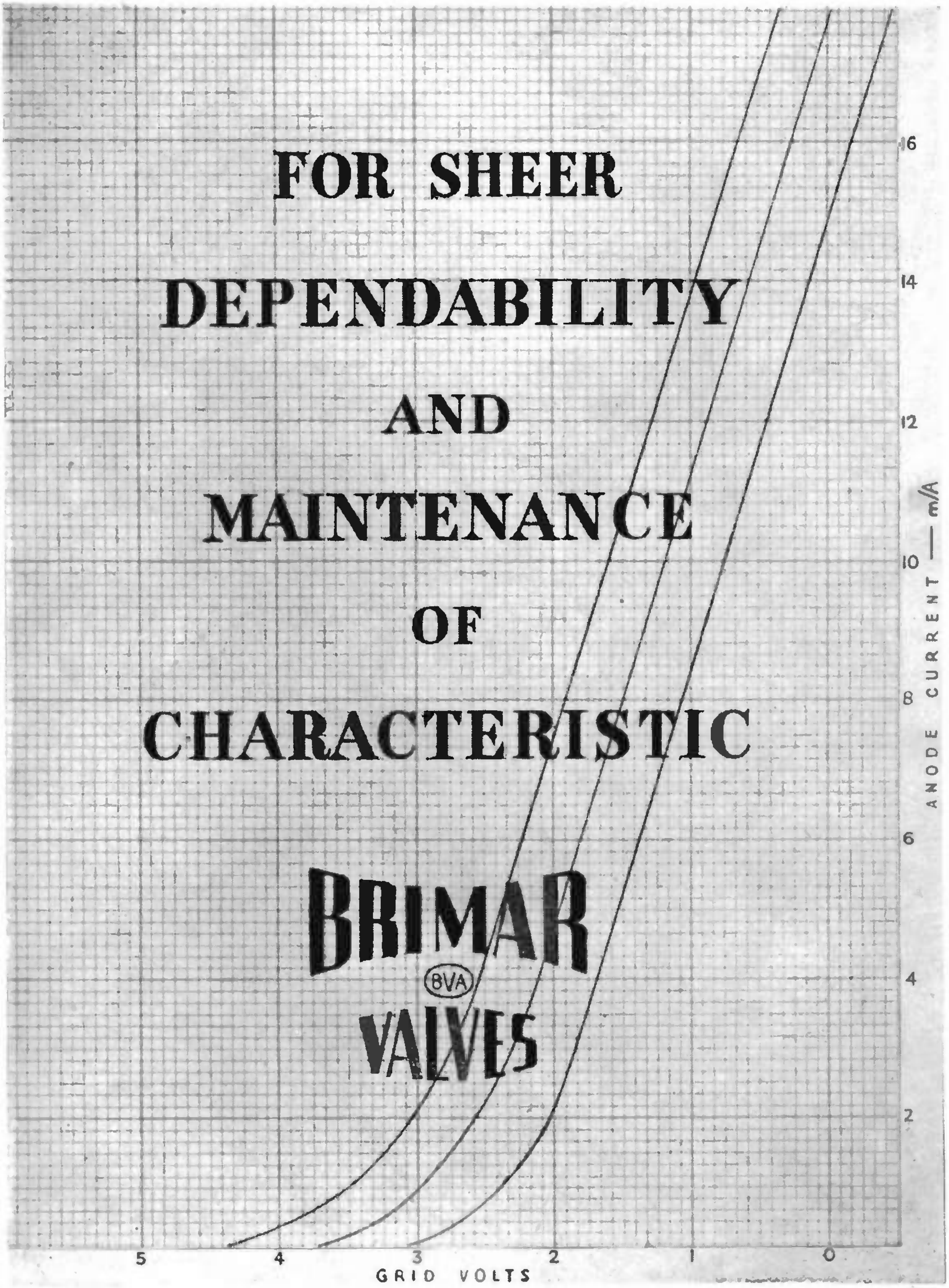
Electronic Engineering

INCORPORATING ELECTRONICS, TELEVISION AND SHORT WAVE WORLD

PRINCIPAL CONTENTS

2/- FEB., 1946


FOR SHEER
DEPENDABILITY
AND
MAINTENANCE
OF
CHARACTERISTIC
BRIMAR
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VALVES
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ANODE CURRENT — m/A
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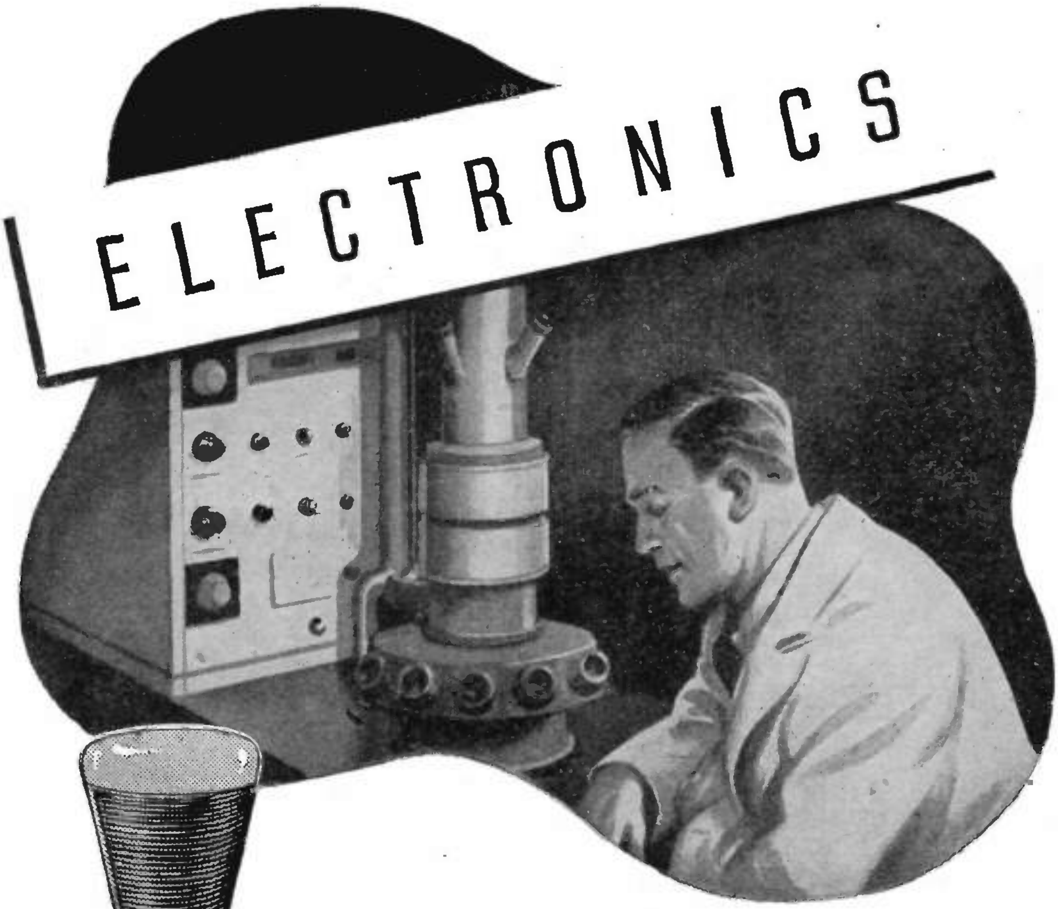
GRID VOLTS

ELECTRONICS



made it possible!

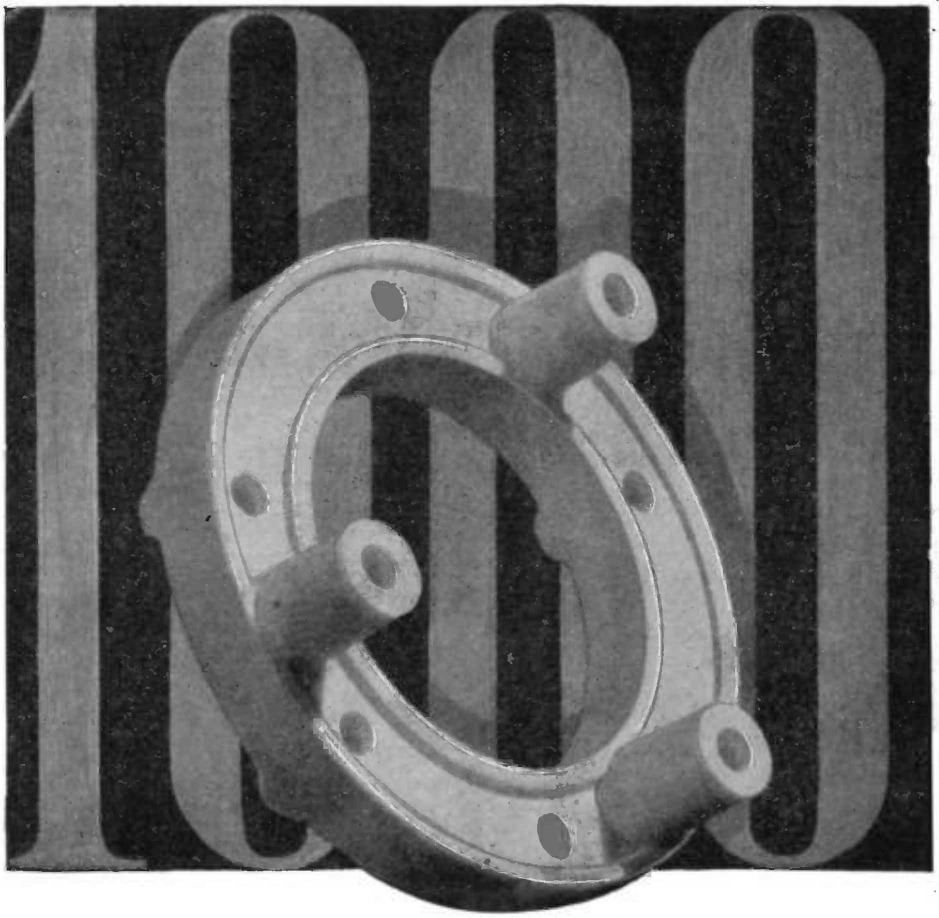
On the screen of the Electron Microscope, the scientist examines the characteristics of tiny organisms less than a millionth of an inch long. Electronics have, in fact, brought under scientific examination many germs and bacteria so small that they have never previously been observed in detail by the human eye.

G.E.C. Cathode Ray Tubes and OSRAM Valves cover every electronic application, and will bring to the pursuits of peace many well-tried electronic devices to speed, smooth, and make safer our way of life.

A typical G.E.C. Cathode Ray Tube 4102, with 2¾" screen, widely used in industry during the war, and with many peace-time applications.

Osram PHOTO CELLS | **G.E.C.** CATHODE RAY TUBES | **Osram Valves**

Advt. of The General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2.



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TELEGRAMS
HULTONPRES, LUD
LONDON.

Success

WHAT determines the success of an exhibition? The quality of the exhibits, the way it is talked about, or the number of people who were unable to get near it?

Judged by any of these standards, the recent Physical Society's Exhibition was an undoubted success. So much so that it is hoped it will never be repeated under the conditions which ruled in 1946. The figures of attendance have been variously put at from 10,000 to 70,000. To the unfortunates who were in the exhibition at closing time, the latter figure is more acceptable.

On another page appears a letter from a reader which is a fair sample of the comments which were made during the exhibition and after.

The truth is that the Exhibition even before the war was outgrowing its premises. From a small conversazione at which certain selected instruments were exhibited it has grown to a national scientific event of the year. After a six-year break it might have been foreseen that technical men from all parts would flock to exchange gossip and see what their colleagues had been doing in the interval. But the arrangements were organised as if no break had occurred—the same cramped accommodation, the same limited time to study the accumulation of new equipment which the manufacturers were just as anxious to show as the visitors to see.

(Incidentally, those who arrived before opening time in many cases walked in and saw the show in comfort!)

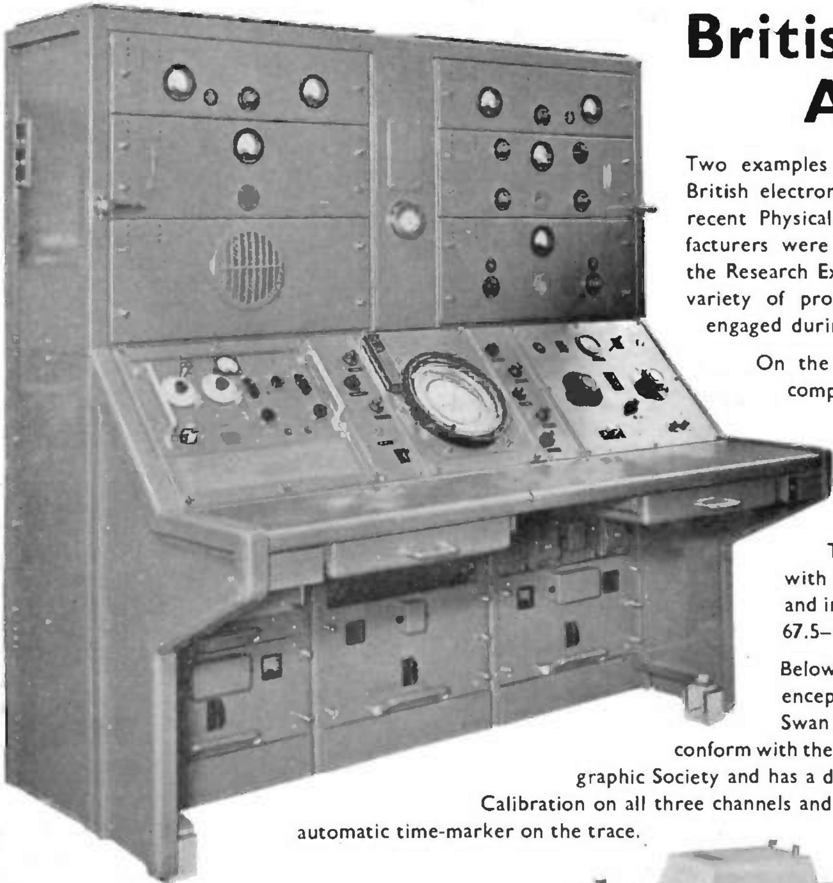
However, there is no use in criticising the efforts of the organisers now that the show is over.

The Physical Society has done the greatest service to the community in founding a truly scientific exhibition. Let us hope that it will continue to encourage the electronic and physical industries by holding its exhibition on a limited scale, say by restricting the entries to research items, or by ruling out standard manufactured products.

On the other hand, it is time the industry itself organised a scientific exhibition in a more commodious building, to which invitation would be by ticket only. Such an exhibition, if it embodied the good features of its forerunner, would be an outstanding success. But it must be open for a reasonable period and the stands must be staffed by technical men who are more versed in the details of their equipment than in the latest brand of sales talk. The avoidance of elaborate stand dressing and advertising signs would help to maintain the scientific atmosphere which is such a feature of the Physical Society's Exhibition, and the participators would feel that their efforts were appreciated by visitors well qualified to pass judgment on them.

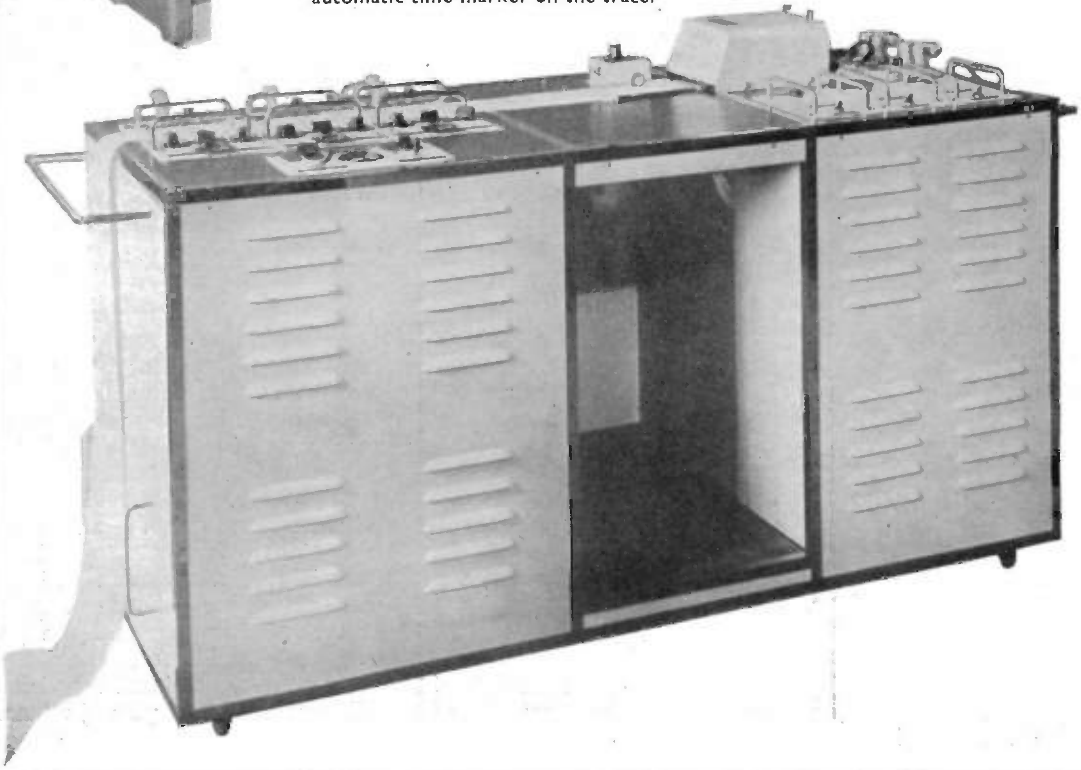
British Electronic Apparatus

Two examples of the many superlative specimens of British electronic equipment which were shown at the recent Physical Society's Exhibition. Over 100 manufacturers were represented in the Trade Section, and the Research Exhibits gave a good cross-section of the variety of projects on which the industry has been engaged during the past five years.



On the left is an instantaneous reading radio compass made by Standard Telephones & Cables, Ltd., incorporating an automatic direction finder using Adcock aerials and a C.R. tube indicator giving instantaneous readings. The readings are free from sense ambiguity. There is a motor-driven gyro-repeater scale, with three indication speeds for various signals and interference conditions. Frequency range: 67.5–100 Mc/s. or 100–150 Mc/s.

Below is a 3-channel pen-recording electro-encephalograph demonstrated by The Edison Swan ElectrIc Co., Ltd. This apparatus is made to conform with the recommendations of the Electroencephalographic Society and has a direct-coupled circuit for driving the pens. Calibration on all three channels and variable paper speed is included, with an automatic time-marker on the trace.



— further Examples of Electronic Equipment shown at the Physical Society's Exhibition

Ammeter, Thermo-Couple Radio-Frequency

An improved form for use on currents up to 30 amp. at 13.5 metres, incorporating a concentric terminal system.

Ernest Turner Electrical Instruments, Ltd.

Amplifier, D.C.

This amplifier has been developed for use with strain-measurement gauges on aeroplane parts. Its performance is summarised as follows:

Gain: A 12-position control is fitted giving gain variations from 5×10^3 to 7.5×10^5.

Input: The input impedance is $5 \times 10^5\Omega$, and is terminated in a concentric shielded socket.

Frequency Response: Linear from zero to 15,000 c/s.

Output: This is provided from a quasi-balanced circuit. Voltage output 170 V peak-to-peak; current output $\pm$ 3.5 mA.

Stability: The stability for full gain, referred to the equivalent input voltage is 0.7 mV for the first hour and subsequently less than 0.1 mV per hour.

Clifton Instruments, Ltd.

Audiometer, Dual (McDonald-Poliakoff)

This instrument has been designed by Dr. D. McDonald and Alexander Poliakoff for research work as well as for rapid routine testing of patients. It provides a guide to the patient's hearing aid requirements. The new audiometer consists essentially of two beat-frequency oscillators with independent attenuators, two earphones, two independently adjustable speech channels and a loudspeaker for measurement of masking with a hearing aid.

Multitone Electric Co., Ltd.

Bridge, Resistance and Capacity

This instrument is designed for quick and accurate measurement of resistance and capacitance; provision is also made for testing leakage and power factor of capacitors. The null indicator is a visual electronic device so arranged that an out-of-balance of $\pm$ 1 per cent. is easily discernible; power factor of capacitors on all ranges is measured by an accurately calibrated control marked over a range of 0-60 per cent.

Measuring Instruments (Pullin), Ltd.

Cables, H.F.

A range of high-frequency cables suitable for Radar and general high-frequency use. The dielectric is Telcothene, a mixture of 87½ per cent. polythene and 12½ per cent. polyisobutylene. The electrical properties of Telcothene are: dielectric constant 2.3, power factor between 0.02 per cent. and 0.03 per cent. at frequencies up to 3,000 Mc/s.

The Telegraph Construction and Maintenance Co., Ltd.

Camera, High Speed

This camera permits the taking of 49 pictures on standard 35-mm. cinematograph film at a maximum rate of 10,000 pictures per second, and is designed for photographing of events which are self-luminous, or illuminated artificially or by daylight.

Scophony, Ltd.

