel diode has been set up to measure the division ratios obtainable. Positive-going, 1 μsec., 0.5V amplitude pulses of varying repetition frequency were obtained from a pulse generator with a 75 Ω output impedance. The waveforms of the sync. pulses and the voltage across the tunnel diode were observed on an oscilloscope with the results shown in accompanying oscillogram, showing a frequency division ratio of 20:1. The highest division ratio measured was 40, but there seems to be no reason why this could not be increased. Significantly, the amplitude of the synchronizing pulse could be varied through a range of 3:1 without upsetting the frequency division. With the circuit values as above, the fundamental frequency of the multivibrator was 6.7 kc/s.

Possible Television Timebase Circuit

The automatic suppression of the unwanted trigger pulses might profitably be exploited in the line time base generator of a television receiver. The line time base oscillator could be a tunnel diode multivibrator locked in the normal way by the positive going line sync. pulse from the sync. separator. Any impulsive noise in the output of the sync. separator would be suppressed in the same manner as the unwanted trigger pulses are suppressed in the frequency divider. The circuit might then be a possible alternative to the more complex flywheel sync. circuits now in use.

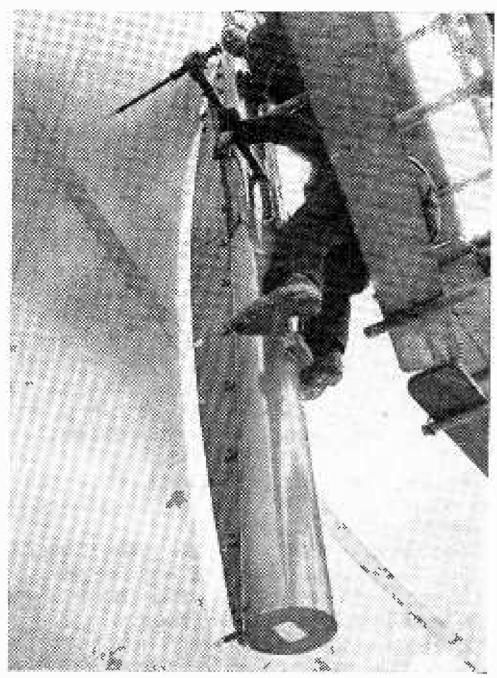
"AQUILA'S" 75TH ANNIVERSARY

Work of the Electrical Inspection Directorate

IT was in 1889 that is was decided to divorce inspection from the functions of other Government departments supplying the needs of the Armed Forces, and the present Electrical Inspection Directorate (motto, *Aquilae Oculo*, "with the eye of an eagle") stems from the Ministry of Aviation's Board of Inspection, the other branch being the Aeronautical Inspection Directorate.

The work of E.I.D. now covers a wide field, including radar, signals, navigation systems, electronic components and aircraft electrical systems. In addition to Electronics (L) and Power and Instruments (P. & I.) there are divisions for Atomic Weapons (AW) and Engineering Services (ES), the latter providing common technical services for the other divisions.

The E.I.D. is administered from Bromley, Kent, but has regional headquarters also in Glasgow, Manchester, Birmingham and Bristol, since much of its work is done in the field. The work of the electronic division is by no means confined to the test bench as the accompanying photograph shows. Here the profile of a precision radar scanner is being checked on site for mechanical distortion, which might give rise to side lobes.



U.H.F. OSCILLATOR

A SIMPLE INSTRUMENT SUITABLE FOR TELEVISION (BAND IV) TESTING

By R. H. BRADSELL and M. GRIMSHAW*

THE u.h.f. oscillator described was the by-product of a research programme carried out by the authors in connection with the NPL mekometer[1,2], an electronic distance measuring device. A signal source was required for the design and testing of 600 Mc/s cavity resonators used in the final stages of a crystal-controlled u.h.f. frequency standard for the mekometer. The unit produced for this purpose was compact and so simple in design and construction that it was felt to be of wide interest. The advent of u.h.f. television broadcasting in the London area on Channel 33, Band IV (567.25 Mc/s vision, 573.25 Mc/s sound) opens up a need for just such an instrument.

A general view of the oscillator is given in Fig. 1 and it can be seen that the unit is quite small, in fact only $4\frac{1}{2} \times 3\frac{1}{2} \times 2$ in. Complete screening is provided by the die-cast box used to house the equipment.

Circuit Description

The circuit diagram is given in Fig. 2. The circuit utilizes a shunt-fed Hartley oscillator based on the A2521 grounded-grid triode. This valve has a high mutual conductance and can be used at frequencies up to 1250 Mc/s. It is a conventional miniature valve using the B9A base.

The tank circuit employed in the oscillator is the coaxial-line resonator shown in Fig. 3 which has a mid-frequency of about 570 Mc/s. Two tapping points are made on the inner conductor for the anode and cathode of the valve V1 to give correct phasing for oscillation.

A coaxial line, which is a quarter wavelength long [3], is a resonant circuit. It has distributed inductance and capacitance and a characteristic impedance Z_0, where

$$Z_0 = \sqrt{\frac{L}{C}} \quad \ldots\ldots\ldots\ldots \quad (1)$$

L is the inductance per metre and C the capacitance per metre.

The equation for Z_0 given by (1) can be expressed also in terms of the internal diameter D of the outer conductor and diameter d of the inner conductor of the coaxial line. The form of the equation is then

$$Z_0 = 138 \log_{10} \frac{D}{d} \quad \ldots\ldots\ldots \quad (2)$$

If a coaxial line is shortened so that the length of its inner conductor is no longer a quarter wavelength at the desired frequency of operation f, it is no longer

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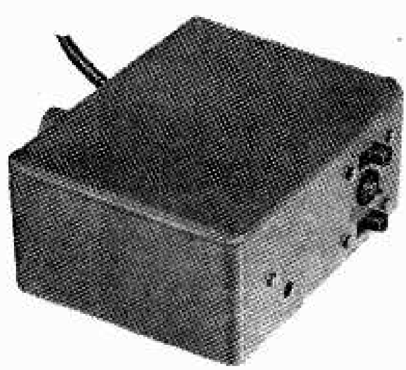
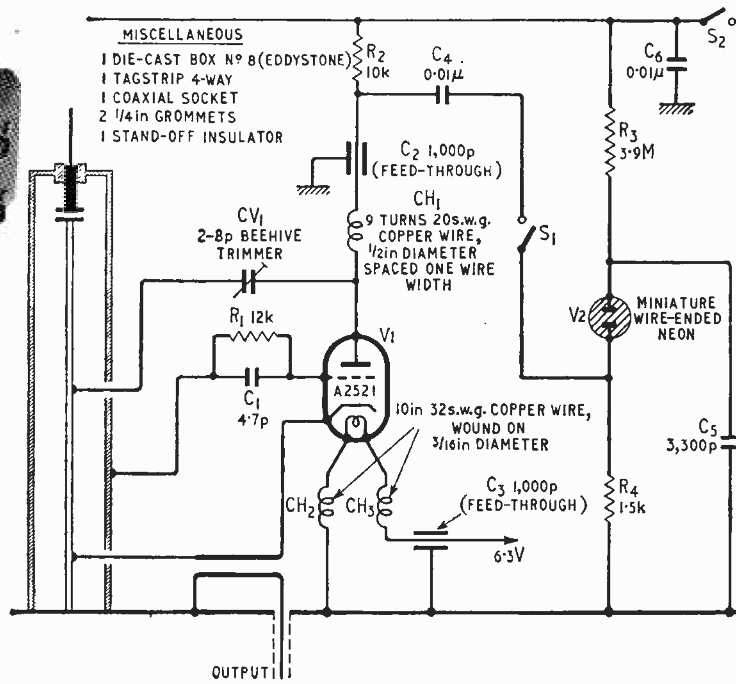


Above: Fig. 1. U.h.f. test oscillator.



Right: Fig. 2. Circuit diagram of the equipment.

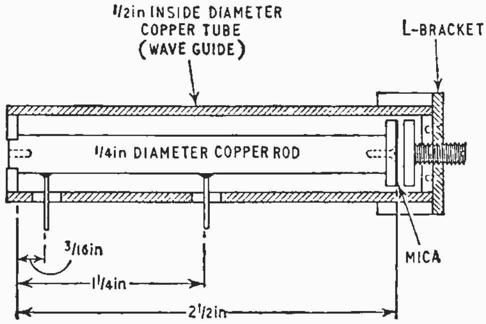


Fig. 3. Details of coaxial cavity resonator.

purely resistive but exhibits an inductive reactance at the open end. If a capacity C, of the correct value, is added across the open end of the line this inductive reactance is tuned out and the coaxial resonator will again resonate at the desired frequency f.

The following equation can be used to find C for a given length of line,

$$\frac{1}{2\pi f C} = Z_0 \tan\left(\frac{2\pi l}{\lambda}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

where l and λ are the length of the inner conductor of the coaxial line and the wavelength respectively.

As can be seen from Fig. 3 the coaxial-line resonator used in the oscillator has capacity and loading in the manner described above. The capacitor C is made from two $\frac{7}{16}$ in diameter copper discs which form an adjustable parallel-plate capacitor. The inner conductor is prepared from $\frac{1}{4}$ in diameter copper rod and the outer conductor from $\frac{1}{2}$ in internal diameter copper tube.

It has been shown that the coaxial line in this form can be looked upon as an inductance. The anode of the triode V1 is tapped into this inductance which acts as an auto-transformer allowing the cathode to be tapped in at a suitable impedance near the bottom of the line. The grid is connected to a point on the outer sheath of the coaxial line, via the grid-leak bias network formed by R_1 C_1 mid-way between the anode and cathode tapping points.

The anode load of V1 is the radio-frequency choke L_1 and the alternating current is coupled into

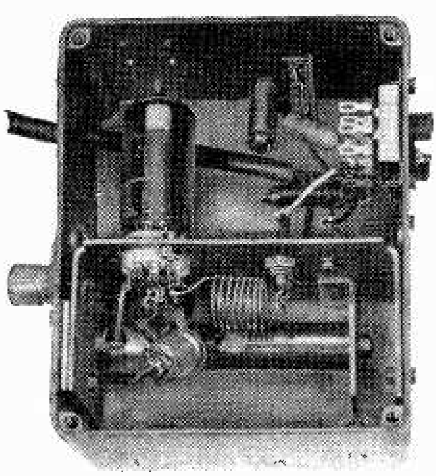


Fig. 4. General layout of components in the instrument.

the coaxial resonator by CV_1 which is used to adjust the feedback to ensure stable oscillation.

Supply decoupling is provided by R_2 and C_2 and the valve heater is fed through chokes CH_2 and CH_3 which isolate it from earth at the signal frequency.

The u.h.f. output from the oscillator is taken from a coupling loop which intersects the magnetic field in the short lead joining the cathode of V1 to its tapping point on the resonator.

It was felt that some simple form of audio modulation would be an added asset. To meet this requirement the miniature neon V2, which also acts as high tension indicator, was connected as a relaxation oscillator producing short pulses at about 400 per second. The pulse output is connected, via S_1, to the junction of R_2 C_2 which varies the h.t. supply voltage at the anode of V1 producing both amplitude and frequency modulation of the u.h.f. signal. This system, though simple, is adequate for most applications.

Constructional Details

The instrument is assembled on a subchassis of brass which is a good fit into the die-cast box. The general layout can be seen in Fig. 4. Leads from the valve holder, which should be of a low-loss type, to the coaxial resonator must be as direct and short as possible. The five grid pins should be bent inwards and soldered to the central spigot of the valve holder, the resistor-capacitor pair R_1 C_1 being connected from the end of this spigot to the outer wall of the resonator. The two heater-lead chokes CH_2 and CH_3 should be positioned at right angles to CH_1 and this component should be well clear of the box lid when it is in position. The rest of the circuit is not critical.

The oscillator, when completed, can be tested initially by placing a milliammeter in the positive h.t. lead and reducing CV_1 to minimum value. The anode current should be approximately 16 mA. If CV_1 is now increased the current should drop suddenly to about 13 mA indicating oscillation. A further increase in CV_1 will ensure stable operation.

The frequency is set by adjusting the parallel-plate capacitor terminating the coaxial resonator. If this capacitor is set to too high a value the resonator is virtually shorted at the signal frequency and will operate, in the half-wavelength mode, at a much higher frequency. Should the test oscillator be required to operate at the low end of its frequency range and this fault found to occur, tuning capacitance can be added halfway down the inner conductor of the coaxial resonator by changing CV_1 for a fixed capacitor of about 33 pF.

With the resonator shown in Fig. 3 the frequency coverage is approximately 530 Mc/s to 600 Mc/s. Operation over other frequency ranges can be accomplished by redesigning the coaxial resonator.

