Wireless World

RADIO AND ELECTRONICS

JUNE 1949

2/-

Vol. LV. No. 6

IN THIS ISSUE: CONTRAST EXPANSION METHODS REVIEWED

AVO REGD TRADE MARK

Precision
ELECTRICAL TESTING INSTRUMENTS

The Model 7 Universal AVOMETER

The world's most widely used combination electrical measuring instrument. It provides 50 ranges of readings on a 5-inch hand-calibrated scale fitted with an anti-parallax mirror, and is guaranteed accurate to B.S. first grade limits on D.C. and A.C. from 25c/s to 2Kc/s.

The meter will differentiate between A.C. and D.C. supply, the switching being electrically interlocked. The total resistance of the meter is 500,000 ohms.

CURRENT: A.C. and D.C. 0 to 10 amps.
VOLTAGE: A.C. and D.C. 0 to 1,000 volts.
RESISTANCE: Up to 40 megohms.
AUDIO-FREQUENCY POWER OUTPUT: 0—4 watts.
DECIBELS: —25Db. to +16Db.

BRITISH MADE

The instrument is self-contained, compact and portable, simple to operate and almost impossible to damage electrically. It is protected by an automatic cut-out against damage through severe overload.

PRICE
£19 : 10s.

Size: 8" x 7¼" x 4½".
Weight: 6¾ lbs. (including leads).

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Fully descriptive pamphlet available on application.

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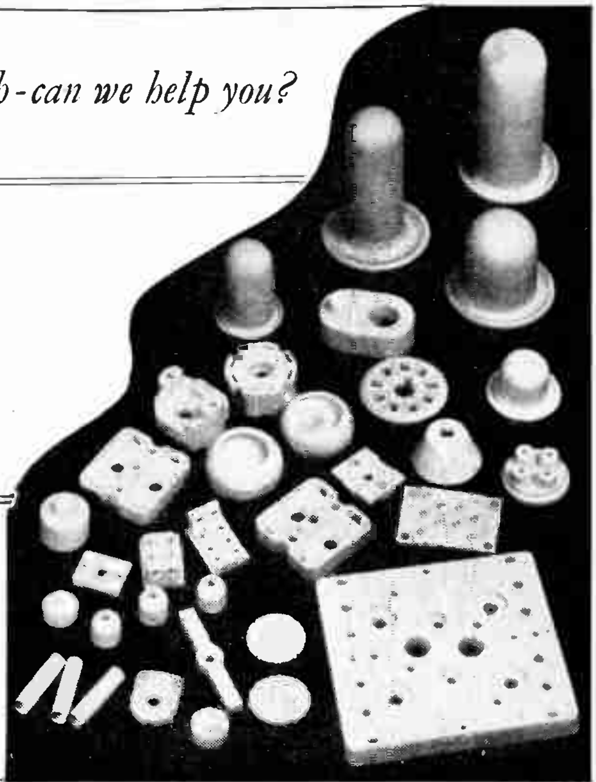

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TAYLOR TUNNICLIFF (REFRACTORIES) LTD.,
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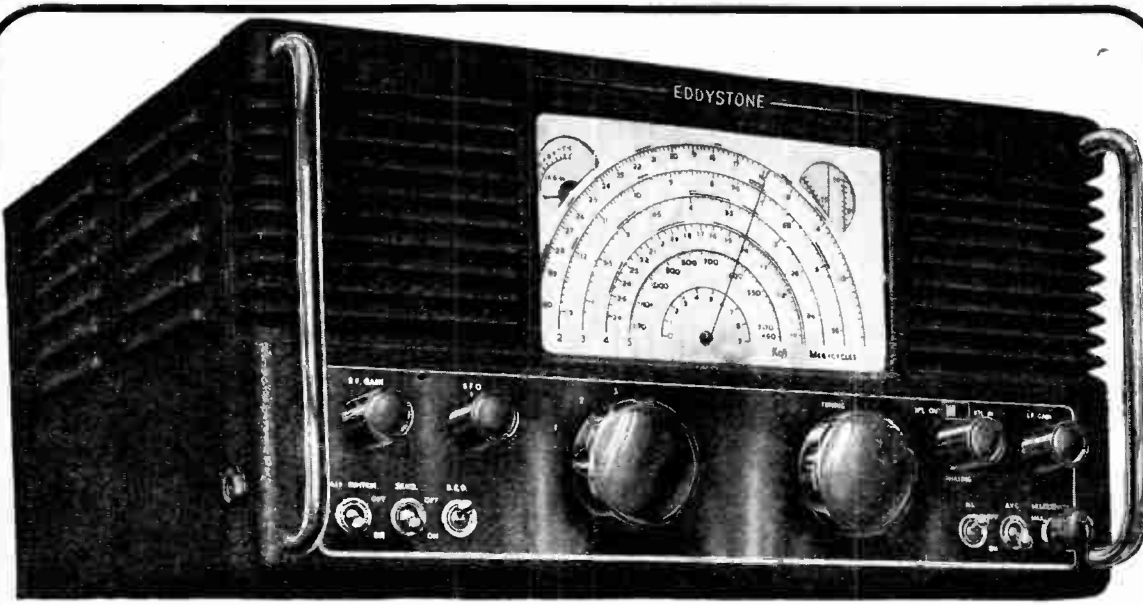

The NEW EDDYSTONE '680' COMMUNICATIONS RECEIVER

A high-grade instrument with wide frequency coverage for PROFESSIONAL COMMUNICATION REQUIREMENTS

The '680' is a fifteen valve superheterodyne receiver embodying advanced technique. New features in the design add to the outstanding and reliable performance of which the receiver is capable. The appearance is impressive, whilst the construction and general workmanship are of the finest in the industry.

SPECIAL FEATURES INCLUDE:

- **Continuous coverage from 30 Mc/s to 480 Kc/s.**
- **Two Radio-Frequency stages.**
- **Two I.F. stages.**
- **Crystal Filter.**
- **Beat Frequency Oscillator.**
- **Push-pull output stage.**
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- **"S" Meter.**
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- **Stabilised H.T. voltage to Oscillator, etc.**
- **Provision for relay operation of transmitter.**
- **High signal-to-noise ratio and sensitivity.**
- **Highly attenuated Image response.**
- **Very effective A.V.C.**
- **Large accurately calibrated dial.**
- **Provision for twin feeder and single aerial.**
- **Variable dial illumination.**
- **Modern miniature all-glass valves.**
- **Flywheel loaded tuning device - 140 to 1 reduction ratio.**
- **Mechanical bandspread logging device.**
- **All controls separate and conveniently arranged.**
- **Robust construction.**
- **Finished for tropical service.**

The complete frequency range—from 30 Mc/s to 480 Kc/s—is covered by five switched coil assemblies with an overlap between each. The gear-driven, flywheel controlled mechanism is positive, free from backlash and very smooth in action. The mechanical bandspread device takes the form of an auxiliary dial and gives a scale length equal to nineteen inches per range. The dial can be read to one degree. I.F. transformers are permeability tuned to 450 Kc/s. Operates from A.C. mains, 110 and 200/240 volts, 40/60 cycles. The front panel and tuner unit chassis are aluminium, and the remaining units of stout brass, heavily nickel-plated. Lift-up lid. The cabinet and front panel are finished a handsome ripple black, set off by plated handles. The finger plate is black and silver.

Dimensions:—16¾" × 13¾" × 8¾" high.

LIST PRICE IN U.K. £85 (No Purchase Tax)

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LEAK "POINT ONE" AMPLIFIER.

The amplifier that cannot be technically faulted either on its measured performance or engineering workmanship. Aural judgment amply confirms the maker's claims. Price £25 15 0

(Separate LEAK remote control pre-amplifier. Price £6 15 0)

ACOUSTICAL "QA/12/P" AMPLIFIER.

Unexcelled for high-quality combined with extreme compactness. Including built-in pre-amplifier giving bass and treble control, the size is 10½in. x 8½in. x 7in. Price £30 0 0

Hear these (and other good amplifiers, such as Charles, Webb's "MC/QA," Sound Sales, etc.) working with speciality equipment.

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Mordaunt "Duplex"	98 Guineas
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Barker "148A" Chassis	£15 15 0
Sound Sales "Phase Inverter"	£12 10 0
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Also—Rola G12—Wharfedale W12CS—Goodmans Axiom—B.T.H. R.K., etc.

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Wilkins & Wright "N" Moving Coil ..	£7 10 7
Brierley "Ribbon"	£10 14 9
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This is only a selection from probably the largest and most varied stock of "High Fidelity" apparatus in the Country.

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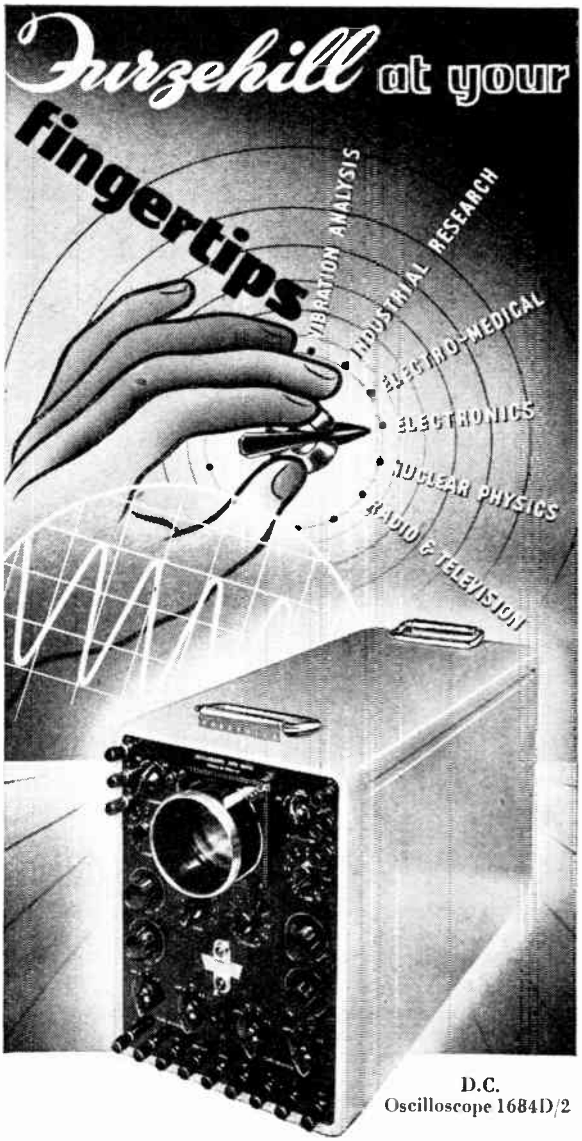

D.C. Oscilloscope 1684D/2

AN EXAMPLE from the Furzehill range of fine instruments is this high-grade oscilloscope for industrial, radio and television applications. Both axes have identical d.c. coupled high sensitivity amplifiers with symmetrical inputs and a level frequency characteristic from zero to 3 M/cs. Particularly valuable features are the instantaneous action of the shift controls, expansion of the time base scan from ½ to 5 screen diameters, negligible phase shift in the amplifiers and automatic amplitude-limited synchronisation.

For full details of this, and other instruments in the Furzehill range, write for our new illustrated catalogue.

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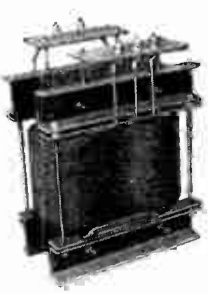
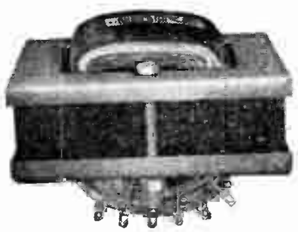
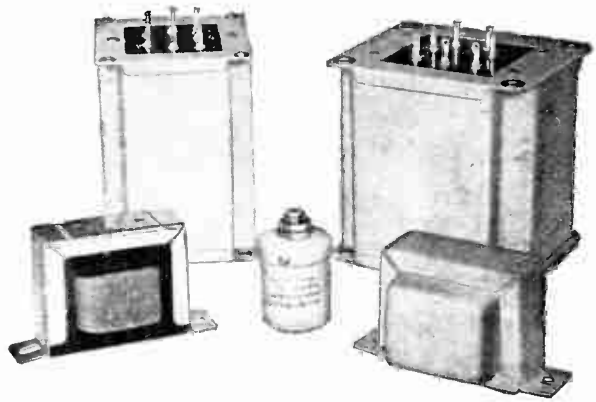


Industrial Transformers, one, two or three phase either open or protected, oil or air cooled, are made for many purposes including Power Distribution, Electric Furnaces, Radio Transmitters, R.F. Heating Equipment, Electronic Apparatus, etc. All types are made up to 100 KVA.



Type R.M.S. 31

Type R.M.S. 31 Drop Through Transformers, as shown above, are particularly suitable for Set Manufacturers and for service replacements.



For manufacturers a very comprehensive range of open, shrouded potted and hermetically sealed components are available in both mains and audio types.

The De Luxe Transformer as shown on the left is ideal for the Amateur Transmitter and Manufacturer of communication receivers. This type of transformer is of attractive appearance and first class design.

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G.P. 15 Microcell cartridge for microgroove or standard 78 rpm recordings.
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For acoustic measurements, industrial noise measurement, disc recording technique, and P.A. systems.
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High fidelity model with flat response from 30 to 10,000 c/s.
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The MAGNETIC TYPES G.P. 6 and G.P. 7
Good performance with exceptionally robust construction. Range 100 — 4,500 c/s.
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High-quality cutting head for professional use.
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For hospital or personal use, giving quality equivalent to normal loudspeaker without disturbing others.
Sole distributors of the 'Pillotone' in the British Isles, Messrs. Philips Electrical Limited.
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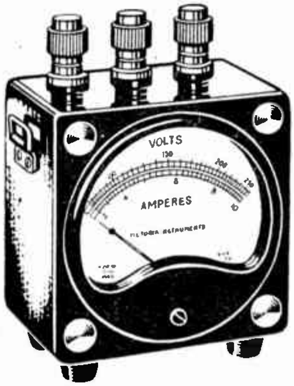
PORTABLE TEST SETS

Robust moving iron instruments. Suitable for the Electrical Contractor or Automobile Electrical Engineer.

Size: 3¾″ x 3¾″ x 2½″ overall complete with carrying strap.



These combined instruments are made in many standard ranges. Combination exa ples:

260V A.C. or D.C.
15A A.C. or D.C.
25V A.C. or D.C.
25A A.C. or D.C.

Other Combinations to order

SQUARE FLANGE METERS

4″ Large Open Scale. Mirror Scale can be supplied if required.

RANGES:
A.C. from 1V-10kV
25uA-100 Amps.
D.C. From 5mV-10kV
5uA-5000 Amps.

Victoria Instruments are made uncommonly well

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The ***Connoisseur***

- Low distortion and noise level.
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- Attractive case to fit in with home furnishing schemes.
- Ease of installation.

We proudly present our Q5 Amplifier which reaches a still higher standard of high quality record and radio reproduction.

Designed primarily for use with the 'Connoisseur' pick-up, it will give superb reproduction when used with any pick-up or radio unit capable of delivering O. 1 V.

Before despatch each amplifier is carefully tested in our laboratory, balanced for minimum distortion and supplied with all necessary cables, plugs, installation and service instructions.

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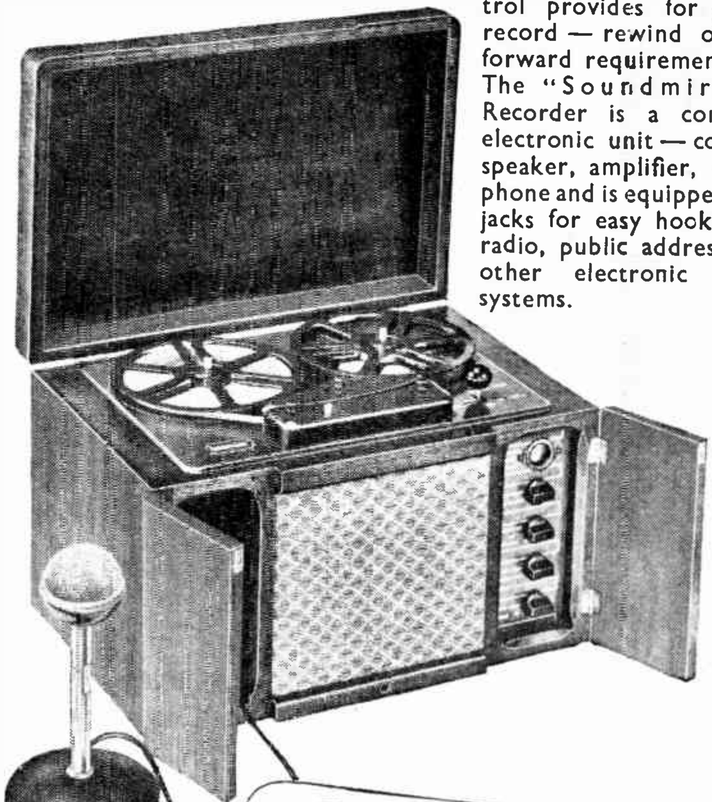
The Soundmirror "Magic Ribbon" offers all these Advantages

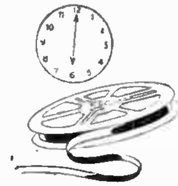
Using reels of magnetised paper—or "Magic Ribbon"—the "Soundmirror" will record and reproduce with perfect fidelity THE SPOKEN WORD; MUSIC, from a violin concerto to a full orchestra; SOUND EFFECTS of all kinds. It gives life-like tonal quality (without scratch or extraneous noises) of any desired volume equal to the best radio receivers.

Perfectly designed for simplicity of operation—you can't go wrong—one single finger tip control provides for play—record — rewind or fast forward requirements.

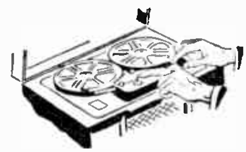
The "Soundmirror" Recorder is a complete electronic unit — contains speaker, amplifier, microphone and is equipped with jacks for easy hook-up to radio, public address and other electronic audio systems.



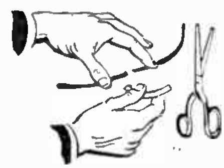
THE
Soundmirror
MAGNETIC TAPE RECORDER



"Soundmirror" gives a full unbroken half-hour's recording on every reel of "Magic Ribbon."



"Soundmirror" "Magic Ribbon" can be erased and used an indefinite number of times. Erasure is accomplished automatically whenever a new recording is made.



"Soundmirror" "Magic Ribbon" can be cut and spliced — short recordings joined together — unwanted parts removed. The unwanted portions can be erased and used again.

"Soundmirror" "Magic Ribbon" is easy to handle — it does not become coiled or tangled. Easy to handle—easy to thread—easy to store.