Centimetric Waves, Apparatus for the Measurement of

General purpose test panel. The unit contains two oscillators of klystron type and their associated power supplies. Each oscillator covers a different band of frequencies and either oscillator may be switched to the common wave-guide system, which includes attenuators, wavemeter and "slotted guide" type of standing wave indicator. Facilities are available for both amplitude and frequency modulation of the oscillators, while the indicating gear includes a mirror galvanometer for use under C.W. conditions and an amplifier and peak voltmeter to be used when the oscillators are amplitude modulated.

Rotating standing wave detector. In this apparatus a "slotted guide" is bent to form a semicircle in such a way that a pick-up probe, attached to a rotating drum, travels along the length of the slot. The output of the probe is taken to a crystal detector and hence to an amplifier and cathode-ray unit, the time base of which is synchronised to the rotation of the drum. The picture appearing on the cathode-ray tube is thus a graphical representation of the voltage appearing in the wave-guide and enables simultaneous measurement of both amplitude and phase of standing waves to be accomplished.

Metropolitan-Vickers Electrical Co., Ltd.

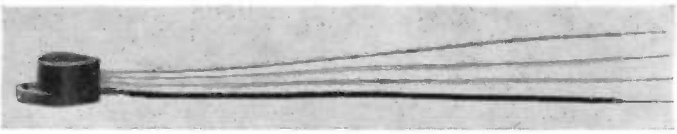
Wheatstone bridge of new design with built-in A.C. supply and galvanometer. Range, 0.1 Ω-10 M Ω.
—Salford Electrical Instruments Ltd.

Automatic ohmmeter manufactured by the Mervyn Sound & Vision Co., Ltd. This automatically selects the optimum range for the resistance under test to give a reading on the most accurate part of the meter scale. Range, 1 Ω-10 M Ω.
Leland Instruments Ltd.

(Below): Sensitive valve voltmeter with feedback amplifier. Range, 0.03-300 V in 9 steps. Frequency response linear from 10 c/s. to 1 Mc/s.
—Dawe Instruments Ltd.

(Left): Frequency spectrometer giving individual components of a complex waveform. 40-16,000 c/s. or 8 kc/s.-3,200 kc/s.
—Standard Telephones and Cables Ltd.

(Above): Photo-electric unit for automatic control of street lighting, signs etc.
—Londex Ltd.



10 mA instrument rectifier moulded in case. Actual size.
—Salford Electrical Instruments Ltd

(Below): Distortion factor meter for measuring total harmonic content of A.F. apparatus.
—Dawe Instruments Ltd.

Colorimeter (Prof. E. J. King)

A very convenient instrument for the rapid measurement of colour depth. The readings are taken from the logarithmic scale on the galvanometer. Colour filters are provided to increase the accuracy. It can be operated from the mains supply or from a 2-V accumulator.

Gambrell Bros. & Co., Ltd.

Condensers, Vacuum

A range of vacuum condensers, in which the electrode system is supported within a glass envelope, developed for use in transmitting and electronic heating equipments. One of the main features of these new condensers is their high current-carrying capacity and high operating voltages.

Scientific Acoustics, Ltd.

Fault Tracer

This instrument comprises:—

(i) *Signal generator*, giving frequencies of 100 kc/s. to 20 Mc/s., modulated or unmodulated.

(ii) *Audio-frequency oscillator* of 1,000 c/s. fixed frequency with variable output.

(iii) *Signal tracer,* tracing the signal through the radio-frequency, frequency-changer, intermediate-frequency and low-frequency sections of high-frequency and low-frequency equipment.

(iv) *A.C. bridge,* 1,000 c/s., calibrated directly to measure resistance capacity and inductance over a wide range; condenser or insulation leakage test is also included; output indicator and H.T. 6.3 V available for external use.

Dimensions: 12 in. × 9 in. × 7 in. approximately. Finish; battleship grey and nickel-plated fittings.

Labgear.

Glass-Metal Joints by Centrifuging, Machine for Making

Suitable for making single and "back-to-back" cylindrical seals from about 10-mm. diameter upwards. The centrifuging technique is designed to eliminate tooling and blowing. The machine as shown was evolved to secure a quick method of glassing both ends of copper cylinders to provide anodes for radio valves.

General Electric Co., Ltd.
M.O. Valve Co., Ltd.

Glass-Sealing Alloys—Telcoseal 1, 2, and 3

These are suitable for glass from the borosilicate to the lead types with their wide variety of coefficient of expansion.

The Telegraph Construction and Maintenance Co., Ltd.

Instrument, Suspended Moving-Coil

A conventional moving-coil instrument in which the normal pivots and jewels are replaced by a special taut suspension of beryllium-copper strip. This gives a shock-proof and frictionless instrument, which can be calibrated to a high degree of accuracy.

The Record Electrical Company, Ltd.

Instruments, Super-Sensitive

Of the P.M. moving-coil double-pivoted type. Special care has been taken to keep the resistance as low as possible consistent with the maximum degree of reliable service. The Model 23, 3½-in. type, can be supplied with a full-scale deflection as low as 10 μA at 2,000 Ω approximately. The Model 32, 6-in. type, has a sensitivity of 20 μA for a resistance of 5,000 Ω.

Ernest Turner Electrical Instruments, Ltd.

Insulation Resistance Ohmmeter and Insulation Tester

The principle of operation is that of the impression of a D.C. voltage on an unknown and a standard resistance in series. The voltage drop across the standard is a function of the current through the unknown resistance and is measured by a valve voltmeter.

Test voltages up to 5,000 can be provided, the resistances incorporated in the test circuit limit the current to a safe value on short-circuit.

Jackson Automatic Controls, Ltd.

Lockstrip

A unit product in tropical insulating material for carriage, housing and protection of small condensers and resistances, etc. A universal connexion device with four basic plates covers almost any requirements. Single- or double-ended tags for connexion fitted to requirements.

Labgear.

Optical Cement

Used for preparing joints between glass and glass, between "Perspex" and metal, and between metal and metal.

Imperial Chemical Industries, Ltd.

Plastics

"Perspex" in the forms of sheet, blocks and rods. Examples of shaping, machining and cementing. Applications are cabinets, tanks, photometric equipment, machine casings, drawing instruments and metal-coated reflecting sheets.

Imperial Chemical Industries, Ltd.

Process Timers, Impulse Operated

(S. J. Smith R. St. G. Terry and the Company's Patents Nos. 566345, 568975.) The single- and dual-hand instruments are examples of impulse-operated timers in their simplest form. The action of setting the hand to the required time for the process has the effect of closing the impulsing circuit, and the time measurement commences. When approaching the end of the run an alarm circuit is set in operation, at the conclusion of which all circuits are automatically opened.

Telephone Manufacturing Co., Ltd.

Radio-Frequency Heating

A demonstration of rapid continuous concentration of chemical solutions which are sensitive to temperatures above a critical limit. This is achieved by feeding the solution down through two bulbs, which trap any rising foam, into a glass cylinder, on each side of which is an electrode. The liquid boils, energy being furnished by a Redifon R.H.2 generator. The top globe is connected to a pump which maintains a vacuum sufficient to lower the boiling temperature to the required figure—in this case about 10° C.

Rediffusion, Ltd.

R.F. Dielectric-Heating Equipment

A self-contained generating and heating unit of 4 kW input delivering up to 2 kW at 35 Mc/s. operating on 200-250 V single-phase 50 c/s. supplies. It has been designed primarily for heating plastic moulding materials and general small-scale heating. The high-frequency generator is a push-pull oscillator employing two triode valves, fed from a D.C. unit in the same cubicle at 3,500 V.

Wild-Barfield Electric Furnaces, Ltd.

Relay, Direct Current

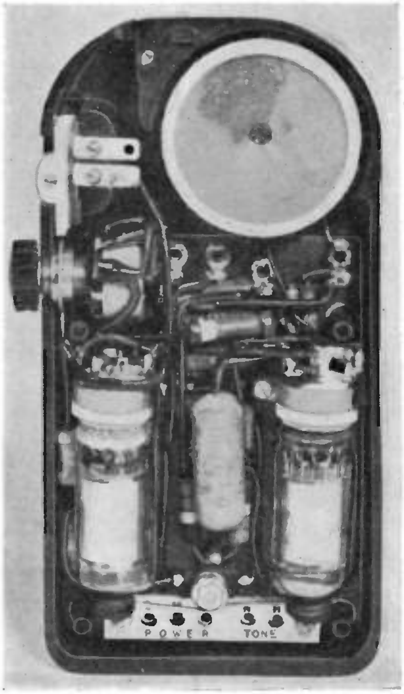
Having a low coil-consumption in the lower voltage range of approximately 1 W and fitted with beryllium-copper contacts capable of handling 10 amp. at 230 V, A.C. or D.C. This relay can be fitted with a mercury switch up to 30 amp., 230 V capacity if desired.

Hendrey Relays, Ltd.

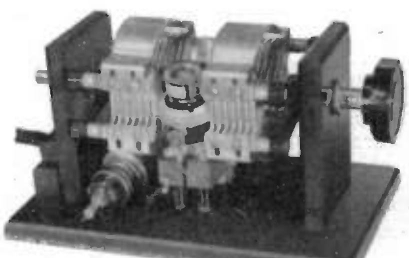
Relay, High Sensitivity, Type H

A very sensitive high-torque high-speed relay of the moving-coil pattern.

Elliott Brothers (London), Ltd.



Pocket two-valve hearing aid with crystal microphone.
—*Multitone Electric Co., Ltd.*



Butterfly oscillator and absorption wave-meter covering 250-650 Mc/s. and 250-850 Mc/s
—*British Thomson-Houston Co., Ltd.*

(Below): Highly sensitive multi-range volt-ammeter 100,000 Ω/V.
—*H. Tinsley & Co., Ltd.*

Relay, High-Sensitivity Snap Action

With a new type of movement, the action of which is shown by the sketch. →

W. G. Pye & Co., Ltd.

Relay, High-Speed Polarised

(R. E. H. Carpenter's Patents Nos. 315496, 484472 and 559047.) This, the latest form of the Carpenter relay has been designed to combine in one instrument high speed, high sensitivity, and high contact pressure together with a high degree of immunity to external vibration. Two chief types are shown: the standard form, intended for general use, where the greatest robustness and reliability of operation are designed, combined with ample sensitivity for most circuit conditions; and a special model in which considerably higher sensitivity has been achieved. →

Telephone Manufacturing Co., Ltd.

Relay, Solenoid Operated

Incorporating a mechanical escapement mechanism adjustable in three ranges to give any time delay between 5 seconds and 1½ minutes. The coil can be wound for either A.C or D.C. operation.

Hendrey Relays, Ltd.

Remote Indication, Smith "Desynn" System

An electrical system for the transmission of indicator movement with accuracy and rapid response. The transmitter, in its simplest form, embodies a circular resistance with three equally spaced tappings and diametrically disposed rotating contacts carrying the 24-V D.C. input.

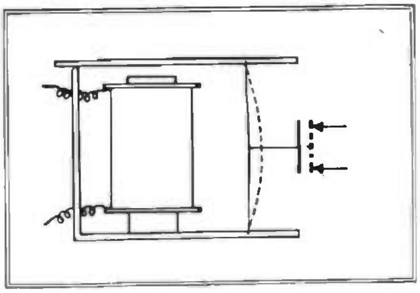
The "Desynn" indicator has a slotted iron stator with star-connected 3-phase distributed winding to which the tappings of the transmitter resistance are connected. Within the stator is pivoted a permanent magnet, forming a two-pole armature, and carrying the pointer. The position of the contacts of the transmitter resistance influences the strength and direction of the currents in the indicator stator windings, causing the armature to assume a position dependent on that of the transmitter contacts.

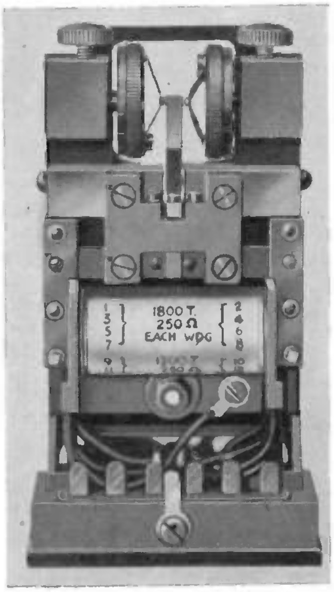
S. Smith & Sons (England), Ltd.

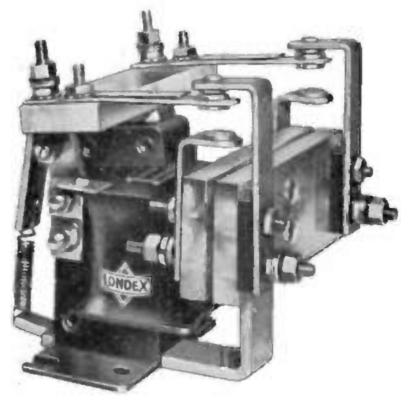
Series Plug and Socket

New model, for inserting ammeters into circuits without interrupting the current when performing experiments.

The London Instrument Co., Ltd.







Heavy-duty relay for automatic starting and stopping of power-driven equipment.

—Londex Ltd.

Signal Generator

Type TF.867, a new design of signal generator for measurements in the range 15 kc/s.-30 Mc/s. mains operated.

Marconi Instruments, Ltd.

Switches, Mercury

(i) An entirely new range of industrial switches, with exceptionally heavy overload characteristics and ability to interrupt currents far in excess of their rating.

(ii) A new range of switches fitted with platinum contacts giving exceedingly low and constant resistance.

(iii) Novel delay-action switches with new features.

Mercury Switch Manufacturing Co., Ltd.

Switch—

Combined Time-Switch and Time-Checker (E. A. Harvey)

A portable A.C. mains-operated switch, which can be used to control an external circuit carrying up to 5 amp. at 250 V, or to measure the period during which an external pair of contacts is closed. When it is used for the latter purpose, *i.e.*, as a "time-checker," three ranges are available: 0.02-19.98 sec. in steps of 0.02 sec.; 0.1-99.9 sec., in steps of 0.1 sec.; and 1-999 sec., in steps of 1 sec.

Ilford, Ltd.

Synchronous Induction Motor

A synchronous motor which, when connected to a 100-V, 50-c/s. A.C. single-phase supply, rotates at 3,000 r.p.m. and consumes 10 W, the power factor of the complete circuit being unity. Reversal of rotation is obtained by connecting the condenser in parallel with either one of the phase windings, which are identical in all respects.

Scophony, Ltd.

Temperature Controller

Designed for electric on-off control. The duration of on-to-off period is directly proportional to the amount of departure from the control point. If the furnace temperature is well below the control point, the instrument is continuously on and maintains a continuous heat-input. As the control temperature comes within the throttling range of the instrument the ratio of the on to the off period is progressively reduced until control point is reached. This is accomplished by using two opposing galvanometers to actuate the necessary power relay. When the temperature falls away the galvanometers deflect in opposition; one actuating the power-relay and the other acting as a restoring device in such a way that the duration of on-off is proportional to departure from control point. A further feature of this instrument is the utilisation of a superimposed current to eliminate galvanometer contact resistance; as soon as the galvanometer contacts close, a current of correct polarity is superimposed to deflect the galvanometer further and so break down contact resistance.

Bristol's Instrument Co., Ltd.

Tester, Valve

Designed for the rapid testing of valves. Tests of mutual conductance, emission of diodes and rectifiers, and heater-cathode insulation are provided for. The instrument is fully mains operated. Switches are fitted for the application of suitable voltages to anode, screens, etc., and heater voltages between 1.4 and 40. Interchangeable valve sockets covering the majority of valves are provided. A high-speed relay fitted in the instrument protects it from damage, should a valve be defective.

Gambrell Bros. & Co., Ltd.

Testmeter, Multi-Range Electronic

This instrument consists of a highly stable thermionic D.C. millivoltmeter with suitable additional circuit switching to enable D.C. and A.C. voltage, D.C. current, resistance, capacity and power measurements to be made over a very wide range. In all, 47 ranges are provided.

Besides the basic D.C. millivolt, six D.C. voltage ranges are provided having full-scale deflections of 1, 2, 5, 25, 100, 250 and 1,000 V. The input resistance on all these ranges is 11.1 MΩ, while an external " × 10 " multiplier increases the input resistance to 111.1 MΩ and enables D.C. voltages up to 10,000 V to be measured. Ten D.C. ranges are provided, allowing measurements from 0.25 μA to 1 amp., the millivolt drop on all ranges being 150 mV. Three resistance ranges enable measurements to be made from a fraction of 1 Ω to 10 MΩ, while an additional insulation range is graduated from a minimum indication of 1 MΩ to a maximum of 1,000 MΩ.

The Automatic Coil Winder & Electrical Equipment Co., Ltd.

Transformers, D.C. Current

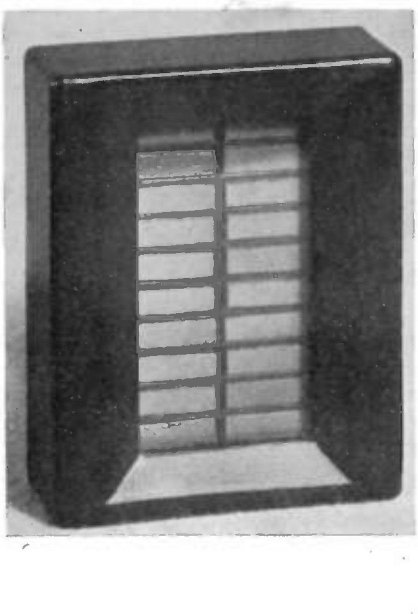
The operation of the D.C. current-transformer depends on the fact that the impedance of an iron-cored inductance falls when magnetised by a direct current, and, by applying an alternating voltage (not necessarily constant) to a secondary winding, a current proportional to the direct current results. In order to eliminate inductive interference by the A.C. with the D.C. circuits, two cores are employed, so connected that during a given half-cycle the A.C. and D.C. assist one another in one core and oppose one another in the other core. The D.C. current transformer may with equal facility be used for operating, indicating and recording ammeters, relays, wattmeters or watt-hour-meters.

Everett, Edgcumbe & Co., Ltd.

Panel-mounting microammeter only 1½ in. in diameter, moving-coil type.
—Nalder Bros. & Thompson Ltd.

Multi-range A.C. D.C. testmeter. 1,000 Ω/V with safety and overload devices.
—General Electric Co., Ltd.

(Below): Multiple selenium photo-cell with series elements suitable for load resistances of 1 MΩ. Actual size.
—Evans Electroselenium Ltd.



Valves, Electrometer

The single electrometer valve already developed has similar electrical characteristics to the F.P.54 and can be used in the conventional circuits as described by Du Bridge and Brown (*Rev. Sci. Inst.*, 1933, *4*, 533). The design of the double valve exhibited was suggested by Dr. J. C. M. Brentano. This is a double-tetrode tube in which both tetrode sections draw their emission from a single filament and each section resembles the F.P.54 in electrical characteristics.

Ferranti, Ltd.

Valve, Radio, Demonstration Panel

A number of instruments, with controls for adjusting appropriate voltages to the different electrodes, together with the necessary power supply, is assembled in a convenient form for demonstrating every type of valve used in radio reception. Every important characteristic is clearly and simultaneously indicated, the uses and misuses being instantly apparent. Primarily designed for the instruction of students, it is equally applicable for laboratory use.

Everett, Edgcumbe & Co., Ltd.

Voltage Selector

Voltage selector designed for laboratory use. It consists of a transformer with windings and tappings so arranged that any voltage from 1 to 599 can be selected by switches arranged in decade.

Gresham Transformers, Ltd.

Wattmeter, Portable Suspended

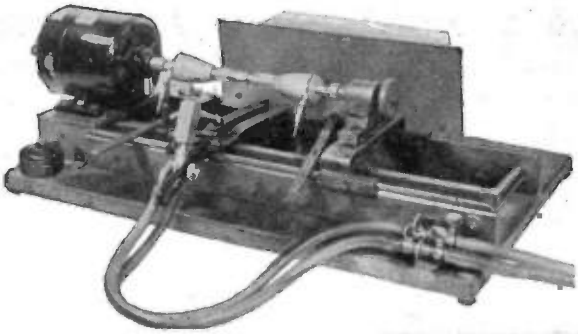
A deflectional instrument suitable for frequencies up to 20 kc/s.

Elliott Brothers (London), Ltd.

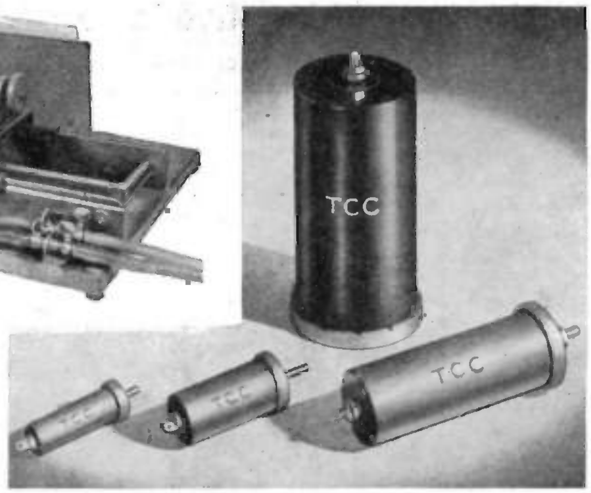
Wavemeter, Direct-Reading Oscillating (30 kc/s.-60 Mc/s.)