The measurement of frequency is most easily accomplished, when an absorption wavemeter is not available, by means of a Lecher line. This comprises a pair of taut parallel wires forming an open transmission line and a bridge to short-circuit the wires. The oscillator is coupled by a loop to one end of the line and a simple loop-probe coupled by a crystal diode to a microammeter used to register the power output of the oscillator. The half-wavelength, and hence the frequency, can be deduced from the distance between successive bridge positions for a "dip" in the output.

In conclusion we feel that the advent of u.h.f. television broadcasting will make this simple and reliable instrument useful to both amateur and professional engineers. It will also enable useful experience in u.h.f. technique to be gained at minimum cost.

The oscillator described was developed as part of the research programme of the National Physical Laboratory and this article is published by permission of the Director of the Laboratory.

References

(1). Froome, K. D. and Bradsell, R. H., *Journal of Scientific Instruments*, 1961, vol 38, p.458.

(2). Bradsell, R. H. *New Scientist*, 1962, vol. 15, p.206.

(3). *The Amateur Radio Handbook*, Radio Society of Great Britain, 3rd edition, p.144.

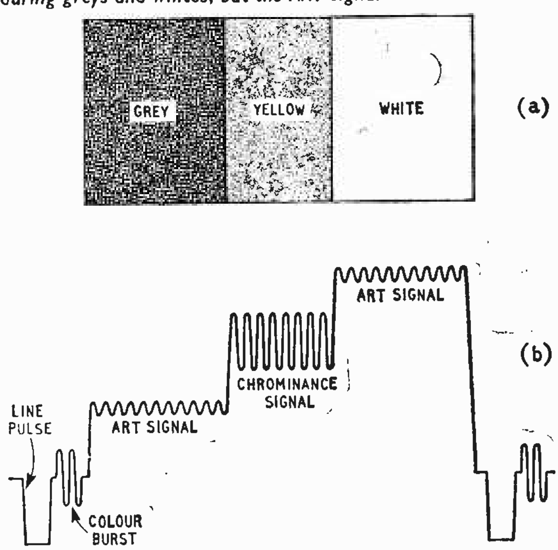
ART: A New Colour System

Now that the C.C.I.R. has prolonged, until April 1965, the competition for a European colour television system, the way may be clear for latecomers to enter the field and—who knows?—perhaps carry off the prize. The latest system to attract serious interest has been put forward by Dr. N. Mayer of the Institut für Rundfunktechnik, in Munich.

Tests with the new system have shown it to be immune to differential phase distortion up to at least 40°, to be less susceptible than N.T.S.C. to multipath distortion, and to have at least the same protection against noise.

Dr. Mayer was led to his new system by reasoning that the principal criticisms of N.T.S.C. were, in one way or another, concerned with the susceptibility of the subcarrier signal to amplitude-dependent phase distortion (i.e. differential-phase). SECAM and PAL are relatively immune to this type of distortion, but need in the receiver both a delay line (64μsec) and an electronic switch operating at the line timebase frequency. Dr. Mayer decided to investigate what improvements could be made to the N.T.S.C. system if the receiver could also include a delay line and an electronic switch.

Fig. 1. Transmitted "picture" (a) and its video waveform (b) showing the ART signal. On any one line, during the transmission of the yellow bar, the ART signal and the normal N.T.S.C. chrominance signal merge into one subcarrier sine wave. The normal N.T.S.C. chrominance subcarrier is zero during greys and whites, but the ART signal is still transmitted.



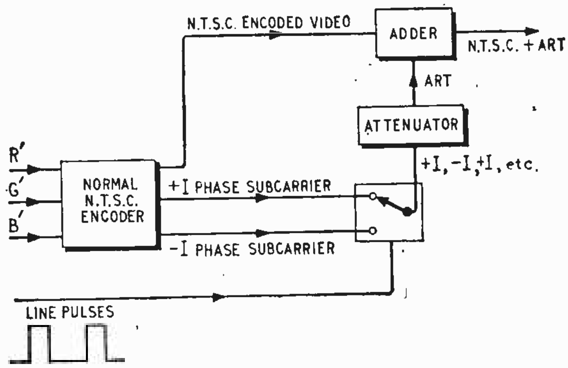


Fig. 2. Simplified block diagram of an N.T.S.C.-with-ART encoder.

So-called linear phase distortion is not particularly worrying in N.T.S.C., since the fundamental component of the chrominance subcarrier signal has the same frequency as the reference colour burst, and the relative phase between the two signals—which determines the reproduced hue—is unaltered. However, the reference burst is always at the black level of the composite signal, whereas the chrominance signal rides up and down on the varying-amplitude luminance signal. If the phase distortion is level-dependent, then the phase of the chrominance signal with respect to the colour burst will change, and this will change the colours of the reproduced picture. If the reference burst were to ride up and down on the luminance signal, together with the chrominance signal, then the relative phase between burst and chrominance could not be altered.

Dr. Mayer proposes that a new subcarrier reference signal should be added to the old N.T.S.C. signal, and that this should be present during the whole of the active part of each line scan, i.e. over all the picture area. He calls this new method of transmitting colour signals: N.T.S.C. with Additional Reference Transmission, which is abbreviated, naturally, to ART.

The additional reference signal is at N.T.S.C. subcarrier frequency precisely, and has the phase of the "I" signal, not of the colour burst. The phase of the additional reference signal is reversed from one scanning line to the next so that it is +I phase on one line and −I phase on the next, etc. At the beginning of every second field, however, the reversing switch is always set to the same polarity, since this improves the compatibility.

The dot pattern which such an additional reference signal produces on a monochrome receiver

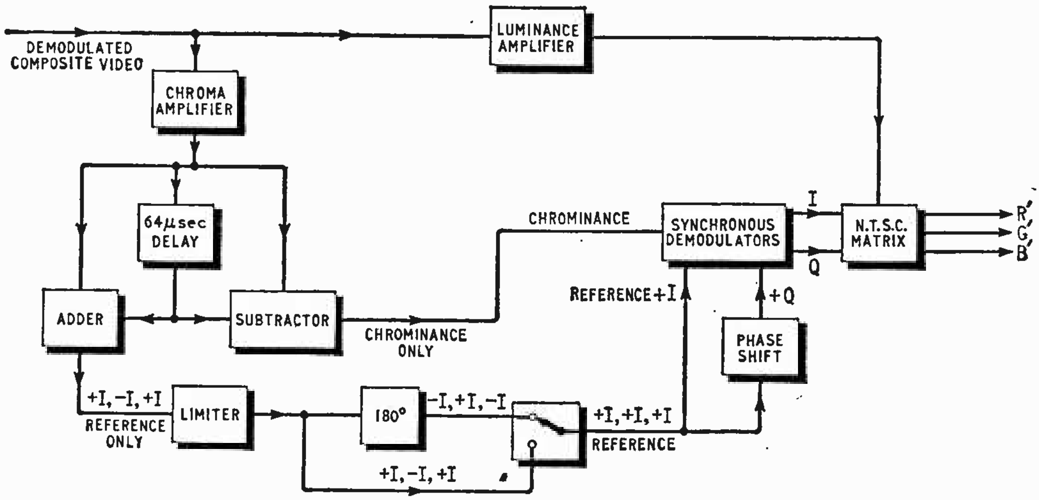


Fig. 3. One type of receiver decoder circuit for N.T.S.C. with ART. The output from the adder is twice the level of the I signal at its input.

screen is similar to that produced by a carrier at an odd multiple of line frequency, as distinct from the interlaced dots of the odd multiple of ½-line-frequency colour subcarrier. Experiments on carriers interfering with N.T.S.C. signals have demonstrated that such an interfering carrier becomes visible when its peak-to-peak amplitude is 24 dB with respect to the composite peak white signal. The p.t.p. amplitude of the ART reference signal is chosen to be 7% of the amplitude of the composite peak white signal, including sync pulses, i.e. 23 dB down.

Very little modification is required to normal type N.T.S.C. encoders in order to generate an ART signal. Outputs from the reference signal generator in the encoder, or feeding the encoder, are taken at 123° and −57°, i.e. ±I phases, and are alternately selected by an electronic switch operated by the line drive pulses. After adjustment to the correct, rather small, level, the ART signal is added to the normal output of the N.T.S.C. encoder.

Dr. Mayer reports that the compatibility of the ART composite signal is slightly worse than the normal N.T.S.C. signal, and several observers rated it at −1 grade (i.e. "slightly worse") on the E.B.U. comparative scale (Scale C).

The N.T.S.C. with ART signal will operate an N.T.S.C. colour receiver without any modification to its circuits, although the sensitivity of the receiver to hue changes produced by differential phase distortion in the signal path is then no better than for a normal N.T.S.C. transmission, since the standard colour receiver still derives its own reference signal for synchronous detection from the normal colour burst on the back porch.

The ART signal is demodulated as a small but unwanted colour signal, but the subjective effect is small. Since the ART signal is constant over any one scanning line, it produces a small d.c. colour shift after demodulation. Dr. Mayer has demonstrated the possibility of removing the effects of the ART signal from an N.T.S.C. receiver by clamping the colour signals before they are applied to the shadow mask tube. A further suggestion from Dr. Mayer is that a line-by-line switch might be added to the N.T.S.C. receiver to feed a small cancelling signal from the receiver's reference oscillator to compensate for the ART signal.

Such a receiver does not need an N.T.S.C. reference generator, since it derives the reference signal for the synchronous demodulators from the ART signal. The incoming chrominance signal is separated from the luminance signal and is then fed into a delay line. The delayed signal, as in a PAL de luxe receiver, is both added to, and subtracted from, the undelayed signal. If the picture content has not changed, then the N.T.S.C. chrominance signal is the same on successive lines except for the phase reversal of the subcarrier with respect to line sync pulses. Only the ART reference signal, therefore, comes out of the adder, since it has the same phase on successive lines with respect to the line sync pulses, although its phase with respect to the N.T.S.C. zero reference phase is alternating +I, −I, +I, −I. This reference signal is now amplified and limited and a line-by-line switch reverses the polarity of the reference on every line so that a continuous stream of signals, all in the same phase, is fed to the synchronous demodulators.

Suitably phase-shifted versions of this steady reference frequency can now be used for decoding the chrominance signal. The chrominance signal used is that coming out of the subtractor at the delay line; it is quite free of ART signal, which has been cancelled out by the subtraction.

Whenever the picture content changes between one scanning line and the next, then the cancellation processes used in the decoder cannot operate correctly. Dr. Mayer reports that these errors are not disturbing in general, although they become worse as the saturation of the adjacent colours increases. Cross-talk of the high frequency components of the luminance signal can occur, as in N.T.S.C. and PAL, and is principally observed as a flickering at vertical colour transitions such as occur in the colour bar signal. Also, if there are differences in response between the delay and direct channels, then cancellation of the signals is not perfect and a half-line-frequency structure becomes visible at the vertical colour transitions of colour bars, but is not normally noticeable on pictures. G. B. T.

A Code in the Head

SOME THOUGHTS ON CLASS B PROVOKED BY TALK OF MODULATED PULSE A.F. AMPLIFIERS

By THOMAS RODDAM

THE publication of Mr. Birt's article on modulated pulse amplifiers (*W.W.* Feb. 1963) seems to have stirred up a good deal of life in both the U.K. and the U.S.A. Over cups of tea and cups of coffee voices can be heard saying: "Isn't that just what I was telling you?" Moral number one of Mr. Birt's article is certainly: shut up and build it. Moral number two is that we must, from time to time, try to get a different perspective on the things we think we know. A good time for doing this is when you are on holiday. This ageing writer, having spent the day laboriously raising himself some 3,000 feet above his starting point and then returning with hesitating feet, finds himself daily with a gap of an hour between the putting on of civilized clothing and the earliest decent moment for the first glass of native liquor. One can read Gibbon or Dostoyevsky, or one can think about the fundamentals of one's trade without being bogged down in the details of a particular brass box.

Somewhere or another (for the six books to hand contain no useful references and one, a novel by a friend, isn't even worth reading) William James classifies temperaments as tough or tender. In other words, some people like to classify their ideas in what they regard as systematic groups, while others prefer to generalize. This appears to be a tremendously important matter. New ideas are usually related in some way to what we already know and are produced most easily by taking the most general view we can of our problem; text-book writers and instructors tend towards classification, towards the numbered paragraph or the topic of the day. Resist the temptation to lock all you know into a multiplicity of separate boxes.