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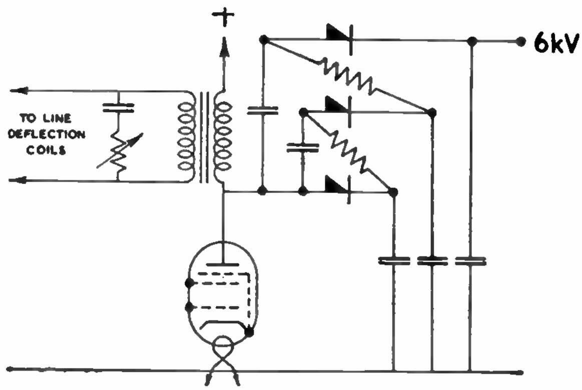

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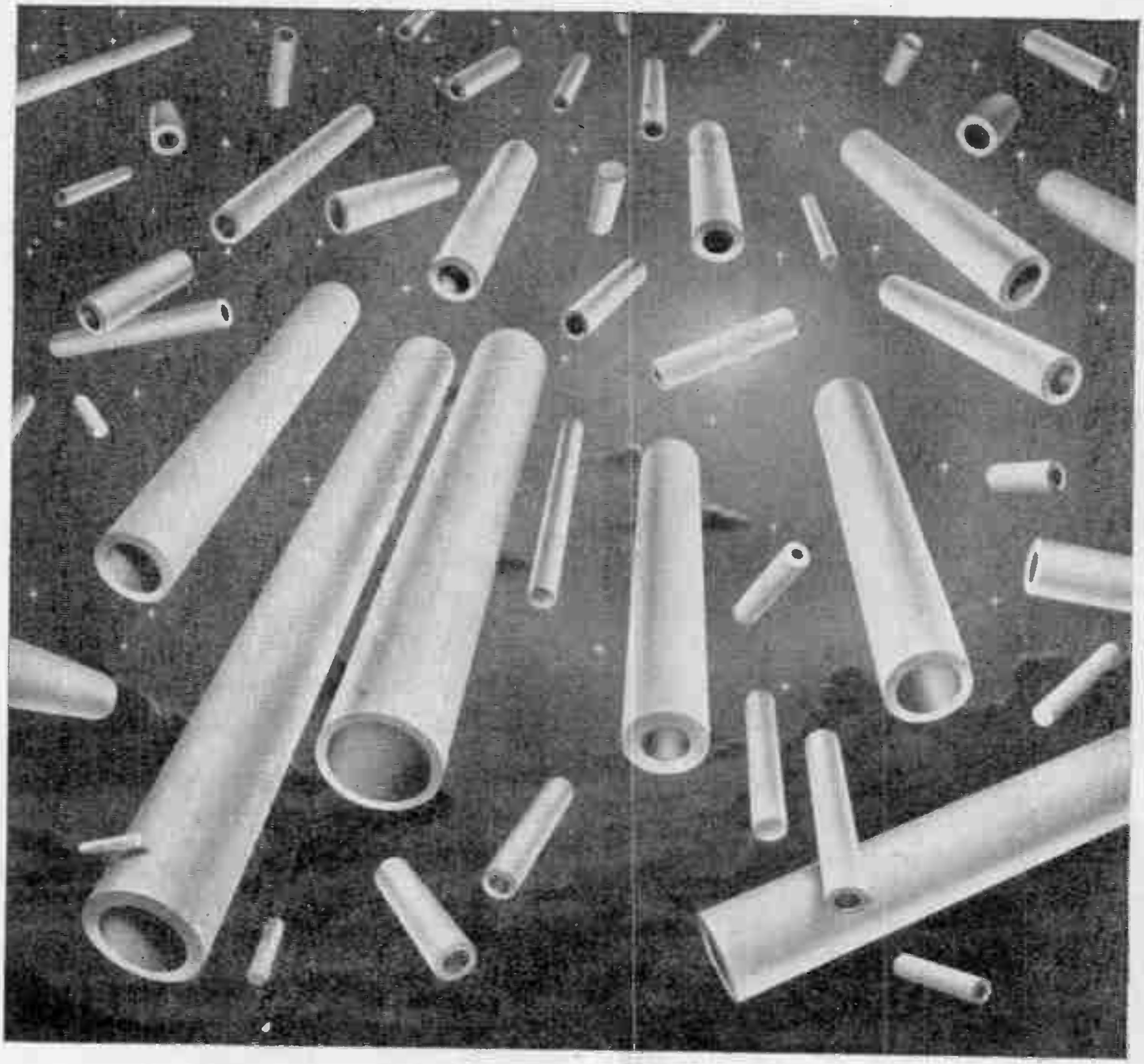

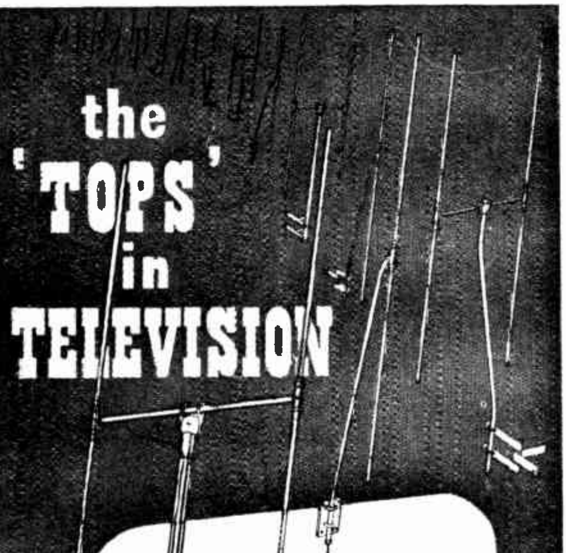

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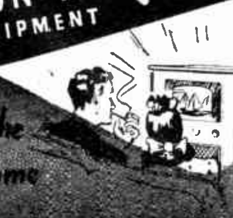

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has no gadgets and switches

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This model will shortly be available with High Fidelity Pick-up for 9/- extra.

RETAILS AT
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with crystal or magnetic pick-up.
OTHER MODELS FROM 8 GUINEAS Plus Tax.

Made and Guaranteed by

Richard Allan RADIO LTD.

CALEDONIA ROAD, BATLEY, YORKS.
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5-step ladder, with fine control.

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Switched via single test-lead, RF. and AF. 1 volt Max.

External Radiation
Less than 1 micro-v.

For A.C. mains operation. Complete with Standard Dummy Aerial.

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EXCELLENT PERFORMANCE
ATTRACTIVE APPEARANCE
LOW PRICE
HIGH EFFICIENCY

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Says Sir Stafford to us all,
"There's a purpose right before us,
PRODUCTIVITY's the call."
See how eagerly DESOUTTER Tools
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They are waiting on your signal—
—give each Little Horse his chance!
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"FLEXILANT"

(RUBBER BONDED TO METAL)

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of

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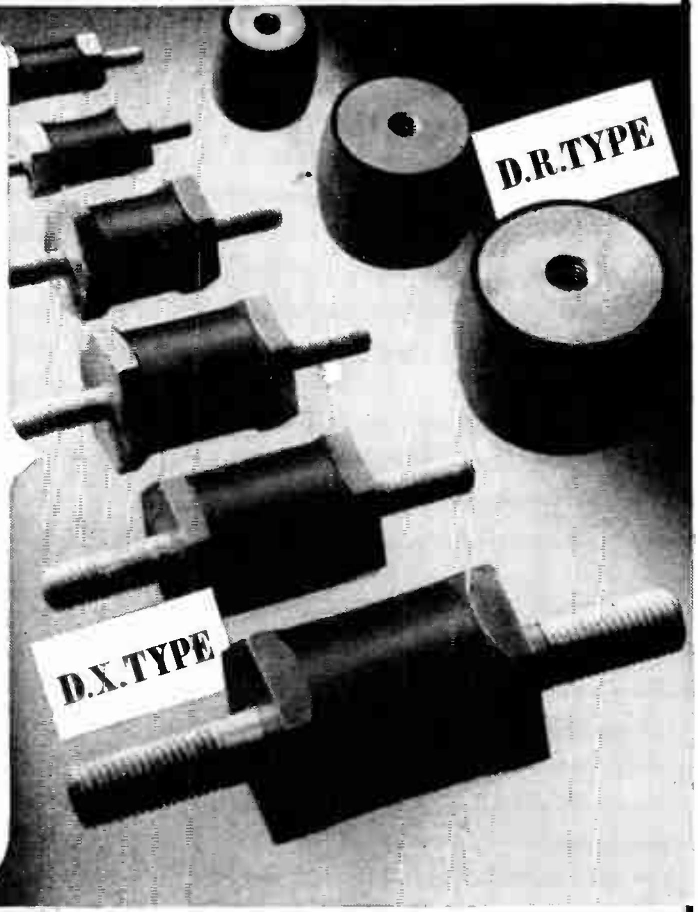

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THE

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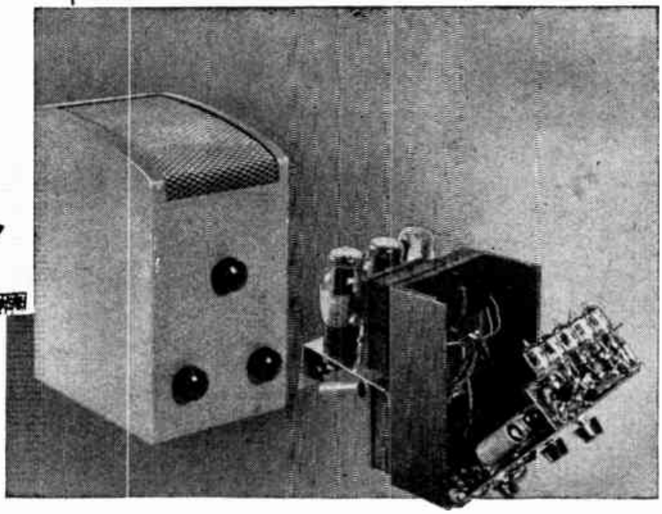
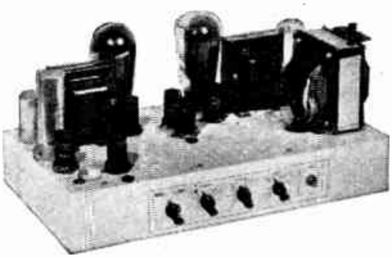


THE SMALLEST 8-VALVE HIGH-FIDELITY AMPLIFIER IN THE WORLD

Charles Amplifiers Ltd. are proud to announce a great new advance in amplifier design. The 'Nocturne' is the smallest high-fidelity amplifier of its type yet offered to the public, and the first to use miniature valves. Its full-sized rectifier gives a wide margin of safety, and the full-sized output valves ensure distortionless reproduction. It is designed primarily for moving coil or miniature moving iron pick-ups or moving coil microphone, and its 8-valve circuit is based on the highly popular "Concerto." Separate bass and treble controls ensure complete control of tonal balance. The handsome metal case eliminates the usual 'laboratory' look and sockets for tuning unit, H.T. and L.T. are fitted. 6 watts output.

Size : 9½" high × 6" wide × 8" deep. Price **£23.0.0**



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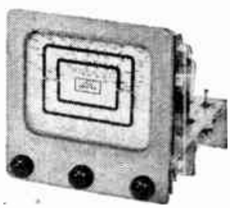

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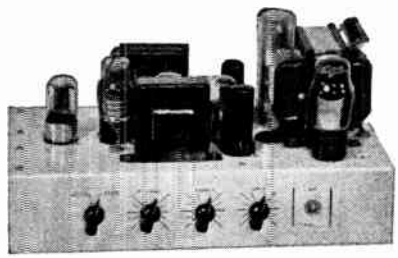

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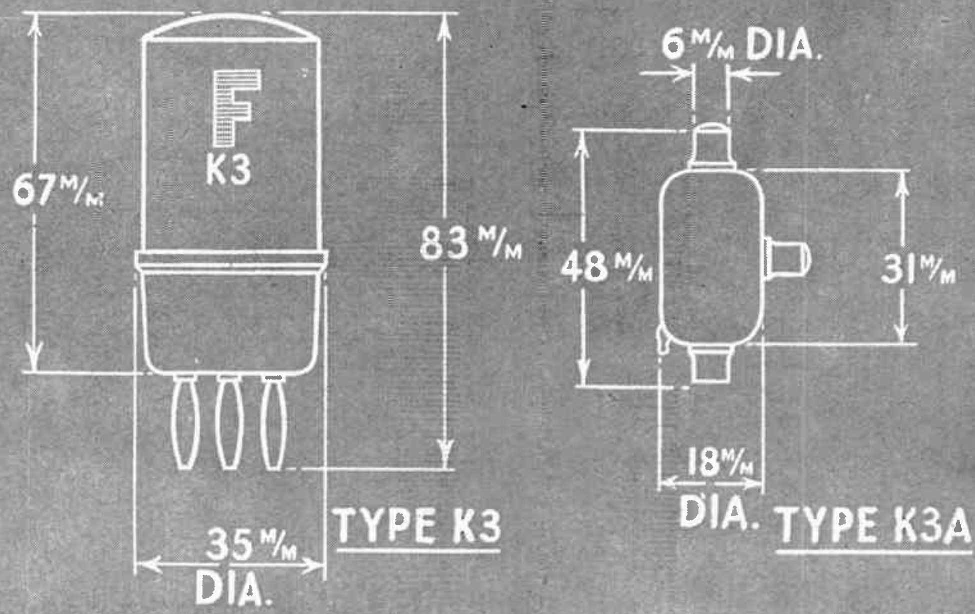

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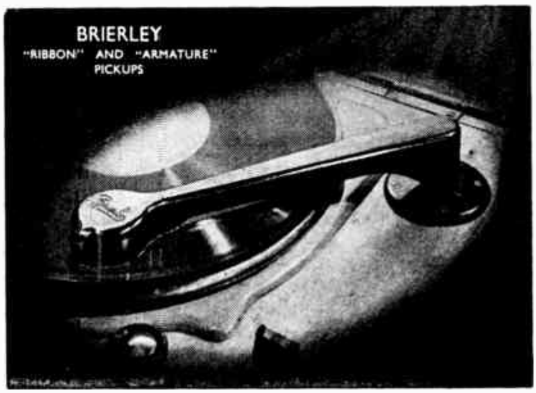

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1 mA	0—1	2½in.×2½in.	M/C	7/6
5 mA	0—5	2½in.	M/C	5/-
30 mA	0—30	3½in.	M/C	10/6
50 mA	0—50	2½in.×2½in.	M/C	8/6
150 mA	0—150	2½in.	M/C	6/-
250 mA	0—250	3½in.	M/C	10/-
2.5 amp.	0—2.5	2½in.	Thermo.	5/-
20 v.	0—20	2½in.×2½in.	M/C	5/9
40 v.	0—40	2½in.×2½in.	M/C	5/9
5000 v.	0—5	4½in.	Elect.	50/-
500 u.a	0—500	2½in.	M/C	7/6

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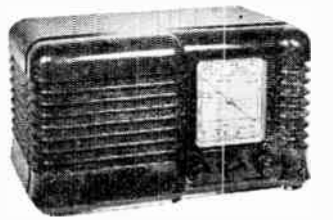

NEW PRICES

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Complete kit of parts with diagrams, **£6/6/-,** inc. Purchase Tax.

PREMIER MIDGET SUPERHET RECEIVER. This powerful Midget Superhet Receiver is designed to cover the short-wave bands between 16 and 50 metres and the medium wavebands between 200 and 557 metres. Two models are produced, one for 200-250 volt A.C. mains; and the other for 200-250 volts A.C. or D.C. mains. Both are supplied in the same plastic cabinet, as the TRF Receiver. The A.C. valve line-up is 6K8, 6K7, 6Q7, 6V6 and a selenium rectifier. The A.C./D.C. line-up is the same, with the exception of the output valve which is a 25A6. The dial is illuminated, making a very attractive receiver. PRICE: **£8/19/6.**
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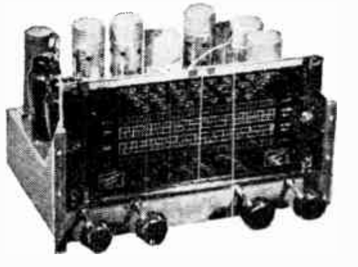

A NEW A.C. ALL-WAVE SUPERHET RECEIVER. 7 Valves (plus metal Rectifiers) for 200/250 volts; 40/60 cycle A.C. mains. 4 wavebands, 13.6-52, 51-200, 200-550 and 900-2,100 metres. Pick-up input. Uses 6K7, 6K8, 6K7, 6B8, 6J7 and 2-6V6 in push-pull, giving an output of 10 watts. Specially designed OP Transformer to match 6V6's to 3 and 15 ohm Speakers. Negative feedback is applied over 3 stages giving a high fidelity output. Completely wired and tested: **£15/17/9.** Our Universal model is still available at **£15** built; or **£13/8/-** in kit form. All prices include Purchase Tax.

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PREMIER MAINS TRANSFORMERS. All primaries are tapped for 200-230-250 v. mains, 40-100 cycles. All primaries are screened. All L.T.s are centre-tapped.

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SP.250A.	250-0-250 v. 60 mA., 6.3 v. 2-3 a., 5 v. 2 a.	25/-
SP.250B.	250-0-250 v. 60 mA., 4 v. 1-2 a., 4 v. 3-5 a.	25/-
SP.300A.	300-0-300 v. 60 mA., 6.3 v. 2-3 a., 5 v. 2 a.	25/-
SP.300B.	300-0-300 v. 60 mA., 4 v. 2-3 a., 4 v. 3-5 a., 4 v. 1-2 a.	25/-
SP.301A.	300-0-300 v. 120 mA., 5 v. 2-3 a., 6.3 v. 3-4 a.	28/-
SP.301B.	300-0-300 v. 120 mA. 4 v. 2-3 a., 4 v. 2-3 a., 4 v. 3-5 a.	28/-
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SP.350B.	350-0-350 v. 100 mA., 4 v. 2-3 a., 4 v. 2-3 a., 4 v. 3-5 a.	29/-
SP.352.	350-0-350 v. 150 mA., 5 v. 2-3 a., 6.3 v. 2-3 a., 6.3 v. 2-3 a.	36/-
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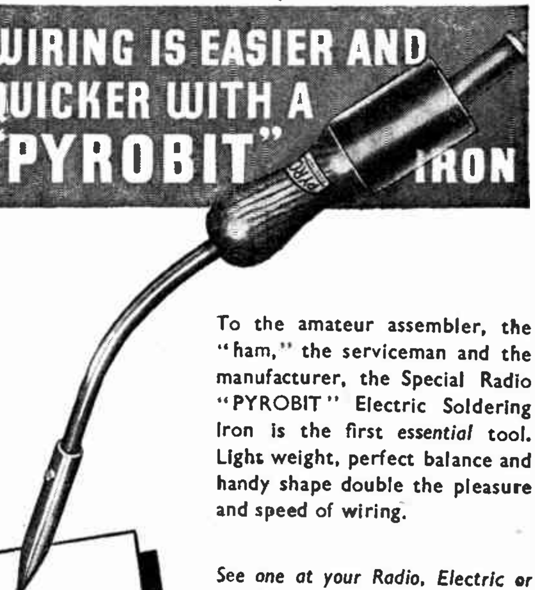

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P.4

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THE SIGNAL RECTIFIER

Before going on to deal with the last major link in the reproduction chain — that of the output stage and loudspeaker, there is one part of the receiver which merits a little closer attention than we have so far given it. We have discussed briefly the radio or carrier side of the amplifier and also the audio frequency amplifier stages. There is an all important link between them, the signal rectifier and often associated with it, the A.V.C. rectifier. It is probably true to say that it is easier to allow harmonic distortion to creep in at this point than at any other part of the complete set. Further, because one is essentially dealing with a rectifier which is a non-linear element, the application of theory to practical cases is far more difficult than it is where the circuit elements are at least intended to be linear.

*Perfect Reproduction?

*** PROBLEMS REFERRED TO IN PREVIOUS NOTES**

Spatial Distribution of Sound.
Echoes in the Listening Room.
Limitations of Single Channel.
Limitations of the Human Ear.
Distortions and Faults caused by Apparatus.
The Radio Link.
Frequency Response.
Non-linearity.

Signal rectifiers of various sorts have been used and proposed since the beginning of radio but the plain diode rectifier is now almost universally used. It combines the excellence of the leaky grid detector for small inputs with a virtually unlimited signal handling capacity ; in fact, the larger the input the more likely it is that the audio output will follow the modulation envelope.

It is far beyond the scope of these few notes to go into the detail of detector design at all fully. All we can hope to do is to mention the points upon which care is needed and leave the elucidation of just how to tackle the problems that arise for future study in suitable textbooks.

Let us look first of all, therefore, at causes of distortion in a diode rectifying circuit consisting of the usual tuned circuit input with a resistive diode load shunted by a by-pass condenser. The function of this condenser is two-fold. Firstly, to prevent as far as possible the passing on to further stages of the unwanted carrier frequency. Secondly, to increase the audio output of the diode by making it a peak, and not a mean, reading device.

This condenser, however, is the first point at which distortion arises. In fact, any integrating condenser must induce some distortion for the following reason :—

Consider the rectification process during a period when the amplitude of the carrier is increasing; *i.e.*, during the positive slope of the modulation envelope. The diode will charge the integrating condenser up to the peak input value at each positive carrier peak and this charge will leak away during the gap before the next cycle. The voltage across the condenser therefore will resemble a series of steps, the rising part of which is nearly vertical while the falling portion will be more or less steep, depending on the time constant of the diode load and condenser.

Now consider the same process when the carrier amplitude is decreasing ; *i.e.*, during the negative slope of the modulation envelope. The same argument as was used above shows immediately that the shape of the audio output we have must be different. In fact, if the time constant of the diode load and condenser is made too large, the rate of decay during one cycle of carrier frequency may not be sufficient for the voltage to have fallen by as much as the modulation envelope has fallen in the same time. When this happens, the diode is said to have failed to "track" and quite severe distortion must result. This is very well known but it is not always realised that even though tracking is achieved, some small distortion must nevertheless still remain.

It is easy to see that the distortion is smallest when the ratio of the modulation frequency to the carrier frequency, and the percentage modulation, are both small. In other words, that distortion is unlikely to be serious for low audio frequencies or for low percentage modulations. As a rough guide, one can say that $R^{I}C$ must be small compared with pM (Where R and C are the resistance and capacitance of the diode load ; p is the modulation pulsatance and M the percentage modulation.)

In transferring the audio component from the diode load to the first low-frequency amplifier, it is usual to interpose a blocking condenser so that the bias conditions of the audio valve are not affected by the carrier level at the diode. It immediately follows, therefore, that the load on the diode for A.C. conditions is different from that at D.C. conditions since the grid leak of the audio valve is in parallel with the actual diode load at audio frequencies. The ratio of this A.C. diode load to the D.C. value must be kept as high as possible since as soon as the modulation depth exceeds this ratio (expressed as a percentage), distortion sets in.