An improved model of the original Sullivan-Griffiths dynatron wavemeter, but now incorporating a nega-

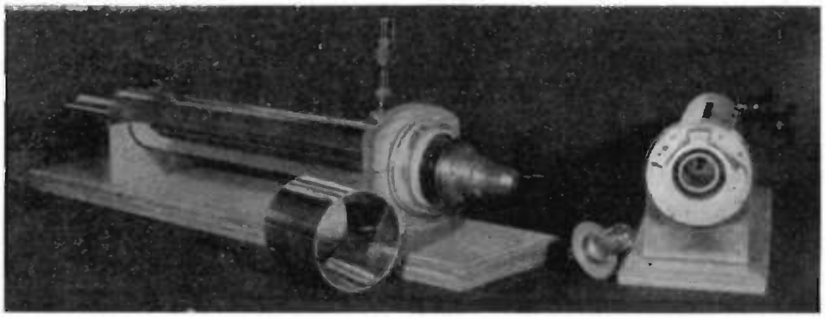
5-kW silica-seal mercury vapour lamp with 100 amp. tapered strip molybdenum seals.
—*British Thomson-Houston Co., Ltd.*



Machine for making glass-to-metal seals by centrifuging.
—*G.E. Research Laboratories*



(Right): "Cathodray" capacitors specially designed for smoothing circuits of C.R. tube supplies.
—*Telegraph Condenser Co., Ltd.*



tive resistance valve circuit designed to use modern valves. Accuracy 1 part in 10,000 immediately upon switching on. Short-period stability a few parts in 10^6. Direct-reading frequency scales to an accuracy of 0.01 per cent. Linear frequency law giving negligible interpolation error, the accuracy of simple interpolation being 2 parts in 10^6. Calibration independent of valve replacement. Fitted with crystal-checking circuit. Mains or battery operated.

H. W. Sullivan, Ltd.

Layer-Type Batteries

These batteries are specially constructed in an exceedingly compact form for use in small radio transmitters and receivers. The normal carbon rod is replaced by a thin conducting layer on the surface of the zinc plate of the adjacent cell, thus eliminating soldered contacts between cells. The elements are completely enclosed in a light plastic container which gives good intercell insulation. The efficiency per unit volume has been increased up to about 70 per cent.

General Electric Co., Ltd.

Generator, Cathode-Ray Tube Dot-Mosaic

This apparatus is a mechanically switched scanning generator, useful in determining the linearity of the deflectional response of all electrostatic cathode-ray tubes.

A. C. Cossor, Ltd.

Sensitive Materials for Photographic Recording with the Cathode-Ray Oscillograph

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Ilford, Ltd.

Corrections

Multi-Range Electronic Tester

In the January issue (p. 15) the manufacturer's name was omitted from a description of this instrument. It is the Automatic Coil Winder and Equipment Co.

SenTerCel Rectifiers

Messrs. Standard Telephones & Cables, Ltd., point out that these rectifiers are of the selenium type and not copper oxide as stated in the January issue (p. 18).

CV90 Oscillator

CV90 is a triode oscillator valve designed for use with a double coaxial resonator of the type shown. The contacts between the valve electrodes and the circuit are self-locking and permit easy insertion and withdrawal of the valve. (Photograph above.)

One coaxial resonator forms a circuit between the anode and grid of the valve and the other resonator forms a circuit between the grid and cathode. The resonators are independently tuned by means of sliding short-circuiting plungers controlled by rack and pinion mechanisms. "Feedback" is obtained by a built-in capacitance between anode and cathode inside the valve itself. This circuit covers a range of 10 cm. to 100 cm. (300 to 3,000 Mc/s.).

CV257 Power Amplifier

This circuit is tunable over the range from 300 Mc/s. to 1,000 Mc/s. The conspicuous feature is that there is no tuning in the grid cathode circuit, the input impedances of the valve matching the characteristic impedances of the R.F. input couple reasonably well.

—*General Electric Co., Ltd.*

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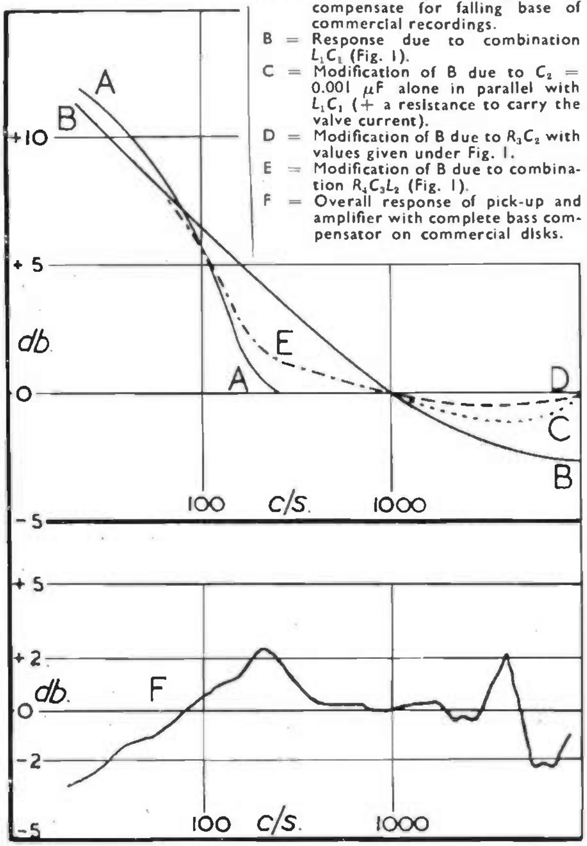
250 c/s. and the measures so far taken raise all frequencies below 1,000 c/s. to some extent, the response thus modified still leaves the level in the neighbourhood of 250 c/s. slightly too high. This is shown by the discrepancy between curves B and A. The level in this region is now therefore reduced by placing in parallel with the network already described a rejector tuned to 250 c/s. in series with an appropriate resistance. L_2, C_3 and R_4 form such a rejector and have the effect of feeding back a slightly greater proportion of these frequencies. Various combinations of values of L_2 and C_3 calculated to resonate at 250 c/s. have been tried out and their overall responses plotted to obtain the desired degree of steepness of the peak, and various values of R_4 have been tried out to obtain the optimal height of peak or amount of compensation. The closest approach to the required curve was found to be obtained with $L_2 = 4$ H, $C_3 = 0.1$ μF and $R_4 = 30{,}000$ ohms. The effect of the combination is shown by curve E. The choke is constructed similarly to L_1 but with a core of 14 mu-metal laminations forming a stack $\frac{3}{8}$ in. × 7/32 in. and a winding of 1,000 turns of 34 S.W.G. enamelled wire having a D.C. resistance of 23.5 ohms. Increase of the value of R_4 increases the bass-lifting efficiency of the whole system since with higher values the standard amount of feed-back which is set by the relation of R_4 to R_1 and R_2 is greater and the reduced feed-back of bass decided by the lower impedance of L_1C_1 to bass is proportionately less. The mean gain of the stage becomes less. Lower values of R_4 somewhat reduce the bass lift relative to the 1,000 c/s. level but improve the smoothing out of the hump at 250 c/s. If a rise of 4 db. be tolerated at 250 c/s. the level at 25 c/s. may be raised above that at 1,000 c/s., but the most satisfactory compromise for music and all general purposes is probably that which leaves a rise of 2.5 db. at 250 c/s. and a 2.5 db. drop at 25 c/s. since neither of these constitutes an at all easily audible discrepancy. It may be mentioned that in fitting R_4 and L_2 it should be remembered that it is these components which carry the valve current, and moreover that it is R_4 which primarily decides the standard amount of feed-back at 1,000 c/s.

To summarise the action of the compensator, the standard amount of feed-back at 1,000 c/s. is reduced in the base by the lowered impedance in this region of L_1C_1. Above 1,000 c/s. it tends to be increased by the increased impedance of L_1C_1 and decreased by the decreased impedance of C_2. R_3 is chosen to make these two effects nearly cancel one another. In the middle register the amount of feed-back tends to be reduced by L_1C_1 and increased by L_2C_3. R_4 is chosen so that these effects also nearly cancel one another.

The data have been obtained throughout by means of H.M.V. constant frequency records and oscillograph measurements of voltages at the L.S. terminals of the amplifier. The amplifier consisted of the first stage described above and in the legend to Fig. 1 (with alternative first stages for other inputs), a second R.C. coupled MH4, a phase changer (HL4+) and two MH4s driving two PP5/400's in push-pull operating in Class A. With the compensator described and the writer's own energised moving coil pick-up and transformer the overall response is within 2.5 db. of the 1,000 level from 25 c/s. to 8,500 c/s. Transients, moreover, are well preserved and listening tests with three speakers and a dividing network have fully justified expectations based on the response data. A typical overall response curve is shown in Fig. 2, F.

Fig. 3 is appended for comparative purposes and shows the overall response curves obtained on the same amplifier, A, with a high fidelity crystal pick-up; B, with a moving coil pick-up with no tone correction; C, with the same moving coil pick-up with bass lifted by frequency selective potentiometer in grid circuit; D, with moving coil pick-up and frequency-selective negative feed-back in cathode circuit as above described. It is anticipated these results will be further improved upon by this method when other stampings become available.

Fig. 2.



A = Amplifier response required to compensate for falling base of commercial recordings.
B = Response due to combination L_1C_1 (Fig. 1).
C = Modification of B due to C_2 = 0.001 μF alone in parallel with L_1C_1 (+ a resistance to carry the valve current).
D = Modification of B due to R_3C_2 with values given under Fig. 1.
E = Modification of B due to combination $R_4C_3L_2$ (Fig. 1).
F = Overall response of pick-up and amplifier with complete bass compensator on commercial disks.

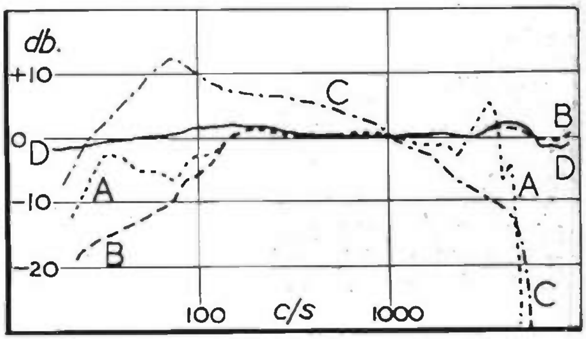


Fig. 3.

High Fidelity Bass Compensation

For Moving Coil Pick-Ups

By F. M. HAINES, D.Sc.*

It has not been possible up to the present to obtain full advantage of the high fidelity of the moving coil pick-up for want of adequate and sufficiently accurate bass compensation. In the absence of this, its excellent top response leads to a want of balance which is musically most unsatisfactory. Methods of bass compensation in common use involving arrangements of chokes, condensers, tuned acceptors or rejectors, or frequency selective potentiometers in grid or anode circuits, all fail where high fidelity is required, since, as a large number of actual response plots made by the writer have shown, they are not capable of giving even approximately correct compensation at all lower frequencies relative to the 1,000 c/s. level without considerably impairing the top response relative to the same standard. Generally the transients are also impaired.

Response measurements show, however, that a very much closer compensation for the falling level of the bass on commercial disks, and a response curve with no departure over 2.5 db. from the 1,000 c/s. level between 25 c/s. and 8,500 c/s. may be obtained by the use of frequency-selective negative feed-back through an appropriate network placed in the cathode circuit of the first valve of the pick-up pre-amplifier following the input transformer.

The circuit is shown in Fig. 1. Its general effect is that all frequencies above 250 c/s. are about 80 per cent. fed back, incidentally giving improved quality by a smoothing of possible minor irregularities in the upper half of the audible band. Below 250 c/s. where a regularly increasing compensation is required down to 25 c/s. (0.75 db. at 200 c/s., 5.5 db. at 100 c/s., 10 db. at 50 c/s. and 11.1 db. at 25 c/s. as shown by curve A, Fig. 2), there is progressively less feed-back until at 25 c/s. there is practically no feed-back and the full amplication of the stage is obtained.

The main agent is the combination of L_1C_1 (Fig. 1) which forms a tuned acceptor with a minimum impedance at or below 25 c/s. Above 25 c/s. the impedance rises so that an increasing proportion of the input signal is fed back. The theoretical optimal values for L_1 and C_1 are respectively 10 H and 4 μF, but in practice response curves show that it is better to tune the acceptor well below 25 c/s. (*e.g.*, to about 10 c/s.), the best results being obtained with a 4 μF condenser and a choke passing 0.46 mA on a 50 c/s. 4-volt supply, *i.e.*, of 27.7 H. The core of this choke is of 25 mu-metal laminations, the centre stack being $\frac{3}{8}$ in. × $\frac{3}{8}$ in. and the winding of 900 turns of 36 S.W.G. enamelled wire, the D.C. resistance being 32.5 ohms. The resistance must be as low as possible: at the same time the choke cannot be made unduly large owing to increased capacitative leak. It may be noted that for C_1 an electrolytic condenser may be used if desired, since it is maintained polarised by the drop of potential across R_4L_2 due to the valve current. The effect of the combination L_1C_1 alone is to raise the bass and shift the originally level response of the amplifier to the curve B shown in Fig. 2. This makes a close approximation to the compensation required by commercial recordings (shown in curve A) up to about 200 c/s. The impedance of L_1C_1, however, increases indefinitely upwards, and this, if the combination were used alone (with a resistance to carry the valve current), would cause a serious loss of top, as is evident on comparing curves A and B. To counteract this and prevent the falling off above 1,000 c/s. the impedance of the network is kept approximately constant above 1,000 c/s. and the top response fully retained relative to this level by placing in parallel with L_1C_1 the condenser C_2. The effect of adding C_2 alone is to give an indefinitely rising response above the point at which the impedance of C_2 becomes comparable with that of L_1C_1. The impedance of L_1C_1 at 1,000 c/s. is 157,000 ohms. For C_2 to equal this,

$$\frac{1}{6{,}280 \times C_2} = 157{,}000, \text{ which gives}$$

$C_2 = 0.001$ μF. Trial shows that this value restores the correct level at 8,500 c/s., but leaves it low at 5,000 c/s. as in curve C. The

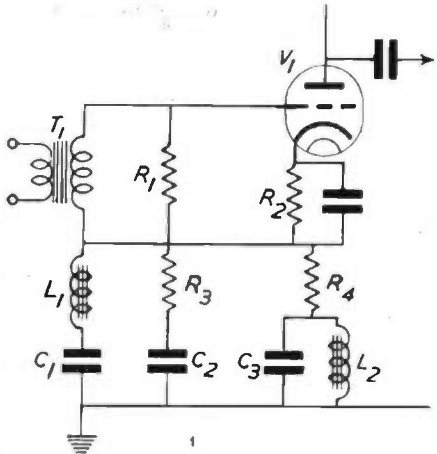


Fig. 1. Circuit for bass compensation by frequency selective negative feedback.

V_1, MH4 : load resistance = 50,000 ohms.
T_1, Input (matching) transformer. Ratio = 350 : 1. Primary: 20 t. of 18 g. enam. wire; secondary: 7,000 t. of 44 g. Core: 14 Ni alloy laminations, $\frac{3}{8}$ in. × $\frac{3}{8}$ in. centre stack.
R_1 = 500,000; R_2 = 1,000; R_3 = 25,000;
R_4 = 30,000 Ω
C_1 = 4 μF; C_2 = 0.002 μF; C_3 × 0.1 μF.
L_1 = 25 H; L_2 = 4 H. (*For details see text.*)

0.001 μF condenser is therefore replaced by a larger condenser (to raise the response earlier) with a resistance in series to limit the lift and give the same total impedance at 8,500 c/s. as a 0.001 μF condenser alone. A 0.001 μF condenser has an impedance at 8,500 c/s. of 18,700 ohms. Thus R_3 must be such that

$$\sqrt{R_3^2 + \left(\frac{1}{\omega C_2}\right)^2} = 18{,}700 \text{ ohms at}$$

8,500 c/s., which gives $R_3 = 16{,}000$ ohms. The effect of R_3C_2 is shown by curve D. Trials show that since minor peaks may tend to appear in this region, 16,000 ohms for R_3 raises the 5,000 c/s. level a little too much, and that in practice 20,000 or 25,000 ohms may allow the minimum departure from the 1,000 c/s. level. The optimal value in any particular case depends upon the properties of the pick-up and matching transformer and the consequent shape of the original response curve in this region. A number of response plots show that with a particular pick-up and transformer used by the writer the most satisfactory values are $C_2 = 0.002$ μF and $R_3 = 25{,}000$ ohms, with which the deviation of the overall response curve is nowhere more than slightly over 2 db. from the 1,000 c/s. level from 1,000 c/s. to 8,500 c/s.

Since the required compensation (curve A, Fig. 2) begins abruptly at

* Queen Mary College, University of London.

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(See Note on p. 43)

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A Single Sweep Time Base

Part II

By D. McMULLAN, B.A.(Cantab), Grad.I.E.E.

IN Part I a description was given of a time base which, although designed primarily for single sweep working, could also be used as a normal free running* time base as well as providing facilities for sweep expansion in conjunction with an auxiliary time base.

The time base circuit is a combination of the Puckle time base and the Eccles-Jordan trigger circuit, and one of its features is the short time delay between the application of the actuating pulse and the start of the working stroke. When used for sweep expansion, the time base is triggered by an auxiliary time base synchronised with the signal under observation. Any part of a cycle of the signal waveform may be expanded by arranging that the time base is triggered at the appropriate point in the sweep of the auxiliary time base.

In this part some practical details are considered and the circuit of a time base designed on the lines indicated in Part I is given.

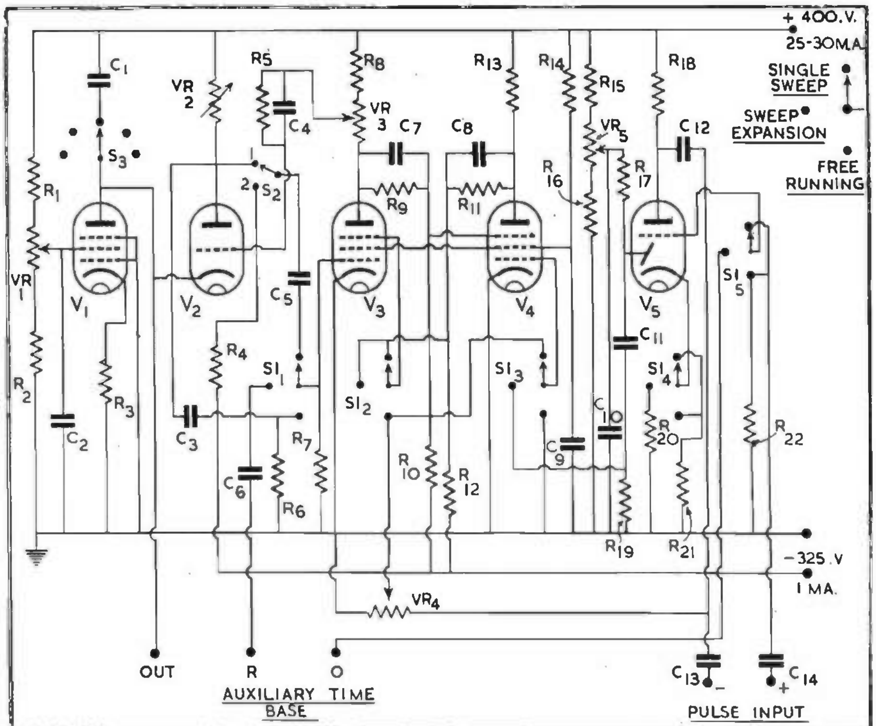


Fig. 2.1. Circuit diagram of time base.

Component Values

R_1	75 K	R_{13}	50 K	C_1	50 pF–1 μF	C_{13}	0.1 μF
R_2	2 K	R_{14}	50 K	C_2	1 μF	C_{14}	0.1 μF
R_3	100 Ω	R_{16}	See text	C_3	0.1 μF	VR_1	50 K
R_4	100 K	R_{14}	See text	C_4	300 pF	VR_2	2 K
R_5	200 K	R_{17}	250 K	C_5	1500 pF	VR_3	25 K
R_6	250 K	R_{18}	15 K	C_6	100 pF	VR_4	500 K
R_7	1 M	R_{19}	250 K	C_7	50 pF	VR_5	100 K
R_8	25 K	R_{20}	50 K	C_8	50 pF		
R_9	500 K	R_{21}	300 Ω	C_9	8 μF		
R_{10}	500 K	R_{22}	500 K	C_{10}	0.25 μF		
R_{11}	500 K			C_{11}	0.1 μF		
R_{12}	500 K			C_{12}	0.1 μF		

V_1 6K7 V_2 6F6 V_3 6K7 V_4 6K7 V_5 6R7

Some Practical Considerations

The circuit of the time base is shown in Fig. 2.1, and its main points will be discussed briefly. The five-pole three-way switch $S1$ 1.5 is used to select the type of operation required: single sweep, sweep expansion or free running. The switch is shown in the single sweep position. The following controls are operative on all three positions: VR_1 and S_3 which vary the velocity of the spot, and VR_3 which controls the amplitude of the time base output. VR_2 and VR_4 are used in the single sweep and free running conditions only and are the trigger control and pulse input control respectively. VR_5 is the sweep expansion control and S_2 is the auto-manual reset switch for single sweep working.