Everybody knows that in designating audio-frequency amplifiers the first choice is the choice of device, the second choice is a decision to use class A, class AB, class B operation, or one of the trick models which need not be further defined at this stage. If you look in the text books you will find each of these discussed separately and once you choose your mode you have set foot on a closely walked path. When we are carrying out the detailed design work we do need the detailed analysis of the particular mode. When we first start to think about the amplifier, however, there is some advantage in a rather different point of view. In one case, at least, the general viewpoint suggested in this article will actually clarify the design problems. In others, you must judge for yourself.

Commonsense suggests that undistorted amplification can only be produced by a device with a linear transfer coefficient. If we restrict ourselves to the use of one valve or one transistor we might expect that this would limit us to class-A operation, with the possibility, to be explored, of using some kind of pulse circuit. The limitation, in fact, applies in the simple sense to only one kind of signal, a signal of variable frequency but constant amplitude.

The important thing to remember in dealing with any problem is that we should not ignore any information which we possess. We may, by choice, leave some information out of our detailed study but in doing so we must remember what we have done. In most of our circuit analysis there comes a point when we say: let us approximate. We must not forget that inside the bundle marked "approximately" we have some information concealed.

Coding the Signal

When we wish to process, that is to amplify or transmit, a signal we may make substantial economics if we separate out the information contained in the signal into two groups. One of these groups is the information on the kind of signal with which we are dealing and this information may be handled independently, by a separate channel if necessary, although this separate channel may be multiplexed into the same path as the other group. This concept of coding the signal, and of transmitting the code independently is usually applied to the techniques of rearranging the bandwidth occupied by a signal. The most important application is the use of various codes, like frequency modulation and the pulse modulation systems, to provide an improvement in signal-to-noise ratio. Part of the signal which you hear from an f.m. receiver is, formally speaking, transmitted by letter post as a leaflet giving the details of the deviation and pre-emphasis characteristic.

There is no reason why we should limit ourselves

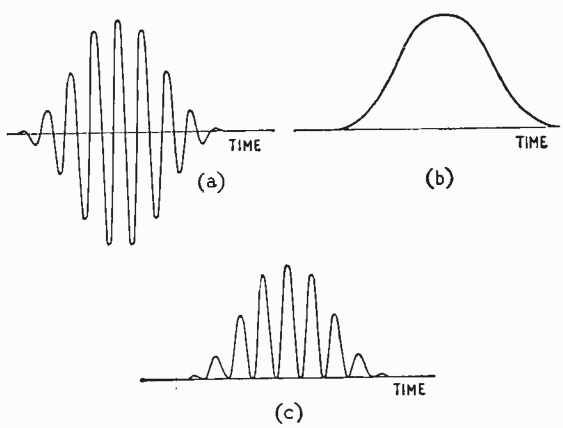


Fig. 1. A syllable of speech and its components.

to coding in terms of frequency. We know, indeed, that we can quantize the instantaneous amplitudes and code these, to give, in one system of transmission, pulse code modulation. We can, and indeed we do, adopt simpler methods of coding. As a first example let us limit ourselves to the amplification of speech. We can say that the signal with which we are concerned consists of frequencies above 200 c/s, modulated by the syllabic frequencies of up to 10 c/s and down to a fraction of 1 c/s. In the gap between these rather arbitrarily chosen figures, 10 c/s and 200 c/s, the speech energy may be neglected. Normally we use only part of this information; we ignore the fact that we have the very low frequency modulation except when we are studying problems of loading in multichannel systems.

Amplifiers using the sliding bias principle make use of more of our knowledge of the characteristics of speech. We can say that a very primitive speech syllable will have a waveform something like that shown as Fig 1(a). Notice that the syllabic frequency appears only as modulation of the audio frequency, so that the lowest frequency will be the sideband term ($f_{audio} - f_{syllabic}$). We can extract the syllabic frequency term by rectifying the speech waveform and passing the rectified signal through a

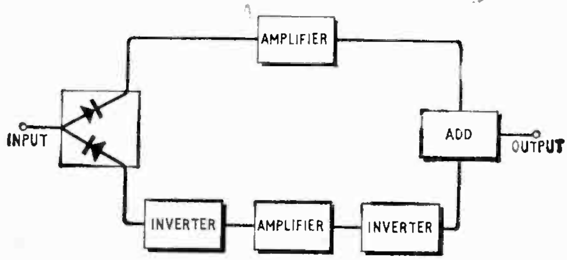


Fig. 2. Principle of coding and decoding.

low-pass filter which has a pass band extending above 10 c/s and gives high attenuation to frequencies of 200 c/s and above. Such a syllabic signal is shown as Fig. 1(b). If we now add this to the original signal, we obtain, provided suitable precautions are taken, the waveform shown in Fig. 1(c). We can always recover the original speech signal, by extracting it with a simple high-pass filter. No part of the added signal (Fig. 1(b)) falls in the audio band and we have not carried out any multiplication operation to cause cross-modulation.

To the extent that Fig. 1(c) represents the waveform which we can produce, we see that it can be amplified by a device which, in its quiescent state, is held just at cut-off and has a linear characteristic through the conduction range. In a practical amplifier we know that we have the cut-off rounding to avoid, and we cannot rely on maintaining the absolute fit of rectified syllabic waveform and speech envelope. Even so, surprisingly high efficiencies combined with high-quality (that is to say high-intelligibility) speech can be obtained.

Putting aside the actual circuit technique, which is usually a reflex system and thus confuses the issue, we see that at the input of the amplifier we code the signal by adding something to it and then decode the signal at the output by filtering out the additive. The coding rules are very simple and are described by Fig. 1.

Let us now consider quite a different position. We shall assume that we know roughly both the frequency and the amplitude of the signal we wish to amplify. This information is of a once-for-all kind, and thus can be built into the code system. Here we have the common problem of the amplifier which follows a master oscillator. The practical solution is to pre-distort the waveform into a pulse of convenient duration and to filter out only the fundamental at the output. The master oscillator provides the information about the exact frequency, somewhere within the allotted range, a range which is defined by the tuned circuits. Here, indeed, we have the familiar class-C amplifier, a highly degenerate case of our more more general problem.

When the frequency is known roughly but the amplitude can vary over a wide range we may still adopt this kind of approach, but the importance which is attached to depth of modulation leads to the use of the rather special case of 180° conduction, the class-B amplifier. The class-B principle is not sacrosanct, for the Doherty amplifier circuit makes use of what we may describe as a topping-up class-C amplifier. It will be interesting to see whether, when really high-power transistors are available, there is a new surge forward in circuit design: valve circuit designers seem to have lost the urge to hunt for the extra few per cent of efficiency and instead of worrying about the extra shillings on the power bill are now trying to save pounds on operators' wages.

Speech and Music

These excursions away from our topic of audio-frequency amplification were not without intent. In the long run we are concerned with signals which have not the simple limitation of high-frequency working. Those readers who have tried to progress from speech compression to music compression will know that in music we have not even got a gap between the syllabic frequency, if we may call it that, and the lowest fundamental frequency which we wish to handle. Compression, a coding system used to improve signal-to-noise ratio, cannot be used for really high quality music. (By compression, of course, I imply subsequent expansion, the overall compansion of the signal).

About the only characteristic of the musical waveform which we can regard as safely to be taken for granted is the fact that it is roughly symmetrical. Let us take this symmetry into account and code the signal by splitting it into two portions, each of which will be handled separately. The only terminology which seems to have been evolved is that used some twenty years ago by tank designers, who may still be using it. They differentiated between the swing and the swang of an oscillatory motion. With a sinusoidal waveform the swing and swang are just the alternate half-cycles, while with a more complicated waveform we may take the swing as all excursions above the axis, and the swang as all excursions below the axis. We know that a pair of rectifiers will then split the audio frequency signal into the two channels, the swing channel and the swang channel. Since the waveform is roughly symmetrical the amounts of signal in the two channels will be about the same. We need to state this formally, because there are ways of splitting the signal up which do not give equal amounts of power in the variable channels. One such system is, indeed,

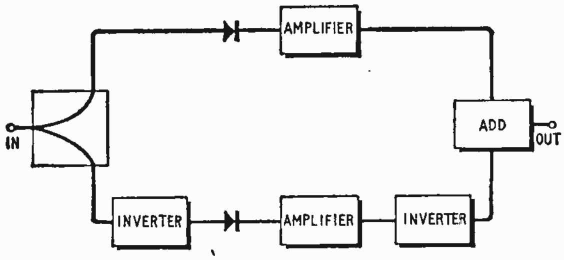


Fig. 3. An alternative input circuit.

the cross-over network used to direct the various parts of the signal to the approximate loudspeakers in a multi-speaker assembly.

Having coded the signal into two channels, they may now be amplified separately. The swang channel may be inverted by either a valve/transistor or a transformer and the swing and swang amplifiers are thus identical. Decoding consists merely of re-inverting the swang channel and adding the two signals together. The overall system is shown as a block diagram in Fig. 2. An alternative construction is to place the inverter in the swang channel before the rectifier, which must then be reversed, giving arrangement of Fig. 3.

The characteristic feature of the two part-signals which we have produced in this operation is that they are unidirectional. A second characteristic feature which must not be overlooked is that in the coding operation we have produced the syllabic frequencies as themselves and not merely as modulation. Unidirectional signals can, of course, be amplified by linear amplifiers working up from the cut-off position, which we know leads to efficient operation with a programme type of signal. The idealized amplifiers, in fact, draw no power at all during quiescent periods. In spite of the apparent complexity of the arrangement we may find it profitable to adopt it. We find that we cannot use the system in the simple form of either Fig. 2 or Fig. 3, because our amplifiers are not linear right down to the cut-off condition. Some sort of compensation for this can be provided by adopting a compromise with a variant of this scheme. In this variant the waveform is still split in two, but an instantaneous compression system is used to squeeze the swang progressively while stretching the swing in one channel, the reverse operation being provided by the other channel. The quasi-rectification again extracts the syllabic frequencies.

When we examine the arrangement of Fig. 3 with the syllabic frequencies in mind we see that the inversion and addition at the output give us a balancing elimination of these frequencies in the output path. This is, of course, vital to the successful operation of a system of this kind for the amplification of music, since we cannot rely on any frequency separation to allow us to filter out the syllabic component. Here there are two points to discuss, one of which leads on to a rather unexpected conclusion, so that I feel I must interrupt the general discussion.

Some, many, most, or even all readers will have seen that the so-called coding system we have just been discussing is, in fact, the common class-B push-pull amplifier. Years ago I should have written stage, but with the advent of the transistor we have seen the use of two or three transistors in tandem on each side and there is a limit to the meaning we can give to "stage". The rectification, of course, takes place at the input electrode, and the inverter is simply one aspect of the phase splitter. The output inverter is the result of the common bridge connection, in one form or another.

In describing this common amplifier in a roundabout way we have stressed the internal production of the syllabic frequencies. It is well known in amplifier design that, *ceteris paribus*, things never are equal. We really cannot rely on balancing out the syllabic frequencies perfectly. Of course, in this day and age, to use one of the most idiotic phrases which ever limped off every tongue, our amplifiers will always be provided with a good deal of negative feedback.

The conclusion is so important that a new paragraph is appropriate. When we use a class-B stage, and this term embraces all push-pull non-linear pairs, the negative feedback loop round the class-B portion must transmit the syllabic frequencies. If we represent the complete amplifier by the diagram in Fig. 4 we must get the syllabic terms which appear at the point O back through the feedback path and the class-A section to the point P. Unless we do this the output will, or at least may, contain terms which we might call interdemodulation terms. Whether, in fact, terms of this kind are objectionable in practice is something which can only be found by a study with a listening panel.

Fluctuating Supply Current

The other point which must be considered in connection with the syllabic component is that in the two amplifiers it is in phase. There is no balancing towards a common supply. We must, therefore, maintain a low supply impedance down to the lowest syllabic frequency. In Mr. Birt's article, which started me off on this track, he lists fluctuation of supply current among the disadvantages of class-B working. However, class-B operation is just one of the ways in which we can code our signal to increase our efficiency or to derive some other advantage. If the coding is used to increase the efficiency we cannot avoid this fluctuation in supply current, as Mr. Birt points out when he considers adding a low-pass filter to his output path. He considers making use of the fact that the waste energy in his system is mainly available as a high-frequency signal, and can be diverted to a resistor by a high-pass, low-pass pair. It is usually convenient to use a resistor rather than a transistor for dissipating the heat.

In practice some class-B amplifiers use regulated power supplies and it is tempting to consider a chopper transistor for regulation purposes. I do not propose to go into this aspect of design here.