A little consideration will show that it is impossible to avoid distortion for, say 90% modulation without losing gain either at carrier frequency or audio frequency. We cannot ask the first audio valve to have a grid leak greater than about 1 megohm so that to obtain distortionless rectification for 90% modulation, the diode load cannot exceed 100,000 ohms. For normal intermediate frequency circuits this is rather a low value and can only be achieved satisfactorily by losing gain in the last intermediate frequency transformer. An alternative method of course is to tap the feed to the audio valve down the diode load, losing in this case audio frequency gain.

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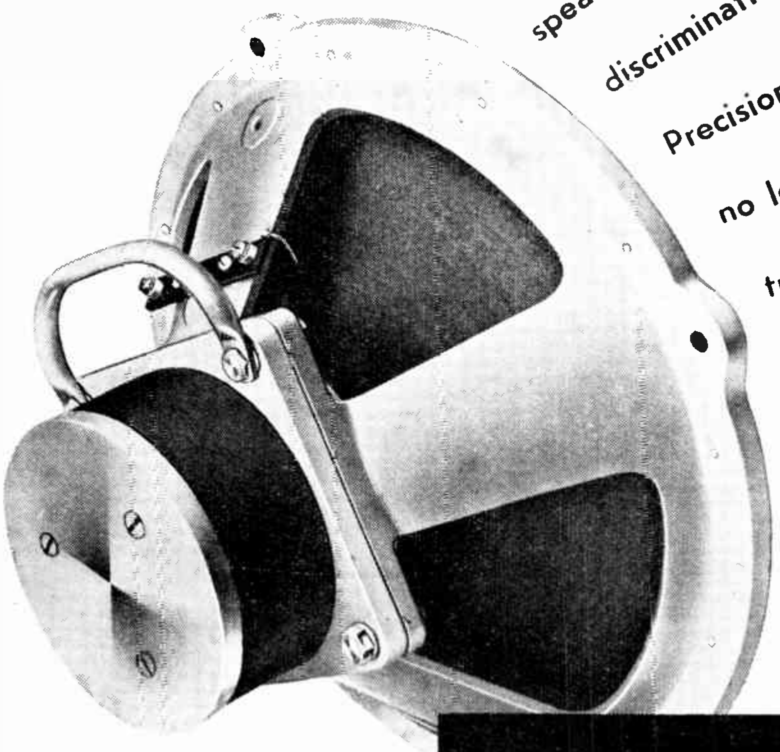

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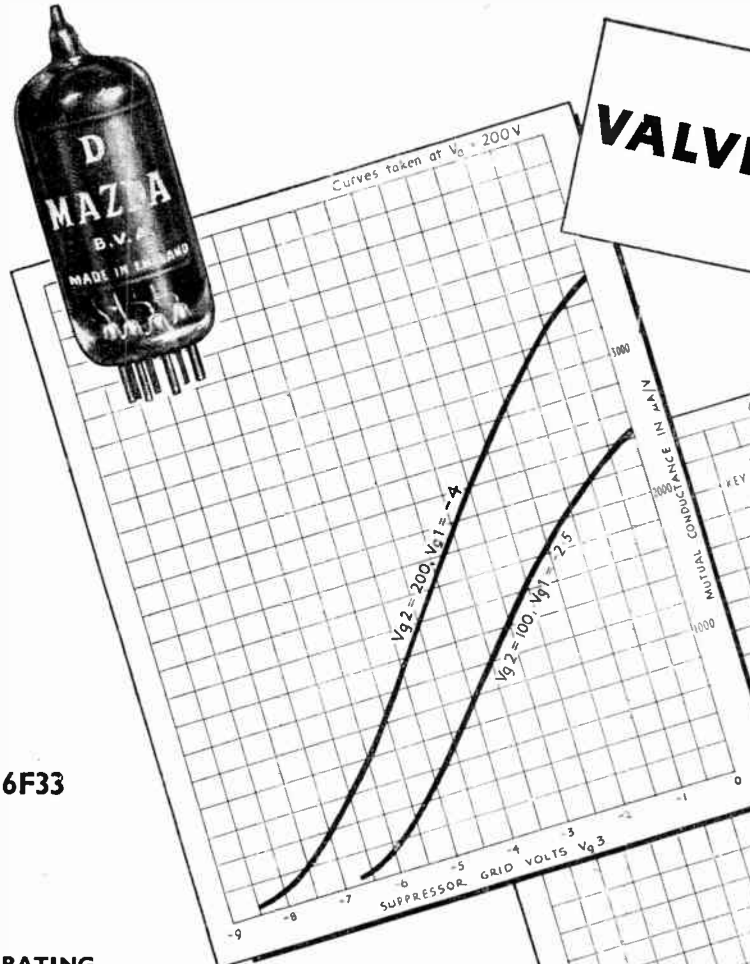

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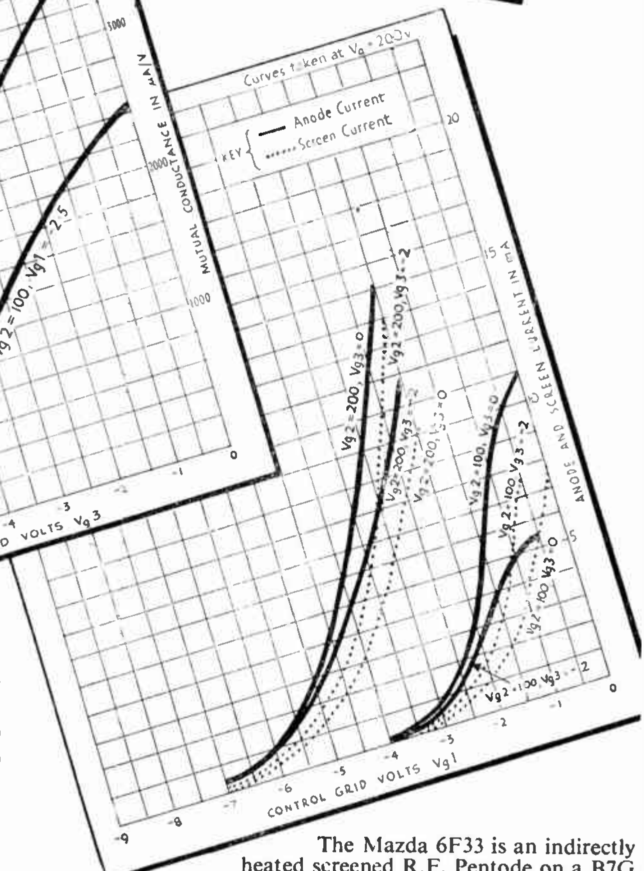

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Maximum Screen Voltage (volts) ...	Vg2(max)	250
Mutual Conductance (mA/v) ...	gm	* 4.35
Inner μ †	μg1g2	* 38
Maximum Anode Dissipation (watts)	pa(max)	2.5
Maximum Screen Dissipation (watts)	pg2	0.8
Maximum Potential Heater/Cathode (volts DC)	Vh-k(max)	100

*Taken at $V_a = 200v$; $V_{g2} = 100v$; $V_{g1} = -1.5v$; $V_{g3} = 0v$

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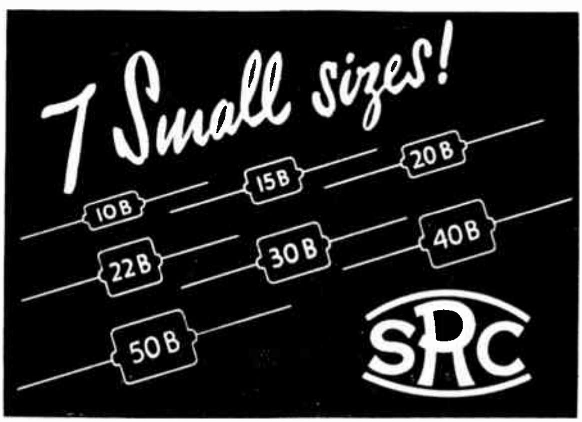

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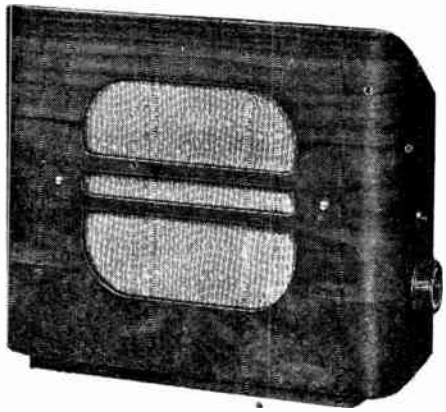

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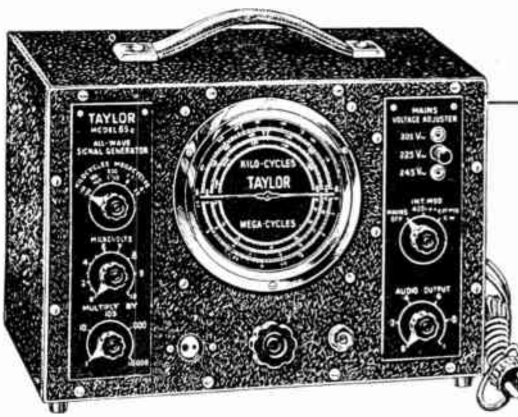

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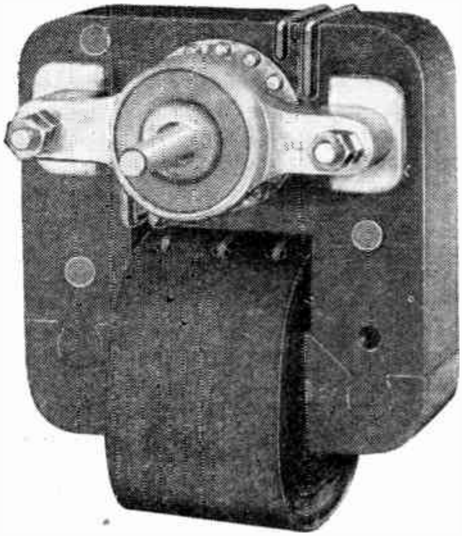

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Wireless World

RADIO AND ELECTRONICS

39th YEAR OF PUBLICATION

JUNE 1949

Proprietors ILIFFE & SONS LTD.

Managing Editor : HUGH S. POCOCK, M.I.E.E.

Editor : H. F. SMITH

Editorial, Advertising and Publishing Offices :

DORSET HOUSE, STAMFORD STREET LONDON, S.E.1.

Telephone : Waterloo 3333 (60 lines).

Telegrams : "Ethaworld, Sedist, London."

PUBLISHED MONTHLY

Price : 2/-

(Publication date 26th of preceding month)

Subscription Rate : 26/- per annum. Home and Abroad

Branch Offices :

Birmingham : King Edward House, New Street, 2.

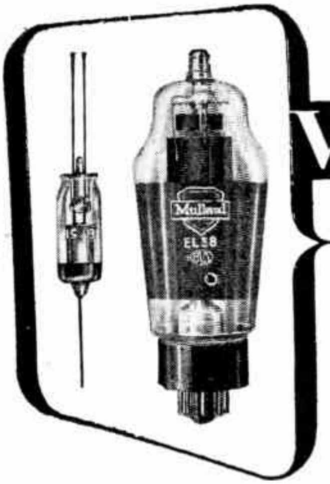
Coventry : 8-10, Corporation Street.

Glasgow : 26B, Renfield Street, C.2.

Manchester : 260, Deansgate, 3.

In This Issue

OUR COVER: Massed Television Transmitters (See Page 205).



Valves and their applications

E.H.T. FROM THE LINE TIME BASE FLYBACK

It is well known that line time base amplifiers produce very high voltages across the output transformer during the flyback; the utilization of this pulse to provide an E.H.T. supply is most economical and, for direct-viewing tubes, gives a simple and satisfactory solution. It is desirable that the source impedance shall not be greater than 5 MΩ and voltage doubling, which is also more expensive, is therefore excluded.

Since the energy stored in the inductive components at the beginning of the flyback is largely determined by the scan requirements of the deflector coils, the E.H.T. voltage developed is controlled by the stray capacitances across the transformer. These are therefore reduced by using air as the dielectric medium between the high-voltage windings and the laminations and also by choosing a lamination with a sufficiently large window to allow good spacing. This also increases the insulation of the windings.

Fig. 1 shows a conventional line time base amplifier circuit, modified for E.H.T. generation. It will be noted that an inductor L1 has been added to the conventional resistance-capacitance damping circuit. Its effect is to oppose the build-up of current in the damping resistors as the beginning of the flyback, thus reducing the dampi ıg and giving a higher pulse voltage. Subsequently, it tends

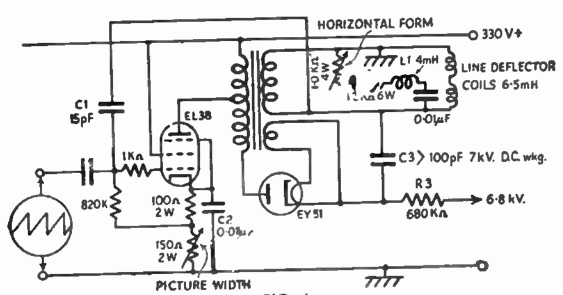


FIG. 1

LINE TIME BASE AMPLIFIER Ia=75mA Ig2=17mA.

to maintain the current and increases the effectiveness of the damping resistors during the later part of the flyback.

The rectifier (EY51) is connected to an overwind on the primary of the output transformer. The overwind reduces the contribution of the output capacitance of the EL38 to the total effective capacitance across the whole winding. It also increases the flyback time, which, with the low capacitance, would be unnecessarily fast and thereby minimizes the losses in the magnetic circuits.

The value of the reservoir capacitance C3 may be as low as 100pF and the capacitor is connected so that,

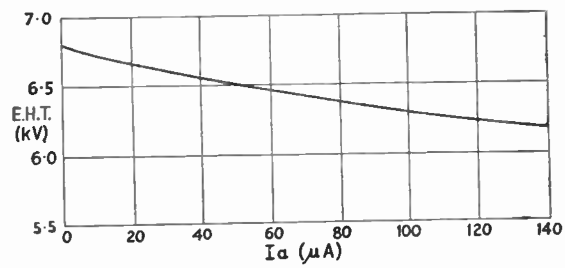


FIG. 2

REGULATION CURVE of E.H.T. SUPPLY

while the EY51 is conducting, a negative-going pulse from the secondary winding is applied to the low potential plate. This increases the D.C. voltage across C3 but necessitates a resistor R3 to prevent the capacitance of the C.R. tube from shunting the deflector coils.

It is important that the EL38 be rapidly and completely cut-off from the beginning of and throughout the flyback. C1 and C2 both help to achieve this. C1 feeds back a negative-going pulse from the deflector coils; C2 increases the grid-cathode potential during the flyback by temporarily removing the negative feed-back.

Mullard

Reprints of this report from the Mullard Laboratories, together with additional circuit notes and full transformer winding data can be obtained free of charge from the address below.

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(MVM91)

VOL. LV. NO. 6

Wireless World

RADIO AND ELECTRONICS

JUNE 1949

MONTHLY COMMENTARY:

Radio Politics

EVER since we published the Copenhagen Plan list of broadcast frequency allocations for Europe in our issue of November 1948, readers have deplored the fact that politics were allowed to enter so largely into the making of decisions that should be influenced mainly by technical considerations, geography and distribution of potential listeners. In most of the letters written on this subject it is suggested that sooner or later those countries—in particular Germany and Spain—that have been given unfavourable allocations will encroach on channels belonging to other countries and will become, in effect, ether pirates. Spain, we are reminded, was given two clear channels under the still-born Montreux plan, but is now to have none. According to a correspondent, the number of receivers in use has increased five-fold since 1939. Germany, considering the high listener density of pre-war days, is almost certainly in an even worse position.

IN the sphere of short-wave broadcasting international co-operation has apparently been similarly bedevilled by political differences, though it is as yet too early to comment on the outcome of the International High-frequency Broadcasting Conference at Mexico City. We may be permitted a sigh in recollection of the "good old days" of 1938 and the Cairo Convention. We were proud of the fact that radio men could then—in a world already riddled with political jealousies but probably more civilized than the present one—settle their problems on a predominantly technical and rational basis.

As recent international deliberations on radio matters have had such an unfruitful outcome it is perhaps inopportune to press for discussions at a higher level than hitherto on the possibilities of uniformity in television for Europe, or at any rate for Western Europe. But no country except France has so far made a definite statement on the standards to be adopted, and it would be a counsel of despair to say that nothing can be done to devise means of bringing about some measure of agreement on matters that are bound to influence the healthy growth of television.

WE are reminded of the present unsatisfactory state of affairs by reading an article in *La Radio Française* by the outspoken and often provocative Editor, Marc Chauvierre, who ventures a forecast of the television systems to be ultimately adopted. They are: 819 lines for France and perhaps Belgium and Switzerland; 625 lines for England, Sweden, Norway, Denmark and Western Germany; 525 lines for Italy "which is equipping herself with television under Marshall Aid," and possibly Spain.

With the details of this forecast we obviously cannot agree, if only for the fact that 625 lines has limited acceptance in England as an export standard only; for home consumption we are committed to 405 lines for some years. However, we do agree that, failing some effective action, Europe may well find herself saddled with a diversity of standards which will make exchange of programmes difficult or impossible and will make international trade even more difficult. The organizing of services in neighbouring countries so as to avoid interference is also a matter that calls for international discussion.

We are still in agreement with M. Chauvierre when he goes on to press on economic grounds for a standard of moderate definition "of the order of 500 lines" for domestic—as opposed to cinema—use. Europe cannot afford to experiment in costly elaborations of doubtful value.

Radio in all its branches—not excluding the visual-range frequencies—is a truly international matter, and its growth will certainly be hampered if effective international co-operation in its organization is lacking.

CATHODE-RAY TUBES FOR TELEVISION

Operating Conditions v. Picture Brightness

By HILARY MOSS, Ph.D., M.Brit.I.R.E. (Chief Engineer, Electronic Tubes, Ltd.)

In this article answers are given to two problems which are often encountered in television. The first is : In a given television system with a constant number of lines, what increase of c.r. tube voltage is needed to maintain constant brightness as the screen diameter is increased assuming (a) constant resolution at the screen and (b) constant spot size ? The second problem is : What increase of tube voltage is needed with a given tube to maintain constant brightness as the number of scanning lines is increased, the frame frequency being unchanged ?

In these, as in all cathode-ray tube problems, the solutions depend on the assumptions made. In the first part of the article it is assumed that the neck diameter is variable and answers are given depending on whether the beam current or cathode loading is constant. The methods are then extended to cover the case of constant neck diameter.

THERE is a wide-spread impression that the cathode-ray tube designer lives in an atmosphere of Hamiltonian mechanics, phase space, Liouvilles theorem and the Principle of Least Action. These abstruse matters have a part to play in the higher realms of the subject—into which the author has never yet penetrated—but it is surprising how much can be done by a combination of logical thinking, simple experiment and fourth-form algebra. Broadly speaking, the higher branches of electron optics are called into play only if we seek to design from first principles. This task calls for superb mathematical ability and is, in any case, of doubtful practical value owing to the manipulative difficulties which arise.

On the other hand, if we are content to design by reference to existing practice, then an enormous simplification can be made. It is possible to set up simple but far reaching relationships between the *relative* characteristics of various types of cathode-ray tube. Therefore, if the absolute characteristics of one tube—the reference tube—are measured, the absolute performance of the other tubes can be computed from the relations established.

The simple laws relating the performance of one tube to another are, of course, approximate only and so the method has one fundamental limitation. It is necessary to be careful not to extrapolate too far or the predictions made may be seriously in error. It is also important to have sufficient appreciation of the physics behind the phenomena which the laws illustrate to be fairly sure that discontinuities in the nature of the laws are unlikely. For example, in the case of brightness/voltage curves we must be sure that any extrapolation made does not extend into the region of "screen sticking."

The sketches of Fig. 1 show diagrammatically the basic form of a typical television c.r. tube having a triode gun and designed for magnetic focusing and deflection. As shown at (a), the electron beam is generated in the tride T, focused by the lens F on to the scheen at S and deflected by the coils D. The lens F may be either a permanent magnet, or excited coil, or a combination of both. In an electron-optical sense these distinctions are of no account whatever, provided that in each case the lens is capable of handling the maximum beam diameter (i.e., that at "full white") without appreciable aberration.

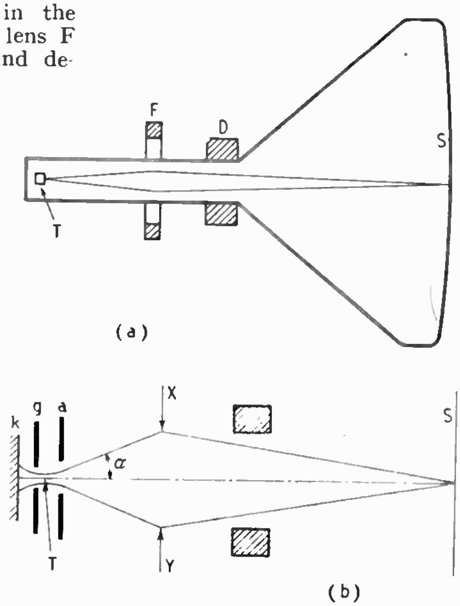


Fig. 1. The general form of a typical magnet c.r. tube is sketched at (a) and an exaggerated view of the electron beam at (b). In the latter the crossover is at T and the magnetic lens at XY.