V_5 is used in the sweep expansion circuit (as described in Part I) and also as a phase reversing stage for triggering the single sweep time base on positive pulses as well as a synchronising signal amplifier in the free running condition.

C_4 and R_5 are included in the grid circuit of V_2 in order that the circuit shall work satisfactorily in the single sweep condition with low spot velocities. In this case, without C_4 and R_5 the time base will not reset at the end of the working stroke since the condenser C_1 does not discharge fast enough for the cathode of V_2 to follow the grid, with the result that V_2 takes a large grid current interfering with the action of the Eccles-Jordan circuit V_3, V_4. R_5 reduces this grid current and is shunted by C_4 so that the circuit will operate satisfactorily at high frequencies.

In the free running condition the circuit works as a normal Puckle time base.

A word of explanation is perhaps necessary for the size of the discharge valve V_2, an output pentode, triode connected. Since a D.C. connexion has to be made between the time base and the cathode-ray tube, when the charging current is varied through V_1 (and hence through V_2 when the time base is in the static condition),

* "Free running" is used in the sense that no external signal is required to actuate the time base although a synchronising signal will probably be used to lock the time base to the waveform under observation.

the starting position of the spot is moved across the screen due to the voltage drop across V_2 and VR_2. Therefore it is advisable to choose a valve with a low D.C. resistance for V_2, and this, of course, has the additional advantage that the discharge current is increased with a corresponding decrease in the flyback time.

It has been found necessary to supply the screens of V_3 and V_4 through a common resistor and to shunt them with a large condenser to chassis in order that the circuit shall trigger on short pulses and that the changeover time shall be as short as possible. With this arrangement the screen voltages remain practically constant whichever valve happens to be conducting, but if the screens are fed through separate resistors, the screen voltage of the valve that is being cut off immediately rises, interfering with the trigger action (unless the screen is connected to cathode through a condenser). If condensers are connected between screens and cathodes the circuit will take a long time to reach its final condition (the time required depending on the time constant of the screen circuits).

The values of the resistors R_{15} and R_{16} in the sweep expansion control (VR_5) resistance chain are not given as these depend on the output voltage of the auxiliary time base. It should be noted that the voltage applied to the grid of V_5 should not exceed 300 volts or the valve will not function as a cathode follower. If the peak output volts from the auxiliary time base (measured to ground) do not exceed 300 volts, a D.C. connexion may be made between this time base and the grid of V_5. Otherwise the connexion must be made through a condenser and the grid of V_5 returned through a high resistance to a point whose positive potential to chassis is equal to half the peak-to-peak output of the auxiliary time base. If the peak-to-peak output of the auxiliary time base is greater than 300 volts some attenuation must be introduced to limit the peak voltage applied to the grid of V_5.

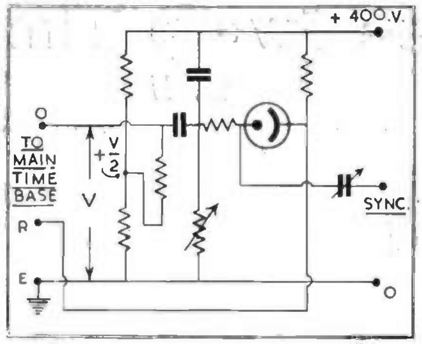


Fig. 2.2. Neon time base for use as auxiliary time base. V = peak to peak voltage output of time base.

The resistors R_{15} and R_{16} are so chosen that the potentials at the top and the bottom of the potentiometer VR_5 are equal respectively to the maximum and minimum voltages applied to the grid of V_5.

An auxiliary time base consisting of a condenser shunted by a neon and fed through a high resistance has been found satisfactory for some work. A suitable circuit is shown in Fig. 2.2. A resistor is included in series with the neon in order to provide the resetting pulse for the main time base. The disadvantages of this arrangement are that the maximum frequency is limited and the voltage output is rather low for working direct into the plates of a cathode-ray tube, although it is large enough for triggering the main time base. However, with an amplifier it is quite adequate for most work.

Care should be taken in the mechanical layout to keep all wires as short as possible. The heaters of V_2 and V_5 should be supplied from separate screened windings on the mains transformer.

D.C. Supplies

The H.T. supply to the time base must be well smoothed. The necessity for providing a negative supply to the time base is a disadvantage, but may be fairly easily arranged, since the current drain is only a milliamp or so. One or other of the following methods may be employed. The voltage may be obtained from the cathode-ray tube potentiometer chain or a separate supply may be used. The latter arrangement is probably the best as the modifications necessary to an existing power pack are very simple. A suitable circuit is shown in Fig. 2.3. A metal rectifier is used and is connected to one half of the main H.T. transformer. Resistance smoothing is satisfactory since the current drain is so low. The negative supply voltage is rather critical, and is therefore made adjustable.

Connexion to C.R.T.

The connexion of the time base to the cathode-ray tube is rather a problem since isolating condensers cannot be included in the deflector plate circuits. This is because the spot will not start from the same place on the X-axis for each stroke if irregularly spaced transients are being observed.

If it is desired to have the final anode of the cathode-ray tube at earth potential, then the positive H.T. rail of the time base must be earthed.

The author has found that a satisfactory arrangement is to have the final anode of the tube at a potential slightly lower than that of the time base positive H.T. supply rail. A schematic diagram is shown in Fig. 2.4. The valves V_6 and V_7 form a cathode-coupled amplifier for the Y-plates. This circuit removes some of the disadvantages of not having the final anode of the cathode-ray tube earthed, and also has the advantage that the amplifier may be used

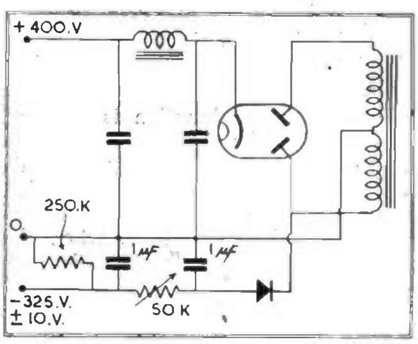
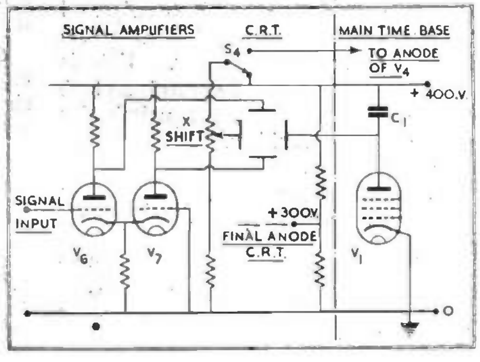


Fig. 2.3 (left). Suggested circuit for obtaining the negative 325-volt supply for the time base from an existing power unit.

Fig. 2.4 (right). Connexion of time base to cathode-ray tube showing the arrangement of the Y-amplifier V_6 and V_7.



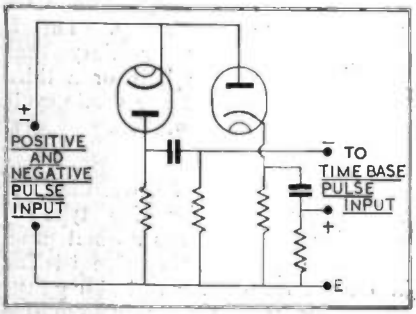


Fig. 2.5. Circuit for separating positive and negative pulses. The condensers and resistors should be selected to suit the duration and repetition frequency of the pulses.

for D.C. voltages. Other advantages are that the deflection is balanced, the amplifier is inherently stable and introduces little distortion. The design of cathode-coupled amplifiers has been fully dealt with previously in this journal and elsewhere.

The switch S_4 connects the X-shift potentiometer either to the + 400-volt line or to the anode of V_4 for beam deflection modulation as described in Part I. With the switch in the latter position the spot is deflected off the screen until the main time base starts. The resistance of the potentiometer chain should be about 1 megohm.

Performance of Time Base

Some figures on the performance of the time base are given in the table. The figures for time delay and changeover time depend to some extent on stray capacities in the wiring and with special care could probably be improved upon.

Notes on the Use of the Time Base

The notes below are an amplification of the methods of using the time base given in Part I. They are not intended to be exhaustive but to act as a guide, since each application of the time base presents its own problems.

Single Sweep Operation

The actuating pulse applied to the pulse input terminals may be derived from the external circuits or may be the actual signal being examined. In either case, it may be necessary to shape the pulse before applying it to the time base in order that its duration shall not be too great (causing the time base to make more than one stroke for each pulse). The shaping may be achieved by passing the pulse through a differentiating circuit. The amplitude of the pulse is unimportant as long as it is large enough to trigger the time base. It may be mentioned here that if the slider of VR_4 is not at its maximum position, a small time delay will be introduced in the start of the time base. This is sometimes useful and if the amplitude of the pulse is sufficient the delay can be varied up to about 10 microseconds. This delay could be increased still further by connecting a small condenser between grid and cathode of V_4, the input circuit acting as an integrator.

Sometimes it is convenient to be able to trigger the time base on negative and positive pulses from the same source, and this may be achieved by separating the positive and the negative pulses, and applying them to appropriate input terminals. A circuit is shown in Fig. 2.5 and with this arrangement the time base will trigger on the leading edges of the pulses. If it is desired to trigger on the trailing edges, it is only necessary to interchange the connexions to the positive and negative pulse input terminals.

It may be noted in passing that sufficient amplification is provided by V_3 to trigger the time base directly from a photo-cell. This can be very useful when the time base has to be synchronised with a mechanical movement, and in many cases is more convenient than using a switch.

When non-recurrent random transients are being photographed, and the time base is required to make only one stroke, the switch S_2 is turned to position 2. To reset the time base, the switch is switched to position 1 and then back to 2. Of course, when S_2 is at position 1 the time base resets automatically at the end of each stroke.

It is often advantageous (and, when photographing, a necessity) to suppress the beam except during the working stroke. As noted in Part I, there are two simple methods—beam deflection and beam brightening. In the former, the beam is initially deflected off the screen of the tube until the start of the working stroke. How this is accomplished is indicated in the section above on the connexion of the time base to the tube. Beam deflection modulation will probably be satisfactory for most applications if not more than 5 per cent. of the stroke is lost. As can be seen from Table 1 the changeover time of the valves V_3 and V_4 is about 5 microseconds, so that the shortest sweep time that can be used is 100 microseconds. For sweep times less than 100 microseconds beam brightening may be employed, the beam being suppressed until the start of the time base. One method is to connect the modulating electrode of the cathode-ray tube through a condenser to the anode of V_4. Very little of the trace will be lost even with high spot velocities, since the voltage change on the anode of V_4 is over 200 volts and only about 10 volts will be required to brighten the spot.

TABLE 1

Performance of Time Base

Single Sweep Operation	
Sweep time maximum	1 second
minimum	5 microseconds
Time delay	½ microsecond
V_3–V_4 changeover time	5 microseconds
Minimum amplitude of starting pulse	3 volts negative approx. / ½ volt positive approx.
Time base output	250 volts
Free Running Operation	
Frequency minimum	1 c/s.
maximum	200 kc/s.
Time base output	250 volts (at the lower frequencies)

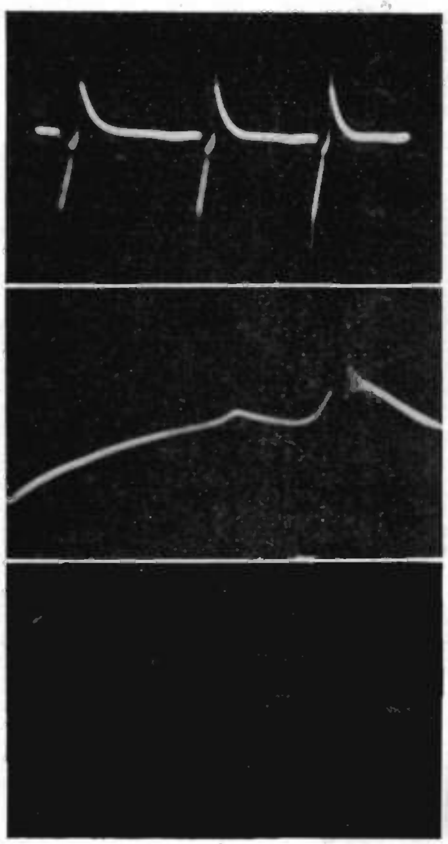


Fig. 2.6 (top). Figs. 2.7 and 2.8. Photographs of traces obtained with the sweep expansion circuit. The bottom photograph is of part of the waveform shown in the top photograph expanded about 500 times.

For many applications it is essential to have the time base sweep calibrated. For this purpose a separate calibrating oscillator may be used and this is especially convenient when a double beam cathode-ray tube is available, as the extra beam can be used to supply the time scale. Alternatively, the X shift potentiometer may be calibrated in time intervals for a specified position of the potentiometer VR_1, assuming also that the values of the charging condenser C_1 are selected so that the calibration will hold whichever charging condenser is switched in.

Sweep Expansion Operation

The procedure for using the sweep expansion circuit is as follows:

A cathode-ray tube is connected across the output of the auxiliary time base which is set so that a stationary two- or three-cycle picture of the signal waveform is visible. An expanded picture of the signal waveform is obtained on a cathode-ray tube connected to the output of the main time base, the degree of expansion being adjusted by VR_1 and S_3 and the part of the waveform expanded being selected by VR_6. In practice a single tube may be used, the X-plates being switched from one time base to the other.

Some photographs of traces obtained with the sweep expansion circuit are shown in Figs. 2.6, 2.7 and 2.8 and give some idea of its capabilities. Fig. 2.6 shows the waveform of an oscillator with a low frequency "squeg," as seen on a normal oscilloscope. The "squeg" frequency is approximately 75 per second. Fig. 2.7 shows the portion between the negative and positive peaks expanded about 20 times and in Fig. 2.8 the total expansion is about 500 times showing a part of the 60 kc/s. damped oscillation.

It is essential that the output voltage of the auxiliary time base should contain no superimposed A.C. ripple or the expanded trace will be very unsteady with high degrees of expansion. The blurring of the bottom photograph of the expanded trace is due to this cause. It may also be noted here that, due to condenser C_{11} discharging, it is possible to expand only about three-quarters of the auxiliary time base sweep. This is unimportant if the auxiliary time base frequency is a half or a third of the signal, so that one whole cycle is within the range of VR_6.

Free Running Operation

Little need be said about the time base when used for this type of operation, as it follows normal practice. The synchronising signal is fed into the terminal marked "negative pulse," or, if it is weak and requires amplification, into the terminal marked "positive pulse" on Fig. 2.1. The potentiometer VR_4 controls the synchronising input to the suppressor grid of V_8.

Conclusion

It is hoped that the time base described in this article will prove useful as a general-purpose instrument. It is, of course, almost impossible to meet every eventuality, but the circuit is fairly flexible and can be modified for special applications. Little has been said about specific applications, but these will readily occur to the reader.

Germanium Rectifiers

At the Rochester Fall Meeting of the I.R.E. and American R.M.A., Edward Cornelius (Sylvania Products) described the properties of germanium crystals as contact rectifiers for U.H.F.

Fig. 1 shows the construction of a rectifier unit Type IN.34, in which a square of germanium $\frac{1}{8}$ in. thick is mounted in a cartridge with a tungsten contact point having a required contour and pressure.

The germanium is reduced from the dioxide by hydrogen and forms, on melting and cooling, crystals of the diamond type with relatively high resistivity at room temperatures.

A small amount of tin added during cooling improves the rectification properties with a slight reduction in resistance.

The characteristics of the crystal are shown in Fig. 2. At values of voltage characteristic of a particular unit (between 75 and 200) the characteristic curve departs from the exponential form and the dynamic resistance becomes zero and then negative as the current is increased, so that the voltage across the unit decreases. The portion of the curve in which the dynamic resistance becomes negative or zero may be used for voltage regulation, and if necessary a small positive resistance may be added in series to reduce the overall resistance to zero. Normal currents for regulator use are 7–30 mA D.C.

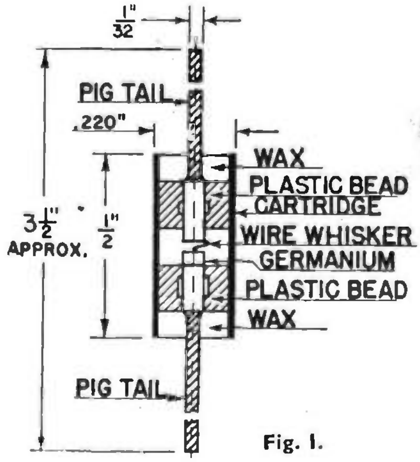
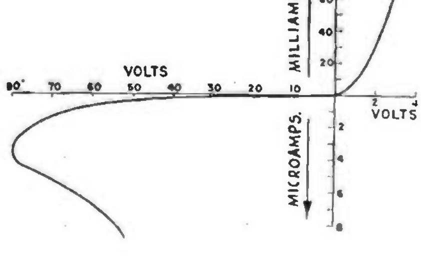


Fig. 1.

Fig. 2.



The advantages of this regulator over the gas discharge-type are freedom from flicker and absence of high striking voltage, although large changes in ambient temperature or heavy currents may affect the regulation and life of the unit.

Comparison between this rectifier and the 6H6 diode shows that the former has an advantage at low values of load resistance. Very high temperatures may be produced at the contact point if an appreciable current is passed through the unit.

Among the many uses suggested for these crystals are modulators, voltage regulators, L.F. oscillators, D.C. restorers and polarising devices.

—*Electronic Industries*, Dec., 1945.

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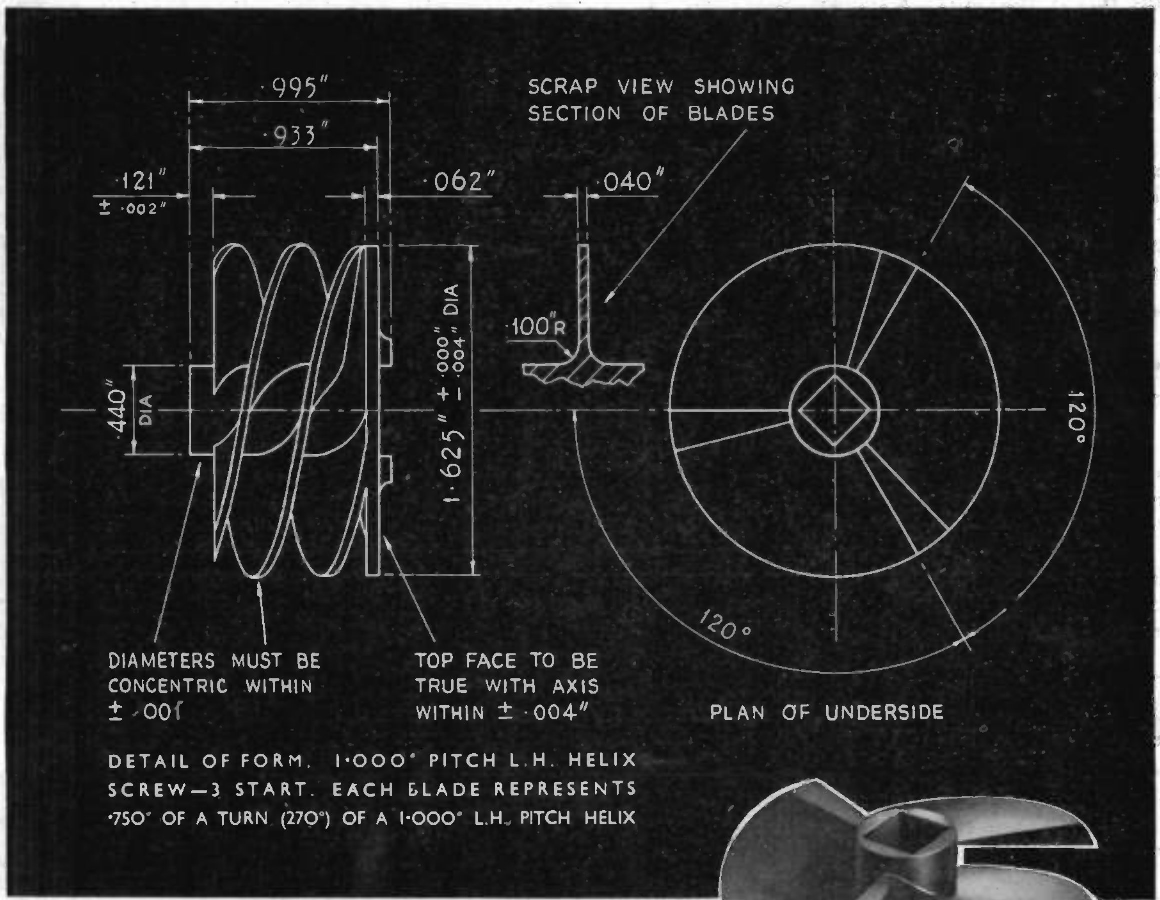
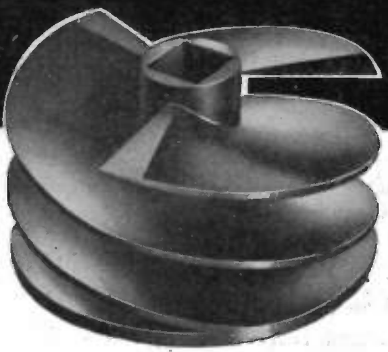
Its flange thickness must be ·040". It must withstand a pressure of over 10 lb. per sq. in.