A feature of signal coding which appears in the

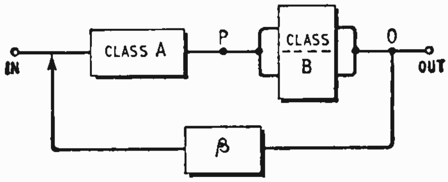


Fig. 4. Complete amplifier with class B and feedback.

systems already mentioned, and in Dome's circuit, which I have mentioned elsewhere and do not propose to discuss, is that all of them appear to involve the introduction of frequencies outside the original signal band. The resulting increase in frequency range which must be considered is the price we pay for increased efficiency. All circuits, indeed, work to the maxim: Hear all, see all, say nowt, and if tha does owt for nowt, do it for thi'sen. A class-A stage, in a silent period, certainly will tak all, gi' nowt.

The object of this approach, this idea that the only way to avoid class-A working is to code the signal, is essentially to change the reader's outlook. In designing an amplifier you may either use class-A stages throughout, or you may adopt a coding system. If you decide to use a coding system, then you may make a choice of an amplitude code or a time code, or even the Dome time-amplitude system. Each system can be considered on its merits, divorced from the old-reliable attitude towards class-B and the new-fangled view of pulse modulation. Be prejudiced, by all means, but at least admit it.

COMMERCIAL LITERATURE

The Series 700 miniature **push-button** switch is described in A.B. Metal Products technical bulletin No. 302. Copies of this 10-page bulletin are obtainable from A.B. Metal Products Ltd., North West House, 119-127 Marylebone Road, London, N.W.1.
9WW 526 for further details

A new brochure giving details of the facsimile method of **transmitting and recording weather charts** is available from Muirhead & Co. Ltd., Beckenham, Kent. Specifications of the current range of Mufax facsimile equipment are included.
9WW 527 for further details

A brochure describing the **activities of the Rank Organisation,** of 38 South Street, London, W.1, in the industrial field, has been sent to us. Thinking ahead in colour (*television*), making it safer to fly, predicting thunder and lightning, communications and control, and applying electronics to surgery are among the sub-titles of this publication.
9WW 528 for further details

A 176-page catalogue listing the products of the Canadian organization Cambridge Thermionic Corporation (Cambion) has been forwarded to us. It lists **equipment fittings and electronic components** and is available from Cambion Electronic Products Ltd., Cambion Works, Castleton, nr. Sheffield.
9WW 529 for further details

A general leaflet, in English, and a technical leaflet, in Swedish, describing a **transistor portable television receiver,** has been sent to us by Luxor Industri Aktiebolag, of Motala, Sweden. A full circuit diagram appears in the technical leaflet.
9WW 530 for further details

A 10-watt servo amplifier, for use in 50, 60 or 400 c/s systems, is described in Evershed and Vignols leaflet No. 1/353. This leaflet is the first of a series covering the whole range of Evershed servo amplifiers and is obtainable from the Company's works in Acton Lane, Chiswick, London, W.4.
9WW 531 for further details

Telettra S.p.A., of Carlo Poma, Milan, have produced a 23-page English edition of their general catalogue. It contains information on their multiplex telephone, microwave and data transmission systems, and their telecommunications, measuring and power supply equipment.
9WW 532 for further details

Trinistor silicon controlled recifiers, with forward current ratings of 4.7A (mean) and peak repetitive reverse voltages ranging from 30 to 480V are described in the Westinghouse technical publication No. 36-12. Larger s.c.rs, rated up to 70A (mean) with peak reverse and forward voltage ratings of 600 volts, are described in publication No. 36-16. Copies are available from Westinghouse Brake & Signal Company Ltd., 82 York Way, King's Cross, London, N.1.
9WW 533 for further details

Revised literature describing the range of American **Holtzer-Cabot servo, induction and synchronous motors** (Publications M.24 and M.25) is available from Elliott Brothers (London) Ltd., Century Works, Lewisham, London, S.E.13. Electrical and mechanical data is included.
9WW 534 for further details

The 1964 **valve catalogue** is now available from Pinnacle Electronics Ltd., Achilles Street, New Cross, London, S.E.14. More than 1,000 types, from manufacturers all over the world, are listed under subject headings. The types covered range from those used in domestic radio and television to power triodes and tetrodes. A number of specialist types are also included.
9WW 535 for further details

A 12-page catalogue listing the different types of **silicon and germanium semiconductors** manufactured by SESCO (Société européenne des semiconducteurs) has been forwarded to us. This French company is represented in the U.K. by M.C.P. Electronics Ltd., Station Wharf Works, Alperton, Middx.
9WW 536 for further details

A new 36-page brochure giving abridged specifications and performance data for several hundred electrical instruments manufactured by the **Cambridge Instrument Company** is available from the company's head office at 13 Grosvenor Place, London, S.W.1. It describes a number of entirely new instruments, including a 6-dial precision bridge with an accuracy of $\pm 0.005\%$ over the greater part of its range (1Ω to 111MΩ) and an a.c./d.c. comparator with an accuracy of $\pm 0.05\%$ between 25 c/s and 10 kc/s.
9WW 537 for further details

A four-page leaflet describing the Siemens & Halske AF 139 Mesa **u.h.f. transistor** is available from the U.K. agents R. H. Cole Electronics Ltd., 26-32 Caxton Street, Westminster, London, S.W.1. A section of the leaflet is devoted to the design considerations of a quarter-wavelength u.h.f. tuner.
9WW 538 for further details

Application notes for cold cathode indicator tubes are contained in a new 24-page booklet (MS/126) from the valve division of Standard Telephones and Cables, Footscray, Sidcup, Kent. Indicator tube applications to digital measuring instruments, computer console displays, frequency counters and telecommunication channel indicators are included. Copies are available from the valve division.
9WW 539 for further details

Literature on the recently introduced Painton-Camblock range of **terminal blocks** is available from Painton & Company Ltd., Kingsthorpe, Northants. In this type of terminal block, the wire is compressed against the busbar with a wedging action by a rotary tapered cam.
9WW 540 for further details

MANUFACTURERS' PRODUCTS

NEW ELECTRONIC EQUIPMENT AND ACCESSORIES

Silicon Controlled Rectifiers

A NEW series of 8-ampere s.c.r.'s are available from Motorola Semiconductors, New Bond Street, London, W.1. Characterized by being much smaller than existing components of the same current rating, they are designated the MCR1304 series. Voltage ratings are available from 25 to 400V. The s.c.r.'s are housed in a steel case 0.278in long and 0.345in in diameter. Capable of switching up to 3.2 kW, rectifiers of this series can control a full 8A d.c. output. They can operate over a junction temperature range of −40 to +100°C.

9WW 541 for further details

Gas Laser

THE new Raytheon, helium-neon gas laser Type LG-10 uses two plasma discharge tubes optically coupled through a prism to produce a single, high-intensity laser beam directed from one tube into the second parallel one. This enables a high power output, to the order of 100 mW, to be produced from a relatively compact apparatus. Excitation of the plasma tubes is accomplished by direct current. This model is designed for optimum output at 6328 Angstroms but it can produce coherent light at 1·15 or 3·39 microns with minor modifications.

Capable of withstanding shocks equivalent to accelerations of up to 10 *g*, the laser is claimed to have an unusual capacity to tolerate extreme environmental conditions due to the frame and suspension system.

The equipment weighs less than 50 lb and is 57 in long.

9WW 542 for further details

Direct-voltage Regulation

A TRANSISTOR voltage regulator, Type TD428 is available from Newton Brothers, Derby (Newton Derby). The regulator was designed for the precise control of 24 to 28 V generators with field resistances as low as 2·5 Ω. A regulation of ±1 % is achieved. The unit can be used over a temperature range of −20 to +50°C. The response time is claimed to be less than 20 msec. A current-limiting device and a reverse-current protection unit using diodes are available as optional extras. The basic cost of a regulator is £26 18s with reductions for quantity purchasing.

9WW 543 for further details

Axial Hall Probe

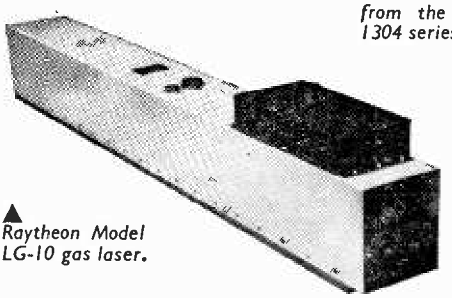
THE axial Hall probe constructed from the Scientifica A.9 kit provides the basis from which a number of Hall devices may be constructed. These include an amplifier, oscillator and multiplier. By having the Hall crystal mounted at right angles to the probe axis the probe can be used to measure the magnetic field inside a solenoid or in any position where the magnetic flux is parallel to the direction of the probe. By connecting the output of the probe direct to a 50μA movement meter, field strengths from 50 to 20,000gauss can be easily measured. An indium antimonide crystal is used because of the large output and zero stability associated with this material. The crystal is square in shape, the connections being made to the four corners.

The probe is supplied with a manual which details the constructional procedure and the theoretical principles involved. A standard magnet is provided for calibration and demonstration purposes. The cost of the kit is £19 12s.

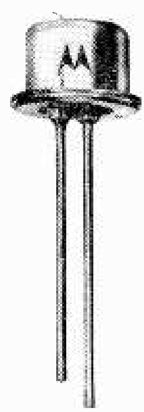
9WW 544 for further details

Instrument Trolley

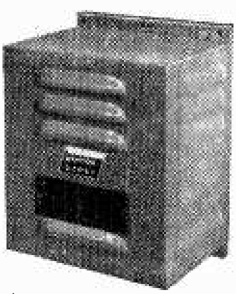
THE main feature of the Type TM10 trolley, manufactured by Avon Communications and Electronics, Christchurch, Hampshire, is that the top tray may be used flat or inclined at any angle up to 20° to the horizontal. Adjustment of the position required is by means of a winding handle. The trolley is constructed



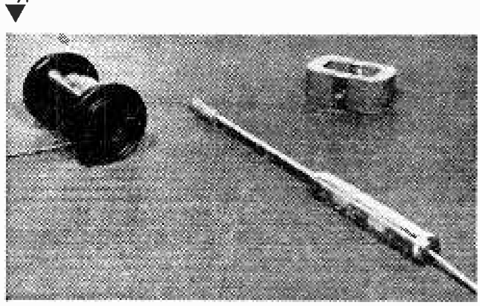
Raytheon Model LG-10 gas laser.



Silicon controlled rectifier from the Motorola MCR 1304 series.

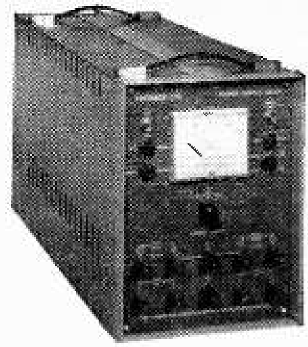


Transistor voltage regulator for direct-voltage generators manufactured by Newton Brothers.

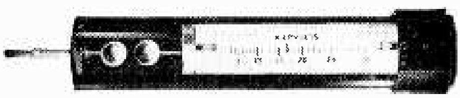


Axial Hall probe constructed from "Scientifica" Type A.9 kit.

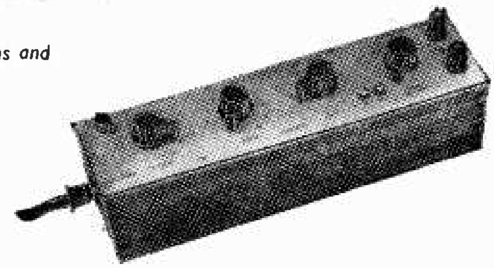
▲ *Instrument trolley Type TM10 manufactured by Avon Communications and Electronics.*



▲ *Feedback power supply Type SD214.*



▲ *Mark II Kilovolter, manufactured by Waveforms.*



▲ *Lionmount Type BW2 Wheatstone bridge.*

from steel tubes welded to form a frame for both shelves. The height of the trolley is adjustable in 1-in steps from 27 to 33 in. The dimensions of the top shelf are $17 \times 28\frac{1}{2}$ in, while those of the lower shelf are 20×30 in. The distance between both shelves is 17 in. Push bars are fitted at both ends of the trolley.

The standard castors fitted are 5-in, heavy-duty, Flexello types with rubber tyres and ball-bearing swivels. Other types can be supplied and these include castors with foot-operated brakes and 5-in, spring-loaded castors with cushion-tyred wheels for transport of delicate instruments, etc. Other accessories that are available include Lexor mains-distribution boards, drawer assembly to fit under bottom shelf and rubber or Formica covers for both shelves.