An elaborated view of the electron trajectories is shown at (b) but with the beam width greatly expanded for clarity ; k is the cathode surface (usually plane), g is the grid or modulator and a the anode. These three elements constitute what is usually known as the "triode." The anode a is normally joined to the graphite wall-coating of the tube. It sometimes contains a second orifice which serves to trim the beam, so preventing the width of the latter from exceeding a defined value. Alternatively in some constructions the electrode a is omitted entirely and its place taken by the coated walls of the tube. Although these variations affect many of the details of the operation of the whole gun, they do not affect the basic arguments presented in this article.

The full details of the operation of the triode are immensely complicated, and even today are not fully understood. Luckily for our purpose we do not need to enquire too closely into them. It is sufficient to accept that the fields in the triode generate a conical beam of electrons as indicated in Fig. 1 (b) which appears to emerge from a small area marked T and usually referred to as the "crossover." This crossover is the object which the focusing lens F images on the screen S. For simplicity this lens is assumed to be infinitely thin and to act at the plane XY. Since the field of the lens has an appreciable spread along the axis of the gun this assumption is not strictly accurate but the subsequent working is in no way affected.

It can be shown that owing to the Maxwellian velocity distribution in the electrons emitted from the thermionic cathode k, the edge of the crossover is not sharply defined. In fact, detailed analysis shows that to a close approximation the electron-density distribution in the crossover has the form shown in Fig. 2—a curve of Gaussian shape.

Physically speaking this means that if we are to speak of "crossover diameter" it is necessary to define a convention which will give this phrase a meaning. The most satisfactory mode of doing this is illustrated in Fig. 2. A straight line is drawn parallel to the X axis at some arbitrary percentage of the maximum and the crossover diameter is then defined as the distance XY. The exact percentage is not important, being largely a matter of convention but a common value is 20% if precise quantitative measurements are being undertaken. However, such measurements are extremely difficult and are rarely made.

The lens F merely serves to image this distribution of electrons on the screen S. In general the scale of the distribution will, of course, be different just as in light optics. In this discussion, incidentally, it is assumed that there are no lens aberrations and that space charge is negligible. If these postulates are not satisfied the shape of the distribution at the screen will not be the same as that at the crossover.

It is unnecessary here to enter into any discussion whatever as to the effect of deflecting the beam, since for the moment the ratio beam width/deflector-coil size, the shape of the deflector coils, and the maximum scanning angles will all be maintained constant. Manipulation of the various relationships in television-gun design become appreciably more involved if these conditions are not satisfied.

Many problems connected with the picture size and brightness can be solved by the application of the laws stated in the following five postulates. It is unnecessary to show here how these are derived, but in order to indicate the reasoning behind them some account is given in the Appendix. These postulates are: (1) If all dimensions of an electron-optical system are multiplied by k, all applied voltages being held constant, then the total current flowing is unchanged and the shape

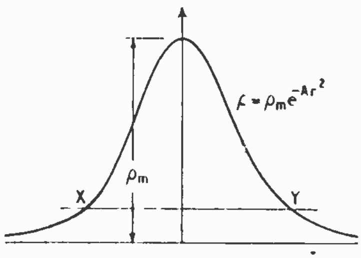


Fig. 2. This Gaussian curve shows the electron density ρ in a cross-section of the beam at the cross-over.

of the trajectories is also unchanged, although on a scale k times as large. In other words the systems transform perfectly—all angles being unchanged. This statement is *absolutely exact* if the electrons of the system start from rest and applies even in the presence of space charge. (2) In any electron-optical system of constant geometry, if *all* electrode voltages are multiplied by k, and all magnetic field intensities by $\sqrt{k}$, the electron trajectories are unchanged. This statement is again absolutely exact if space charge is neglected and the electrons in the system start from rest. (3) If the average current density at the screen is kept constant, the screen brightness is proportional to some power of the electron voltage; i.e., to the velocity of impact. It is proportional to V^n where V is the anode voltage of the tube. In this statement it is assumed that the integration time for determining the average current density is too short for flicker effects to be noticeable. (4) If all anode voltages in a tube are multiplied by k, then the spot diameter is inversely proportional to $\sqrt{k}$. This is an approximation only but is a good one, especially if the beam angles in the gun are maintained constant by making a corresponding change in the grid voltage whenever the anode voltages are changed.

(5) If two triodes, *physically identical except for their cathode grid spacings*, are operated at different anode voltages such that their cut-off voltages are equal, then to a fairly close approximation the modulation characteristics both in respect of current and beam angle, are identical. The cut-off voltage is, of course, the grid voltage for which the anode current just becomes zero.

Provided that the beam current is kept constant these postulates enable a number of important practical problems to be solved. One common one is: Suppose that we have a certain tube, tube 1, with a certain screen diameter, what operating voltage will be needed for another tube, tube 2, of k times the diameter if the brightness and resolution of the picture are to be unchanged?

Using subscrips 1 and 2 to refer to conditions in tubes 1 and 2, from postulate (3) the surface brightness of the original tube is proportional to V_1^n/A, where A is the screen area, and the surface brightness of the derived tube will be V_2^n/k^2A. Hence for equality of screen brightness it follows that

$$V_2^n = k^2 V_1^n \quad .. \quad .. \quad (1)$$

where n is a constant (see Appendix).

This equation (1) satisfies the condition maintaining constant brightness. We next investigate the spot size. The original spot diameter, using postulate (4), is proportional to $1/\sqrt{V_1}$ and the spot diameter on the derived tube will be proportional to $1/\sqrt{V_2}$, but we require to have an arbitrary control over the spot size independent of that imposed by postulate (4). This is most simply done by using postulate (1) and multiplying the linear dimensions of the triode *only* by λ. Thus the spot diameter of the original tube is proportional to $1/\sqrt{V_1}$ and the spot diameter of the derived tube is proportional to $\lambda/\sqrt{V_2}$. But we require constant resolution at the screen (i.e., the same ratio of spot diameter to screen diameter in both tubes) so that on the derived tube with a screen diameter k times as large as on the reference tube, the spot diameter must also

Cathode-ray Tubes for Television—
be k times as large as on the reference tube. Thus we derive the equation

$$\lambda/\sqrt{V_2}=k/\sqrt{V_1} \quad \ldots \quad (2)$$

which gives us freedom to adjust the spot size appropriately.

Solving (1) and (2) gives us $\lambda=k^{(1+1/n)}$ which defines the linear scaling factor for the triode.

In order to make the modulation characteristics of the two tubes identical we now merely employ postulate (5) and adjust the cathode/grid spacing of the derived tube so that it operates at the same cut-off voltage as the reference tube (to a close approximation the cut-off voltage is inversely proportional to the cathode/grid spacing). Thus the problem is completely solved. Taking a numerical example, suppose we wish to double the diameter of the screen, then assuming the index n equals 2, which is a good average value (see Appendix), it follows $\lambda=2^{3/2}$. Thus all the dimensions of the tube are multiplied by 2 except for the triode which is multiplied by 2.83. From postulate (4) the anode voltage is multiplied by 2. This will result in a picture of twice the linear dimensions and of the same surface brightness, the voltage of the tube being doubled. The spot size is also doubled so that the resolution is unchanged.

If, instead of making the spot size proportional to the screen size, we decide that the spot size must

Basic Operation		**Screen diameter multiplied by k**				**No. of lines multiplied by μ. Tube dimensions constant**	
Secondary Operations		**All linear dimensions of bulb, neck and scanning coils multiplied by k**				**Triode only scaled**	
Geometrical Changes made	Triode Dimensions	$\times\ k^{(1+1/n)}$	$\times\ k^{1/n}$	$\times\ k$	$\times\ k^{1/(1+n)}$	$\times\ \frac{1}{\mu}$	$\times\ \frac{1}{\mu^{n/(n+1)}}$
	Cathode-grid spacing*	$\times\ k^{2/n}$	$\times\ k^{2/n}$	$\times\ \frac{1}{k^{4/3}}$	$\times\ k^{2/3(1+n)}$	$\times\ 1$	$\times\ \mu^{(6+4n)/3(n+1)}$
Electrical changes made	Anode Voltage	$\times\ k^{2/n}$	$\times\ k^{2/n}$	$\times\ 1$	$\times\ k^{2/(1+n)}$	$\times\ 1$	$\times\ \mu^{2/(n+1)}$
	Cut-off Voltage	$\times\ 1$	$\times\ 1$	$\times\ k^{4/3}$	$\times\ k^{4/3(1+n)}$	$\times\ 1$	$\times\ \frac{1}{\mu^{4n/3(n+1)}}$
	Grid Drive	$\times\ 1$	$\times\ 1$	$\times\ k^{4/3}$	$\times\ k^{4/3(1+n)}$	$\times\ 1$	$\times\ \frac{1}{\mu^{4n/3(n+1)}}$
	Scanning-coil Current	$\times\ k^{1/n}$	$\times\ k^{1/n}$	$\times\ 1$	$\times\ k^{1\ (1+\ )}$	$\times\ 1$	$\times\ \mu^{1/(n+1}$
Effects produced	Beam Current	$\times\ 1$	$\times\ 1$	$\times\ k^2$	$\times\ k^{2/(1+n)}$	$\times\ 1$	$\times\ \frac{1}{\mu^{2n/(n+1)}}$
	Spot Diameter	$\times\ k$	$\times\ 1$	$\times\ k$	$\times\ 1$	$\times\ \frac{1}{\mu}$	$\times\ \frac{1}{\mu}$
	Beam Angle α	$\times\ 1$	$\times\ 1$	$\times\ 1$	$\times\ 1$	$\times\ 1$	$\times\ 1$
	Screen Brightness	$\times\ 1$	$\times\ 1$	$\times\ 1$	$\times\ 1$	$\times\ 1$	$\times\ 1$
	Cathode Loading	$\times\ \frac{1}{k^{2(1+1/n)}}$	$\times\ \frac{1}{k^{2/n}}$	$\times\ 1$	$\times\ 1$	$\times\ \mu^2$	$\times\ 1$

* This adjustment to be made *additionally* to that effected by the scaling of the whole triode.

be kept constant, the answer is different. Equation (1) still applies to satisfy the condition of constant brightness, but to satisfy the condition of constant spot size $\lambda / \sqrt{V_2} = 1 / \sqrt{V_1}$. The solution of these equations gives $\lambda = k^{1/n}$. Taking again the case of doubling the screen size, this means that we must multiply the triode dimensions by $\sqrt{2}$ only in order to achieve constant spot size. The anode voltage again is doubled.

In both these solutions *all the rest of the tube geometry* apart from the triode has its linear dimensions multiplied by k.

Deflection System

We must now enquire what changes are needed in the deflection system. These follow at once from postulate (2). It is merely necessary to multiply the coil current by $\sqrt{k}$ since the anode potential has been multiplied by k. This applies to both problems.

Let us now suppose the number of lines is to be multiplied by μ, what changes in tube design are necessary? One possible solution of this problem is exceedingly simple. Since the total light output from the screen must be constant if the integrated energy delivered to the screen is also constant, it follows that merely increasing the number of lines in the system does not necessarily entail an increase in anode voltage and beam current. All we need to do is to reduce the spot diameter in proportion to the increase of the number of lines. Thus, applying postulate (3), the simplest solution consists of merely multiplying all dimensions of the triode by $1/\mu$ and keeping all voltages constant. This will satisfy all the imposed conditions. Thus increasing the number of lines from 400 to 600 will require that the linear dimensions of the triode are multiplied by 2/3 and no other change is necessary. This is the simplest possible solution.

In the methods so far used it must be carefully noted that we have kept the total beam current and beam angle constant, adjusting the spot size where necessary by scaling the triode gun. It is obvious, therefore, that the cathode loading (the current extracted per unit area from the cathode) has varied inversely as the area of the cathode; i.e., as μ^2. In the last problem, therefore, the cathode loading has been multiplied by the factor 9/4 and this fact may make the solution not practically acceptable on account of reduced cathode life.

It is quite possible to inject another postulate into the reasoning; viz., that the cathode loading should be held constant and the beam current allowed to vary. This involves a more complicated treatment and one additional postulate. This is that the screen brightness is proportional to the average current per unit area over its surface.

Hence the condition of constant screen brightness now requires

$$k^2 I_1 V_1^{\,n} = I_2 V_2^{\,n} \quad \ldots \quad (3)$$

By way of illustration we shall treat the first problem again where the resolution at the screen is constant.

Equation (2) applies. But to obtain constant cathode loading it is *necessary* that

$$I_2 / I_1 = \lambda^2 \quad \ldots \quad (4)$$

This is not, however, a sufficient condition. In addition we must arrange that the fraction of the cathode surface which is emitting is the same as previously. This is equivalent to securing constancy of beam angle α, Fig. 1 (b). From Fig 4 (in the Appendix), this requires

$$V_{d_1} / V_{c_1} = V_{d_2} / V_{c_2} \quad \ldots \quad (5)$$

where V_d is the grid voltage measured with respect to the cut-off grid voltage V_c.

We also need the law connecting current and voltage. It has been shown elsewhere[1] that to useful engineering accuracy the cathode current

$$I_k = 3\, V_d^{7/2} / V_c^2 \quad \ldots \quad (6)$$

where I_k is in microamperes and potentials are in volts. Therefore

$$\frac{I_2}{I_1} = \left(\frac{V_{d2}}{V_{d1}}\right)^{7/2} \left(\frac{V_{c1}}{V_{c2}}\right)^2 \quad \ldots \quad (7)$$

The solution of this system of equations gives the results shown in the 3rd row of Table 1. Exactly similar methods give the solutions of the other two problems. These are also shown in Table 1 together with the simpler solutions of constant beam current previously considered.

Comparing rows 1 and 3 it can be seen that instead of increasing the anode voltage $k^{2/n}$ times and working at constant beam current, the voltage can remain unchanged and the current increased k^2 times. The cathode loading in the large and small tubes is then the same. The deflector coil current is now unchanged instead of being multiplied by $k^{1/n}$.

When discussing the use of a given tube for an increased number of lines it was said that only the triode gun need be changed to give the reduced spot size but that as a result the greater cathode loading might be dangerously high. An alternative tube would be one operating at the normal cathode loading (Row 6, Table 1). This requires $\mu^{2/(n+1)}$ times the anode voltage and $\mu^{1/(n+1)}$ times the deflector-coil current.

If 5kV gives adequate brightness with 405 lines and the factor n is 1.67, then with 625 lines the anode must be operated at $(625/405)^{2/2\cdot67} = 1.545^{0\cdot75} = 1.39$ times the voltage or 7kV. The deflector-coil current must be 1.18 times as great. The back e.m.f. across the deflector coil is μ times as great for the same current because of the increased velocity of scan, and taking the greater current into account it is $\mu^{2/(n+1)}$ times as great or 1.39 times. The power in the scanning generator thus increases by $1.39 \times 1.18 = 1.64$ times. These figures agree well with practice.

(To be concluded)

[1] "Electron Gun of the Cathode Ray Tube—Part 2," by H. Moss, *J. Brit. Instn. Radio Engrs.*, June, 1946.

OUR COVER

TELEVISION *EN MASSE*. The forest of towers forming the subject of this month's cover illustration includes the aerials of six American television stations. They are at the summit of Mount Wilson (5,700 feet), which is some 25 miles from Los Angeles, California. Each of the transmitters operates, of course, in a different television channel varying from 66 to 216 Mc/s. The remaining two towers shown in the illustration are for an f.m. transmitter and a relay station of the Pacific Telephone and Telegraph Company.

PARASITIC OSCILLATIONS

Some Predisposing Conditions and How to Avoid Them

By "CATHODE RAY"

IT is quite usual for published valve circuits to include components that seem to serve no useful purpose. Inquisitive or thrifty experimenters try leaving them out, and when no obvious harm befalls they rejoice in having saved a component, or in having "put one over" the designer. These happy thoughts may possibly be clouded by some uneasiness lest, after all, the designer may have known better. The commonest example of such a component is a resistor in series with the grid. Sometimes the author may briefly explain its presence by a reference to "parasitic oscillation." But the principle, if any, on which the value of resistance is decided is generally left very vague. In fact, vagueness is often the outstanding feature about this parasitic business. How can one tell whether anti-parasitic precautions will be necessary or not? What will happen if they are necessary and are not adopted? And if they are necessary, how are their details decided?

The difficulty about giving crisp and clear answers to these questions is that they cover such a variety of circumstances. A doctor would need more than a minute or two to answer them about his sort of parasites, but the radio kind are more elusive still. They are liable to infest almost any apparatus worked by valves, and have even been found on ordinary filament lamps.

Parasitic oscillation, in its broadest sense, is unwanted oscillation. But the principles that govern oscillation are the same whether it is wanted or not. After all, how is an oscillation to know the difference? Although those principles are well known, let us review them, to see how they can work to our disadvantage as well as to our benefit.

There are several ways in which oscillations can be generated, but by far the most important is by a combination of amplification and feedback. The reason why valves are usually involved is their almost unique ability to supply the amplification. That part of the matter is so well known that I will take it for granted; but the feedback may need more detailed discussion, because in the case of parasitic oscillation it will generally exist unawares.

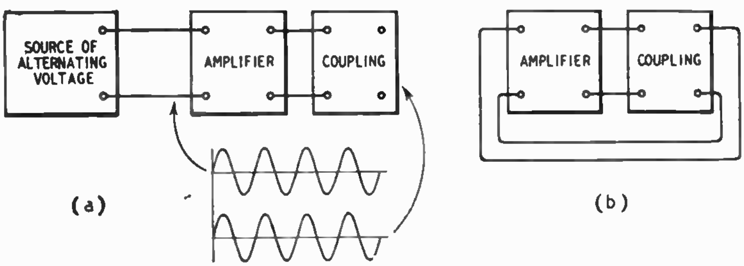


Fig. 1. If an alternating voltage is applied to an amplifier, some frequency or frequencies can generally be found at which the output is exactly in phase with the input, and at least equal in voltage. When that happens, the output can be substituted for the input and the amplifier will become a self-oscillator. If the back-coupling is unintentional, the oscillation is described as parasitic.

The mere existence of amplification combined with feedback does not inevitably cause oscillation, of course; otherwise negative feedback for amplifiers would hardly be as highly esteemed as it is. The conditions for oscillation must be fulfilled. These are short and simple: oscillation will occur at any and every frequency at which the phase shift and the gain round the loop are zero. To see what this means, consider *any* amplifier and coupling, represented by the "boxes" in Fig. 1(a). (This method of representing them is merely in order to cover all possible arrangements, and certainly not to suggest that they must always be elaborate pieces of apparatus. The coupling might be merely stray capacitance or mutual inductance).

Imagine that the source of alternating input voltage can be adjusted to any frequency, from zero to microwaves. If the resulting voltage across the coupling is compared with the input, it may be found that at one or more frequencies it is exactly in phase and equal in amplitude. At such frequencies, then, it is equivalent to the source of input voltage, and can be substituted for it, as in Fig. 1(b). Provided that the impedance conditions are not thereby upset, the amplifier will go on generating an alternating voltage without any outside source; it is, in fact, oscillating.

As I explained in connection with negative feedback,* there is no need for the fed-back voltage to start off by being equal to the input in amplitude. It is very unlikely to be *exactly equal*, but it may easily be greater, in which case it will make the oscillation grow until the amplifier overloads sufficiently to cut down its gain to exactly zero (i.e., voltage amplification = 1). So it doesn't matter how small the original voltage is; in fact, there is no need for any outside source even to start the oscillation going—the minute "thermal agitation" voltages present in every circuit are enough.

When designing valve apparatus for particular frequencies or bands of frequencies, one can very easily overlook its possibilities at

* "When Negative Feedback Isn't Negative," May, 1949 issue.

other (perhaps very remote) frequencies. Hence the unexpectedness and general obscurity of parasitic oscillation.

In audio amplifiers with negative feedback, for example, one takes care to make the phase shift as far from zero as possible; namely, 180°, bearing in mind that 360° is as good (or bad) as zero. Voltage fed back with 180° phase shift, so far from encouraging oscillation, tends to suppress it. But however successful the designer may be in keeping the phase on or near 180° at frequencies inside the amplifier's working range, there are always plenty of frequencies outside. Every amplifier contains reactances (intentional or otherwise), and their phase-shifting effects are bound to assert themselves at some frequencies, usually the very low and very high. The more stages that are subject to feedback, the greater is the risk that the intended 180° will be reduced to the fatal 0 or increased to the equally fatal 360° at some frequency at which there is still some gain left in the amplifier. Then there will be oscillation, which by definition would be parasitic, though perhaps not the sort that is generally considered under that title. A parasite by any other name is just as nasty, however; and the "negative" feedback sort (being generally far outside the working frequency band) may be as baffling to the uninitiated as most of them.