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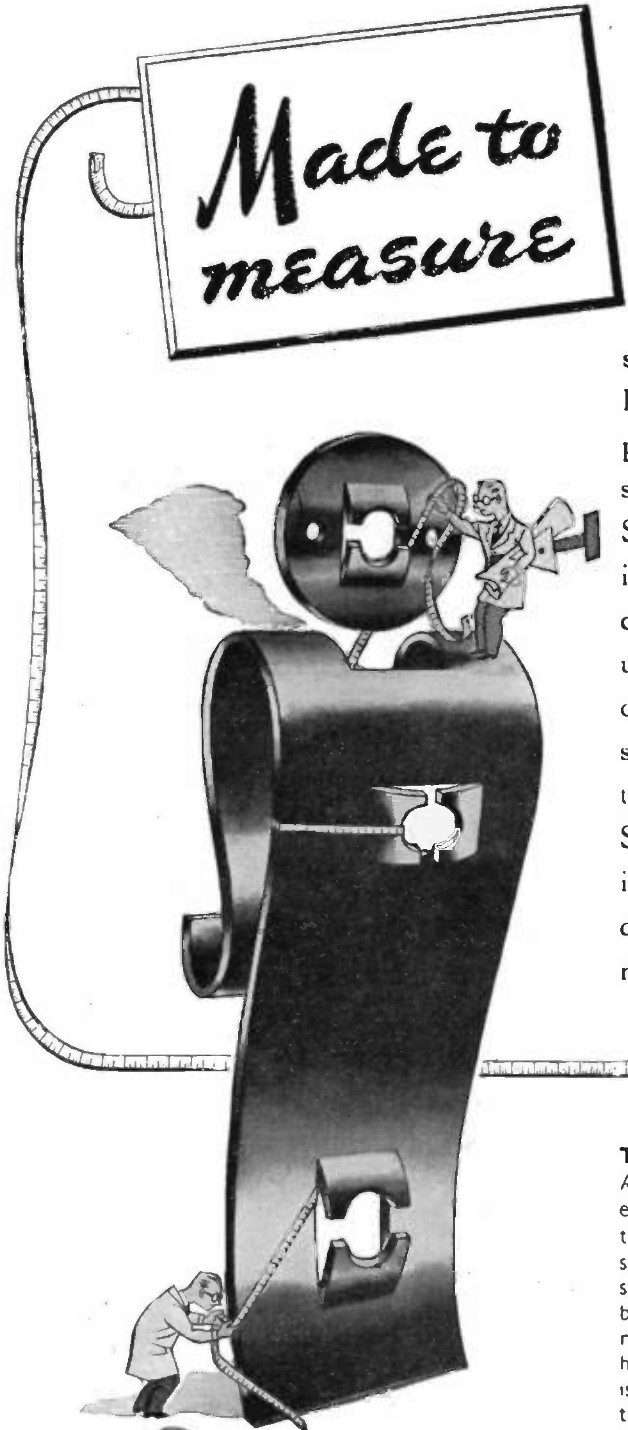

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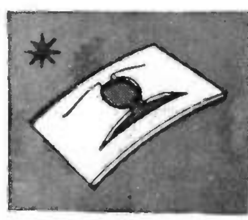

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H.F. Band-Pass Filters

Part II.—Similar Circuits

By H. PAUL WILLIAMS, Ph.D., A.M.I.E.E.

2.1 Similar Circuits

2.11 General

As was mentioned in the Introduction, it is possible to develop the theory of H.F. band-pass filters quite simply from first principles. Owing to the fact that the circuits involved have Q values of the order of 20 and upwards, it is possible to make an exceedingly useful approximation. This approximation concerns the series impedance of a tuned circuit near resonance and leads to an expression which greatly simplifies the subsequent calculations.

In Fig. 4 the series impedance is given by:—

$$Z = R + j\omega L + \frac{1}{j\omega C}$$

$$= R\left[1 + j\left(\frac{\omega L}{R} - \frac{1}{R\omega C}\right)\right]$$

$$= R\left[1 + j\left(\frac{\omega^2 LC - 1}{R\omega C}\right)\right]$$

By putting $\omega = \omega_0 + \delta\omega$ where ω_0 is the resonant frequency, and by neglecting $(\delta\omega)^2$ we have:—

$$Z = R\left[1 + \frac{2\delta\omega L}{R}\right]$$

$$= R\left[1 + j\frac{2\delta\omega}{\omega_0}\cdot\frac{\omega_0 L}{R}\right]$$

At this stage we introduce the parameter q which equals the distance off tune in terms of band-width. q may be positive or negative according to which side of the on-tune position we go. In this manner the band-pass curves are made applicable to any frequency. It merely becomes a matter of making the appropriate substitution of the number of kc/s. for unit q.

Now the band-width of a single circuit is given by $\frac{f_0}{Q}$ where Q has the conventional meaning and equals $\frac{\omega_0 L}{R}$.

Therefore $q = \delta f \Big/ \frac{f_0}{Q} = \frac{\delta f}{f_0}.Q = \frac{\delta\omega.Q}{\omega_0}$

$$\therefore q = \frac{\delta\omega}{\omega_0}\cdot\frac{\omega_0 L}{R}$$

Hence $Z = R(1 + j2q)$ .... (1)

q is a dimensionless quantity of the order of ± 1, 2 or 3. If, for example,

$f_0 = 1{,}000$ kc/s.
$Q = 100$
then $f = 985$ kc/s. means $q = -1.5$
$f = 1{,}020$ kc/s. means $q = +2$

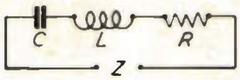


Fig. 4.

2.12 Mutual Coupling

The circuit equations for Fig. 5 may be written as follows (N.B.—in practice R includes the damping due to valves, *see* Section 3):—

$e = i_1 Z_1 - i_2 j\omega M$ .... (i)
$0 = i_2 Z_2 - i_1 j\omega M$ .... (ii)

$$\therefore i_2 = \frac{ej\omega M}{Z_1 Z_2 + \omega^2 M^2}$$

In all practical cases, $V_2 = i_2 j\omega L$ to a close approximation

$$\therefore \frac{V_2}{e} = \frac{-\omega^2 ML}{Z_1 Z_2 + \omega^2 M^2}$$

In the present case $Z_1 = Z_2$ and both are equal to $R(1 + j2q)$.

$$\therefore \frac{V_2}{e} = \frac{-\omega^2 ML}{R^2(1 - 4q^2 + j4q) + \omega^2 M^2}$$

We now introduce a very convenient parameter K, which equals the common coupling impedance divided by the series resistance of a single circuit. For the case of unequal damping we use the geometric mean of the two values, *i.e.*, $\sqrt{R_1 R_2}$.

$$\therefore K = \frac{\omega M}{R} = \frac{\omega L}{R}\cdot\frac{M}{L}$$

= Q × percentage coupling

Over the range of frequencies we are interested in, K may be taken as being a constant and equal to $\frac{\omega_0 M}{R}$.

Critical coupling occurs when $K = 1$. *When* $K > 1$ *the circuits are over-coupled and two peaks are formed.*

Making this substitution, we have:

$$\frac{V_2}{e} = -Q\frac{K}{(1 + K^2 - 4q^2) + j4q} \quad (2)$$

An alternative expression is:

$$\frac{\text{Response off tune}}{\text{Response on tune}} = \frac{1 + K^2}{(1 + K^2 - 4q^2) + j4q} \quad (2a)$$

Graphs of this expression for different values of K are given in Section 4. The choice of the parameter q (which involves the band-width) permits these curves to be applied for any value of f_0.

Gain On Tune

From Equation (2) we find that when $q = 0$,

$$\frac{V_2}{e} = -Q\frac{K}{1 + K^2} \quad (2b)$$

This has a maximum value when $K = 1$ and then

$$\frac{V_2}{e} = -\frac{Q}{2}$$

Therefore the maximum gain on tune is half that given by a single circuit of the same Q.

It must be remembered that e in the above expressions is the series-injected voltage and not the grid voltage e_g. In the case of pentode valves we have $e = ke_g$ where k is some constant whose values will usually lie somewhere between 4 and 10 (*see* Section 2.31).

Position of Peaks

Equation (2) has its maximum value when $(1 + K^2 - 4q^2)^2 + (4q)^2$ is a minimum. Calling the latter expression y we have:—

$$\frac{dy}{dq} = 2(1 + K^2 - 4q^2) \times (-8q) + 32q$$

This is zero when $2 = 1 + K^2 - 4q^2$. Giving this value for q the suffix $_m$, we have:

$$q_m = \pm\sqrt{\frac{K^2 - 1}{4}} \quad \text{............ (2c)}$$

The above equation is only valid when $K \geqslant 1$.

Note that $q = 0$ is also a solution to $dy/dq = 0$. This, of course, represents the on-tune point which is a maximum when $K \leqslant 1$ and a minimum value when $K > 1$. The equation for dy/dq is really a cubic and has to be solved as such in the case examined in Section 2.23.

Maximum Response

Using the value for q given in Equation (2c) we have:

$$\frac{V_2}{e} = \frac{-QK}{1 + K^2 - 4\left(\frac{K^2 - 1}{4}\right) + j4\sqrt{\frac{K^2 - 1}{4}}}$$

$$\therefore \frac{V_2}{e} = -\frac{Q}{2} \quad \text{........................ (2d)}$$

The maximum voltage is therefore independent of K when $K > 1$ and always half of that given by a single circuit.

From (2b) and (2d) we find:

$$\frac{\text{Response on tune}}{\text{Maximum response}} = \frac{2K}{1 + K^2} \quad \text{... (2e)}$$

Response Equal to that On Tune

In the case of two peaks, the response becomes equal to that on tune when:

$$(1 + K^2 - 4q^2)^2 + (4q)^2 = (1 + K^2)^2$$

Giving this value for q the suffix $_s$, we obtain:

$$q_s = \sqrt{\frac{K^2 - 1}{2}} \quad \text{............. (2f)}$$

Also, by using the value for q_m given in Equation (2c) we find:

$$q_s = \sqrt{2}\,q_m$$

Rough Plot of Response Curve

Using Equations (2c), (2e) and (2f) we can immediately obtain 5 points on the resonance curve.

Suppose, for instance, $K = 1.5$, then from (2e) we find that the response on tune is .923 times that at the peaks. The position of the two peaks is given by q_m, which equals $\pm .56$. Finally, the response again equals .923 when $q_s = \pm\sqrt{2} \times .56 = \pm .79$.

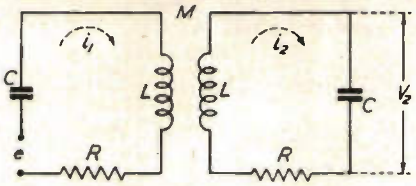


Fig. 5. Mutually coupled circuits.

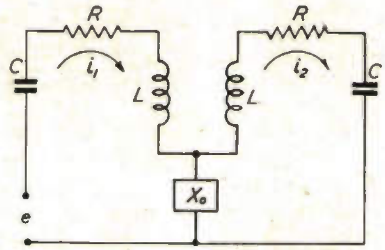


Fig. 6. Circuits with bottom-end coupling.

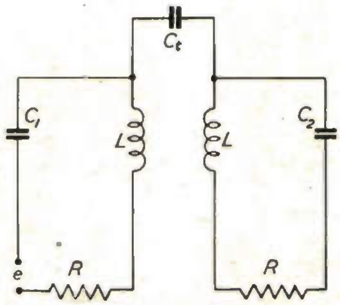


Fig. 7. Circuit with top-end capacity coupling.

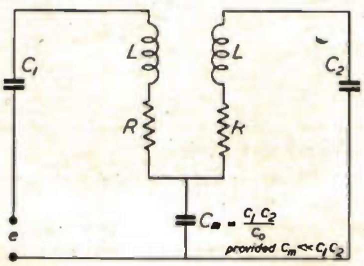


Fig. 8. Circuit of Fig. 7 with top-end capacity replaced by equivalent bottom-end capacity.

Response well Off Tune

If $q > \pm 3K$, then a good approximation for $\frac{V_2}{e}$ is $\frac{QK}{4q^2}$.

This indicates that well off tune the shape of the response curve is independent of K and is, in fact, given by:

$$\text{Response} \propto \frac{1}{q^2}$$

Separation between Peaks

The separation between the two peaks $= 2q_m$.

$= 2q_m$ times the bandwidth (in kc/s.)

$$= 2\sqrt{\frac{K^2 - 1}{4}} \cdot \frac{R}{2\pi L} = \frac{1}{2\pi L}\sqrt{R^2(K^2 - 1)}$$

$$\therefore \text{Separation} \propto (\omega^2 M^2 - R^2)^{1/2} \quad \text{(2g)}$$

Comparison with Single Circuits

With very loosely coupled circuits $K \ll 1$ and we may neglect K^2 in Equation (2a).

$$\therefore \frac{\text{Response off tune}}{\text{Response on tune}} = \frac{1}{1 - 4q^2 - j4q} = \frac{1}{(1 - j2q)^2}$$

Comparing this with the resonance curve of a single circuit as given by Equation (1), we see that the loosely coupled band-pass has a similar selectivity curve to that given by two single circuits in cascade. For large values of q (say 3 or more), the response for a single circuit $\propto \frac{1}{q}$, while that of any band-pass (whether loosely coupled or not) $\propto \frac{1}{q^2}$.

A further comparison with a single circuit is given by examining the relative widths at 3 db. and 20 db. down. Suppose we can tolerate an attenuation of 3 db. down from the maximum, then the optimum band-pass (*i.e.*, minimum width at 20 db. down) is obtained when the circuits are over-coupled as far as possible—in this case until the response on tune has dropped to 3 db. down relative to the peaks.

	Width at 3 db. down	Width at 20 db. down
Single circuit	1.0	10
Best coupled circuit (3db down on tune)	3.12	8.6

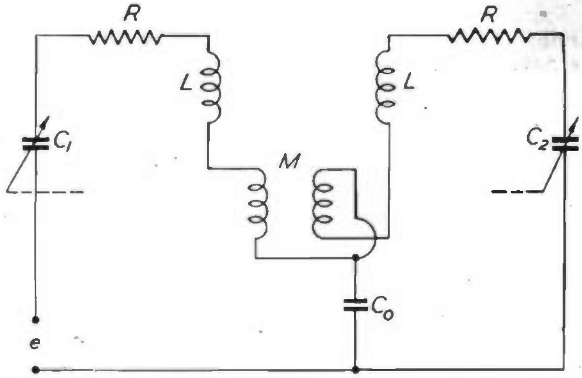


Fig. 9. Circuit with mixed coupling.
Values: L_1–L_2 = 2,310 μH
M = 11.8 μH
C_1 = C_2
C_0 = 0.03 μF

In the above table it was assumed that the coupled circuits had the same Q as the single one. If the coupled circuit Q values were increased so that the bandwidth at 3 db. down equalled that of the single circuit (*i.e.*, 1.0q), then the width at 20 db. down becomes $\frac{8.6 \times 1.0}{3.12} q = 2.75q$.

Therefore a 3.6 : 1 improvement is obtained over a single circuit at the 20 db. attenuation level.

If no higher Q circuits are available, then the correct coupling to give a width of 1.0q at 3 db. down is $K = .67$. This results in a width of 3.7q at 20 db. down and consequently gives a 2.7 : 1 improvement over a single circuit.

2.13 Bottom-End Coupling

The circuit for this case is shown in Fig. 6. X_o is the impedance of the coupling reactance at the on-tune frequency. In the equations that follow, the reactance is assumed to have a positive value, *i.e.*, the coupling is a common inductance. If the coupling is a capacity, the sign of X_o is changed throughout, resulting in a ratio of V_2/e that is the same as before in magnitude, but has a phase relationship on tune which differs by 180° from the inductive case.

Let Z = total series impedance, *including* X_o

$$= R + j\left(\omega L - \frac{1}{\omega C}\right) + jX_o$$

$$= R(1 + j2q)$$

The circuit equations are therefore:

$$e = i_1Z_1 - i_2jX_o$$
$$o = i_2Z_2 - i_1jX_o$$

Proceeding on the same lines as for Equation (2) we find:

$$\frac{V_2}{e} = -Q\frac{K}{(1 + K^2 - 4q^2) + j4q} \quad \ldots.. (3)$$

where $K = \frac{X_o}{R}$

Therefore the response is exactly the same as for mutual coupling. But now, since Z includes the coupling impedance, when we increase the coupling the peaks do not move out symmetrically on either side of the centre frequency.

The difference with mutual coupling, therefore, lies in the fact that trimming cannot be done by first reducing the coupling and then increasing it to the required amount after the circuits have been trimmed.

This feature is brought out if we take $Z = Z^1 + X_o$, where Z^1 is the series impedance without X_o. The expression for the response then becomes:

$$\frac{V_2}{e} = -Q\frac{K}{(1 - 4Kq - 4q^2) + j2(K + 2q)}$$

From an examination of the denominator of the above equation we see that the peaks are no longer symmetrical about $q = 0$ *if the resonant frequency* f_o *is taken without* X_o *in circuit.*

In fact, one peak remains at approximately f_o, while the other appears above or below f_o as we increase the coupling. The same is true of top-end coupling and the results may be tabulated as shown below.

Frequency of Second Peak	Bottom-End Coupling	Top-End Coupling
Below f_o	ωL	$\frac{1}{\omega C}$
Above f_o	$\frac{1}{\omega C}$	ωL

2.14 Top-End Coupling

A circuit involving top-end capacity coupling is shown in Fig. 7. The theory of top-end inductive coupling can be developed on similar lines, but since such a circuit involves the use of a high inductance, the case is obviously not used in practice.

The circuit of Fig. 7 can be analysed by using three circulating currents. Such an analysis results in an unsymmetrical expression for positive and negative values of q. It is therefore easier to replace the top-end capacity by its equivalent bottom-end capacity and use the results of the previous section. To do this we make use of a T arrangement of condensers which is equivalent to the arrangement of top-end coupling.

This procedure reduces the circuit to that shown in Fig. 8. In the latter figure $C_m = \frac{C^2}{C_t}$ provided $C_t \ll C$, which is true in practical cases.

When this substitution has been made, Equation (3) *applies.*

In this case

$$K = \frac{X_m}{R} = \frac{1}{\omega RC_m} = \frac{C_t}{\omega RC^2}$$

Now $\frac{1}{\omega RC} = Q \quad \therefore K = Q\frac{C_t}{C}$

The last expression for K shows that critical coupling occurs when the ratio of the capacities is equal to the Q of the circuits.

Although the approximation given in Fig. 8 leads to the correct shape of curve, erroneous conclusions can be arrived at both with regard to the manner in which the peaks move on increasing coupling and also with regard to the effect of damping one side. For instance, it might be thought that since the resonant frequency of either mesh in Fig. 8 is *above* that given by excluding the common coupling, the second peak should be *above* f_o. The table at the end of the Section 2.13, however, contradicts this deduction.

The explanation lies in the fact

that the equivalent circuit is not sufficiently accurate for this deduction. The true equivalent circuit has tuning condensers of value $(C + 2C_t)$ and a bottom-end condenser of $\left(\frac{C^2}{C_t} + 2C\right)$.

Thus the value of the two capacities in series (*i.e.*, the total tuning capacity of either mesh) is actually of the order of $(C + C_t)$ and not $(C - C_t)$ as would be inferred from Fig. 8. Hence increasing the top-end capacity causes the second peak to move further *down* the frequency scale.

2.15 Mixed Coupling

The equations previously developed will also hold for mixed couplings (provided they are purely reactive); for example, we may have $X_o = \left(\omega L_o - \frac{1}{\omega C_o}\right)$ It is obvious that the value of X_o will not vary with the tuning frequency in a simple way. So to avoid unnecessary calculations it is useful to examine the change in X_o with frequency to give either:

(a) approximately constant peak separation;

or (b) to pass near, or through, some predetermined points.

(a) Using Equation (2g) we see that the peak separation varies as $(\omega^2M^2 - R^2)^{1/2}$.

i.e., in the general case,

Peak separation $\propto (X_o^2 - R^2)^{1/2}$.

Therefore the separation is constant if $(X_o^2 - R^2)$ is constant. To approximate to such a condition we must first plot R against f from experimental results. Then values of X_o are chosen to give the best constant difference with this R versus f curve.