9WW 545 for further details

General-purpose Power Supply

THE power supply Type SD214 manufactured by Feedback, Crowborough, Sussex, enables the user (by connection alteration) to obtain two separate, "floating" 300 V supplies at 150 mA, a supply of +600 or −600 V at 150 mA and a + or −300 V supply at 300 mA. In addition three 6.3 V outputs are available which can supply up to 16 A. A current-monitoring meter is provided. The total ripple content of the d.c. outputs is less than 3 mV (r.m.s.) and the output impedance is less than 1Ω. The long-term stability of the outputs is greater than 300:1 for variations of up to 15% of the nominal value of the supply. An unusual feature is that the outputs are available either from screw/socket terminals on the front panel or from two, 6-way Painton sockets at the rear. The weight of the power supply is 36 lb and the dimensions are $8.5 \times 12.5 \times 22$ in. The cost of the equipment is £135.

9WW 546 for further details

Kilovolt Measurement

MEASUREMENTS of high voltage over the range 3 to 30 kV can be quickly carried out with the new Kilovolter Mark II manufactured by Waveforms, Vauxhall Bridge Road, London, S.W.1. The instrument is of the calibrated, spark-gap type and is read after withdrawal from the high-voltage source. It does not retain the charge. A $2\frac{1}{2}$ in scale is employed.

9WW 547 for further details

Wheatstone Bridge

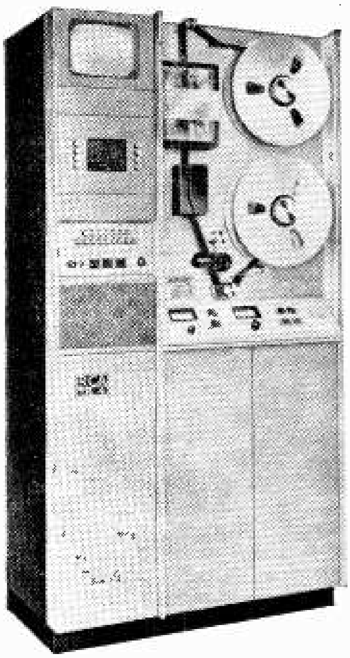
A RANGE of inexpensive Wheatstone bridges is available from Lionmount and Co., Lynton Road, London, N.8. They have been designed for the user who needs to make only occasional resistance measurements and who has access to a sensitive detector. The Type BW2 bridge has a range of 0.1 Ω to 1.11 MΩ achieved with 3 decades and a range multiplier. Other models permit measurements up to 11.11 MΩ. The resistors used are adjusted to 0.1% and are non-inductively wound with a low temperature coefficient wire. The instrument is housed in a mahogany case.

9WW 548 for further details

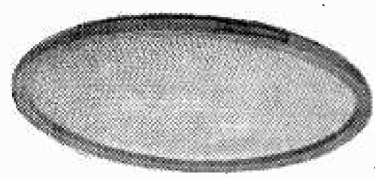
Photoconductor

A MINIATURE photoconductor developed by Sylvania and available from Thorn Electronics, Judd Street, London, has a diameter of $\frac{1}{4}$ in and is only $\frac{1}{2}$ in long. The response is claimed to be closely akin to that of the human eye and is ideal for applications ranging from street-lighting control to industrial safety devices. The component can also be used for critical work such as colour matching or flame detection (or failure).

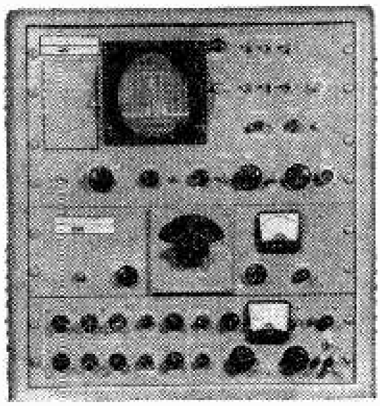
The sensitive area of the cell is restricted to the top of the glass bulb. The field of sensitivity can be effectively screened for precision applications by mounting in a tube. The photoconductor can be used in



▲ *TR-4 television tape-recording equipment (R.C.A.).*



▲ *Instrument air filter (Machine Control.*



▲ *Panoramic spectrum analyser Type SSB-3b.*

ambient temperatures from −40°C to +70°C. Available for a.c. or d.c. use, up to 300 V can be handled.

9WW 549 for further details

Time-delay Units

VARIABLE, electronic, time-delay units are now available from the Electrical Remote Control Company, Harlow. The units are insensitive to temperature variations of −30 to +65°C and mechanical shocks equivalent to accelerations of up to 15*g*. They can operate in any mounting position. Cold cathode tubes are used in the delays which may be set, by potentiometer, to operate in ranges of 0.5 to 5 sec, 2 to 15 sec, 5 to 30 sec and 10 to 60 sec. The reset time is 15 msec. The tube operates only during the actual time-delay period. The size of each unit from this ER series is $4\frac{5}{16} \times 1\frac{27}{32} \times 4\frac{21}{32}$ in. The maximum continuous contact current is 15 A resistive or 5 A inductive.

9WW 550 for further details

Television Tape Equipment

A NEW range of video tape equipment using solid-state techniques has been introduced by R.C.A., Sunbury-on-Thames, Middlesex. The equipments involved at present are the TR-5, a compact, quadruplex recording device with limited playback facilities to permit on-the-spot cueing and preview to check picture quality; the TR-3 playback apparatus which can be easily operated for preview, editing and "on-air" playback, thus freeing existing video tape recorders from replay-only functions; and the TR-4, a complete record-playback unit.

All these equipments are switchable between 405, 525 and 625 line standards and operate on 230 V, 50 c/s. They also have two speeds, 15 and $7\frac{1}{2}$ in/sec (accessory units will be available for colour operation). An important feature of this new range is that they are compatible with other quadruplex recorders.

The TR-4 equipment includes picture and waveform monitors, audio monitor and a full complement of instrumentation for check-out and adjustment purposes. Facilities are provided for plug-in accessories including cue record/playback unit, electronic splicer, automatic timing correctors and air-bearing head-wheels.

9WW 551 for further details

Air Filters

NEW air filters which are designed as plug-in units for electronic instrumentation are available from Machine Control, Crawley, Sussex. Standard sizes are available to fit holes of 3, 6, 8, 9, 10 and 12 in diameters. The standard range of filters is only suitable for insertion in material thickness between 16 and 22 s.w.g. The filters have circular, polythene frames which dispense with the need for separate frames on the equipment. The filtering medium, which is inserted at the time of moulding, consists of 2 grades of "de-membraned," synthetic foam. Four standard filters are available giving collecting efficiencies between 48 and 98% on 5-7 micrometre (microns) dust particles. A p.v.c. mesh is used to protect the filter material. The manufacturers claim that the only maintenance necessary is periodic washing with water and detergent. Special sizes and shapes can be produced to customer specifications.

9WW 552 for further details

Spectrum Analyser

THE frequency range of a new spectrum analyser Type SSB-3b manufactured by Panoramic, extends from 2 to 40 Mc/s. The input impedance is 50 Ω but when used with the cathode-follower probe it is 12 MΩ (5 pF). Special features of this instrument include pre-set sweep widths of 150 and 500 c/s and 3.5, 7

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and 14 kc/s, a 0 to 100 kc/s variable scan, continuously-adjustable two-tone generator and a marker display that checks the residual distortion of the analyser to better than 60 dB. The sensitivity of the equipment is virtually uniform over the complete frequency range. The instrument is marketed in the U.K. by Roberts Electronics, Hitchin, Herts.

9WW 553 for further details

Oscilloscope Cameras

TWO new Fairchild-Du Mont oscilloscope cameras Types 453 and 453A are available from Aveley Electric, South Ockendon, Essex. Photographic records from 4×5 in down to 35 mm can be obtained. The camera shutter is lever actuated and the oscilloscope screen can be viewed during recording. The object-to-image ratio is continuously variable over a range of 1:1 to 1:0.7 with one lens and without the need for extra attachments such as spacers or gauges, etc. Either *f*1.9 or *f*2.8 lenses can be supplied.

9WW 554 for further details

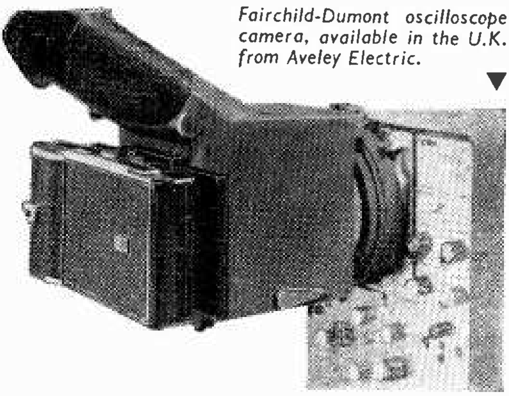
In-line Indicators

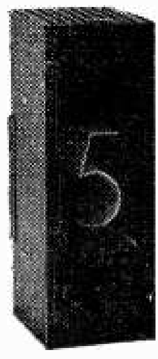
NEW digital-indicators are available from Hilger and Watts, St. Pancras Way, London, N.W.1. Designated the Hiray series they can be used in high ambient light conditions and are designed to be powered from supply voltages of 6, 12 or 28 V. The figures, $\frac{3}{4}\times\frac{1}{2}$in, are edgewise lighted and mounted in an insulated case 3×1×1·5 in in size.

Each unit, or decade, comprises a stack of 10 Perspex plates engraved with the numerals 0 to 9 (two extra plates can be added). Each plate is edge illuminated by a midget lamp. Contact with the lamps is via a printed-circuit plate which hinges back to facilitate lamp changes. External contacts are to hollow rivets, each clearly marked to show the numeral connected. The lamp life is expected to be 2000 to 3000 hours at 12V. Components of the Hiray series may be mounted behind or in front of a panel.

9WW 555 for further details

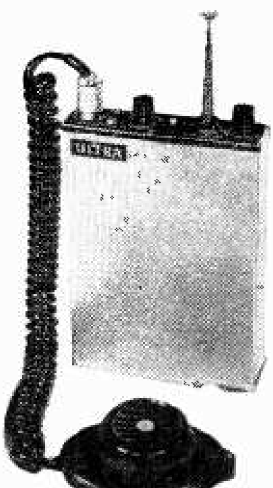
Fairchild-Dumont oscilloscope camera, available in the U.K. from Aveley Electric. ▼

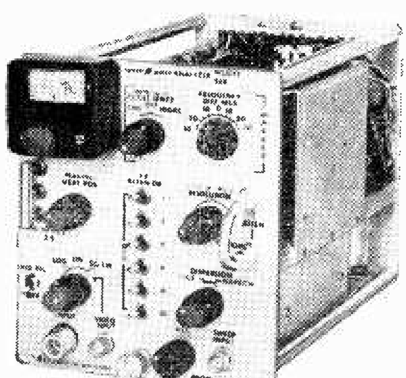




▲ *Digital in-line indicator from the Hilger and Watts "Hiray" series.*

Ultra Electronics Type 4B6 f.m. transmitter receiver. ▼





▲ *Plug-in unit Type L20 may be used with Tektronix oscilloscopes to provide spectrum-analysis facilities (manufactured by Pentrix).*

Transmitter-Receiver

OPERATING over the frequency ranges 71 to 101 Mc/s and 156 to 174 Mc/s, the Ultra Electronics f.m. transmitter/receiver Type 4B6 weighs only 3 lb and measures only 8×5×1¼in. The equipment includes a retractable whip aerial but a socket permits connection of an external aerial. The standard equipment contains a combined loudspeaker and microphone (with a press-to-talk switch) but other hand or head sets can be provided. The power output is 500 mW. The equipment is powered by a nickel-cadmium rechargeable battery which permits 8 hours continuous operation on a 10:1 receive/transmit ratio. The operational range is approximately 5 miles. The equipment is G.P.O. type-approved. The address of the manufacturers is Ultra Electronics Ltd., Telecommunications Division, London, W.3.

9WW 556 for further details

Spectrum Analysis

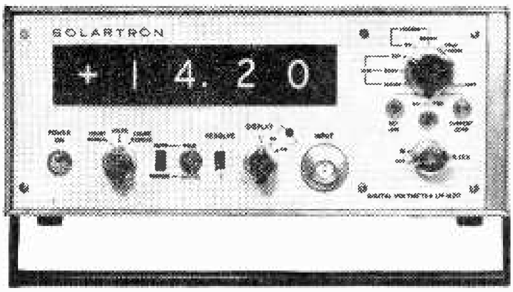
A SERIES of plug-in units is available which, when used with the Tektronix 530/540 series of oscilloscopes, provides spectrum-analysis facilities. Manufactured by Pentrix and available in the U.K. from Livingston Laboratories, Camden Road, London, N.W.1, the available units can be used in h.f., u.h.f. and microwave fields. The Type L20 unit covers the frequency range 10 to 4,000 Mc/s and the sweep width can be varied from 2·5 kc/s to 5 Mc/s on the narrow range and from 100 kc/s to 60 Mc/s on the wide range. The sweep rate is adjustable from 0·02 to 1000 c/s. Fixed and variable markers are provided and the display can be logarithmic, linear or square law. Provision is made for a video input with a response from 10 c/s to 10 Mc/s.