We studied the cause of this sort, and how to nip it in its smallest bud, last month; but what about amplifiers with no intentional feedback? There are, of course, plenty of ways in which positive (zero-phase) feedback can occur unintentionally, and the greater the gain of the amplifier the greater the risk. If the voltage amplification is 10,000, then it is only necessary for 1/10,000th of the output to find its way back to the input to cause oscillation. Most of the precautions against this are well known—keeping input and output wiring, and especially transformers, far apart and/or carefully screened; using adequate decoupling filters; and so forth—but occasionally there are less obvious feedback paths. Using the chassis as a common "earth" may look all right by the circuit diagram, but even its low resistance can couple the output of a high-gain amplifier to the input if it is common to both circuits.

All these cases of undesired oscillation in amplifiers are more often called *instability* than parasitic oscillation; and that subject is comparatively familiar. The term *parasitic* is usually associated with the obscurer forms of oscillation affecting individual valves or stages, which we shall now consider.

In an effort I once made to see how high a frequency of oscillation I could get out of a small high-slope triode, I finished up with the delightfully simple circuit shown in Fig. 2(a). The oscillatory inductance consisted, not, as might be supposed, of the one and only obvious coil (which was a r.f. choke), but of the short leads connecting the 10 pF to anode and grid. Drawing in the inductances of the leads and the interelectrode capacitances we have Fig. 2(b), which can now be recognized as a Colpitts oscillator circuit.

The point of this little story, if we bear in mind that the capacitance between wiring can soon add up to 10 pF, and that the inductance of the choke was not at all critical, is that Fig. 2(a) might easily be part of almost any apparatus containing a triode. But one would not necessarily be prepared for that apparatus to oscillate at 400 Mc/s.

In circuits where it is not intentional, feedback is most likely to occur via stray capacitance, and especially anode-to-grid capacitance. Such coupling becomes more and more effective as the frequency is raised, which is the reason why parasitic oscillation is so often at a very high frequency. This tendency is partly off-set by the fact that the input impedance of a valve, across which any feedback voltage has to be established if it is to cause oscillation, goes down rather steeply at very high frequencies. Now the gain of a valve depends mainly on two factors—its mutual conductance, and the impedance of the coupling circuit. The higher the mutual conductance, therefore, the lower the impedance before the gain drops below zero. The impedance depends on frequency, so if a wider range of impedence is able to provide the critical gain, the range of frequency at which oscillation can occur is widened, too. And the wider the range of possible frequencies, the greater the likelihood that at once or more of them (in addition to the desired frequency) the phase shift will be zero. So progress in valve design, resulting in higher mutual conductance, tends to increase the risk of parasitic oscillation. That is why we are hearing more about it than we used to.

The other thing to remember when looking out for parasites is that the circuit diagram shows only a part of the apparatus—as we saw with Fig. 2, it is generally the "invisible components" that cause the trouble. So when studying the circuit diagrams from this point of view, dot in the inter-electrode capacitances and the inductances of the leads to the valves and see if they form possible oscillatory circuits.

Fig. 3(a), for example, looks like an ordinary a.f. output stage

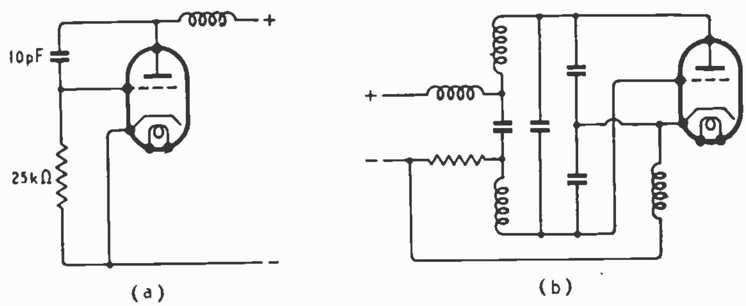


Fig. 2. (a) might be a fragment of almost any triode circuit, and is quite capable of oscillating at a high frequency. If the inductances of the leads and the stray capacitances are shown, it develops into (b).

Parasitic Oscillations—
with two triodes in parallel. There is no intentional or obvious unintentional feedback to cause oscillation, except possibly the anode-to-grid capacitance which, with stray capacitances across the transformers, might make the circuit into a tuned-anode, tuned-grid oscillator. But the natural frequency of the input transformer would almost certainly be in the audio band or thereabouts, so unless the anode-to-grid stray was unusually large it would hardly provide enough feedback.

But the actual wiring layout would probably be something like Fig. 3(b); and when the inductances of the grid and anode leads and the interelectrode capacitances are marked in (Fig. 3(c)) there is no difficulty in recognizing a push-pull v.h.f. oscillator. To have the stage oscillating violently at perhaps 300 Mc/s would be no help towards getting the best out of it as an a.f. amplifier, and the cause of the unsatisfactoriness might be quite hard to locate unless one was on the look-out for parasitic oscillation.

It should now be clear that the exact layout and dimensions of the wiring are often the decisive factors, so that a circuit wired up by one person might be perfectly stable, whereas another constructor's version might oscillate its head off. That is why the anti-parasitic devices prescribed by the designer could perhaps be dispensed with in some sets but not in all. Or why they might turn out to be necessary even though the designer didn't find them so.

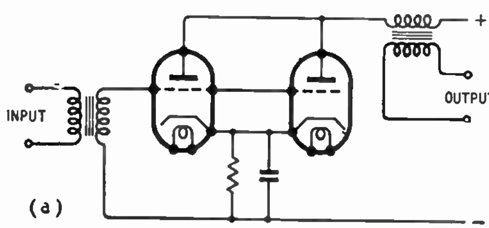
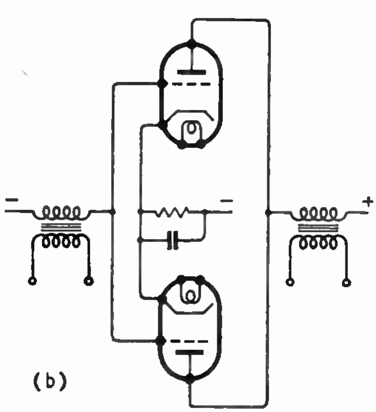
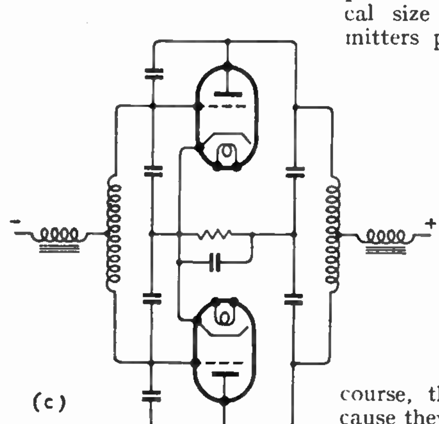


Fig. 3. An apparently harmless amplifier stage (a) with two valves in parallel can be re-drawn as at (b), and if the strays are indicated it is revealed as a push-pull oscillator (c).





If the grid and anode leads in Fig. 3(b) are shortened, their natural frequency is raised. The higher the frequency, the lower the input impedance of the valves, and the smaller the risk of the loop gain being sufficient for oscillation. So one anti-parasitic precaution is to keep the length of leads down, and especially to avoid parallel anode and grid leads. The best that can be done in this direction may not guarantee freedom from very-high-frequency parasites with high-slope valves, but a very effective policy is to lower the Q of any potentially oscillatory circuits by inserting series resistance. The best position for such resistance is at a current anti-node (i.e., place where the oscillatory current would be a maximum); but a more practical rule is to connect it as near the grid pin as possible, which generally comes more or less to the same thing. As for its value, it should be enough to suppress any oscillation, without upsetting the normal working. In receiving circuits, a fairly high value can usually be tolerated, but there is seldom any point in going above about 2,000 Ω. In transmitters where heavy grid current flows it may not be allowable to use more than a few ohms.

When valves are used in parallel—an arrangement particularly liable to parasites—it may be necessary to insert resistance in the other valve leads, too (anodes, screens, etc.), but, of course, the values are restricted. About 50Ω is usual in the anodes of receiver-type valves.

Anti-parasitic grid resistors should not be confused with the considerably higher resistance "stoppers" that are sometimes employed to suppress oscillation in multi-stage amplifiers or to exclude r.f. currents from a.f. stages. They work on a different principle, using the input capacitance of the valve as the other element in a simple RC filter.

You may say that triodes in parellel, as in Fig. 3, are nowadays seldom favoured, for reasons quite apart from parasitic oscillations. But the popular push-pull arrangement is by no means immune; and one should be on guard, especially when using high-slope valves, and in triode transmitting circuits.

Owing to the relatively high powers involved, and the physical size of the circuits, transmitters present the worst parasite problems. In fact, it is taken almost for granted that they will occur in any new design of transmitter, and its delousing is part of the routine. As many as twelve different "modes" of oscillation have had to be suppressed in a single high-power transmitter.

Triodes are, of course, the most vulnerable, because they have to be neutralized, and that is fully effective only at the working frequency, leaving the door wide open at remote frequencies. At much higher frequencies, for example, the inductance of the leads throws it right out. Consider the neutralized push-pull stage in Fig. 4. At very high frequencies, the tuning capacitances, $C_1 C_2 C'_1 C'_2$, are practically short-circuits, joining up the inductances constituted by the grid and anode leads and making a v.h.f. oscillator circuit very much as shown in Fig. 3 (b and c). Try redrawing the circuit on these lines and see. What the neutralizing capacitors will do depends on how much inductance their leads present, and whereabouts on the grid and anode leads they are connected.

Incidentally, it must be remembered that, owing to the inductance of quite short leads, it is possible for parts of the circuit that are supposed to be earthed to attain quite high r.f. potentials.

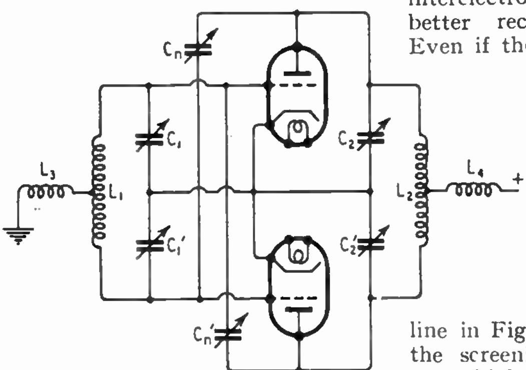


Fig. 4. This push-pull oscillator, if scrutinized on the same lines as Fig. 3, shows itself capable of oscillating at higher and lower frequencies than that intended.

At a frequency much lower than the working frequency, L_1 and L_2 are practically short-circuits, and we are left with a tuned-grid, tuned-anode circuit in which L_3 and L_4 are the tuning coils and the two valves are effectively in parallel, with C_n and C_n' adding to the other feedback capacitance. This dire possibility is easily avoided, however, by suitably proportioning L_3 and L_4. One of the favourite transmitter anti-parasitic precautions, in fact, is to put extra inductance in each anode circuit. This may seem to contradict the rule that anode-to-grid capacitance tends to cause oscillation when the anode circuit is inductive. The contradiction is only apparent, however, because if the natural frequency of the anode circuit is lowered (by means of inductance, say) below the natural frequency of the grid circuit, then to oscillatory currents at the natural frequency of the grid circuit, the anode circuit appears capacitive, and oscillation is suppressed.

If that explanation only makes confusion worse confounded, don't worry about it, because several readers have already asked me to deal with this relationship of anode circuit to interelectrode feedback (Miller effect), and I hope to devote an article to it very soon.

People who, because they use tetrodes or pentodes instead of the old-fashioned triode, imagine themselves to be immune from the parasite-provoking effects of interelectrode capacitance, had better reconsider the matter. Even if they have taken care to exclude stray capacitances outside the valve (C_1 in Fig. 5), which might nullify the screening inside the valve, there is the question of inductance in the screen bypass circuit, marked in heavy line in Fig. 5. This may render the screening null and void at very high frequencies. It has even been known for the screen to act as an anode and oscillate with the grid.

Well, of course, one could go on indefinitely showing how various circuits might be capable of oscillating somewhere in the vast range of frequency, but I hope the general principles are clear enough by now to make this unnecessary. There are, however, one or two special types of oscillation that do not depend on feedback.

First there is the comparatively little-known Barkhausen type of oscillation, which I need not say much about because its unauthorized occurrence is confined mainly to high-power transmitters, and is of minor importance even there. It is a transit-time effect, generating centimetre-length waves when the grid is positive and the anode around zero potential.

Then there is the dynatron, depending on secondary emission, which in certain circumstances can cause what amounts to negative resistance, capable of neutralizing the resistance of any tuned circuit and making it oscillate. An ordinary tetrode displays this

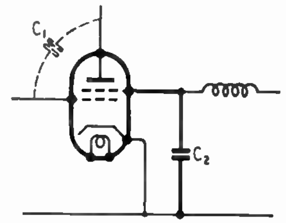


Fig. 5. Before a screened-grid stage can be assumed free from liability to oscillate through back-coupling, attention should be paid to external stray capacitance (C_1), and the inductance of the wiring drawn in heavy line.

effect when the screen grid is held at a higher voltage than the anode. Any reasonably low-loss circuit in series with the anode will then oscillate. Similar conditions sometimes arise in transmitters, whenever the grid runs positive at the peak of its swing and the anode is simultaneously at its least positive. Parasites generated in this way belong to the class that occur during only a portion of the working cycle, and are thereby much more difficult to trace because they usually disappear altogether when the signal is shut off.

A particularly obscure case of this kind was revealed some years ago.* It occurred in audio output stages, and caused an irritating "buzz" in the loudspeaker, but only when low notes were being reproduced. One would naturally tend to suspect filings or other impediments in the path of the loudspeaker cone; but the trouble was found to be due to the output valve. Finally the cause was traced to the metallic film deposited on the inside of the bulb during its evacuation. Sometimes there was leakage between it and the anode, which raised it to a high potential and enabled it to act as a secondary-emission electrode. At certain phases in each low-frequency cycle its potential would click over suddenly, giving rise to a disturbing transient.

A rather similar phenomenon in vacuum-type, metal-filament

* K. A. Macfadyen, *Wireless Engineer*, June, 1938, p. 310.

Parasitic Oscillations—

lamps was responsible for short-wave interference that was found to be coming from them. Although too thin to see easily, a semi-conducting film of evaporated tungsten does exist on the inside of the bulb in such lamps, and can act as a generator of parasitic oscillations. These oscillations are not of the continuous-wave type we have been considering, but are more like the interference discussed in the April issue, due to switching and other transients.

In this connection it must be remembered that even damped oscillations can be a nuisance. A parallel-feed choke in the anode circuit, for example, may be quite free from any circumstances tending to maintain it in continuous oscillation, but if normal working causes the anode current to be frequently and suddenly varied it may shock it into damped oscillation each time, perhaps at some frequency capable of causing interference.

And that raises the question of the harm that can be wrought by parasites. Interference, as we have just seen, is one possible nuisance. Distortion, rattles or buzzes, whistles, general noise, reduced output and efficiency, excessive anode current, leading to short life of valves, are some of the results in receivers and amplifiers. In transmitters, parasites are not only more likely to occur, but their effects are more serious. Besides causing interference, they can run away with a lot of the power that ought to be going into the proper frequency; they can modulate the carrier wave; and (perhaps worst of all) can cause highly expensive valves to die prematurely by overheating the seals or starting a flash-over.

Leaving out of account high-power transmitters, which are managed by persons who would hardly look to me for guidance, how can we detect parasites?

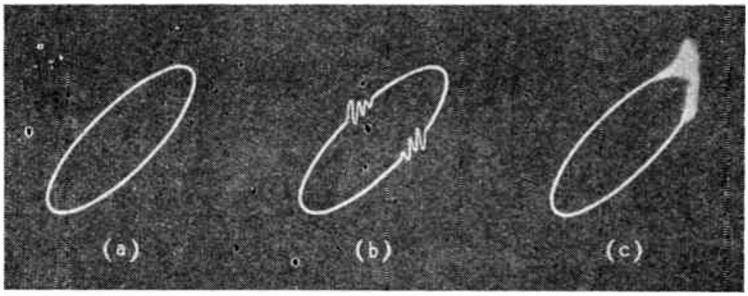


Fig. 6. At (a) is shown a typical signal trace on an oscilloscope when X and Y plates are connected respectively to input and output of an amplifier. (b) is an example of a transient parasite, and (c) a sustained oscillation; both occurring only at particular phases of the signal cycle.

The most usual clue, I find, is given by the anode current meter. Even if one is not fitted in the final circuit, it is (or should be) included in the experimental version. If the readings are not quite what they should be, and vary erratically—especially when moving things about near the grid circuit, or touching it—then parasitic oscillation should be suspected. The corresponding audible symptoms may be an excessive noise level, and clicks as the circuits are touched or approached. In apparatus where the power to the valves is about 10 watts or more it may be possible to detect and locate parasites by moving a small neon-tube around.

The intermittent sorts that occur at particular phases of the signal cycle are more elusive, and a cathode-ray oscilloscope is almost indispensable. When a stationary picture of the signal is put on the screen, as in Fig. 6, this type of parasite can generally be seen as a "blip" or haze growing out of the normal trace. Before oscilloscope monitoring became part of the normal procedure when trying any new circuit, much perplexity and dissatisfaction was probably due to unsuspected parasites. Now, this sort of trouble can generally be seen quite clearly, and the effectiveness of remedies checked.

Summarizing these remedies, resistance close up to the grid (and perhaps other electrodes) is the most generally useful, in conjunction with an enlightened policy of laying out of the circuit.

REPRINTS OF ARTICLES

A LIST of articles which have appeared in *Wireless World* recently and of which reprints are now available is given below. The date of the original article is given in brackets. They are obtainable from our Publisher, Dorset House, Stamford Street, London, S.E.1. The price in parentheses includes postage.

Ex-Government Valves and C.R. Tubes. List giving valve type designations and their commercial equivalents (August, 1945), together with the characteristics of some ex-Service c.r. tubes (December, 1947). 6d (7½)

Ex-R.A.F. Communication Receiver. Modifications to the R1155 for civilian use (July, 1946). 6d (7½d)

Quality Superheterodyne. Design for a nine-valve receiver. By S. A. Knight (December, 1947). 6d (7½d)

Television Receiver Construction. Details for building a straight vision receiver and a sound channel (up to the detector), sync separator, line and frame time-bases and power supply unit (January-December, 1947). 2s 6d (2s 9d)

General-Purpose Oscilloscope. Modifications for converting an ex-Government radar unit such as the Admiralty Type 6A or 6B and the R.A.F. Type 10QB/24. By J. F. O. Vaughan (May, 1948). 9d (10½d)

Copenhagen Frequency Allocations. Complete list of European medium- and long-wave stations showing the frequencies allotted in the Copenhagen Plan which comes into operation on March 15th, 1950 (November, 1948). 6d (7½d)

Cathode-Ray Oscilloscope. Design for a general-purpose instrument with a three-valve time base, single-valve amplifier and two-valve wobbulator. By S. A. Knight (December, 1948). 6d (7½d)

Television Superheterodyne Unit. Constructional details for a long-range receiver for reception of Alexandra Palace transmissions (February and March, 1949), with a map showing the service area of A.P. (February, 1949). 2s 6d (2s 8d)

Midget A.C. Mains Receiver. Details of a two-valve medium-wave portable. By S. W. Amos. (March, 1949). 6d (7½d)

High-Quality Audio Amplifiers. A composite reprint of the following articles: "*Wireless World* A.C./D.C. Quality Amplifier"—two-valve circuit giving 2 watts from the output pentode (December, 1945); "*W.W.* Quality Amplifier"—circuit details for 4-, 8- and 12-watt designs (January, 1946); "Push-Pull Phase Splitter"—high-gain amplifier circuit, by E. Jeffery (August, 1947); "High-Quality Amplifier Design"—unit with push-pull tetrodes in the output stage, by P. J. Baxandall (January, 1948); "Economical 50-watt Amplifier"—circuit with KT66 output valves in push-pull, by G. R. Woodville (December, 1948). 2s 6d (2s 8d)

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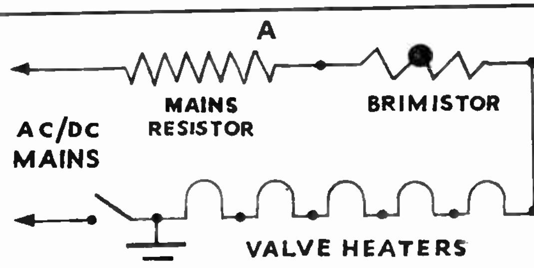
Diagram "A" shows the correct positioning of a Brimistor in the average circuit.