Usually the required value for X_o is of the form $\left(\omega M_o + \frac{1}{\omega C_o}\right)$ where M is a negative mutual. This can be made to satisfy two frequencies exactly. A practical example of such a mixed circuit is shown in Fig. 9. In this example the peak separations are correct at 250 and 400 kc/s.

(b) In practice, constant peak separation is usually not of so great importance as the obtaining of certain responses at certain frequencies over the tuning range. A neat method of achieving this as closely as possible has been described by Beatty (*Wireless Engineer*, October, 1932).

The method as applied to mixed mutual and bottom capacity coupling is as follows:

$X_o = \omega M + \frac{1}{\omega C}$ (where M is a negative mutual).

Then a plot of X_o against ω on log – log graph paper results in the same shaped curves if the product MC is kept constant (this can be appreciated if we consider the case when M and C are replaced by kM and C/k on the graph).

As for the *position* of the curve, this depends on the ratio M/C.

We now plot X/X_o against f/f_o on log-log paper (the suffix $_o$ is here reserved for *some particular value* of the coupling impedance and tuning frequency, and is dropped for the general case).

$$X/X_o = \frac{\omega M + \frac{1}{\omega C}}{\omega_o M + \frac{1}{\omega_o C}} = y, \text{ say.}$$

$f/f_o = x$, say.

Then x and y can be related as follows:

Put $\omega_o M = A\left(\omega_o M + \frac{1}{\omega_o C}\right)$

(where A is constant)

also $\frac{1}{\omega_o C} = (1 - A)\left(\omega_o M + \frac{1}{\omega_o C}\right)$

$$\therefore\ y = A\frac{\omega}{\omega_o} + (1 - A)\frac{\omega_o}{\omega}$$

$$= Ax + \frac{(1 - A)}{x}$$

Curves of x against y will be shown plotted for different values of A in Fig. 33 of Section 4.

$A = 1$ corresponds to pure mutual coupling.

$A = 0$ corresponds to pure capacity coupling.

The curves of Fig. 33 are used in practice by putting the desired curve of x against y on tracing paper and moving it about over the figure (keeping the respective x and y axes parallel) until the best fit is obtained with some particular value of A.

The point 1.1 then gives f_o and $\left(\omega_o M + \frac{1}{\omega_o C}\right)$, while the best A value decides the ratio of $\omega_o M$ to $\frac{1}{\omega_o C}$.

(*To be continued.*)

German Tape-Recording Equipment

The U.S. Broadcasting Commission in Europe have recently reported on a German-developed recording and playback equipment, which they consider superior to any used in Europe or America.

The equipment is manufactured by the E.E.G. Magnetophon and uses thin tape of a plastic base, specially made by the I.G. Farben industry. This tape is a form of dry-processed unplasticised polyvinyl chloride 0.035 mm. thick, on which is coated a layer of iron oxide mixture .008-.01 mm. thick.

This mixture consists of black oxide prepared at 230° C. for 6 hours with agitation to give small crystals of magnetic ferric oxide, together with Igelit MP.400 in equal proportions.

The cost is estimated at $3.00 per roll, which plays for about 20 minutes.

In operation, the tape passes through the gap of a small magnetic armature with the surface bearing the oxide in contact with the armature. Recording and playback is accomplished in the usual way, and there is a wipe-out mechanism enabling the tape to be used again.

At the regular tape speed of 80 cm/sec. it is said that the instrument will record and reproduce frequencies as high as 10,000 c/s. and the normal range is from 20 to 8,000 c/s.

The system was in general use throughout the German Army for fixed station recording and for mobile units, and in 1943-44 the production was approximately 6,000 tapes per month.

The performance of this equipment was apparently known to the B.B.C. engineers, and a demonstration was given to the American mission at Radio Luxembourg, where the equipment has been operating without a fault since 1941. No deterioration in recording has been experienced, surface noise is negligible, and the tape can be easily edited and spliced.

—*Electronic Industries*, Nov., 1945.

Polyphase from Single Phase

for Valve Supply Circuits

—Communication from E.M.I. Laboratories.

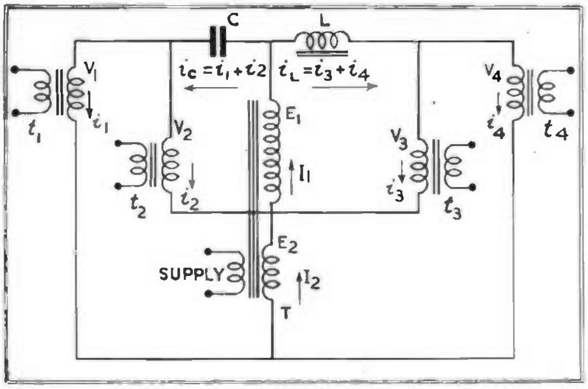


Fig. 1.

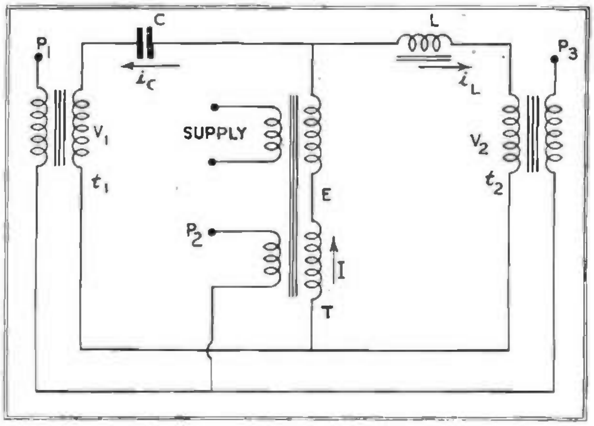


Fig. 2.

It happens on occasions in the design of radio apparatus that it is very desirable to employ a polyphase supply circuit rather than a single phase circuit. One instance may be found in the A.C. heating of the filaments of transmitting valves. Often it is observed that the anode current of a transmitting valve is modulated at double the frequency of the heating supply. This is due to the filament heating current setting up a magnetic field within the valve which is able to exert an appreciable controlling influence upon the electron flow to the anode. The effect is known appropriately as the "magnetron effect." When several transmitting valves are operated in parallel it will be clear that the severity of the hum modulation can be reduced by feeding the filaments from a multiple supply so that the magnetron effect in the several valves is out of step. Often, however, the supply available is only single phase.

Again, for supplying direct current to equipment from an A.C. source it is frequently advantageous to use, say, a three-phase rectifier circuit because, for one reason, the smoothing required subsequent to rectification is more simple than with single-phase rectification. Again, however, it may happen that the supply to hand is not the desired polyphase but single phase.

Conversion circuits that are able to provide a polyphase supply when connected to a single-phase source and so overcome in these and like instances the difficulties that may arise with single-phase supply are shown in Figs. 1 and 2.

Fig. 1 relates to a transmitting circuit in which the filaments of a bank of four transmitting valves are to be fed in different phases so that there is no resultant hum modulation. It can be shown that in the case of a bank of four valves the "magnetron effect" is reduced to a minimum when the phases of currents fed to the filaments of the four valves differ from each other by 45°. Thus, the transformers t_1, t_2, t_3, t_4 have to be arranged to feed the four filaments with currents of equal amplitude in a phase sequence having equal spacings of 45°. This is accomplished by feeding transformers t_1 and t_2 through a capacity C from the transformer T and transformers t_3 and t_4 through an inductance L and properly choosing the tapping points on the transformer T appropriate to individual transformers, so that the current delivered by the secondary of transformer t_1 leads the supply current in transformer T by $22\frac{1}{2}°$ and that delivered by the secondary of t_2 leads by $67\frac{1}{2}°$, whereas the currents from the secondaries of t_3 and t_4 are made to lag by $67\frac{1}{2}°$ and $22\frac{1}{2}°$ respectively. It should be noted that to this end, namely, the establishment of the required phase relationships, the primary windings are given different values of inductance. These values determine the transformation ratio of each transformer when it is decided, for instance, that each transformer is to feed the same power to its load.

In the case of a bank of three valves the phase difference between the three supplies should be 60° and this may be obtained as shown in Fig. 2. It will be seen that similar principles are employed, but as only three supplies are required, it is sufficient to obtain one supply lagging by 60° by means of a series inductance, one leading by 60° by means of a series capacity and the third in phase with the supply by means of a winding coupled to the supply transformer.

Electronic Aids to Pig-keeping

The trouble for our designers and engineers is to be able to get to know over all the vast range of industrial processes of this country what are the needs in any particular industry. For example, my colleague has suggested a grand help to farmers—an instrument to measure the thickness of the fat layer on the back of a pig. This thickness apparently determines the price a pig fetches. The farmer of the future won't prod the pig as of yore, but he will carry round a suitable little instrument. This will have a dial that can be set to the latest Fat Stock Prices when the B.B.C. once again broadcasts such information; the instrument will determine the exact thickness of the fat layer, and the worth of the beast will be directly shown on the dial!

—From an address by T. W. Heather (G.E.C.) at the opening of an exhibition of electronic apparatus.

Triode Equivalent Circuits

By D. A. BELL, M.A., B.Sc.

1. Introduction

SEVERAL articles on phase conventions in triode circuits have been published recently (References 1, 2, 3), but the net result appears to be to leave confusion worse confounded,* and probably the main trouble is that different authors have different implicit assumptions and conventions which may not be appreciated by the reader. It therefore seems worth while to show the development of equivalent circuits from first principles, with all assumptions and conventions explicitly stated. The less-known triode equivalent circuit using a fictitious current generator is included, as well as the familiar circuit with fictitious e.m.f. generator.

2. The Linearity Approximation and the Omission of D.C.

Consider first the diode circuit of Fig. 1(a), which includes both a battery maintaining a constant potential difference E_b and an alternator providing an alternating potential E_a which we will assume to be small compared with the constant potential. (The internal resistances of both battery and alternator are assumed to be negligible.) Then we know that in fact the current through the diode is very nearly:

$$I_a = AV_a^{3/2} = A(E_a + E_b)^{3/2} \quad \ldots\ldots (1)$$

Since E_a is assumed small compared with E_b, a binomial expansion gives:

$$I_a = AE_b^{3/2}(1 + E_a/E_b)^{3/2}$$

$$\approx AE_b^{3/2}\left[1 + \frac{3}{2}\cdot\frac{E_a}{E_b} + \frac{3}{8}\left(\frac{E_a}{E_b}\right)^2 + \ldots\right] \quad \ldots (2)$$

and to the first power in E_a, with a fixed value of E_b, this may be recast in the form:

$$I_a = i_0 + E_a/R_a \quad \ldots\ldots\ldots (2a)$$

where both i_0 and R_a are functions of E_b. For applications in which the steady potentials and currents are not required in the answer, Equation (2a) shows that a circuit equivalent to the real diode arrangement is that shown in Fig. 1(b), the equivalent of the diode being simply a resistance of value R_a. The two conditions for this equivalence are (a) exclusion of steady components from the problem and (b) the varying components being small enough compared with the (suppressed) steady components to allow the system to be regarded as linear.

As a further step, suppose that a resistance of value R is connected in series with the diode anode. Clearly the anode voltage will now be:

$$V_a = E_a + E_b - RI_a \quad \ldots\ldots\ldots (3)$$

and the equivalent circuit for A.C. components is that of Fig. 1(c).

3. Voltage Generator Equivalent Circuit for the Amplifying Triode

Fig. 2(a) shows a triode having D.C. sources and A.C. generators in both anode and grid circuits, the resultant anode and grid voltages being V_a and V_g. Since we now have two circuits, grid and anode, it is necessary to establish some convention to relate the senses of potential differences occurring in them. It is fundamental that the convention relating to some specific item should agree with more general conventions wherever possible, and where an "earth" is available it is a general convention that one may refer to the potential (with respect to earth) of a point, as well as the difference of potential between two points. Applying this to Fig. 2(a), the potentials

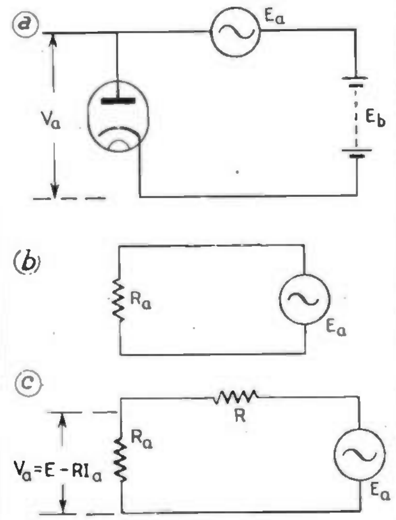


Fig. 1.

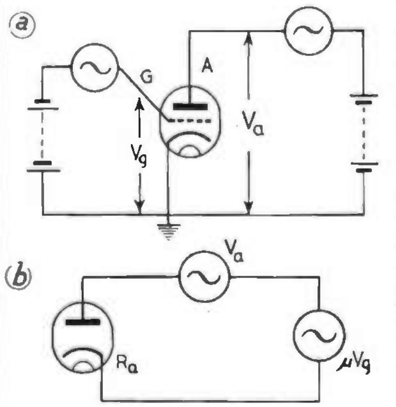


Fig. 2.

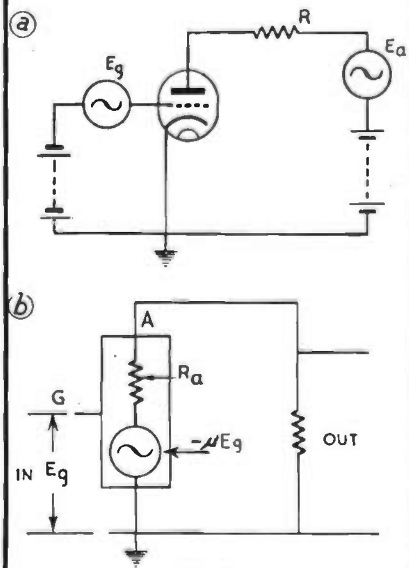


Fig. 3.

* Reference 1 started the trouble, 2 relies upon expressing the output as a cathode-anode potential difference instead of anode-cathode, while 3 endeavours to avoid the difficulty by suggesting that there is no phase relationship at all between anode current and grid voltage.

of A and G are V_a and V_g respectively, and clearly any alternating components of these two potentials are in phase if the two points reach their maximum positive potentials simultaneously. Now it is a well-known property of the triode that the anode current is a function of the factor $(V_a + \mu V_g)$, and for changes of potential small enough for the linearity approximation to be valid:

$$I_a = (V_a + \mu V_g)/R_a \quad \ldots\ldots\ldots\ldots (4)$$

The circuit equivalent to Fig. 2(a), referred to the anode circuit of the triode, is then as shown in Fig. 2(b). But when we proceed, just as in the diode case, to insert a resistance in series with the triode anode (Fig. 3(a)), we find it impossible to modify Fig. 2(b) in the same way that Fig. 1(b) was turned into 1(c), because R is in series with E_a but not in series with E_g. Resorting, therefore, to algebra, we write for the alternating components of Fig. 3(a):

$$V_g = E_g \quad \ldots\ldots\ldots\ldots (5a)$$

$$V_a = E_a - RI_a \quad \ldots\ldots\ldots\ldots (5b)$$

In the particular case of an amplifying valve having a signal applied to its grid but no source of alternating e.m.f. in its anode circuit, *i.e.*, if $E_a = 0$, Equation (5b) reduces to

$$V_a = -RI_a \quad \ldots\ldots\ldots\ldots (6)$$

and V_a is, of course, the output voltage of the triode amplifier. Eliminating I_a between (4) and (6):

$$-V_a/R = (V_a + \mu V_g)/R_a$$

$$V_a = -\mu V_g R/(R + R_a) \quad \ldots\ldots\ldots\ldots (7)$$

The equivalent circuit which pictorially represents Equation (7) is that shown in Fig. 3(b), in which the valve is replaced by a resistance R_a in series with a fictitious generator of e.m.f. *minus* μE_g. But it must be clearly understood that, unlike Fig. 2(b), the circuit shown in Fig. 3(b) *does not contain a valve*; if it is desired to retain the valve in the picture, we must revert to Fig. 3(a) and Equation (4).*

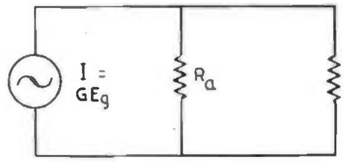


Fig. 4.

4. Current-Generator Equivalent of the Amplifying Triode

An alternative circuit which produces the same answer is shown in Fig. 4, where instead of a voltage generator in series with R_a, we have in parallel with R_a an infinite-impedance generator delivering a current of magnitude GE_g, where G is the mutual conductance and is equal to μ/R_a. The external load resistance R is in parallel with R_a, so that the current I_a flows through an impedance $RR_a/(R + R_a)$, thereby generating a potential difference:

$$V_a = -GE_g RR_a/(R + R_a) \quad \ldots\ldots (8)$$

(The negative sign arises because the constant-current generator may be regarded as the limiting case of a generator of large e.m.f. in series with a high resistance, and the potential difference across the external circuit is obviously opposed to the e.m.f. of the generator.) The substitution of $G = \mu/R_a$ in Equation (8) immediately reproduces Equation (7), and the equivalence of Fig. 4 with Fig. 3(b) is thus demonstrated.

The current-generator equivalent circuit of the amplifying triode has been introduced in the preceding paragraph simply as an algebraic transformation from the voltage-generator circuit; but the current-generator circuit has the advantage of avoiding a reversal of phase between the grid voltage in the real circuit and the fictitious generator in the equivalent circuit. It can further be argued that there is a better physical basis for Fig. 4 than for Fig. 3(b), and the author's approach to this is through shot noise phenomena. The passage of an electron from cathode to anode of a valve is equivalent to a pulse of current which charges the condenser formed by the anode-cathode capacity; and disregarding any effects of space-charge during the flight of the electron, the mean square fluctuation current due to this effect is:

$$\overline{I_{df}^2} = 2ie.df \quad \ldots\ldots\ldots\ldots (9)$$

Now the varying charges placed on the anode are dissipated partly through the external resistance R and partly by virtue of the fact that they cause changes of anode potential which in turn affect the mean anode current through the valve, *i.e.*, the charges are dissipated partly through the internal anode resistance R_a of the valve. In effect, therefore, the current flows through resistances R and R_a in parallel, and the resultant mean square output voltage (see, for example, Reference 4) is then:

$$\overline{V_{df}^2} = \overline{I_{df}^2} \cdot \left(\frac{RR_a}{R + R_a}\right)^2 \quad \ldots (10)$$

Equation (10) would be represented by Fig. 4 if the output of the current-generator were changed from GE_g to $\sqrt{\overline{I_{df}^2}}$.

It may also be argued that the effect of a positive voltage on the grid of a triode is to cause additional electrons to pass to the anode, and that the charge so reaching the anode will be dissipated partly through the external circuit and partly through the anode resistance R_a of the valve, as described from the shot noise example. This provides some physical basis for Fig. 4 and the concept that E_g primarily generates a *constant current*, but the presence of a finite R_a modifies the magnitude of net current flowing through the external circuit. This physical basis provides a case for the more frequent use of the circuit of Fig. 4.

* For example, it would be wrong to insert the *fictitious generator* voltage $-\mu E_g$ into the *valve* equation (4); the grid voltage of the valve is $+E_g$.

REFERENCES

[1] K. R. Sturley, *Wireless World*, May, 1945, p. 140.
[2] G.W.O.H., *Wireless Engineer*, June, 1945, Vol. 22, p. 261.
[3] D. H. Parnum, *Wireless World*, July, 1945, p. 209.
[4] E. B. Moullin and H. D. M. Ellis, *Journ. I.E.E.*, 1934, Vol. 74, p. 323.

NOTES FROM THE INDUSTRY

New Year Honours

Many names familiar in scientific and industrial circles are included in the New Year Honours list. SIR EDWARD APPLETON, K.C.B., D.Sc., Ll.D., F.R.S., Secretary, Department of Scientific and Industrial Research, is made K.B.E. SIR ROBERT RENWICK, Bart., lately Controller of Communications, Air Ministry, and Communications Equipment, M.A.P., is also made K.B.E. MR. P. DUNSHEATH, O.B.E., D.Sc., M.I.E.E., chief engineer and director, W. T. Henley's Telegraph Works Co.; MR. A. P. RYAN, of the B.B.C.; MR. C. O. STANLEY, O.B.E., managing director, Pye Limited, and MR. B. C. WESTALL, chairman and managing director of Thomas de la Rue, Ltd., all become C.B.E. DR. ROBERT COCKBURN and MR. J. A. RATCLIFFE, who superintended T.R.E., are made O.B.E., as are MR. E. HARLE, MR. K. C. SINCLAIR, MR. W. F. R. CAMPLING and DR. D. N. TRUSCOTT. MR. C. S. AGATE, of the Gramophone Co., MR. C. A. W. HARMER, of Pye Ltd., MR. J. W. RIDGEWAY, of the Edison Swan Electric Co., and MR. W. H. PETERS, of the G.E.C., Coventry, are also given the O.B.E.

New Chairman of BREMA

The new executive council of the British Radio Manufacturers' Equipment Association have elected Mr. A. McVie, B.Sc.(Eng.), A.C.G.I., A.M.I.E.E., general manager and director of Kolster-Brandes, Ltd., as the Council's new chairman.