9WW 557 for further details

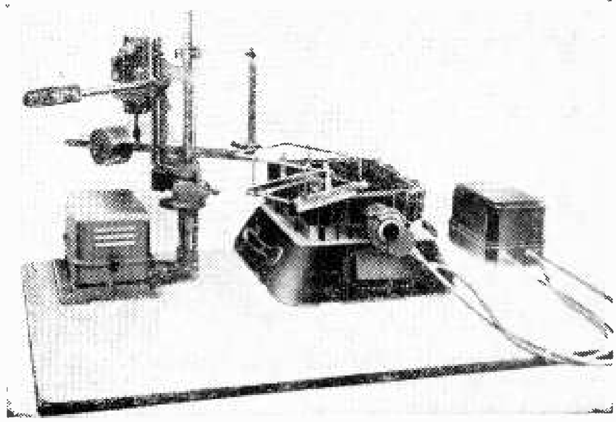
Screened-room Filters

SCREENED-ROOM filters, manufactured by Aerovox are now available in the U.K. from F. G. Robinson and Partners, Wimbledon, London, S.W.19. These filters, with their simple mounting arrangements, ensure that mains supplies taken into screened rooms are free from inter-

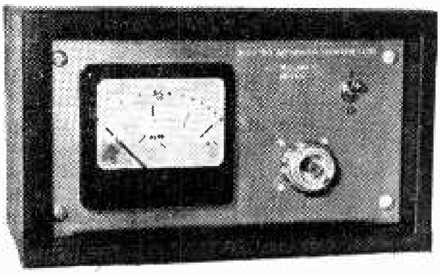
(*Continued on page* 317)



▲ *Solartron digital voltmeter Type LM. 1420.*

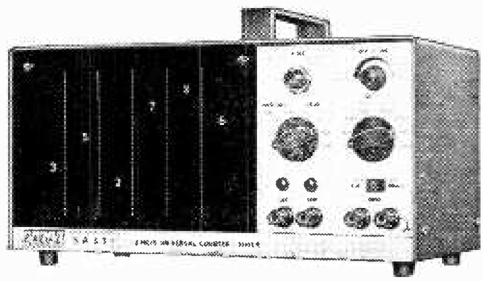


▲ *Semi-automatic, dip soldering equipment (Zeva).*



▲ *R.f. power meter manufactured by Electro Apparatus.*

Electronic counter/timer Type GA. 535 manufactured by Racal Instruments. ▶



ference and that signals inside the room are not fed into the mains. Several different current and voltage ratings are available and the frequency band attenuated extends from 14 kc/s to 1,000 Mc/s. (Two special types extend the range to 10,000 Mc/s). In the lower current types (30 and 50 A) single-, two- or three-circuit units are available. The maximum size for a single-circuit version is $4\frac{3}{8} \times 4\frac{3}{8} \times 22$in. All types are hermetically sealed with shielded terminals.

9WW 558 for further details

Digital Voltmeter

A FOUR digit, display system employing cold-cathode tubes is utilized in the Solartron digital voltmeter Type LM.1420. The six ranges permit full scale readings from 20 mV to 1000 V. Apart from the display tubes transistors are used throughout, but even so, very high input impedances are achieved (greater than 5,000 MΩ on the 2 V range). The inputs are isolated from the chassis. The stability of the power circuitry is such that the instrument can be used with mains supply variations of −20 to +15%. The temperature range over which the instrument works is 0°C to 50°C. The instrument can be obtained in a portable case, the total weight being 25 lb. It can also be supplied as a rack-mounting voltmeter.

9WW 559 for further details

Soldering Machine

A NEW dip-soldering machine is available in the United Kingdom from Avo, Vauxhall Bridge Road, London. Manufactured by Zeva (W. Germany), the equipment consists of a thermostatically-controlled solder bath, which presents a surface area of $9\frac{1}{2} \times 11\frac{3}{4}$ sq in and a semi-automatically controlled dipping cradle. The soldering time can be varied over a range of 0 to 10 sec.

9WW 560 for further details

Power Meter

AN R.F. milliwattmeter has been developed by Electro Apparatus, Stansted, Essex, with a v.s.w.r. of better than 1.1 up to a frequency of 1,000 Mc/s. Two versions are available, one enables power to be measured on two, full-scale ranges of 3 or 10 mW and the other has a 25 mW range. This latter version can be extended to 250 mW and 2.5 W by attenuators available as optional accessories. The impedance is 50Ω and the input connector can be fitted on either the rear or front panel. Connectors that can be supplied include EID $\frac{3}{4}$in, G.R., C, B.N.C. or Dezifix types. The overall accuracy of the instrument is 10%. The instrument weighs 10 lb. and the dimensions are 11×8×7 in.

9WW 561 for further details

Electronic Counter

A SOLID-STATE, 1-2Mc/s counter/timer has been added to the Racal (Bracknell, Berks) range of digital counters and frequency meters. Using a 6-digit display the Type SA.535 counter enables direct frequency measurement from z.f. to 1.2Mc/s from signal levels as low as 70mV. The 1Mc/s oven-controlled crystal oscillator permits a measurement accuracy of ±1 count ±1 part in 10^6 over a temperature range of 0 to 45°C. Time measurement from 1μsec to 2.8 hours and multiple-period, average measurements are among the applications of this instrument. An external 1Mc/s standard may be used to increase the accuracy of the equipment. Other facilities include outputs in decade steps from 100c/s to 1Mc/s and an output for a printer. The instrument can be powered from 115/230V, 50c/s supply, 115V, 400c/s supply or from external batteries.

9WW 562 for further details

Bridge Source and Detector

TRANSISTOR SINGLE-FREQUENCY OSCILLATOR AND AMPLIFIER

By F. BUTLER, O.B.E., B.Sc., M.I.E.E., M.I.E.R.E.

A BATTERY-POWERED transistor audio oscillator followed by a Class B power amplifier makes an ideal power source for an impedance bridge. As an output indicator or null detector, a transistor high-gain audio amplifier is equally good and may be used with headphones, a rectifier voltmeter or some type of visual indicator. Both units are compact enough to build into a general-purpose bridge, with negligible increases in overall size and weight. The low capacitance to ground helps to maintain the bridge accuracy at extremes of the measuring range, there is no power-supply hum or noise and no trouble due to multiple earth points as there may be with mains-powered equipment.

In the ordinary way it is necessary to use specially screened transformers to couple the source or detector to the bridge. Where the highest precision is required it will always be necessary to use some screening, but it can be simplified or left out altogether in general-purpose wide-range bridges in which the complex internal switching causes errors large enough to swamp those caused by the small parasitic capacitances introduced by the source and detector.

One point is vitally important; it is that there should be no direct coupling between source and detector except through the bridge impedances. Gross errors are inevitable if spurious coupling exists. In principle it is a simple matter to provide the necessary isolation, but if source and detector are in the same cabinet, and if they use a common power supply, quite elaborate screening, grounding and decoupling measures must be taken to prevent interaction. It is simpler and cheaper to build two physically separate and self-contained units and resist any temptation to combine them.

Some Design Considerations

A typical general-purpose bridge may be called upon to measure resistance between 1 milliohm and 1 megohm, capacitance between 1 pF and 100 μF and inductance between 1 μH and 100 H. Resistors have residual series inductance and shunt capacitance, capacitors have series inductance and an equivalent series or shunt loss resistance, while inductors have distributed capacitance and series loss resistance. In all cases the impedance and phase angle are functions of frequency and no single measurement is sufficient to describe the properties of a circuit element over a wide range of frequencies. Nevertheless, useful information comes from equivalent resistance and reactance measurements made at a single frequency and this is all that the simpler wide-range bridges set out to do. The test frequency is commonly 1 kc/s when telephones are employed as the null detector.

There are, in fact, some advantages which spring from the use of a single frequency. In the first place, a tuned detector-amplifier may be used to reject hum, noise and harmonics of the test frequency, whether present in the driving oscillator output or generated by non-linear elements (like iron-cored coils), in the bridge itself. Secondly, when measuring inductors or capacitors, it is generally required to know something about the losses as well as the nominal inductance or capacitance. The quality factor Q of a coil or capacitor is the ratio of reactance to series resistance at the specified test frequency. The dissipation factor D is the inverse or reciprocal of Q and, for reasonably low-loss components, is almost equal to the power factor. Thus $D=1/Q=R/X=\cos\phi$, where $X=\omega L$ or $1/\omega C$, R is the equivalent series loss resistance and ϕ is the phase angle. It is convenient if the D and Q dials on the bridge can be made direct-reading and this is only possible at a single frequency.

Assuming operation at 1 kc/s, some thought must now be given to the level of input power to the bridge and, related to this, the requisite sensitivity of the null detector. Low input power can be offset by increased detector gain, subject to limitations set by the output signal-to-noise ratio. However, there are more subtle points to be considered. Over the whole of its measuring range the input impedance of the bridge may vary between 100 ohms or less up to as much as 20,000 ohms. Its output impedance, as seen by the detector, may cover a similar range. True impedance matching is inconvenient if not impracticable. A difficulty is that the maximum undistorted power output from an amplifier is only delivered into a specified load resistance. The output is less, and the distortion greater, for an unmatched load, particularly if this is reactive. One solution is to place a dummy load resistance of low value in shunt with the bridge input, and design the amplifier to match the composite load. Though inefficient, this limits the possible range of variation of impedance. It should be backed up by the use of a tuned output stage to reject harmonics and by negative feedback to make the amplifier less sensitive to load changes.

It is well known that the inductance of iron-cored coils depends on the level of the applied voltage. Ideally the test conditions should approximate to those under which the component will be used and this implies that the bridge oscillator output must be variable over a wide range. Microphone and low-level interstage transformers operate with flux densities so low that the effective permeability of the core is small and may be taken as the initial permeability. Small iron-cored coils of low inductance also require low test voltages in order to avoid incipient saturation and consequent waveform distortion which may be so serious as to make it impossible to balance the bridge.

By contrast, output and power transformers, filter chokes and similar components will show abnormally low inductance if measured under small-signal conditions. One must also allow for the effects of d.c. bias in filter chokes and output transformers, including unbalanced d.c. in push-pull stages. On the whole, it is best to make measurements under low power conditions since the results will then err on the pessimistic side.

Another advantage of low-power operation is that electrolytic capacitors can be safely measured without a polarizing voltage. Finally, it may be remarked that bridge measurements on non-linear components are meaningless unless the test conditions are precisely specified.

Taking everything into consideration, experience shows that a low-distortion 1 kc/s source, capable of maintaining 2 or 3 V r.m.s. across the bridge input terminals, combined with a tuned detector-amplifier giving 60 dB power gain, meets most requirements. This amount of detector gain is easily provided by a 3-stage amplifier. The use of low-impedance headphones (50 ohms d.c. resistance and about 100 mH inductance), simplifies transformer design since the load impedance is around the standard value of 600 ohms. Limitation of the output power from the detector-amplifier is of advantage since it prevents the operator from being deafened by the signal from a grossly unbalanced bridge.

Transistor Oscillator-Amplifier

To construct and adjust the practical equipment to be described in the rest of this paper calls for a certain amount of test equipment. This should include a calibrated audio oscillator, a simple impedance bridge and an oscilloscope as well as a multirange meter. So far as possible, standard components have been incorporated, but a few items need to be specially made.

The bridge oscillator-amplifier circuit is shown in Fig. 1. The oscillator itself, built around the transistor Q1 has an unfamiliar look but is basically of the earthed-base configuration. The tuning inductance L_1 (125 mH) resonates at 1000 c/s with the series combination of C_1 and C_2 (0.25 and 1μF respectively). Emitter drive is taken from the junction of C_1 and C_2. The inductance L_2 (also 125 mH) acts as an a.f. choke but, because of its low value, effectively modifies the capacitance of C_2 across which it is shunted. Both L_1 and L_2 consist of a few hundred turns of wire wound on small nickel-iron E I laminations, core section $\frac{1}{4}$in.$\times\frac{1}{4}$in. The inductance is trimmed to the desired value by adjustment of the airgap. Alternatively C_1 and C_2 may be selected to give the correct operating frequency, which should lie between 990 and 1010 c/s.

Both these methods of adjusting the frequency are tedious and time-consuming. A simpler way is to choose the main components so that the frequency is rather higher than 1 kc/s and then reduce it by a small capacitor (0.005μF is used in Fig. 1), connected between collector and base of the oscillator transistor. Miller feedback increases the effective value of this capacitor by a factor almost equal to the voltage gain. Quite small capacitances will cause a substantial drop in frequency. The method should be used with caution because of the dependence of capacitance (and oscillator frequency), on voltage gain. The gain is a function of emitter current and this current will fall drastically as the supply battery nears the end of its working life.