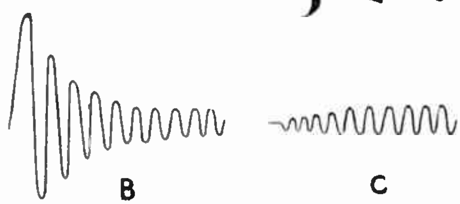
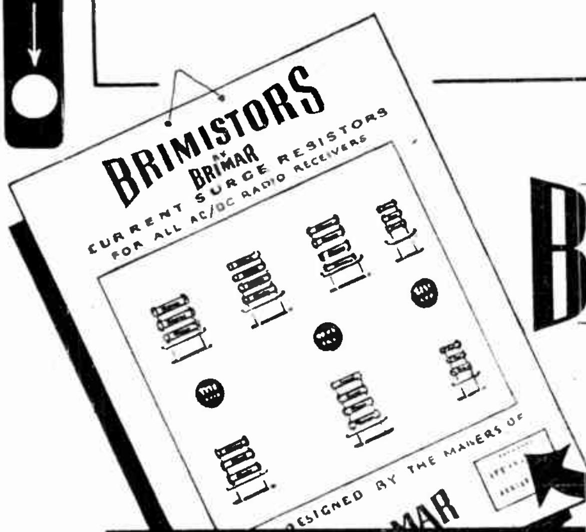


Diagram "B" shows an oscillogram of the normal 'switch-on' surge which damages valves and dial lights.

Diagram "C": this oscillogram shows the gentle rise of BRIMISTOR controlled current and complete surge suppression.



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CONTRAST EXPANSION

A Review and Some Further Notes

By L. J. WHEELER

In the manufacture of commercial gramophone records, limits are imposed on the range of contrast between the loudest and quietest passages. These limits are mainly physical in nature and are related to the combined necessities for maintaining a satisfactory signal/noise ratio and retaining adequate playing time at the standard speed of 78 r.p.m. with the existing groove size. A similar restriction, of course, applies in the case of radio transmissions, but the useful contrast range is greater and the upper limit is produced by the necessity for avoiding over-modulation of the r.f. carrier.

The greatest contrast between minimum and maximum volume of a full symphony orchestra is of the order of 70 db, and if such a range were used in cutting a record, and maximum cutting stylus velocity (corresponding to maximum amplitude of the signal being recorded) were set to the limit after which break-through of the groove walls occurs, then the amplitude of the quietest cut would be nearly comparable with the physical particle size in the finished pressing, with consequent very low signal/noise ratio. Alternatively, if minimum amplitude is to give a satisfactory signal/noise ratio, then maximum amplitude will cause break-through of the groove walls. In practice the upper limit is generally restricted manually by an engineer who, with the aid of a copy of the score, does his best to anticipate the advent of any crescendos and reduces the gain of the recording amplifier accordingly, the resultant contrast range being of the order of 45 db. Thus an expansion of 25 db is necessary for complete correction, although as far as one's neighbours are concerned this figure is apt to have too high an annoyance factor, and from 12 to 15 db is preferable. Accurate restoration of the original contrast is virtually impossible by automatic means unless a monitoring signal accompanies the required intelligence; or until such time as the compression is introduced automatically to some well-defined and published law. The author would like to stress the fact here that the foregoing does not apply to *all* recordings or transmissions, as compression is unnecessary if the greatest range of contrast is within the powers of the transmission medium, as is the case of the solo violin, solo piano and similar items. In fact a contrast expandor carelessly used on such recordings can, and will, completely ruin the reproduction.

Although contrast expansion, as produced by the use of any of the following circuits, can, at best, be only a compromise, judicious employment of the advantages it has to offer will considerably enhance the reproduction of quite a number of recordings and radio transmissions.

The simplest type of contrast expandor is that which uses one or more lamps, shunted or arranged in a bridge circuit, across the secondary winding of the output transformer. Whilst effective to a small degree, these circuits offer little or no control over the amount of expansion available, or any of its characteristics, and the expandor itself consumes a fair amount of the audio power available for driving the loudspeaker. Although lamps have been suggested in feedback circuits, the power demands remain the same, and there is the invariable delay due to the thermal inertia of the lamp filament. The most satisfactory system is one that behaves as a voltage-operated device, and can consequently be included in the signal chain without drawing power from it. Numerous such systems employing valves have been developed in the past, and it is the author's intention to review them briefly, discussing their respective merits as experienced in practice, and to describe a unit which has enabled considerably greater satisfaction to be obtained from the reproduction of gramophone records.

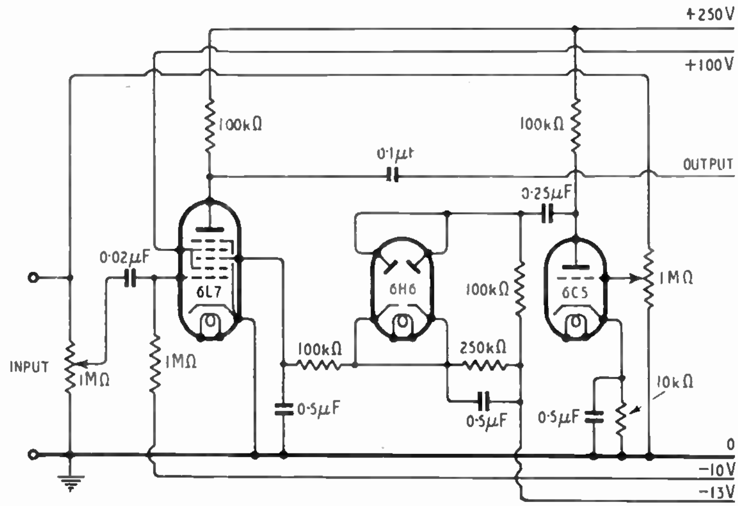


Fig. 1. Controllable-gain amplifier making use of a pentagrid valve.

Modern contrast expandors consist of two parts, a controllable-

Contrast Expansion—

gain amplifier, which must under all conditions introduce the absolute minimum of hum or distortion, and a means for obtaining a voltage proportional to the instantaneous value of the signal envelope, and with which the gain of the amplifier section may be controlled, together with the components for producing the necessary delay constants, control of the amount of expansion used and determination of the level at which expansion begins. It is an accepted fact that, for most realistic results, the time constant for the increase of gain shall be no greater than 20-25 milliseconds, although for the decline a time constant of up to 2-3 seconds is desirable, both to maintain the gain in staccato passages, and to improve the "liveliness" of the reproduction by not accentuating the decay of reverberation.

An obvious choice of circuit for the controllable-gain amplifier is, despite its disadvantages, one using a variable-mu valve, and most of the early expandors were designed around such valves as the 6L7, the gain of which can be controlled by an electrode other than that which handles the signal. A typical example, shown in Fig. 1 (reproduced from "The Radio Designer's Handbook" by F. Langford Smith), operates on the principle that the gain of the 6L7 is a function of the bias applied to its control grid g_3. This d.c. bias is proportional to the amplitude of the signal and is obtained from it by the 6H6 rectifier. In order to obtain a sufficient voltage to produce the required change in g_m of the 6L7, and to prevent the diode imposing a load on the signal source, a separate amplifier (6C5) is provided for the 6H6; the amount of expansion being controlled by the potentiometer in the grid circuit of the 6C5. The time constant for the increase of the gain is 50 milliseconds, and for the decline nearly four times that amount; no control of the point at which expansion commences is provided.

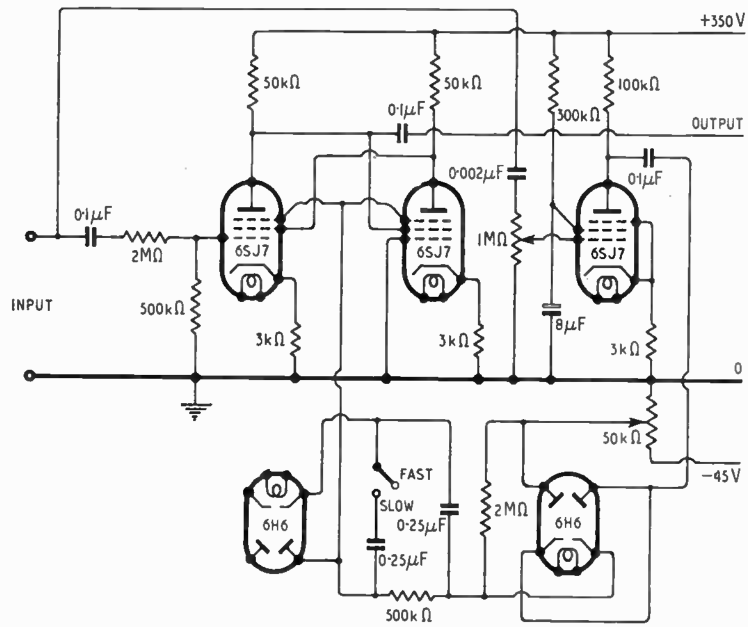


Fig. 2. Cross-connected pentodes are used in this circuit to remove distortion arising from changing anode current.

This circuit, whilst quite successful, has a few disadvantages, not the least important of which is the necessity for supplying two values of negative bias which must *not* vary with changes in the anode current of the expandor valve. The expandor itself introduces a new component into the output waveform which is due to the change in anode current of the 6L7 with changing bias from the 6H6. This can be a very disturbing factor if the amplifier which follows the expandor has a particularly good bass response. Additionally, and this applies to numerous other expandors, the rectifier is a half-wave unit and further distortion can occur due to poor smoothing of the control voltage on g_3 of the 6L7, necessitated by the importance of maintaining a short time constant in the network between the 6H6 and the 6L7. It can best be judged how unpleasant this form of distortion is, when it is realised that it comprises a partially rectified version of the signal introduced into the output! In fact it is very much worse than the periodic fluctuation of the 6L7 anode current, which can be ameliorated by arranging for the amplifier to have a sharp cut-off below about 40½ c/s.

A later circuit, by A. Nelson Butz, Jnr. of the Pennsylvania State College, U.S.A. (*Electronics*, September, 1946), quite satisfactorily disposes of the distortion component due to the changing anode current of the controlled valve (in this case a pentode controlled from its suppressor grid) by applying the control voltage to the suppressor grid of a second dummy pentode, the anode

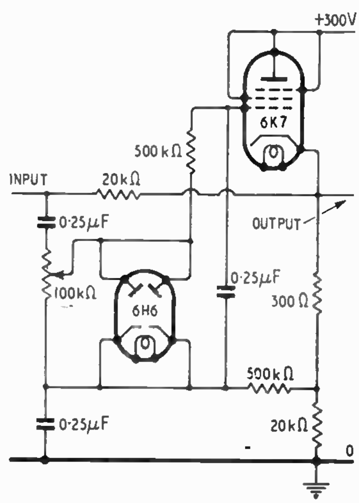


Fig. 3. Cathode-follower contrast expandor.

and screen of which are cross-connected to the corresponding electrodes of the signal amplifier.

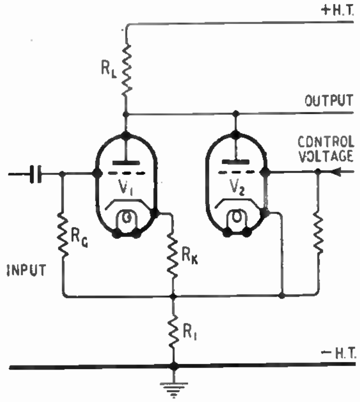


Fig. 4. Contrast expansion by negative feedback. V_2 and R_1 constitute the control potential divider.

If the bias on g_3 of a pentode is varied the change in anode current is opposite to the change in screen current; hence, by cross-connecting the screens and anodes of two pentodes the net change in the anode current of whichever is the signal amplifier can be reduced to zero, or negligible proportions, by an equal and opposite change in the screen current of the dummy valve, assuming the appropriate circuit constants and correct choice of valves. The author's experiments with this circuit, shown in Fig. 2, have proved the claims with regard to the removal of the fluctuating d.c. component from the output, and, due to the low g_3-a mutual conductance of the 6SJ7, the failings of the half-wave rectifier are nothing like so apparent. The amount of expansion available, however, has been found to be somewhat restricted, and a steady supply of -45 volts has to be produced either from the h.t. or from a separate source.

Another very satisfactory method of removing the pulsing component due to the changing anode current of the controlled valve is to use two such valves in push-pull. If their signal grids are fed out of phase and the expansion control grids in phase, the fluctuating anode current is in the same direction for both valves and is consequently cancelled out in the expandor output transformer. The cost of the unit however, is increased by the cost of this transformer.

An oft-alleged disadvantage of contrast expandors is based on the fact that, owing to the difficulties attendant on electronically controlling the gain of high-level amplifiers with their large grid and anode voltage swings, the expandor must be introduced at a low signal level with the consequent risk of hum and similar troubles. The majority of contrast expandors are designed to operate on an input of the order of 0.25 volts, but an interesting design (due to M. O. Felix, and previously published in *Wireless World*[1]) is that shown in Fig. 3. It is extremely simple in operation, requires only two valves and functions with an input of the order of 20 volts. However, owing to the desirability of providing volume and tone control circuits in the early stages of amplifiers, use of this expandor calls for major rearrangements of the circuit with which it is to be used.

[1] March, 1944

It is probably not surprising that later developments of contrast expandors should revolve around circuits employing negative feedback. This panacea for almost all amplifier "ills" has long since ceased to be a plaything for the few and is now generally accepted as an essential and integral part of any equipment having any claims to high fidelity or consistency of operation. The next logical step was to apply its abilities to what, for want of a better name, we can call "unusual" circuits, i.e., really flexible tone controls, specialised circuits for measuring equipment, and the like.

The methods of using negative feedback to effect contrast expansion have previously been

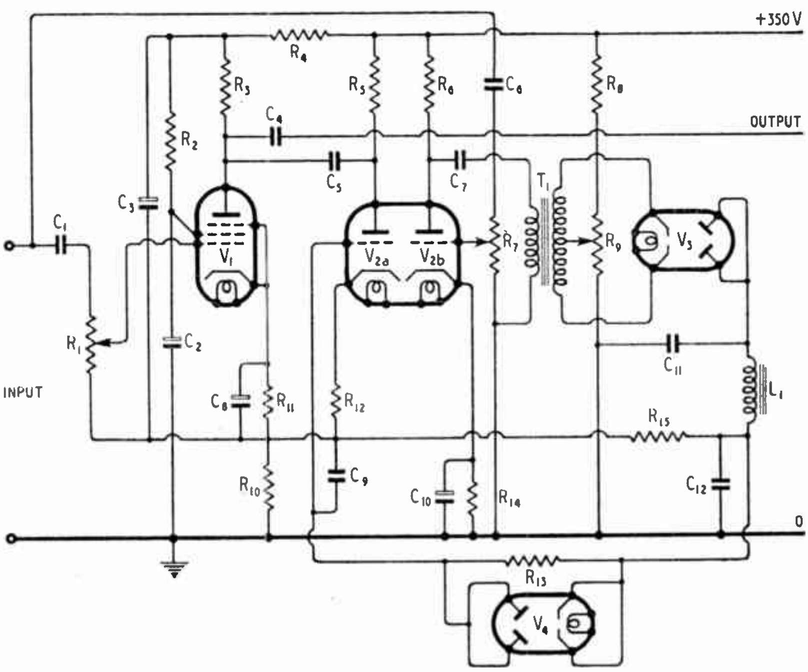


Fig. 5. Modified negative feedback control circuit used by the author. Components are as follows: R_1, 1MΩ; R_2, 330kΩ; R_3, 100kΩ; R_4, 22kΩ; R_5, 100kΩ; R_6, 56kΩ; R_7, 1MΩ; R_8, 270kΩ; R_9, 100kΩ; R_{10}, 220Ω; R_{11}, 2.2kΩ; R_{12}, 330Ω; R_{13}, 2MΩ; R_{14}, 3.3kΩ; R_{15}, 1MΩ; C_1, 0.1μF; C_2, 8μF; C_3, 8μF; C_4, 0.1μF; C_5, 0.1μF; C_6, 0.1μF; C_7, 0.25μF; C_8, 50μF; C_9, 1μF; C_{10}, 50μF; C_{11}, 0.05μF; C_{12}, 0.1μF; V_1, EF37; V_{2a}, V_{2b}, ECC34; V_3, V_4, EB34; T_1, 1 : 2 midget a.f.; L_1, 40/60H midget.

Contrast Expansion—

discussed by J. G. White[2] and it will be sufficient here to outline the basis very briefly. Fundamentally, feedback is applied over an amplifier by means of a potentiometer in which the relation between the two sections can be varied by the application of the control voltage derived from the signal; thus varying the amount of feedback and hence the overall gain. Obviously this can be achieved by making one section of the potentiometer a valve and altering its impedance by variation of its grid potential. This is shown in simple form in Fig. 4, in which V_1 is the amplifier and negative feedback is obtained from the potentiometer formed by the anode-cathode impedance of V_2 and R_1, the former being variable by a voltage applied to the control grid of V_2. Negative current feedback, due to R_1 alone, also exists and reduces the amount of expansion obtainable, as well as materially increasing the effective input impedance of V_1. As previously shown by J. G. White, this disadvantage can be offset by returning the "earthy" end of V_1 anode decoupling capacitor to the junction of R_1, R_k and R_a provided that the decoupling resistor is large compared with R_1.

² *Wireless World*, Sept. and Oct. 1946

In the author's circuit, shown in Fig. 5, a pentode is used for V_1 as a greater ratio between the gains with and without feedback is obtainable with this type of valve, due to its initially higher amplification capabilities. It has been found experimentally that a small degree of cathode bias is necessary for V_2; the omission of this bias causes the grid circuit of the V_2 to impose a load on the rectifier system until the output of the latter is sufficient to prevent the flow of grid current in V_2, with the result that the amount of expansion is small up to a certain level and then increases rapidly, giving rise to an unpleasant "snatching" effect. The value of this bias resistor also determines the maximum amount of expansion for a given input to V_{2b}, a higher value reducing the expansion.

The rectifier for supplying the control voltage is a straightforward full-wave circuit, with the exception that, as a negative voltage is required, the double-diode is reversed; the only component at all unusual in this application being the 40/60-henry choke in the "smoothing" circuit. This can be of the miniature hearing-aid output variety designed to maintain its specified inductance at 0.2 mA, d.c. Whilst the presence of this inductance in the charging circuit of the 1 μF condenser in the grid circuit of V_{2a} does tend to increase slightly the time taken for the gain to increase, its greatly increased efficiency in removing all traces of the expansion voltage from the output more than compensates for this.

The required difference in the time constants for the rise and fall of the gain is produced by the inclusion of V_4 and its parallel 2MΩ resistor in series with C_9. When V_3 conducts, a negative voltage is produced at its anodes and applied to the grid of V_{2a} via V_4 which is also conducting and therefore of low enough resistance effectively to short-circuit R_{13}. The discharge path for C_9 is, of course, through R_{13} (V_4 now being non-conductive) and R_{15}. In practice the time constant for the increase in gain for a 5-millisecond transient is 18 kΩ × 1.15 μF or 20 milliseconds approximately, and whilst this does represent distortion of the transient it is in practice inaudible. For the decline the values are 3MΩ × 1 μF or 3 seconds.

The fact that the diode V_4 must, of necessity, be shunted by a 2MΩ resistor, leads to the conclusion that a metal rectifier could be substituted for these two components. Experiments along these lines have shown that a Westector type W2 forms an ideal substitute. Negligible change in characteristics resulted from this modification, and the Westector is considerably less expensive than the 6H6, valve-holder and resistor. There is also a saving in heater current requirements.

From the foregoing the author was naturally led to try replacing V_3 with metal rectifiers, and Westectors type W4 proved satisfactory for this purpose, two such units, of course, being required.

The degree of expansion obtained depends on the setting of R_7, and the level at which expansion commences is determined by the delay voltage applied to the cathodes of V_3 by the poten-

TABLE

Input, V_1 (Volts, r.m.s.)	Input, V_{2b} (Volts, r.m.s.)	Output, V_{2b} (Volts, r.m.s.)	Delay on V_3 (Volts)	Output, V_3 (Volts)	Anode current, V_{2a} (mA)	Output, V_1 (Volts, r.m.s.)	Gain, V_1 (db)
0.1	—	—	—	—	3.1	0.9	19.1
0.25	—	—	—	—	3.1	2.25	19.1
0.5	—	—	—	—	3.1	4.5	19.1
1.0	—	—	—	—	3.1	9.0	19.1
0.1	0.1	1.0	—	1.0	3.0	1.0	20
0.1	0.5	5.0	—	5.0	2.5	1.1	20.8
0.1	1.0	10.0	—	10.0	1.9	1.2	21.6
0.1	2.0	20.0	—	20.0	1.0	2.0	26
0.1	4.0	40.0	—	40.0	0.17	4.0	32
0.1	0.1	1.0	1.0	—	3.1	0.9	19.1
0.1	0.5	5.0	1.0	4.0	2.6	1.05	20.4
0.1	0.5	5.0	5.0	—	3.1	0.9	19.1
0.1	1.0	10.0	5.0	5.0	2.5	1.1	20.8
0.1	1.0	10.0	10.0	—	3.1	0.9	19.1
0.25	2.5	25.0	10.0	15.0	1.5	4.0	24.1
0.5	5.0	50.0	10.0	40.0	0.17	20.0	32
1.0	10.0	100.0	10.0	90.0	0.05	48.0	33.6

tiometer R_9 in series with R_8 across the h.t. supply. The table shows the relationship between input and output voltages in the expandor for varying values of input delay voltage, and the relative settings of R_1 and R_7.