Dubilier Laboratory Manager

Dubilier Condenser Co. (1925), Ltd., have appointed Wing Commander H. Andrewes, O.B.E., B.Sc., A.M.I.E.E. (late Chief Radar Officer Base Air Forces, South Asia Command), their laboratory manager. He has had a wide experience of radio, Radar, and electronic engineering and will be responsible for all research and development in connexion with the company's products.

T.C.C.

Mr. C. T. Nuttall has joined the Telegraph Condenser Co., Ltd., as sales engineer. He was formerly component design engineer for the Gramophone Company, and in his new capacity will contact set manufacturers regarding the use of capacitors in radio and television receivers.

Electronic Developments at B.T.-H.

The British Thomson-Houston Company's Report of Progress in 1945 contains an account of electronic developments in the company's laboratories at Rugby. Many electronic servo mechanisms have been produced for the accurate remote position control for searchlights, guns and Radar aerial systems. Instrument type remote position control servo mechanisms of a few watts output have also been produced during the past year, and induction and D.C. motors driven directly from the electronic circuits have been employed.

In the industrial field thyratron voltage regulators have been developed for controlling the voltage of high frequency alternators used for induction heating. No exciter is used, the whole of the excitation power being obtained from thyratrons. A feature of the control is the high speed of response of the voltage regulator.

An electronic time delay relay has been developed to provide an inexpensive short interval timer. The main features are infinitely variable adjustment over a wide range of the time delay period by knob control, and compactness and high accuracy.

Met-Vick and Newton & Wright

An agreement has been concluded by which the Metropolitan-Vickers Electrical Co., Ltd., will acquire a substantial interest in Newton & Wright, Ltd., manufacturers of X-ray apparatus and optical equipment. Newton & Wright will remain a separate entity, but there will be the closest co-operation between the organisations of the two companies. The present directors of Newton & Wright will remain on the board; Mr. R. S. Wright is relinquishing his position as managing director, but retains that of chairman; Mr. H. A. Quinton becomes general manager.

Liverpool University

Dr. J. M. Meek has been appointed to the David Jardine Chair of Electrical Engineering at Liverpool University. Dr. Meek graduated from Liverpool in 1934, and received the degree of Doctor of Engineering at the University in 1942. He was elected to the I.E.E. Council in July last, and will commence his new duties in July of this year.

Standard Telecommunication Laboratories, Ltd.

Standard Telephones and Cables, Ltd., announce the formation of a central laboratory organisation to undertake long-term research and development in the telecommunication, electronics and allied fields. The new laboratories, to be known as Standard Telecommunication Laboratories, Ltd., will be housed at Progress Way, Gt. Cambridge Road, Enfield, pending the erection of suitable permanent premises. The principal objective will be the intensification of research and development in all aspects of telephony, telegraphy, electronics, cables, radio, television, etc.

Muirhead and Co., Ltd.

Muirhead and Co., Ltd., have appointed Mr. W. C. Lister, B.Sc., chief sales engineer, to take charge of sales, publicity and customer technical services. Prior to joining Muirhead and Co. in 1930, Mr. Lister was at the G.P.O. Radio Research Station at Dollis Hill. For some years he has been Muirhead's chief development engineer and is, therefore, in a unique position to give technical advice to all users of the company's products.

Mr. P. Cannon, superintendent of the Instrument Making Department, retired at the end of last year after nearly fifty-four years' service.

Mr. J. Bell, M.Sc., M.I.E.E., is relinquishing his appointment with the Admiralty to join Muirhead and Co., Ltd., as chief research engineer on March 1 next.

Gardners Radio, Ltd.

Correction

We have been asked to make two corrections in the data which appeared in the Gardners Radio advertisement in our January issue. These are as follows: the price of the mains transformer type R.116 should be 52s. 6d., and the tappings of the R.125 should read: 0-4-6.3 volt 3 amp., 0-4-6.3 volt 4 amp.

"Pylon" Hearing Aid

An unobtrusive hearing aid has been developed by Park Royal Scientific Instruments, Ltd. Containing a three-valve amplifier and crystal microphone, the complete unit, including batteries, weighs only 10 ounces and measures 4⅛ in. by 3⅜ in. by 1⅛ in.

New Insulation Co., Ltd.

Mr. A. E. Judge, A.M.I.E.E., has joined the technical sales staff of the New Insulation Company and will be in charge of their London office at Windsor House, 46 Victoria Street, S.W.1.

B.B.C. Television

The transmission of a still pattern from the London Television Station at Alexandra Palace will start on February 1. Transmissions will thereafter be made on weekdays from 11 a.m. to noon and from 4 p.m. to 5.30 p.m., and will consist of a tuning note and interval signal on the sound channel of 41.5 Mc/s. (7.23 metres) and a still pattern of a black cross on a white background on the vision channel of 45 Mc/s. (6.67 metres).

The choice of the still pattern which can be produced without the use of studio cameras and apparatus will allow the B.B.C. to continue the work of overhauling the studio vision apparatus at Alexandra Palace without interruption from the tests, and will at the same time provide a test signal which is most suitable for the use of the radio trade.

While these transmissions will be of no immediate interest to the general public, the B.B.C. is undertaking them in order to assist the radio trade in the production, testing and servicing of television receivers. The date of the opening of the public television service from Alexandra Palace will be announced later.

B.I. Callender's Staff

British Insulated Callender's Cables, Ltd., announce the following staff appointments among others :—

Mr. P. V. Hunter, engineer-in-chief.

Mr. D. W. Aldridge, deputy engineer-in-chief and production manager.

Dr. L. G. Brazier, research manager.

Dr. J. L. Miller, chief engineer (equipment and telecommunications).

Mr. J. L. Harvey, general works manager.

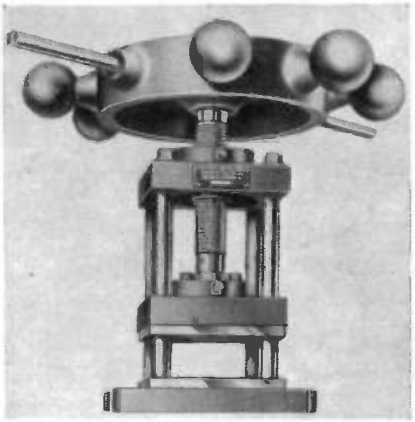
Mr. H. J. Allcock, deputy production manager.

Mr. S. H. Parsonage

Mr. S. H. Parsonage has resigned his appointment as manager at Compound Electro Metals, Ltd., but continues to act as adviser to the company. His new work concerns, among other items, the economic forms of electric heating. Address: 42 Pall Mall, London, S.W.1 (ARN. 6691).

The "Lab" Press

An experimental laboratory moulding press has been designed by the development department of Wright and Weaire, Limited, High Road, Tottenham, London, N.17. It is small, hand-operated and heated electrically. The manufacture of simple moulding tools, with or without provision for inserts, can be accomplished in very little more time than it takes to produce one or two model pieces in ebonite or other insulating material. Once made, the mould will give 50 or 100 pieces, and even more, according to the material used. Hard brass may be used for short runs or steel for more extended numbers.



N.E. Coast Exhibition

An Exhibition of Scientific and Engineering Inspection Equipment will be held in Northumberland Road Drill Hall, Newcastle-on-Tyne, from February 12 to 22. Among the exhibits will be the electron microscope, appliances for measuring the thickness of metal coatings, hardness testing apparatus, the magnetic sorting bridge, X-ray industrial units, glass thickness viewers and strainometers. Magnetic, fluorescent and radio-frequency methods of crack detection will be demonstrated. The Exhibition will be opened at 3 p.m. on Tuesday, February 12, and thereafter will be open daily from 11 a.m. to 8 p.m.

Marconi College

The Marconi Company's training establishment hitherto known as the Marconi School of Wireless Communication will, as from January 1, 1946, be known as Marconi College. Full postal address: Marconi's Wireless Telegraph Co., Ltd., Marconi College, Arbour Lane, Chelmsford, Essex. Tel.: Chelmsford 4401/2.

Amateur Radio Transmission

Amateur radio transmission is now permitted again in this country. Transmitters are being returned to owners, and the Post Office are to commence the reissue of licences. Two wavebands have been allotted for amateurs' use, 28-29 megacycles and 58.5-60 megacycles.

Mr. W. H. Stevens

Mr. W. H. Stevens, late of the research laboratories of A. C. Cossor, Ltd., has taken up a position with R.F. Equipment, Ltd., at Amersham, Bucks, where he will be responsible for the design of television receivers.

Dubilier Agents

The Dubilier Condenser Co. have appointed the following agents in Great Britain :—

Manchester: L. Backhouse, 274 Deansgate.

Durham: A. J. Burke, Leadgate House, Leadgate.

Cardiff: A. E. Luen, 17 Dumfries Place.

Birmingham: A. J. Marc, 18 Newhall Hill.

Bournemouth: F. G. Lawrence, 393 Holdenhurst Road.

Enemy Radio and Radar Exhibition

There is a possibility that members of the trade will have an opportunity of inspecting captured enemy radio and Radar equipment. The Ministry of Aircraft Production is hoping to secure a suitable hall for an exhibition of this equipment in the very near future. Admission will be restricted to representatives of interested industries, research and experimental staffs and students.

Startling New Discovery?

Sir Robert Watson-Watt gave the 116th series of lectures for children at the Royal Institution during the Christmas holidays, his subject being "Wireless.".

The caption supplied with this agency photograph reads : "Sir Robert demonstrates magnetism with an ebonite rod and a piece of paper."

FEBRUARY MEETINGS

*NOTE.—In general, visitors are admitted to the meetings of scientific bodies on the invitation of a member, or on application in writing to the Organising Secretary at the address given. In certain cases (marked *) tickets may also be obtained on application to the Editorial offices of this Journal.*

Institution of Electrical Engineers

All meetings of the London Section will be held at The Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2.

Radio Section

Date: February 6. Time: 5.30 p.m.
Lecture:
"Tendencies in the Design of the Communication Type of Receiver."
By:
G. L. Grisdale, Ph.D., and R. B. Armstrong, B.Sc.

Date: February 20. Time: 5.30 p.m.
Lecture:
"New Methods for Locating Cable Faults particularly on High Frequency Cables."
By:
F. F. Roberts, B.Sc.(Eng.).

Date: February 26. Time: 5.30 p.m.
Discussion on:
"Comparison of Electrostatic and Magnetic Deflection in Cathode-Ray Tubes."
Opened by:
V. A. Stanley, B.Sc., and E. W. Bull, B.Sc.(Eng.).

The Secretary:
The Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2.

London Students' Section

Date: February 18. Time: 7 p.m.
Lecture:
"The Measurement and Reduction of Noise."
By:
Dr. A. J. King, M.Sc.(Tech.).

Hon. Secretary:
R. V. Darton, 27 Church Rise, Forest Hill, London, S.E.23.

Cambridge Radio Group

Date: February 19. Time: 6 p.m.
Held at:
The University Engineering Laboratory.
Lecture:
"Some Principles of Ultra Short Wave Aerials."
By:
Prof. E. B. Moullin, M.A., Sc.D.

Group Secretary:
D. H. Hughes, c/o Pye Ltd., Radio Works, Cambridge.

Institute of Physics

Electronics Group

Date: February 20. Time: 5.30 p.m.
Held at:
The Royal Institution, 21 Albemarle Street, London, W.1.
Discussion:
"Permanence of Components in Electronic Equipment."
Opened by:
Dr. W. B. Lewis.

Group Secretary:
A. J. Maddock, M.Sc., F.Inst.P., Messrs. Standard Telephones and Cables, Ltd., Oakleigh Road, London, N.11.

Manchester and District Branch

Date: February 15. Time: 7 p.m.
Held at:
Large Physics Theatre, Manchester University.
Lecture:
"Vision at Low Intensities of Illumination."
By:
W. S. Stiles, D.Sc.

Hon. Secretary:
Dr. F. A. Vick, O.B.E., F.Inst.P., Physics Dept., The University, Manchester, 13.

Institution of Electronics

London Section

Date: February 11. Time: 5.30 p.m.
Held at:
The Royal Society of Arts, John Adam Street, London, W.C.2.
Lecture:
"Glass for Electron Tubes."
By:
Dr. J. H. Partridge.

Tickets may be obtained from 64 Winifred Road, Coulsdon, Surrey.

The Association for Scientific Photography*

Date: February 22. Time: 6.30 p.m.
Held at:
The Royal Society of Arts, John Adam Street, London, W.C.2.
Lecture:
"The Photographic Copying of Documents and Plans."
By:
F. J. Tritton, B.Sc., F.R.P.S.

The Secretary: A.S.P., 34 Twyford Avenue, Fortis Green, London, N.2.

R.S.G.B.

All meetings are held at the Institution of Electrical Engineers, Savoy Place, London, W.C.2.

Date: February 15. Time: 6.30 p.m.
Lecture:
"The Amateur Bands: Past, Present and Future."
By:
Arthur O. Milne.

The General Secretary, R.S.G.B., New Ruskin House, Little Russell Street, London, W.C.1.

British Kinematograph Society

Meetings held at the Gaumont British Theatre, Film House, Wardour Street, London, W.1.

Date: February 13. Time: 6 p.m.
Lecture:
"Current Processes of Colour Kinematography."
By:
J. Coote, F.R.P.S.

Secretary:
R. H. Cricks, Dean House, Dean Street, W.1.

Brit.I.R.E.

North-Eastern Section

Date: February 13. Time: 6 p.m.
Held at:
The Mining Institute, Neville Hall, Westgate Road, Newcastle.
Lecture:
"Reproduction from Sound on Film."
By:
G. Dobson.

Section Secretary:
H. Armstrong, 69 Osborne Road, Jesmond, Newcastle-on-Tyne.

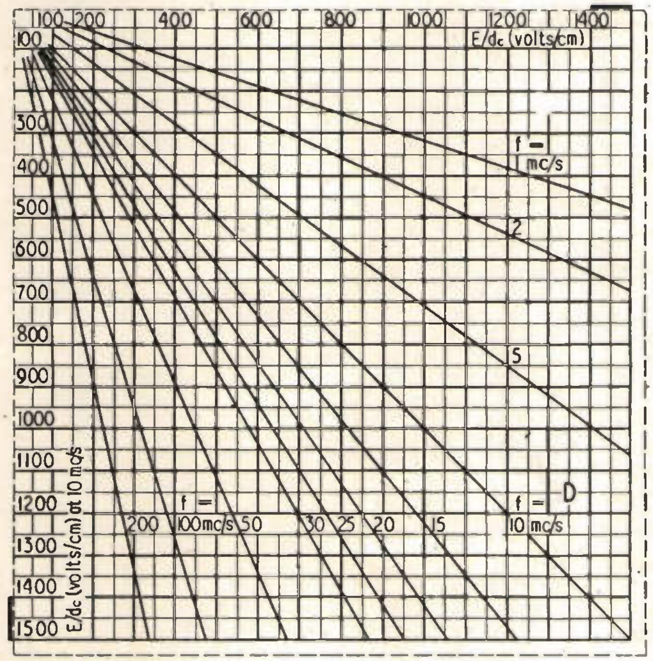
Royal Photographic Society of Great Britain

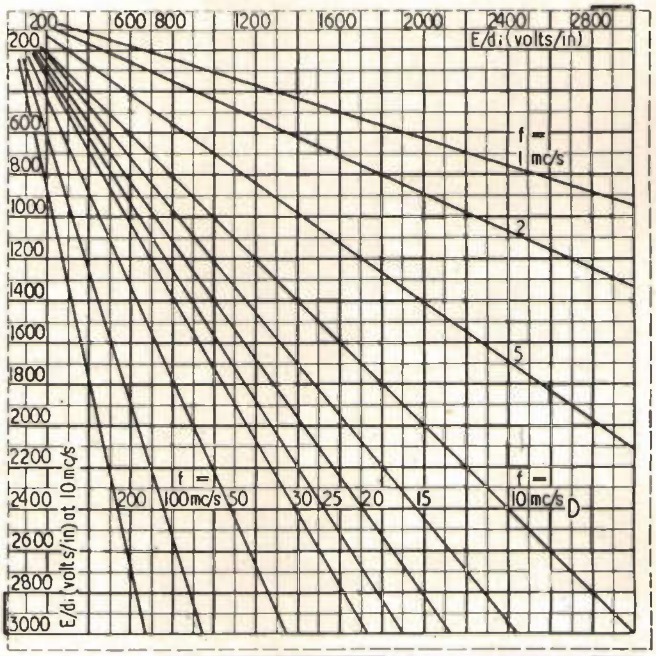
Date: February 15. Time: 6 p.m.
Held at:
16 Princes Gate, London, S.W.7.
Lecture:
"Colour Television."
By:
L. C. Jesty.

The Secretary:
Scientific and Technical Group, Research Laboratories, Kodak, Ltd., Harrow, Middlesex.

DIELECTRIC HEATING DESIGN CHART: A CORRECTION

On pages 638 and 639 of the August, 1945, issue appear two Design Charts for Dielectric Heating. It is regretted that an error occurs in the lower right-hand quadrants of each chart, and the corrected curves are reproduced below. Readers are asked to cut out these corrected curves at the dotted lines shown, and superimpose them on the existing curves. Good gum should be used to avoid paper shrinkage.





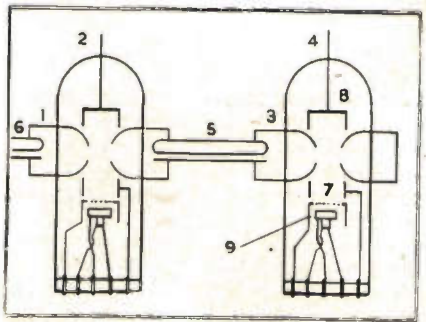
Frequency Stabilisation of Resonators
Influenced by Electron Discharge

Communication from E.M.I. Laboratories

IN the generation and amplification of electrical oscillations of ultra-high-frequency it is common to-day to employ resonator devices through which there is arranged to pass an electron beam. The function of the resonator may be, in ways now well known, to modulate the velocity of the beam or to extract energy from a beam which has already been appropriately modulated, for example, by being modulated in velocity and then being allowed to traverse a drift space. In some instances it is desired to vary the average beam current, and when this is so an effect arises that is often inconvenient. The effect is that with the change in mean beam current passing through the resonator the natural frequency of oscillation of the resonator also suffers a change. Thus, if the resonator constitutes the frequency determining circuit of an oscillation generator, the frequency of the generated oscillations is apt to undergo variation as it is attempted to modulate them in amplitude by modulating the mean current of the beam. Or if the resonator is used in an amplifying arrangement and the gain of the amplifier is adjusted by adjusting the beam current, the amplifier may become detuned.

There are several methods, all applications of a common principle, by which difficulties of this kind may be surmounted. The general principle is to utilise a second electron discharge which also influences the resonator and to vary the intensity of the second discharge simultaneously with variation of the first so that the effect of modifying the second opposes the effect of modifying the first. A second electron beam may thus be employed having the essential function of neutralising the undesired changes occurring in association with the first. In general, it may be said, it should have only this function, since if it were employed also for generating oscillations, for example, this secondary function might have a disturbing effect upon the operation of the first beam.

The figure shows one application. The tube 2 is a klystron tube of reflexion type for generating ultra-



high-frequency oscillations. The resonator 1 both modulates the velocity of the beam that passes through it and also, after the beam is returned back toward the cathode by a reflector electrode, extracts energy from it and so is maintained in a state of sustained oscillation. The line 6 coupling with the resonator 1 affords an output. The tube 4 is a tube similar to tube 2 but is not arranged to generate oscillations. Its resonator 3 is coupled with the resonator 1 of tube 2 by the coupling line 5, and depending upon the length of this line the beam current of tube 4 is controlled in intensity relative to the control of beam intensity in tube 2, so that the frequency of oscillations set up in the resonator of tube 2 remains constant, or nearly so, as their amplitude is modulated by modulating the beam current in tube 2 by the control grid provided for that purpose. The tube 4 is prevented from itself generating oscillations by applying an appropriate potential to its electrode 8 relative to the potential of its cathode 9. The potential on electrode 8 may be positive with respect to cathode 9, but it may also be negative provided oscillations are not set up in resonator 3, since such oscillations would affect the output from resonator 1. If the line 5 is correctly chosen in length the beam currents of the two tubes may be modulated in antiphase.

It will be clear that instead of employing two tubes and two resonators, but one tube may be employed with a single resonator, this resonator, however, being arranged to have pass through it two electron beams. Instead also of utilising an auxiliary electron beam a controllable gaseous discharge may be used.

Motor at High Temperature in High Vacuum

During the war Westinghouse motor engineers were asked to build special direct-current armatures that could operate continuously in a temperature of 600° F., and in high vacuum of a few microns pressure. Furthermore, the armatures must give off no gases to contaminate the vacuum system. To add to the rigours of the problem, the armatures had to turn at 1,200 r.p.m. without noticeable vibration and without the addition of any balance weights.