Three resistors in the base circuit set the forward bias of Q1. Of these, R_1 (10-33 kΩ), ensures a constant-current base drive and limits the oscillation amplitude so that the output waveform is undistorted. The precise value is best established by trial, being set to give the maximum possible output without waveform clipping. Drive to the next stage is taken from the emitter of Q1 through blocking capacitors and a gain-control potentiometer R_3. An additional series resistance R_2 ensures that the output stage is not overdriven when the gain control is fully advanced. With a 6V battery, the collector currents of Q1 and Q2 are each about 0.75 mA.

A small driver transformer (REPANCO Type TT 21, ratio 4:1+1), couples Q2 to the push-pull Class B output stage. Local series feedback is by means of

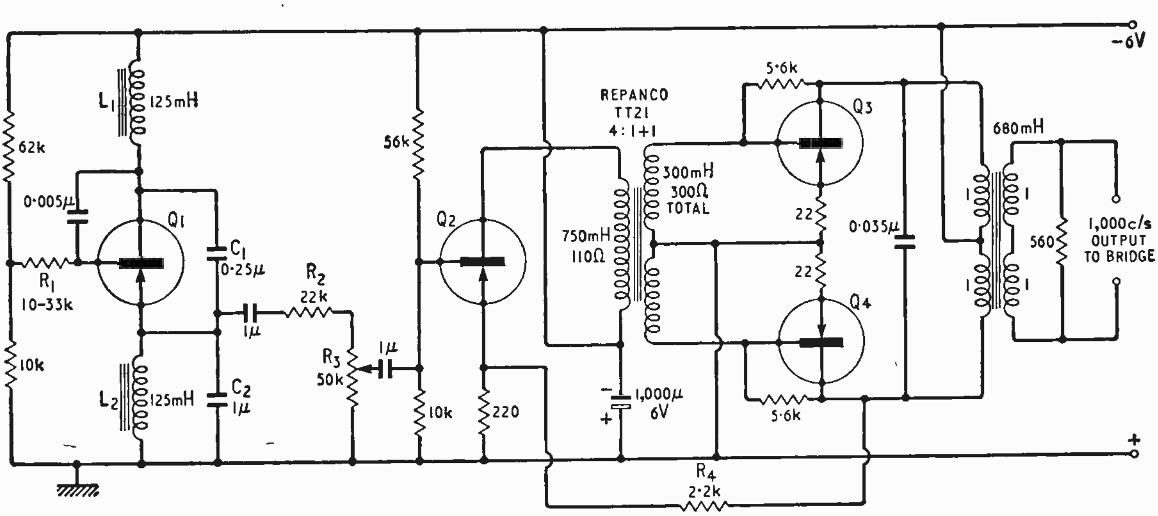


Fig. 1. Practical circuit of 1kc/s oscillator-amplifier.

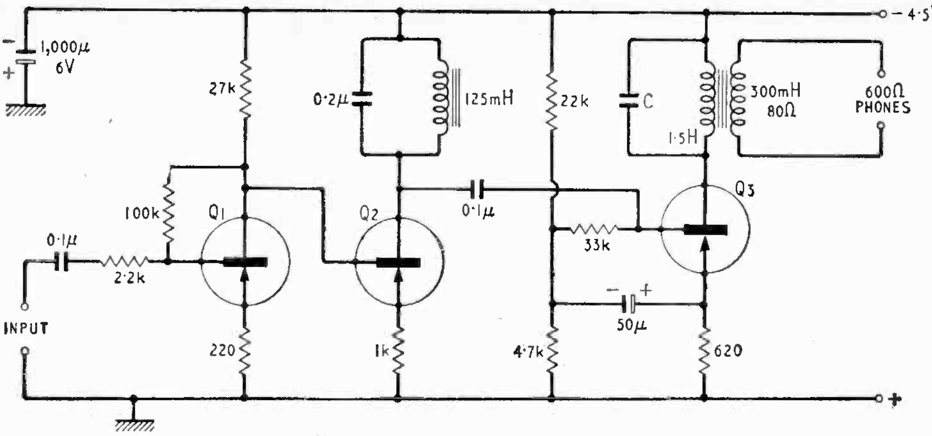


Fig. 2. Tuned detector-amplifier. C is selected to tune output stage to 1 kc/s.

22Ω unbypassed emitter resistances, with shunt feedback through 5.6 kΩ collector-base resistances which serve also to set the quiescent current (5 mA total) for the output stage. This is just sufficient to avoid crossover distortion under low drive conditions. At full drive the collector current rises to 40 mA from a 6 V supply.

Overall negative feedback is taken from one side of the output transformer through 2.2 kΩ to the emitter of Q2. The feedback voltage is developed across a 220 ohm resistor. If self-oscillation occurs, the feedback is positive. To suppress this, R_4 should be changed over to the opposite end of the transformer winding.

To compensate for the wide variations of input impedance of the bridge, the secondary of the transformer is loaded by 560 Ω. Even so there is some waveform distortion. This may be cured by shunting a suitable capacitor across the primary winding to make it resonant at 1 kc/s.

Although the input power to the bridge need be no more than a few milliwatts, the output transformer should be conservatively designed and a 500 mW size is not unreasonable, since it is the key component in the whole equipment.

The overall turns ratio should be about 1:1, the primary being centre-tapped for push-pull working. Winding resistances each up to 10 ohms are permissible. The winding capacitances to ground should be small and, more important, they should be symmetrically distributed. Ideally the windings should be individually screened and a third shield should be used between primary and secondary. In practice, for use with a general purpose bridge, it is sufficient to use symmetrical windings with a single inter-winding screen of copper foil, earthed to the metal panel of the bridge or to the bridge earth point.

Assuming a core cross-section about $\frac{5}{8}$in.×$\frac{5}{8}$in., the best method of construction is to make up two former-wound coils as the half-primary windings (500 turns each, 36 s.w.g. enamelled copper), assembled side-by-side on the core. Two similar coils, large enough to slip over the primary, should constitute the secondary, space being left between the pairs for a primary-to-secondary shield. True symmetry can be guaranteed by winding one of each pair in the opposite sense of rotation to the other. The inner, starting ends of both half-primary windings can be joined together and used as the h.t. centre-tap, the outers being joined to the transistor collectors. The two half-secondaries are similarly joined but the centre tap is unused. If this drill is correctly carried out, the two sets of half-windings will be connected series-aiding and with perfect symmetry. The construction does not minimize the leakage inductance but this consideration is not so important as it would be in a wide-band audio output transformer.

Finally, the transformer should be fitted into a heavy-gauge drawn steel case or, better, in a mu-metal screening box. These are available at low cost on the surplus market.

If this method of construction is felt to be over-laborious, an easier alternative, with little degradation of performance, is to bifilar-wind both primary and secondary coils. It is still worth while to use an inter-winding screen, taking care to leave a gap or an insulated overlap to that the foil does not behave like a short-circuited turn. One test of a successful design is that reversal of the transformer connections to the bridge should cause no change in the balance setting.

The output transformer shown in Fig. 1 has a total primary inductance of 680 mH, with a d.c. resistance of 8 ohms. The secondary characteristics are almost identical.

Tuned Detector-Amplifier

This unit is shown in Fig. 2. Here Q1 is a simple RC amplifier with shunt and series feedback. It is direct-coupled to the tuned amplifier Q2 in which local series feedback gives a high output impedance with low damping of the associated tuned circuit. The output stage Q3 is boot-strapped to give high gain. The resulting high input impedance assists in preserving good selectivity.

The output transformer is a miniature driver transformer with an overall step-down ratio of about 2:1 for matching low impedance telephones (50 Ω d.c. resistance; impedance 600 Ω at 1 kc/s). High winding resistances cause a relatively large insertion loss but the overall voltage gain is still in excess of 200, the power gain to a 600 Ω resistive load being about 56 dB.

Traces of distortion may be removed by tuning the output stage to 1 kc/s by means of a shunt capacitor. Selectivity is so high that it is essential to adjust both oscillator and amplifier to the same frequency, even if this is not exactly 1 kc/s.

Connection of the Bridge

One, and only one, of the four corners of an impedance bridge may be earthed directly. In some bridges this point is actually connected to the metal panel or cabinet of the instrument. In other cases the bridge is electrically isolated from the metalwork. The question of how and where to put grounds on the ancillary equipment thus becomes important. Some designers prefer to earth one side of the detector. This is good practice when head telephones are used since their capacitance to ground is less liable to cause errors than if neither side were earthed.

The difficulties are thus transferred to the oscillator side of the bridge. The use of a symmetrically-wound supply transformer with separate winding screens and an inter-winding shield has the effect of substituting known, small and equal capacitances for the large, unequal and indefinite capacitances which would otherwise lead to large measurement errors. One can be driven to desperation while tracking and correcting minute sources of error caused by parasitic capacitances and spurious couplings in precision bridges but, when 1 per cent accuracy is the target figure, some precautions can be relaxed.

Normally it is sufficient to connect one side of the oscillator supply battery (and hence one bus-bar of the circuit), to the metal case. The earth connection shown in Fig. 1 is made to the aluminium cabinet at a single point. It is desirable, but not always essential, to make another connection from the box to a true earth such as a copper main water pipe.

The null detector-amplifier wiring may be grounded at one point to its metal chassis or may be left isolated. In either case the cabinet itself should be connected by a single wire to the oscillator chassis. The inter-winding shield of the output transformer should be connected to the earth point of the bridge network.

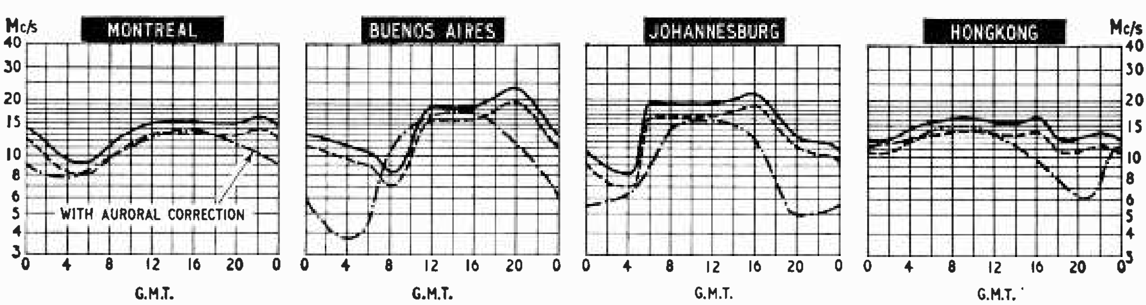
Finally, some checks should be made to establish confidence in the complete assembly. With the oscillator switched on, close to, but disconnected from, the bridge. there should be no output from the null detector at any setting of the oscillator gain control. Telephones are in fact so very sensitive that a faint residual sound is almost certain to be heard but its level should be comparable with the circuit noise.

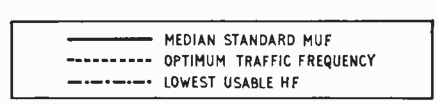
With the bridge in use to check a variety of components, the balance settings should remain constant when the leads from the output transformer to the bridge are changed over. Moreover, the balance setting should not change as a result of varying the oscillator output power by means of the gain control (except when testing iron-cored coils or non-linear components).

Even when stray capacitance effects are small enough to cause negligible errors in the measurement of inductance or capacitance, there may be serious inaccuracies in the dissipation factor indications or Q measurements. With most wide-range bridges these latter measurements are rather crude and are unlikely to be worsened by the use of transistorized ancillaries.

The two units described were constructed for use with a General Radio Impedance Bridge, Type 650-A. This normally uses a built-in microphone hummer as an a.c. source, with high-impedance headphones as the null detector. Its specified accuracy is unaffected by substituting the transistor oscillator and null detector, while the sensitivity and discrimination have been much improved. Control of the oscillator power output is particularly useful when measuring low-inductance iron-cored coils, small ferrite toroids and high-capacitance low-voltage electrolytic capacitors.

H. F. PREDICTIONS—JUNE





The prediction curves show the median standard MUF, optimum traffic frequency and the lowest usable high frequency (LUF) for reception in this country. Unlike the standard MUF, the LUF is closely dependent upon such factors as transmitter power, aerials, local noise level and the type of modulation: it should generally be regarded with more diffidence than the MUF. The LUF curves shown are those drawn by Cable and Wireless, Ltd., for commercial telegraphy and they serve to give some idea of the period of the day during which communication can be expected.