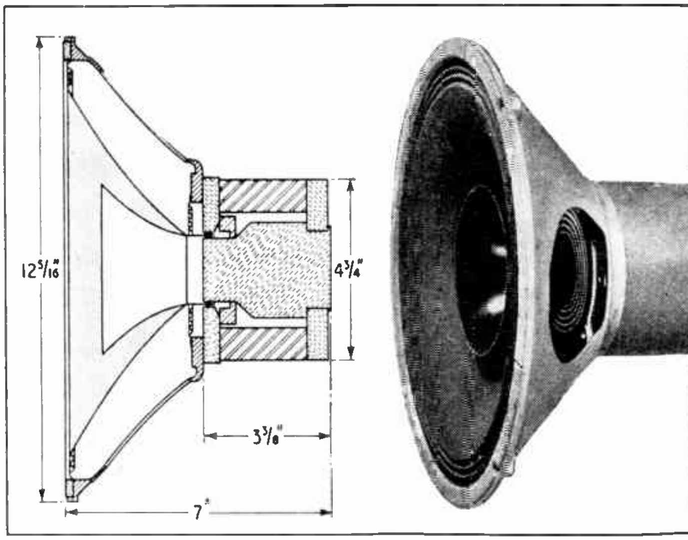
HIGH-FLUX LOUDSPEAKER

Details of the Goodmans "Axiom 22"

THE trend towards the use of higher flux densities in loudspeakers designed for high-quality reproduction is well exemplified by the new Axiom 22 made by Goodmans Industries, Lancelot Road, Wembley. So far as the diaphragm is concerned, it is the same as the Axiom 12 and has twin curved-sided cones with a reinforced edge to the high-frequency cone. The back centring device consists of a porous bakelized linen diaphragm with concentric corrugations.

The ring type magnet makes use of one of the new high-performance alloys, and by careful design of the poles the flux density has been raised to 17,500 gauss. This is in a gap 1.15mm wide, 7.8mm deep, with a nominal pole diameter of 44mm.

We have had an opportunity of hearing the Axiom 22 with an Axiom 12 as reference standard, and there can be no doubt of the improvement conferred by the increased flux density. Sensitivity is of course higher, but the outstanding impression is one of tautness and the grip the Axiom 22 has on transients. The increased magnetic damping is no doubt also responsible for an apparent reduction in intermodulation from self-generated transients, and a consequent improvement in "presence" and the segregation of the instruments of the orchestra. The Axiom 12 is a very good loudspeaker, but the "22" is quite definitely better. The price is £12 13s.



Goodmans "Axiom 22" loudspeaker. The sectional drawing shows the general arrangement of the ring magnet and polepieces.

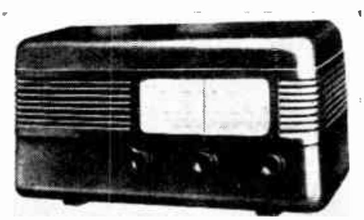
1949 A.R.R.L. HANDBOOK

THIS is the twenty-sixth edition of the Radio Amateur's Handbook, issued by the American Radio Relay League, West Hartford, Connecticut, U.S.A. It is written for radio amateurs and covers a very wide field, with a nice balance between transmission and reception techniques. Its 605 pages of technical matter includes 1,651 illustrations, charts and tables, and they are divided into 25 chapters each dealing with a specific subject. For example, chapter 5 is h.f. receivers, chapter 13 is v.h.f. transmitters, and chapter 19 deals with the elimination of interference with broadcast.

Most of the chapters have been revised with new material and equipment replacing some of the old. This is particularly the case in the v.h.f., microwave and aerial equipment chapters. Finally, a word must be said about the very comprehensive valve data, no fewer than 52 pages being devoted to this.

The handbook is obtainable in this country from, among others, A. F. Bird, 66 Chandos Place, London, W.C.2, the price being 15/6 (16/3 by post), or it can be ordered through The Radio Society of Great Britain, New Ruskin House, Little Russell Street, London, W.C.2, and the price, for delivery from America, is 12/6, including postage.

SMALL MAINS RECEIVER



Operating from a.c. or d.c. mains this new Model 47X four-valve receiver by Pye, Cambridge, measures 13¼in × 6¾in × 5¾in and costs £11 9s. 5d. including tax.

NEWS FROM THE CLUBS

Birmingham.—The meeting of the Slade Radio Society on June 10th will be addressed by Dr. W. Summer on the subject of electro-medical instruments. Meetings are held on alternate Fridays at 8.0 at the Parochial Hall, Slade Road, Erdington. Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23, Warwicks.

Catterick.—Meetings of the Catterick Amateur Radio Club (G3CIO) are now held on Wednesdays at 7.30 in Catterick Camp. Sec.: G. R. Styring, c/o 2 Squadron, I.T.T.K., Royal Signals, Catterick Camp, Yorks.

Derby.—New headquarters are being sought by the Derby and District Amateur Radio Society which at present meets on alternate Wednesdays at 7.30 at 119, Green Lane, Derby. Sec.: F. C. Ward, G2CVV, 5, Uplands Avenue, Littleover, Derby.

Exeter.—Meetings of the Exeter and District Radio Society are now held in the club's new headquarters at 9, Palace Gate, Exeter, on Thursdays at 7.30. Sec.: E. G. Wheatcroft, 34, Lethbridge Road, St. Loyes, Exeter, Devon.

Reading.—An instructional section of the Reading Radio Society has been formed for newcomers to amateur radio. Club meetings are held on the second and fourth Saturday of each month at 6.30 at Palmer Hall, West Street, Reading. Sec.: M. Hill, G2FZI, 997, Oxford Road, Reading, Berks.

Southend.—In preparation for a d.f. contest between the Romford and Southend radio societies, members of the latter are taking part in a walking d.f. practice at Belfairs on July 17th. Sec.: J. H. Barrance, M.B.E. (G3BUJ), 49, Swanage Road, Southend-on-Sea, Essex

"Q"-METER CONTROVERSY

What Are We Trying to Measure?

IT is curious that although the "Q" Meter has been well known and used by radio engineers for some years, the article by H. G. M. Spratt in the January 1949 *Wireless World* was, to my knowledge, the first account of this nature to be published in any English-speaking technical journal.

My chief purpose is to raise a question of nomenclature, but in order to make the case it will be necessary to try to clear up certain prevalent misconceptions, not only about the functioning of the instrument, but also as to the meanings of the terms "Q" and circuit magnification. A second purpose is to present (in the appendix below) some theoretical considerations which may also serve to clear the mind as to the way the instrument functions.

The proposals will be stated first, so that the proposed terms can be used in what follows.

(a) "Q" is one of the most inelegant terms yet thrust into the English language on the other side of the Atlantic. The alternative suggested is Q-factor which, although only half-way to perfection, at least has some degree of acceptance already, since it appears in the British Standards Institution Glossary. The proper place for "Q" is, of course, in algebraic equations.

(b) The instrument should be called a circuit magnification meter, because it works by measuring the magnification of a circuit of which the impedance being measured forms a part. Again, a strong precedent for this exists, as the British firm which introduced the instrument to this country so called it, and still does.

Q-factor.—This is a property possessed by every two-terminal network, and its value varies with frequency. It is correctly defined by Mr. Spratt in the first paragraph of his "Fundamental Considerations" as the ratio of energy stored to energy dissipated in the network. With the remainder of this paragraph the writer does not wholly agree, as there seems to be some confusion between Q-factor and circuit magnification. The writer's view is as follows.

An equally valid, and perhaps more useful, definition of Q-factor is the tangent of the phase angle (ϕ) of the network; i.e., the angle between the applied voltage and the resultant current, reckoned positive when voltage leads current. Thus $Q = \tan.\phi$, and Q and ϕ are real and of the same sign. In the special case of a network which consists of a pure resistance (R) and a pure reactance (X), it is then easily seen that, when these are in series, $Q = X/R$. If however the components are in parallel, $Q = R/X$. Thus the statement that Q-factor is reactance/resistance needs some qualification.

Mr. Spratt later states, not without precedent, "the effective Q . . . whose value differs slightly from that of the real Q." Now the Q-factor of a coil, or any other

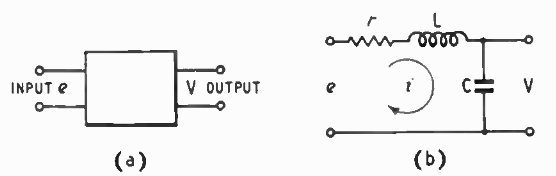


Fig. 1. Circuit magnification.

two-terminal impedance, at a given frequency, is as measured at its terminals. The same is true as to its reactance, impedance, or whatever other parameter we may find it convenient to use and measure. Nothing is more real than this. The writer has yet to find any practical, or even theoretical, use for the so-called "real Q" of a coil, and suggests that it is a misleading notion and best forgotten.

A common misstatement (from which Mr. Spratt is absolved), which is freely indulged in by an American "Q-meter" manufacturer, is that the Q-factor of a certain coil is so-and-so, or is approximately so. This is meaningless unless the frequency, or limits of frequency, are stated. At low frequencies the Q-factor of a coil will be proportional to frequency ($\omega L/R$) but as the frequency is raised it rises less steeply, and flattens out to a broad maximum in the region of half the frequency at which the coil is self-resonant. At the self-resonant frequency, $Q = 0$, and at still higher frequencies it becomes negative, the reactance of the coil then being capacitive. It is thus nonsense to assign any one value for the Q-factor of a coil.

Circuit Magnification.—Circuit magnification (m) is a property possessed by every four-terminal network, and also varies with frequency. When it is less than unity it is called attenuation, but this is basically the same. It may be defined as the scalar ratio of the voltage output to the voltage input, at a given frequency. Thus in Fig. 1(a) $m = |V/e|$, and is always real and positive.

The particular case with which we are constantly concerned in circuit magnification meter measurements is shown in Fig. 1 (b). When the capacitor is varied slowly through resonance the voltage output will pass through a maximum value. It is this maximum voltage, calibrated in terms of circuit magnification, which is, in fact, measured by the meter, and which we will denote by M. It is shown in the appendix below that the Q-factor of the coil is then correctly given by $Q = \sqrt{M^2 - 1}$, but that in practice $Q = M$ numerically within the limits of error of the instrument.

Thus within certain limitations a commercial instrument will give a direct reading of the Q-factor of a coil. If this were its only application, the term "Q-factor meter" might be defensible, but the instrument can handle a much wider field of measurement, as Mr. Spratt rightly shows. The writer fails to see why he should

"Q" Meter Controversy—

measure, say, the attenuation constant of a cable with a Q-factor meter, but can see clearly how this might be achieved with a circuit magnification meter.

P. H.

APPENDIX.

In Fig. 1(b), r and L are the equivalent series circuit, at the frequency of measurement, of a coil whose Q-factor is being measured. For a small change of frequency, as when tuning through resonance, it may be assumed that these values are constant.

Now

$$i = \frac{e}{r + j(\omega L - 1/\omega C)}$$

and

$$V = \frac{i}{j\omega C} = \frac{e}{j\omega C[r+j(\omega L - 1/\omega C)]}$$

$$\frac{e}{V} = j\omega Cr - \omega^2 LC + 1$$

$$\left|\frac{e}{V}\right|^2 = \frac{1}{m^2} = (1 - \omega^2 LC)^2 + \omega^2 C^2 r^2 \quad \ldots \quad (1)$$

Differentiating this with C as the independent variable, and equating to zero, we obtain,

$$2\omega^2(r^2C - L + \omega^2 L^2 C) = 0 \quad (2)$$

Inspection shows that the function here is a minimum; i.e., m is a maximum (M). Physically this represents tuning the capacitor to obtain a maximum voltage output. From (2) the conditions at resonance are

$$C = \frac{L}{r^2 + \omega^2 L^2} \quad \ldots \quad (3)$$

and

$$\omega^2 = \frac{1}{LC}(1 - r^2C/L)$$

$$= \frac{1}{LC}(1 - 1/Q^2) \quad \ldots \quad (4)$$

where Q is the Q-factor of the coil.

Substitute the value of C in (3) in equation (1) and we obtain,

$$M = \sqrt{Q^2 + 1} \text{ (M being always positive)} \quad \ldots \quad (5)$$

and

$$Q = \sqrt{M^2 - 1}$$

Here again, only the positive value is possible since the series arm of the circuit must be inductive for a resonance to occur.

In some circuit magnification meter measurements the oscillator is tuned for resonance, the capacitor remaining fixed. It is therefore of interest to find what happens if we differentiate equation (1) with ω as the independent variable. This leads to the curious results,

$$\omega^2 = \frac{1}{LC}\left(1 - \frac{1}{2Q^2}\right) \quad \ldots \quad (6)$$

and

$$M = \frac{2Q^2 + 1}{\sqrt{4Q^2 + 1}} \quad \ldots \quad (7)$$

It remains to try L as the independent variable. Though not usual in practice, this is quite possible physically. This gives results,

$$\omega^2 = 1/LC \quad \ldots \quad (8)$$

and

$$M = Q \quad \ldots \quad (9)$$

In practice no commercial instrument reads a circuit magnification less than 10, and it may be seen in this case that equations (4) and (6) approximate to (8), and (5) and (7) to (9), with an error not exceeding 1 per cent, and certainly inside the limits of error of the instrument.

THE AUTHOR'S REPLY

WHILST agreeing with P.H.'s comments to a large extent, I feel they cannot be accepted *in toto*.

Regarding nomenclature I agree that neither "Q" nor Q-Factor Meter is an elegant name for the instrument but both these terms have now been sanctified by usage and the inclusion of one of them in the B.S.I. Glossary would seem to settle the matter. On the other hand, I am by no means convinced that Circuit Magnification Meter would be wholly acceptable. P.H. upholds this title on the grounds that the instrument "works by measuring the magnification of a circuit of which the impedance being measured forms a part," the circuit referred to being, of course, that of the instrument. If, however, the impedance being measured is a coil and we transfer it to another circuit, the *circuit* magnification will almost certainly be different. Hence the use of this title could be condemned as misleading and we must resign ourselves to the absence of a term defining the instrument accurately, comprehensively and elegantly.

The suggestion that Q-factor can be defined as the tangent of the phase angle of the network must again, I think, be accepted with some reserve for, taking this proposal to its logical conclusion, as the writer has done, we find ourselves faced with a negative Q in the case of capacitive reactances. I cannot recall any reference ever to a negative Q and indeed such a possibility would appear to violate the fundamental conception of Q as the ratio $\frac{\text{Energy stored}}{\text{Energy dissipated}}$. It could not be applied to any passive network but might, analogous to a negative conductance, be applicable to a circuit containing an energy source.

I agree that the determination of the real Q in addition to the effective Q is seldom important. It should be borne in mind, however, that the instrument is expected to measure effective and real inductance as well as Q and the two real values go hand in hand. The usefulness of the knowledge of the real Q is certainly limited if it is proposed to derive from it the value of Q over a wide frequency range. Apart from P.H.'s observations regarding the variation of Q-factor with frequency, there is the change in effective resistance which inevitably occurs at the same time and makes accurate prediction impossible.

I particularly appreciate the analysis included in the appendix. It certainly fills one of the more obvious gaps in the original article.

H. G. M. S.

"Q"-METER ELEGANCIES

Dr. V. A. Sheridan, of British Physical Laboratories, makes these comments on the original article.

I WAS rather surprised that the article on "Q" meters describes in detail a very old type of circuit. It is well known that this arrangement has the disadvantage of using a 0.04-ohm resistance as a "standard." It is extremely difficult, if not impossible, to produce a resistor of this type without an appreciable series reactance, which, naturally, produces large errors at the higher frequencies.

The more elegant approach to

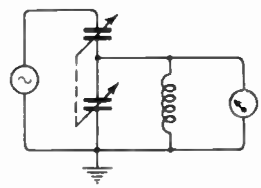


Fig. 2. Injecting r.f. through a ganged feeder capacitor.

the design of Q meters would obviously be to avoid the use of the series resistance. A number of years ago my firm introduced a method, which has since been

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DISTORTION IN F.M.

Selective Delay of the Signal in Tuned Circuits

By THOMAS RODDAM

THE Fat Boy in "Pickwick Papers" has always been a favourite character of mine. He would, I am sure, delight in Fig. 1, which shows the affect of passing a f.m. signal through an amplifier having a tuned circuit in one anode: the i.f. amplifier of the receiver you are building. This is the effect on the audio frequency, not on the carrier,

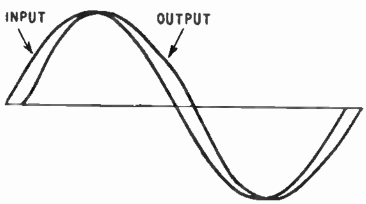


Fig. 1. Effect of tuned circuit on f.m. signal.

and represents quite a lot of distortion. In this article I shall try to explain where this distortion comes from, and how to keep it within bounds: I say try, because the only discussions of this problem which have been published make use of long mathematical analyses which the Editor would consider to be beyond the scope of this journal.

It is usually assumed that f.m. does not involve any distortion problems, except in the discriminator and audio-frequency amplifier. After all, thinks the unwary student, nothing could be more non-linear than the limiter stage, and that is supposed to be a Good Thing. He probably reads the descriptions of transmitters, too, with their Class "C" amplifiers and harmonic generators: once the stuff is frequency-modulated it never seems to go through a linear circuit again. All this is true, although there are some relatively small effects produced by amplitude distortion. Unfortunately there is quite a different source of distortion in an f.m. receiver, and it is not any easy thing to measure without a special set-up. The distortion in f.m. is produced in the inter-stage couplings of the intermediate-frequency amplifier.

In Fig. 2 there is a skeleton diagram of a typical i.f. amplifier stage for 4.3 Mc/s, or whatever you have chosen for your f.m. receiver. The pentode is assumed to act as a current generator, so that the voltage applied to the grid of the second valve is

$$g_m e_g \, (R + j\omega L)/(1 - \omega^2 LC + j\omega CR)$$

where g_m is the mutual conductance, e_g is the input to the amplifier grid, ω is the angular frequency $2\pi f$ and LCR is the anode load shown in the figure. I do not propose to start manipulating this

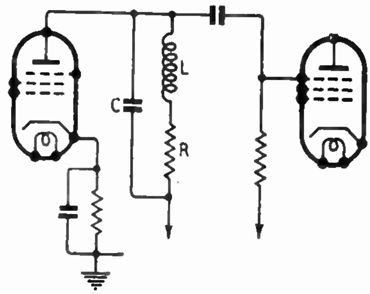


Fig. 2. Skeleton circuit of i.f. amplifier stage.

expression, because that is done in every textbook on circuit theory ever published. What it means, without the mathematics, is that the voltage at the second grid is displaced in phase from the voltage at the first grid by an amount depending on the frequency, in addition to the usual amplitude characteristics of the tuned circuit. This phase characteristic is shown in Fig. 3.

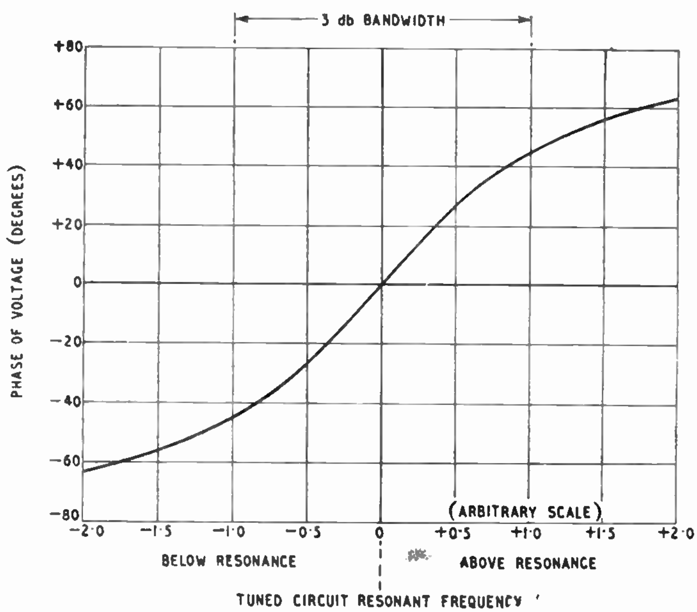


Fig. 3. Phase characteristic of tuned circuit.