The armatures were wound with glass- and silicone-insulated wire, the coils being wound on both sides of the shaft to maintain weight symmetry. After winding, the armatures were placed in an oven at about 500° F. to burn out any organic material and to drive out all other volatile matter. The entire armature was then subjected for hours to a filling of sodium silicate and mica dust under alternate vacuum and pressure. This was followed by another bake and removal of surplus impregnant.

—*Westinghouse News Service Pittsburg.*

New R.C.A. Beam Power Valve

RCA-2E24 is the designation of a new, quick-heating, transmitting, beam power amplifier designed for mobile and emergency-communications equipment.

Requiring relatively low plate voltage, the 2E24 has a maximum plate input of 30 watts (CCS) or 40 watts (ICAS) in class C telegraph service. In such service, it can deliver 20 watts (CCS) at a plate voltage as low as 400 volts, or 27 watts (ICAS) at 600 volts, with a driving power at the tube of only 0.2 watt.

The 2E24 can be operated at maximum ratings to 125 megacycles and at reduced plate voltage and input to 175 megacycles.

The filament is of the coated type and requires only 0.65 ampere at 6.3 volts.

BOOK REVIEWS

Television To-day and To-morrow

Lee de Forest. (Hutchinson's Scientific and Technical Publications, 1945, 16s. net.) 176 pp., 76 figs.

One is often asked at the present time to recommend a book on Television. The book under review, as its name implies, is not a text book, but contains sufficient technical information for a radio man or an intelligent amateur to follow. To the many men and women now leaving the Services with a good grounding in the principles of radio and Radar the book should prove extremely helpful by giving them a correct perspective of the way the things they have learnt fit together into the layout of Television as a whole.

One must remember that Lee de Forest is an American and a very important worker in the radio industry whose opinions are very worthy of consideration. While some of the views he expresses are particularly applicable to Television in the United States, in general his outlook is international. On the technical side the book contains a very fair treatment of the stages of development in which the important steps in both Europe and America are placed in chronological order.

Intermingled with the technical matter of the book in an unorthodox but interesting manner are many notes on the financial, artistic, and other viewpoints on the new Television industry. The chapter on "Suppose Television is your Job" brings to one's notice the fact that the electronic engineers will eventually become a minority in an organised television service. This is a point not generally realised while we are in the development stages of the art, but is obvious when we consider the demands of the programme side of a public service. In fact, the author prophesies that the new industry has the capacity to employ in America more people than any others which have flourished since the railroads were built.

The whole book is infused with a tremendous rising tempo of enthusiasm which it would do well for those in authority in this country to read if they could be persuaded to spare the time.

The Editor points out that the American text of the book has been Anglicised as much as has seemed necessary to ensure understanding by the English readers.

The only criticisms one can raise here are that the inclusion of photographs of the equipment described would have enhanced the set up of the book, and secondly, the price is high for the class of reader for which it is intended, bearing in mind that this is not a text book.

T. M. C. LANCE.

"Electrical Engineer" Reference Book

Edited by E. Molloy, assisted by M. G. Say, R. C. Walker, and G. Windred. (Geo. Newnes, Ltd., 42s. net.)

This book is one of the most comprehensive summaries of electrical engineering yet published in this country. It also has the qualification of being thoroughly up to date, each section having been specially written by one or more engineers closely connected with the particular subjects dealt with. In view of prevailing conditions and the fact that the book contains nearly 1,600 pages of actual descriptive matter the price may be considered very reasonable. There are 32 sections, covering the whole of electrical engineering, with the exception of radio and communications generally, but the subject of electronics is well represented both in a special section and incidentally in various places throughout the text.

The first section, on Theory and Calculations, is a prominent feature of the book. It occupies 102 pages, and forms in itself a useful compendium of those basic facts on which the practising engineer so often needs to refresh his memory and almost equally often fails to find in his books of reference. The treatment here is clear, brief and accurate; in fact, a model of exposition for reference purposes.

Subsequent sections deal with the various branches of power supply, distribution and utilisation, omitting very little and giving on the whole quite adequate treatment to the multitude of subjects. Although a certain amount of overlapping is hardly to be avoided in a work of this kind, the reader may notice this defect rather frequently. Thus the principles of the cathode-ray tube are dealt with in two different sections and types of construction described in at least two other places. Valve voltmeter circuits are given in two different places and the different types of photocells are also described twice, as also are electron lenses; once in connexion with electron optics and again in describing the electron microscope — two subjects which should, of course, have been treated together.

In view of the fact that communications and television are excluded from the book it is rather disconcerting to find descriptions of five types of electron cameras in the section on Electronics. The omission of any treatment of amplifiers or oscillators, apart from a mention of the magnetron, in this section is a serious lapse which calls for attention in future editions.

A feature of the book which will be useful to many engineers is the section on Electrical Literature, representing a bibliography subdivided according to the various sections and giving under each heading a list of books, articles and British Standard Specifications. There is also a section on Progress containing illustrations and descriptions of modern industrial apparatus. Other non-technical sections are on Education for the Electrical Industry and Electricity Rules and Regulations, including the principal points of Home Office and Supply Regulations and Points of Law.

The professional electrical engineer will find this book an indispensable source of reference and information, and it should certainly be available in all works libraries.

CORRESPONDENCE

Phys. Soc. Exhibition

DEAR SIR,—I hope your columns are available to protest at the quite inadequate arrangements made to meet the wide interest aroused by the recent exhibition of the Physical Society. This exhibition is of very great interest to all who are concerned with scientific or engineering matters, but it extends even beyond that because it could have considerable commercial value.

The latter part of this statement may cause some of the exhibition's more academic promoters to raise their eyebrows in horror, but I feel convinced that some reflexion would satisfy them that it is to the considerable advantage of the more abstract aspects of physics that it should be based upon solid commercial foundations.

The exhibition held at South Kensington at the beginning of January was laid out in an extraordinarily unsatisfactory manner; it was widely scattered about a large building although the amount of space was inadequate even had the attendance been a tenth of what it was. In such circumstances it was impossible for any individual to see and absorb more than a small fraction of the intensely interesting exhibits collected there.

Surely the promoters of this exhibition could find means for improvement. It might be that keeping the exhibition open for considerably longer would be sufficient, but it might be desirable to consider charging for admission on one or more days. This would make provision for the less crowded attendance of trade visitors and those having some real and direct interest in the exhibits and, at the same time, it might provide sufficient funds to permit the exhibition to be housed in premises more suitable for its purpose.—Yours faithfully,

J. R. HUGHES.

Phase Splitter

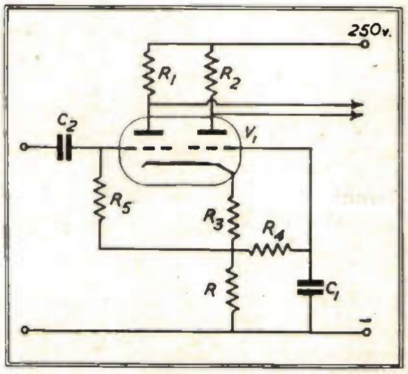
DEAR SIR,—Your reference chart* "Methods of Driving Push-Pull Amplifiers" was of particular interest to me because of the circuit depicted in Fig. 4 of a form of the differential phase splitter. This form of splitter has been used in a simple amplifier which I designed early last year (*R.S.G.B. Bulletin*, March, 1945), and I would point out the greater convenience of using a double-triode for phase splitting, rather than trying to do it in the output stage itself.

An additional A.F. stage is required in any case to drive the output valves fully; consequently the cost of the double-triode and its associated components is outweighed by the saving in the lower H.T. required, and in the simpler smoothing required, since the double-triode is working effectively in push-pull, and needs no decoupling.

The resulting balance of this circuit is very good, and frequency distortion is very low, due to a form of current feed-back inherent in the action of the circuit.

A valuable and interesting property of this circuit is that of being able to reject in-phase signals on the principle used in biological amplifiers (due to Offner).

As will be seen, this property ensures that phase inversion is complete, and the two driven valves are presented with a push-pull signal automatically balanced.



Component Values

V1	...	6N7G, 6C8G, ECC31, etc.		C1 ...	0.01mF
R1, 2	...	68K	1 W	C2 ...	0.1mF
R3	...	1K	¼ W		
R4, 5	...	0.75m	¼ W		
"R"	...	10K	½ W		

A simple circuit of a driving stage is shown; it may be noted that the value of "R" is not critical.

As will be seen, this circuit is very simple, and easy to apply to all types of amplifiers, and gives a gain equal to a normal medium mu triode.—Yours faithfully,

L. A. SAUNDERS.

* December, 1945 issue, p. 816.

ABSTRACTS OF ELECTRONIC LITERATURE

CIRCUITS

Cathode-Coupled Wide-Band Amplifiers

(G. C. Sziklai and A. C. Schroeder)

A general analysis indicates that, in wide-band amplifiers, stable operation is possible with triodes in circuits using the cathode as a signal terminal. The amplification, however, is approximately equal only to the square root of that available with grounded-cathode amplifier, and therefore twice as many tube units are required to obtain the same amplification. In certain applications, however, the utility of such circuits outweighs the loss of gain.

A simple radio-frequency amplifier was designed for television receivers, using a cathode-input circuit. By combining a cathode-output and a cathode-input stage using one single twin-triode tube, a circuit was devised which compares favourably with pentode stages with respect to gain, stability and economy, while it has far superior noise characteristics. The new circuit, called the "cathode-coupled twin-triode" amplifier, provides greater flexibility than conventional amplifier circuits, and can be used for radio-frequency, intermediate-frequency, video, converter, or detector services. Since the same tube type can also be used for synchronising and deflection circuits, the number of tube types can be materially reduced, and greater standardisation with further economical advantages may be obtained. An interesting application of the new circuit is a novel bidirectional amplifier.

—*Proc. I.R.E.*, October, 1945.

Band-Pass Bridged-T Network for Television Intermediate-Frequency Amplifiers

(G. C. Sziklai and A. C. Schroeder)

Bridged-T networks offer great economy in television intermediate-frequency amplifiers for sharp attenuation of the associated and adjacent sound channels. A simple design method was obtained by the use of the equivalent lattice. By the same method, general formulæ were obtained for the phase, attenuation and delay characteristics. Two designs are given to illustrate the convenience of the method.

—*Proc. I.R.E.*, October, 1945.

MEASUREMENT

A Method of Measuring the Radio-Frequency Resistance of Wires

(C. Stewart)

A new and relatively simple method of measuring the resistance of wires at frequencies between 200 kc/s. and 40 Mc/s. is described. By this method, the test specimen is strung down the centre of a metal pipe about ten to a hundred feet in length, depending upon the test frequency, to form a transmission line. One end of the line is short-circuited and the other connected to a standard commercial Q-meter. Readings are taken from the Q-meter and applied to curves to obtain the desired resistance. This method of measurement appears to be more reliable than the use of coils, and the results agree closely with calculation by skin-effect formulæ.

—*Jour. App. Phys.*, Oct., 1945, p. 608.*

The Photoconductivity of Zinc-Cadmium Sulphide as measured with the Cathode-Ray Oscillograph

(A. E. Hardy)

A new method for the measurement of photoconductivity, involving the cathode-ray oscillograph as a recording instrument, is described. Several interesting aspects of photoconductivity of phosphors, including the quenching effect of red light, are discussed. New evidence in support of the "trapping centre" or metastable-state theory in regard to phosphorescence is presented.

—*Trans. Electrochemical Soc.*, vol. 87 (1945).*

TELEVISION

Problems of Theatre Television Projection Equipment

(A. H. Rosenthal)

Some of the more important problems of theatre television projection technique and equipment are discussed. The importance of the two principles of optical storage and light modulation for overcoming certain limitations is stressed, and some scophony developments are described in which these principles are utilised.

—*Jour. Soc. Mot. Pic. Eng.*, Sept. 1945, p. 218.

Capacitors for High-Frequency Induction Heating Circuits

(F. M. Clark and M. E. Scoville)

This paper describes the development of a new type of dielectric liquid called Lectronol. Capacitors containing this liquid are particularly well adapted for use in the tank circuit of electronic heaters used in induction heating. The capacitor is noteworthy because of the absence of cellulose sheet insulation, satisfactory operation being entirely dependent on the superior insulating properties of the Lectronol. Capacitors containing this liquid are characterised by low dielectric loss and high dielectric strength over the frequency range utilised in power oscillators. The capacity per unit volume is approximately twice that obtained with mineral oil. The electrical characteristics of the capacitor are stable under severe conditions of use.

—*Trans. A.I.E.E.*, November, 1945, p. 791.*

The Role of Frequency in Industrial Dielectric Heating

(G. W. Scott)

An analysis of the effects of frequency in industrial dielectric heating is given and the expression for the rate of heating is examined in an attempt to determine the practical upper limit of frequency for large-scale industrial heating installations. Graphs are given showing the variation of loss factor with frequency, the maximum tolerable electrode length as a function of frequency and the variation of tuning inductances with frequency for loads of specified capacitance. The advantages of employing high frequencies are pointed out and reference is made to the efficiency of various heating installations.

—*Trans. A.I.E.E.*, Aug., 1945, p. 558.*

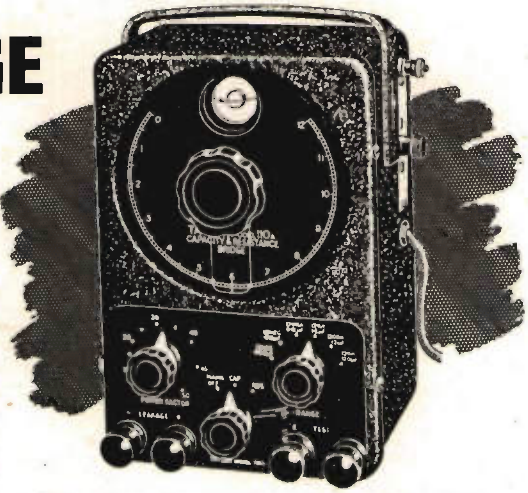
Electronics Applied to Instrumentation

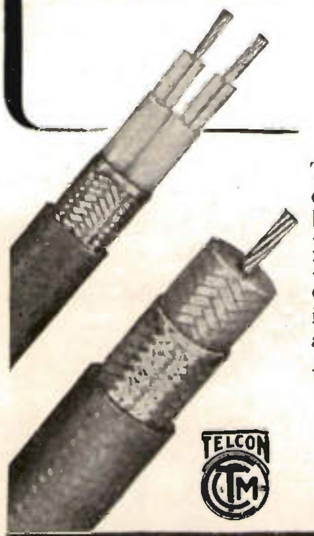
(H. D. Middel)

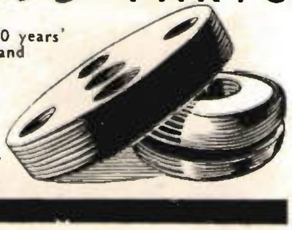
This article deals with the contribution of electronics to industrial measurements and control. Recent applications dealt with include measurement of hydrogen-ion concentration, recording spectrophotometers, torque amplifiers, gas analysis and pressure, flow and temperature measurement. Various methods of measurement are described with the aid of circuit diagrams, and their applications outlined.

—*Instruments*, March, 1945, p. 144.*

* Abstracts supplied by the courtesy of Metropolitan Vickers Electrical Co. Ltd., Trafford Park, Manchester







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Vacancies advertised in these columns do not relate to men between the ages of 18 and 50 inclusive, or women between the ages of 18 and 40 inclusive, unless they are exempted from the provisions of the Control of Engagements Order, 1945, or the vacancies are for employment excepted from the provisions of that order.

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IN STOCK. Rectifiers, Accumulator Chargers, Rotary Converters, P.A. Amplifiers, Mikes, Mains Transformers, Speakers of most types, Test Meters, etc., Special Transformers quoted for.—University Radio, Ltd., 22, Lisle Street, London, W.C.2. GER. 4447.

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LOUDSPEAKERS—We carry on. Sinclair Speakers, 12, Pembroke Street, N.1.

LOUDSPEAKER repairs, British, American, any make, moderate prices.—Sinclair Speakers, 12, Pembroke Street, N.1.

MISCELLANEOUS

WE WILL BUY at your price used radios, amplifiers, converters, test meters, motors, pick-ups, speakers, etc., radio and electrical accessories. Write, phone or call, University Radio, Ltd., 22, Lisle Street, London, W.C.2. GER. 4447.

WEBB'S Radio Map of the World enables you to locate any station heard. Size 40 in. by 30 in. 2-colour heavy Art Paper, 4/6, post 6d. Limited supply on Linen, 10/6, post 6d.—Webb's Radio, 14, Soho Street, London, W.1. 'Phone: GERrard 2089.

MORSE Practice Equipment for Class-room or Individual Tuition. Keys, Audio Oscillators for both battery or main operation. Webb's Radio, 14, Soho Street, London, W.1. 'Phone: GERrard 2089.

MECHANICAL ENGINEERS to the Electronic Industry. Precision and Optical Instruments of all types designed and constructed in collaboration with Electronic Engineers. Tecnaphot Ltd., Mile Lane, Coventry.

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AMATEUR RADIO PRODUCTS, 50 Glasslyn Road, Crouch End, N.8. Designers and Manufacturers of short-wave radio components and equipment, both for transmitters and receivers. Enquiries invited. Phone: MOUntview 4745.

"COALS TO NEWCASTLE."—Our Service on components is now so well known that we are even receiving orders from America.
Our regular customers include many industrial organisations of world-wide repute, who find that for the development of urgently required prototypes, they can get better service and quicker delivery from us—often on components unobtainable elsewhere.
Our suppliers include famous names such as Avo, Pullin and Weston instruments and test equipment; Bulgin, Belling & Lee and Clix components; Buller's ceramics; B. & I., Dubilier, T.C.C. and T.M.C. condensers; Cyldon transmitting condensers; Dubilier and Erie resistors; Dubilier and Morganite carbon potentiometers; Colvern wire-wound potentiometers; Cossor, G.E.C. and Mullard cathode-ray tubes; Cossor and Mullard oscilloscopes; Denco Maxi-Q coils and polystyrene products; G.E.C. photo-cells and amplifiers; Muirhead precision drives and dials; Partridge transformers and chokes; Q.C.C. crystals; S.T.C. transmitting valves; S.T.C. and Westinghouse rectifiers; Welwyn precision resistors, etc., etc., etc. Send 2½d. stamp for List. TELE-RADIO (1943), LTD., 177, Edgware Road, London, W.2. Telephone: PADdington 6116.

VALVES! 6K8G, 6B8G, 6Q7G, 6V6G, 6F6G, 6K7G, 6X5G, 6A7, 5Y3G, 6AC7, 25Y5, 80, 77, 78, 807, 813, EA50, 866A, PEN36C, X42, UU4, AC/P2, PENA4, PM1LF, 1A5GT, 12Q5GT, L2, or equivalents, at list prices.—M.O.S., BCM Electronic, London, W.C.1.

1946 AMPLIFIERS.—De Witt 20-watt high-fidelity model, complete with all valves, ready to use, £7 19s. 6d. Comprises high-mu input stage, twin 6L6 output tetrodes, heavy-duty speaker transformer for 2.5 and 15 ohms, massive A.C. power pack, grey enamelled chassis with volume control, input and output sockets. Carriage extra.—Sole distributors, Kossuth Radio Co., 410, Dudley Road, Edgbaston, Birmingham.

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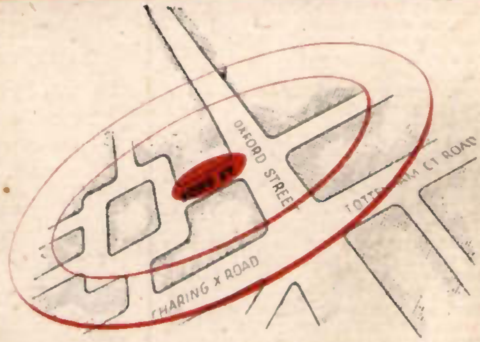

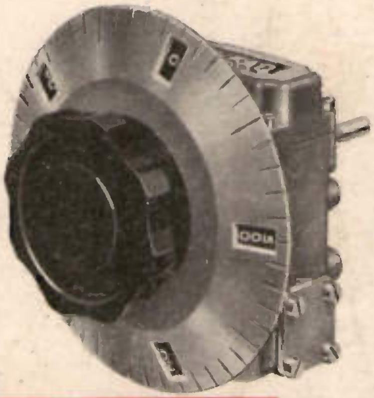

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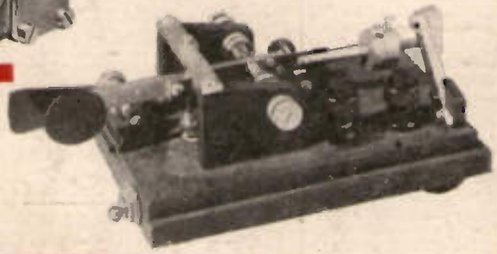

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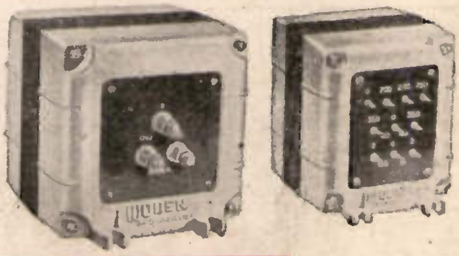

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