During the summer months in the minimum of the solar cycle past experience has shown that frequencies considerably higher than the predicted standard MUF can at times be received. This effect is mainly confined to daytime on the radio path and has been especially noted on reception in the U.K. from the Far East. The cause is thought to be associated with sporadic-E ionization.

NEWS FROM INDUSTRY

£18.9M Semiconductor Sales.—According to figures from the British Radio Valve Manufacturers' Association (BVA) and the Electronic Valve and Semiconductor Manufacturers' Association (VASCA), British valve, c.r. tube and semiconductor sales totalled £61.6M last year. This figure, which is the first ever to be released for total sales, includes total exports of £11.2M.

The present **telephone system in South Africa** is to be augmented by a large S.T.C. microwave radio-telephone network. Orders worth more than £500,000 have just been received through S.T.C.'s South African subsidiary company for microwave equipment for routes between Bloemfontein, Port Elizabeth, Cape Town and East London. And equipment already on order for the 366-mile Johannesburg-Durban link, soon to be installed, brings the total of recent S.T.C. microwave orders from South Africa to well over £1M. The 6 Gc/s equipment will be manufactured at S.T.C.'s North Woolwich plant near London, and a high proportion of wave-guide components and similar items will be manufactured at S.T.C.'s new Scottish plant at East Kilbride.

25-Year Liberian TV Contract.—Rediffusion has signed a twenty-five-year agreement with the Government of Liberia to manage and operate the commercial radio and television services in that country. A new company, Rediffusion (Liberia) Ltd., has been formed for this purpose, and it will also trade in sound radio and television receivers. The country's first commercial television station in Monrovia, the capital, began broadcasting in January this year (see February issue, p. 82).

"Condor I", the Italian hydrofoil being used by Condor Ltd. of Guernsey for regular services between the Channel Islands and the northern French coast, is fitted with a Decca D202 radar. Her radio equipment comprises a Marconi Fulmar transmitter and Guardian receiver.

A new company, **General Precision Decca Systems Incorporated,** has been formed jointly by the Decca Navigator Company and the General Precision Equipment Corporation of New York, to manufacture and market Decca equipment in the United States. Products will include hyperbolic navigation systems, position fixing systems for survey, airborne computers, and pictorial displays.

A.P.T. Electronic Industries Ltd. have acquired a majority interest in **Cybernetic Developments Ltd.** It will operate under the same name from Chertsey Road, Byfleet, Surrey, where A.P.T. Electronic Industries Ltd. have their factory and offices, and will continue to market "Cybervox" language laboratories and "Saki" keyboard training machines.

The Ilford Group of Companies has acquired **Zonal Film (Magnetic Coatings) Ltd.** Zonal products will complement the range of magnetic materials which Ilford already market. Future plans, outlined by Mr. G. A. Jones, commercial director of Ilford Ltd., included the development of new magnetic recording materials designed specifically for videotape and computer applications. Zonal Film (Magnetic Coatings) Ltd. will be operated as a separate manufacturing company within the Ilford Group.

A.M.P. Aircraft-Marine Products (G.B.) Ltd., makers of crimped terminals, announce they are to set up a new production unit at Bideford, North Devon. The factory will be built in two stages and while the first 15,000 sq ft is being constructed the new production unit will be housed in a temporary factory. The second stage provides for a further 15,000 sq ft and will be completed within the next three to five years.

£5M Undersea Cable Order.—Standard Telephones & Cables and Submarine Cables Ltd. have each received orders valued at £2.5M from Cable & Wireless Ltd. for undersea cable and associated equipment for the first section of SEACOM, the South-East Asia Commonwealth telephone cable system. This section will link Jesselton in Sabah (formerly North Borneo), Hong Kong and Singapore. The laying of the 2,000 nautical miles of cable, with repeaters every twenty miles, is expected to be completed later this year and to be opened for public service next February.

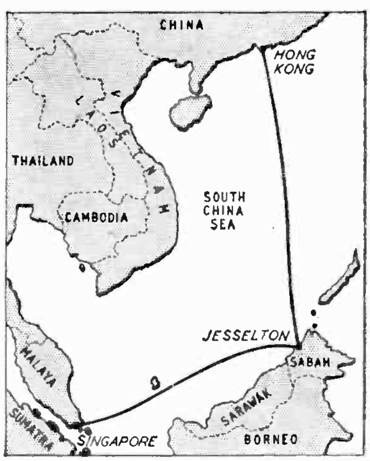
As can be seen from the map, the first section of SEACOM will link Singapore, Jesselton and Hong Kong.

Livingston Group. — Circetch Ltd., printed circuit board manufacturers of Bognor Regis, have been acquired by Livingston Holdings Ltd. the parent company of the Livingston Group. It is also announced that the recently acquired company, re-named Livingston Burge Electronics, has been merged with Livingston Control Ltd. which now comprises three divisions covering electronic organs, control equipment and components. Livingston Control has closed its Retcar Street, London, premises and has taken over a 16,000 sq ft factory adjoining the Burge electronic organ factory at Watford, Herts. Mr. D. C. Rennie, managing director of the group, is general manager of both Watford factories.

Unicam Instruments Ltd., Cambridge, members of the Pye Group, announce an agreement with **Ernst** Leitz G.m.b.H., Wetzlar, for the marketing of **Unicam spectrophotometers in West Germany.** Ernst Leitz already have an interest in spectroscopy which is complementary to that of Unicam. Both companies will retain complete independence of operation in all other fields.

Decca Radar Ltd. have produced an **electronic alarm** for the detection of intruders. The system depends on the generation of ultrasonic Doppler frequencies, which are detected and used to operate the alarm. Transistors are used throughout and all circuits fail safe.

DEAC (Great Britain) Ltd. have moved their main factory to Crewkerne in Somerset. The new unit, which is twice as large as the Slough factory, will manufacture the whole range of button cell batteries with the exception of the 20DK and 50DK types.



Rank-Bush Murphy Electronics announce the formation of three new marketing units: Rank Telecommunications; Rank Medical Equipment; and Rank Nucleonics & Controls. These marketing units will handle all the products previously sold by Murphy Electronics, General Radiological, and the electronics section of Bush Radio. A fourth unit, a military and contracts section, will continue to operate under the name of the parent, Rank-Bush Murphy Electronics.

A new company, **Douglas A. Lyons & Associates Ltd.,** has been formed by Douglas Lyons, who was until last year the managing director of Trix Sound Equipment, to provide import and export facilities. Mr. Lyons already has exclusive U.K. agency rights for a number of overseas audio products, including LEM and BOUYER microphones, and DNH industrial loudspeakers.

The General Data Corporation, of Orange, California, whose products include analogue/digital converters data amplifiers, a.c./d.c. converters and a range of equipment for data logging and industrial control, have appointed Bendix Electronics Ltd., of New Basford, Nottingham, **as their sole U.K. agents.**

A new department has been set up within Industrie Elettriche di Legnano of Milan, to handle the marketing of **Ferranti automatic control systems in Italy.**

French Agents.—SIEDMÀ S.A. (Société Importation Exportation Distributrice Matériel Anglais) of Paris, have been appointed exclusive agents for the specialized components division of the Marconi Company.

Princetown Applied Research Corporation, of New Jersey, U.S.A., have appointed Rank Cintel, of Worsley Bridge Road, London, S.E.28, U.K. marketing agents for the full range of electronic instruments and systems they manufacture.

Solitron Devices Inc., of Norwood, N.J., semiconductor manufacturers, have appointed Auto-Electronics Ltd., of Peel Grove, London, E.2, to act as their U.K. distributors.

To facilitate the distribution of their products in the South, **Welwyn Electric Ltd.,** of Northumberland, have appointed the Radio Resistor Co. Ltd., of Palmerston Road, Wealdstone, Harrow, Middx., their stockists and distributors.

(*Continued on page* 324)

Using a high-pressure process, Standard Telephones and Cables are manufacturing synthetic crystals at their Harlow, Essex, factory. The process takes three weeks.

Television translators for four "pockets" along the northern coast **of Jamaica** have been ordered from Cossor Communications Company by the Jamaica Television Company. The island's television service operates in the v.h.f. band on 625-lines in 6 Mc/s channels.

Elliott-Automation group pre-tax profit for 1963 rose to £3.24M from £2.86M in 1962. Net profit for the year, after providing for depreciation (£979,142) and taxation (£1,341,000), amounted to £3,237,513. This represents an increase of £375,000 on the previous year's results.

BSR Ltd. group trading profit for 1963 amounted to £2,342,876 and showed an increase of £231,652 on the previous year's result. After providing £1.1M for taxation, profit for the year totalled £1,310,162 (£1,086,928).

Chloride Electrical Storage Co. report a group pre-tax profit of £3,532,130 for 1963. This shows an increase of almost £500,000 on the previous year's results.

Marconi Instruments Ltd. have opened a 32,500 sq ft extension to their St. Albans works, which houses their research and development laboratories, and administration offices. This brings the total floor area to 219,500 sq ft.

Brush Clevite Company is the new name of Brush Crystal Company, of Hythe, Southampton, which is a member of the Clevite Corporation, of Cleveland, Ohio.

Data-logging and monitoring equipment, providing a continuous watch on all temperatures, levels, pressures, etc., of the main engine and auxiliaries in two 9,100-ton refrigerated cargo vessels, is to be supplied by English Electric-Leo Computers Ltd. These 350-channel systems will also monitor the temperatures in the refrigerated space in these vessels being built for Shaw Savill and Albion Co.

General Radio Company (U.K.) Ltd. has been formed by General Radio Company of West Concord, Mass., to operate a sales and service headquarters in the U.K. The new company, of which the directors are I. Sichel (managing), M. H. Evans and D. E. Schonhut, will "support and supplement the existing sales and service activities of the Claude Lyons organization" who have been G.R. agents for nearly 40 years. Temporary offices are at Westminster Bank Chambers, Bridge Street, Leatherhead, Surrey (Tel.: Leatherhead 2671), but a new factory and offices are being built at Bourne End, Bucks.

Industrial Instruments Ltd. have recently combined with Transipack Electronic Engineers and have taken premises in Stanley Road, Bromley, Kent (Tel.: RAVensbourne 9212). Mr. W. Kiryluk is technical director of Industrial Instruments.

The servicing **of Akai tape recorders,** which are imported from Japan by the Pullin Optical Company, of Perivale, Middx., is being undertaken for them by Sound Equipment Servicing Co. Ltd., of 163 Lower Richmond Road, London, S.W.15. (Tel.: PUTney 1021.)

Vactric Control Equipment Ltd., manufacturers of precision electromechanical servo components, have moved from London into a new factory and offices in Garth Road, Morden, Surrey.

Ray-O-Vac.—Alpha Accessories Ltd., of H.M.V. House, 363 Oxford Street, London, W.1, have changed their name to Ray-O-Vac (U.K.) Ltd.

U.S. Trade Mission.—Five representatives of the United States electronics and automation industry are visiting the U.K. from 12th May to 2nd June "to promote mutually advantageous trade and investment" between the two countries. Information is available from the American Embassy, Grosvenor Square, London, W.1. (Tel.: GROsvenor 9000, Ext. 445.)

Venezuelan Microwave Network.—General Telephone and Electronics International, of Geneva, have been awarded a contract for the first phase of a $12 million microwave network in Venezuela, which will replace the present overhead wire lines between Caracas, Maracay, Valencia and Barquisimeto. The entire 620-mile system, in which 23 repeater stations are to be used, is expected to be completed in 1967. Capacity of the completed system will be six radio channels, each capable of carrying 960 voice circuits.

CLUB NEWS

Durham.—The Durham City Amateur Radio Society, which was formed in January and meets on alternate Thursdays at 7.30 at the "Bridge Hotel," North Road, is holding a constructional competition on June 4th.

Gt. Yarmouth.—The region of the R.S.G.B. covering Norfolk, Suffolk and Essex is holding a regional meeting at Great Yarmouth on 14th June. It is being organized by the Gt. Yarmouth & District Radio Club.

Longleat.—The seventh annual mobile rally to be held in the grounds of Longleat House, Warminster, will be on 21st June. Talk-in stations will be operating in the 2-metre band (G3SJI/A) and in the vicinity of 1,885 kc/s (G3JMY/A). The rally organizer is E. C. Halliday, 4 Parkside Avenue, Winterbourne, Bristol.

Loughton.—Meetings of the Loughton & District Radio Society are held on alternate Fridays at 7.30 at Loughton Hall, Debden Community Centre, Rectory Lane. During the Debden Fair Week (11th-18th July) the club will be operating station GB3LOU on all bands and is also planning a mobile rally and an amateur television demonstration by G3MJZ/T.

A Crossword for Numerates

Solution to the puzzle set by A. J. Key on page 257 of the May issue.