"Q" Meter Elegancies—

[*Concluded from page 217*]

used in a number of other commercial Q meters, of injecting the r.f. into the tuned circuit. This is accomplished by means of a series-feeding capacitance, which is ganged with the tuning capacitor. This method, which is used in our instruments, also enables the values of inductance and self-capacitance to be measured directly. This particular method is shown in Fig.2 (see preceding page).

When a signal passes through a network it does not appear at the output at the same instant as it was applied at the input. It is delayed by a time depending on the nature of the network. This is quite obvious if the network is, say, 100 miles of cable, but it is equally true for simple lumped networks, so long as you can find a definition for delay. The delay is equal to the slope of the phase characteristic: a low-pass filter with a 1,000 c/s cut-off has a slope of about π radians /1,000 c/s for low frequencies, so that the delay for a 100 c/s wave, say, is $\pi/2\pi \times 1{,}000$ seconds, which equals $\frac{1}{2}$ millisecond. This sort of thing is used in some voice-operated devices, where, for example, 100 sections with a 5,000 c/s cut-off will be used to delay speech by 10 milliseconds in order to allow the switching operation to take ahead. By using the delay curve of Fig. 4 the waveform shown in Fig. 1 can be plotted. The peaks of the modulation lead the zeros, so that the waveform is distorted as though it had been drawn on an elastic sheet held down in the middle and pulled sideways at the edges in the way shown in Fig. 5. If the circuit is not tuned to the centre frequency, but is off tune, the distortion will be worse, because one half of the wave will swing even further up the curved delay characteristic, and will thus be even more distorted.

Of course, Fig. 1 is greatly exaggerated, like the report of Mark Twain's death. By the time that the waveform had reached this amount of distortion a new trouble would have arisen: as the frequency varies, the amplitude also varies, due to the selectivity of the tuned circuit, and

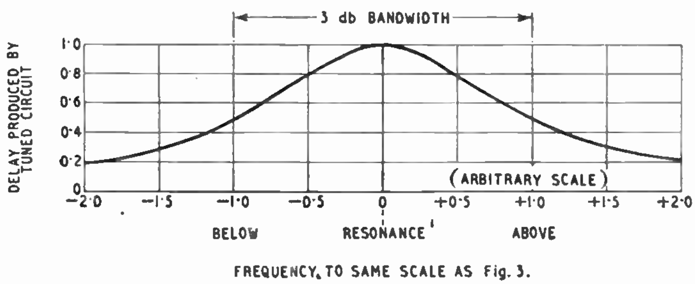


Fig. 4. Slope of phase characteristic.

place. The switching control circuits are connected to the delay network input, and the speech moves through the network while the switch at the far end is being operated. Radar and pulse modulation systems also use delay networks both for pulse formation and for delaying the pulses.

Looking at Fig. 3, it will be seen that the slope of the phase characteristic is not constant. In Fig. 4 I have shown how the delay varies for frequencies away from the resonant frequency of the network. It will be seen that the delay decreases as the frequency is shifted away from the resonant frequency in either direction.

What happens to a frequency-modulated signal when it encounters such a network? The centre frequency passes through slowly, but as the frequency is moved away from the centre frequency by the modulation the wave gets even at the edges of the band, that is ±75 kc/s away from the centre frequency, the limiter must be fully loaded. If the Q of the tuned circuit is too high, the extreme frequencies will be attenuated too much to drive the limiter and then, with some types of discriminator, you are in for trouble of a different kind.

The mathematicians do not approach the problem in this way. They write down the sidebands—that horrid array of Bessel functions—shift the phases and then add up all the sidebands again. If you do this, you find that the distortion is given by the following expression:

$200\ Q^3\ (\Delta f/f)^2\ (f_m/f)\ \%$

where f is the centre frequency—4.3 Mc/s in the i.f. amplifier

Δf the deviation—75 kc/s.

f_m the modulating frequency.

Q the "goodness" of the circuit.

If Q = 10, this is 0.16%, but if Q = 30 it becomes 4.3% for a modulating frequency of 10 kc/s.

Actually, this distortion is not entirely produced by the mechan-

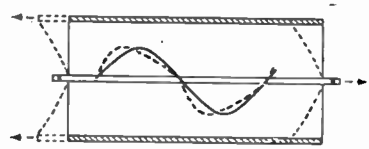


Fig. 5. Model using rubber sheet to show distortion due to phase shift.

ism described above, but by a "ringing" of the tuned circuit as the frequency passes through the resonant frequency of the circuit. There is, therefore, some production of very high harmonics, and a typical observed waveform is shown in Fig. 6.* I haven't discussed this effect because it is not easy to see what is happening: the equations are so-and-so, and the results are such, is the usual treatment.

The expression above is for the third harmonic. If the circuit is off tune, the second harmonic appears. This is

$800\ Q^3\ (\Delta f/f)\ (f_m/f)\ (\delta f/f)\ \%$

where, in addition to the terms previously defined δf is the detuning.

The amount of second harmonic given by this expression is equal to the third harmonic given by the previous equation when $\delta f = \Delta f/4$, which means that the detuning is 18.75 kc/s. This means that the oscillator

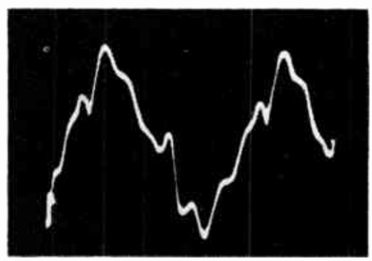


Fig. 6. Typical distortion produced by "ringing" in a circuit of narrow bandwidth.

must be stable to within 1 in 5,000 if the second harmonic is to be less than the third harmonic.

As soon as several stages of

* Based on Fig. 18 of an article "Tuned-circuit F.M. Distortion," by D. L. Jaffe, *Proc. I.R.E.*, Vol. 33, May, 1945.

Distortion in F.M.—

i.f. amplification are used the situation becomes very difficult. Tuned transformers can have very awkward phase characteristics, and as a general rule it can be said that it is better to under-couple than to over-couple. A very good phase characteristic can be obtained with a triple-hump circuit, using a very flat centre hump and two compensating ears, rather like a full face view of a terrier; but the design of such circuits is difficult, their construction impracticable for receiver work and the hope of keeping them in adjustment is quite non-existent.

So much for the Fat Boy: Mr. Boffin, you will remember, was a dustman; must you call in his services to take your junk away? I do not think so: in our Dickensian tour there is that other character, who always expected something to turn up. Let us see what we get for our circuits.

With a Q of 10, and a tuned circuit capacitance of 50pF we shall have a tuned circuit impedance of 50,000 ohms. This is more than we can safely use, anyway, if the i.f. amplifier is going to be stable. We can, therefore, design the amplifier round a Q of 10 and be fairly sure that the distortion will be kept below 1%. If we do this, there is really not much point in using staggered circuits, because they must be lined up much more carefully than ordinary single-tuned circuits if the response is to be symmetrical. Stray feedback is probably the greatest danger, as it can tip the response sideways in a most damaging way and thus produce an unsymmetrical phase characteristic, with the consequent production of second harmonic.

Double-tuned circuits, as one would expect, give more distortion than single-tuned circuits, because in general there is more phase shift, and thus more likelihood of the phase shift being non-linear. Double-tuned circuits are also liable to have more "bumpy" phase characteristics, which produce a lot of intermodulation under suitable conditions. In addition, it is extremely difficult to keep them symmetrical, and any deviation from symmetry destroys the second-harmonic balance. Another possible circuit, which I hope to describe later, is the negative feedback pair. This gives some squaring up of the ordinary tuned - circuit characteristic. Squaring up must not be carried too far, however. For amplitude modulation the ideal characteristic is the flat-topped "maximal flatness" characteristic, but for f.m. it is better to have the gentle droop which gives a good phase characteristic.

Another thing which must be watched very carefully is the effect of high signal levels. If the amplifier valves run into grid current the response can be seriously affected, and in comes the distortion. That is why the distinction between limiter and amplifier must be made quite definite. The limiter stage, or, if you are extravagant, stages, can be very flat, so that no detuning is apparent, while the amplifier stages are carefully controlled to work under Class "A" conditions.

I have tried to describe the way in which f.m. receivers produce distortion in fairly simple terms: I have not tried to explain how the phase characteristic of the receiver can be measured. There are a number of methods available, but anyone who has the facilities for measurement of sufficient accuracy will probably also know where to find descriptions of the methods. So long as low-Q circuits are used and the amplitude response is made symmetrical, smooth and without humps, the main distortion will come from mistuning. This is a separate problem, and the only suggestion I have is the use of automatic tuning correction circuits. That means more valves, but that is the price of quality.

PIEZOELECTRIC CERAMICS

New Materials for Pickups, Microphones, etc.

EXPERIMENTS have shown that ceramics of high dielectric constant, such as the titanates, can be endowed with piezoelectric properties by placing them in a strong electric field. The residual piezoelectric effect in barium titanate, for example, is comparable in strength with that of Rochelle salt, and a gramophone pickup making use of prepared ceramic strips is described in the December, 1948, issue of *Electronics*. This pickup which is called the "Titone" and is marketed by the Sonotone Corporation, Elmsforth, New York, gives an output of 0.75 volts at 1,000 c/s on a standard test record.

The chief advantage of barium titanate as a piezoelectric element is that, unlike Rochelle salt, it is unaffected by moisture. Its disadvantage is that it is brittle, but this has been overcome by soldering to a metal support. On cooling, the solder contracts more than the ceramic, and subjects the latter to longitudinal compression; this is said to prevent fracture in use.

When the ceramic leaves the kiln after firing, it has a polycrystalline structure with random orientation of the grains. According to an article in the previously mentioned issue of *Electronics*, contributed by members of the research organization of the Gulton Manufacturing Corpn. Metuchen, New Jersey (manufacturers of the crystals) "individual cubic crystals are twinned within themselves (optical axes of different domains of a crystal are at 90 degrees to each other). When the polarizing potential is applied, the domains of one orientation grow gradually, at the expense of the other, so that, finally, the crystal approaches a single domain. This growth of one domain and shrinkage of the other can be seen with a microscope, using polarized light."

The induced piezoelectric property is lost if the temperature of the ceramic is raised to the Curie point (120°C in the case of barium titanate), but it is claimed that the sensitivity remains constant over the range −70 to +70°C.

Special techniques have had to be devised to prepare sheets of the material of the required uniformity and thickness. Elements of the required dimensions are then cut from these sheets by an abrasive wheel. The activating process is varied according to the thickness of the material and is a product of the polarizing voltage and the time of application. Generally, the time required is less than an hour with polarizing voltages limited to 100 volts per mil. (0.001in). For more rapid production, the voltage can often be increased if the form of the element and its electrode assembly can be designed to reduce corona effects.

WORLD OF WIRELESS

A.M./F.M. Tests from A.P. ◆ Centimetric-wave Television Link ◆ Amateur Bands ◆ Recording and Reproduction Standards

E.H.F. Broadcasting Tests

IT will be recalled that, as suggested by *Wireless World*, the B.B.C. intends to make a full scale trial of both a.m. and f.m. broadcasting in the e.h.f. band from the new station at Wrotham, Kent. As this is unlikely to be ready for some time experimental transmissions with both methods of modulation are being radiated from Alexandra Palace. In addition to the f.m. transmissions on 90.3 Mc/s, which, after a break of some weeks for aerial overhaul, have been restarted, amplitude modulation on 93.9 Mc/s is being used.

Both transmitters carry the Third Programme every day from 6 p.m. to midnight and in addition the f.m. transmitter radiates the Light Programme from 11 a.m. to 12 noon and from 2.30 to 4.30 on Mondays to Fridays, inclusive.

Vertical polarization is normally used for both transmissions but the B.B.C. points out that horizontal polarization may be substituted at any time and, moreover, the operating schedule is liable to alteration.

4.5-cm Television O.B. Link

B.B.C. engineers, in collaboration with radio manufacturers, are investigating the possibilities of using micro-wave radio links for transmitting television from outside broadcast points to Alexandra Palace. Tests have been made between Alexandra Palace and Broadcasting House and places as far afield as Ascot and Aldershot.

The transmitting equipment consists of a klystron oscillator operating on a wavelength of 4.5 cm, which is frequency modulated by the vision signal, and a 4ft diameter paraboloid reflector with a waveguide feed. The power of the transmitter is about 100 mW and the aerial gain is 5,000. A similar aerial system is used at the receiving end. The actual transmitter and receiver are built into the back of the paraboloid reflectors, whilst the associated equipment is housed in cases.

Dividing Amateur Bands

FOR some time the Radio Society of Great Britain has been considering the possibility of introducing a voluntary plan for the reservation of a section of each of the amateur bands for the exclusive use of telegraphy.

The plan, which has been drawn up on the replies received to a recent questionnaire, has been submitted to member societies of the International Amateur Radio Union in the hope that it may be adopted by other amateurs in Region 1.

We give below the division (P, 'phone; T, telegraphy) as it applies to the bands at present in use and, in parentheses, for the additional bands allocated at Atlantic City but not yet used by British amateurs.

3.5	— 3.6	T
3.6	— 3.635	P
3.685	— 3.8	P
(3.6	— 3.8	P)
7.0	— 7.05	T
7.05	— 7.3	T & P
(7.05	— 7.15	T & P)
14.0	—14.15	T
(14.0	—14.1	T)
14.15	—14.4	T & P
(14.1	—14.35	T & P)
(21.0	—21.15	T)
(21.15	—21.45	T & P)
28.0	—28.2	T
28.2	—30.0	T & P
(28.2	—29.7	T & P)

It will be seen that no division is proposed for the 1.7-Mc/s band or for those above 30 Mc/s.

Acoustics Standards

SOME months ago the British Standards Institution set up an Acoustics Standards Committee under the chairmanship of H. L. Kirke (B.B.C.). From this main committee were formed eight technical committees each responsible for a different aspect of the main subject. The task of the first of these, which meets under the chairmanship of Dr. R. W. Robinson (N.P.L.) is to prepare Standards defining terms and definitions used in acoustics, and also to review the proposed American Standard for acoustical terminology.

The other committees deal with architectural acoustics and sound insulation (chairman, A. T. Pickles, D.S.I.R.); noise measurement (N. Flemming, N.P.L.); audiometers and hearing aids (R. S. Dadson, N.P.L.); electro-mechanical sound recording and reproduction (R. W. Lowden, B.S.R.A.); magnetic sound recording and reproduction—film, tape, wire and disc (M. J. Pulling, B.S.R.A.); concert pitch (Llewellyn S. Lloyd); and loudspeakers, microphones and other electro-acoustic transducers (W. West, G.P.O.).

The committee dealing with magnetic sound recording is continuing the work of a provisional committee which has recently produced a draft Standard for magnetic-tape recording for broadcasting. This specifies the requirements necessary for the interchangeability of recordings and is based on recommendations made by the B.B.C.

Naval Commissions

A SCHEME for short-service commissions in the Electrical Branch of the Navy, previously restricted to those with commissioned service in the R.N.V.R., has been extended to include men who have held commissions in the Army or R.A.F. and undertaken electrical or radio duties, and to civilians possessing suitable qualifications.

Ex-Army and R.A.F. candidates must be under 35 and civilians under 30. The latter must have a degree or diploma in electrical engineering or science, or be graduate members of the I.E.E. or Brit. I.R.E., or have passed such examinations as are recognized by these Institutions as qualifying for graduate membership.

The period of service will be five years on the active list and four years on the emergency list. A gratuity of £500 tax free will be granted to officers completing five years on the active list. Further particulars are obtainable from the Director, Naval Electrical Department, Admiralty, Queen Anne's Mansions, London, S.W.1.

Hospital Television

GUY'S HOSPITAL, London, has installed permanent closed-circuit television equipment as an aid to surgical instruction. The apparatus comprises basically the C.P.S. Emitron camera, operating on the British standard 405-line system, but has been designed by E.M.I. entirely for its special function, being built as an integral

World of Wireless—

part of the "shadowless" lighting equipment over the operating table. Thus a virtually unlimited number of students can see an operation from an ideal viewing position just above the surgeon's hands. Lens selection and focusing are remotely controlled from a room adjoining the theatre. Close-up, life-sized and reduced views may be selected.

Australian Television

THE recent demonstrations of Pye television equipment in Australia, to which reference was made last month, has called forth an official statement from the Commonwealth's P.M.G. He has stated that the demonstrations, which were given on a closed circuit, "will contribute very little toward the introduction into Australia of a television service . . . The Government has not committed itself to the provision of a television service in any Australian centre and does not intend to do so until proposals, which are now being formulated, have been submitted to the Australian Broadcasting Control Board and the Postal Department."

It is understood that tenders for equipment of varying standards, manufactured in the Commonwealth, Great Britain, U.S.A., France and the Netherlands, are being considered. These have been submitted in response to the invitation made some months ago for the supply of 5-kW transmitters for Sydney and Melbourne, or alternatively for 5-watt stations for each of the six State capital cities.

Our Sydney contemporary *Radio Electrical Weekly* states that 25-watt sound and vision transmitters were used to feed 19 standard Pye receivers via a 75-ohm co-axial cable.

Radar Certificates

RECOMMENDATIONS made by the Radar Training Committee of the Radio Officers' Union for radar maintenance certificates for radio officers have been adopted by the Ministry of Transport.

Provision is now made that a holder of a first-class Admiralty certificate with a year's experience on a radar set at sea, during the last two years, may receive the M.o.T.'s radar maintenance certificate without further examination. Holders of a second-class Admiralty certificate, or those who have completed an Admiralty radar course but have not taken an examination, and who in both cases have served afloat as above are exempt from the practical part of the examination for the certificate.

Application forms are obtainable from the Ministry.

OBITUARY

We regret to record the death of **Dr. E. H. Colpitts,** inventor of the oscillator circuit which bears his name, at the age of 77. He retired from the vice-presidency of the Bell Telephone Laboratories some time ago. He was recently awarded the Cresson Medal of the Franklin Institute, New York, for his work on the development of long-distance radio communication.

We also record with regret the death at the age of 79 of **Admiral H. W. Grant,** C.B., who was chairman and managing director of Marconi's W.T. Co. from 1941 to 1946. He specialized in navigation during his naval career and was for two years in command of the Navigation School at Portsmouth. On retirement from the Navy in 1918 he joined the Eastern Telegraph Company as managing director and was on the Boards of a number of other cable companies.

PERSONALITIES

Sir Ernest Fisk, managing director of E.M.I., has been re-elected president of the International Federation of the Phonographic Industry at a general meeting of the Federation in Amsterdam attended by representatives of twelve countries.

Brigadier J. B. Hickman, C.B.E., M.C., M.A., has been appointed managing director of British Telecommunications Research, Ltd. For four years prior to leaving the Army in March, he had held the position of Director of Telecommunications Research and Development in the Ministry of Supply. Brigadier Hickman has been in radio throughout his army career and filled many technical administrative posts, among them Asst. Commandant, Wireless Wing, School of A.A. Defence; Deputy Chief Inspector Telecommunications, Inspectorate of Electrical and Mechanical Equipment (1941/44), and Deputy Director of Signals (Equipment) at the War Office (1944/45). He was at the radar research station at Bawdsey in 1938.

W. T. Ditcham, personal assistant to the engineer-in-chief of Marconi's, has retired after 34 years' service with the company. He began his radio career

W. T. DITCHAM.

in 1906 with the De Forest Wireless Telegraph Syndicate, which, on acquiring the Poulsen arc patent, became the Amalgamated Radio Telegraph Company. He was associated with H. J. Round in the early development of direction finders and operated Marconi's experimental broadcasting station at Chelmsford in 1920. Prior to 1939 Mr. Ditcham was in charge of the development of broadcasting transmitters at the Chelmsford works.

W. E. Dickinson, who joined the Gramophone Company in 1936 and has for some time been in charge of the company's technical publications division, is now to specialize in the sale of schools' radio and gramophone equipment.

R. J. Dippy, O.B.E., B.Sc., who, as one of the original team at the Bawdsey Research Station, was responsible for the development of Gee, is leaving the Ministry of Supply, where he is senior principal scientific officer, to become Controller of Telecommunications (Civil Aviation) for the New Zealand Government. Before going to Bawdsey Manor in 1936 he was for two years in the G.E.C. Research Laboratories, Wembley.

Leslie Gamage, vice-chairman and joint managing director of G.E.C., has been re-elected chairman of the Overseas Standards Advisory Committee of the British Standards Institution and, for the seventh successive year, has been re-elected president of the Institute of Export.

A. Miall-Allen has been appointed by Taylor Electrical Instruments, Ltd., as sales engineer for the company's panel instruments.

S. L. Robinson, B.E.M., who has been with Masteradio, Ltd., for over twelve years as general manager and latterly was in charge of research and development engineering, has joined Sargrove Electronics, Ltd., who are now at Effingham, Surrey, as general manager.

R. O. Seccombe, who has been with Murphy Radio for some twelve years, has succeeded **J. Wilson** as service department manager. As announced recently, Mr. Wilson has been appointed general manager of Murphy Radio (India), Ltd.

R. T. B. Wynn, C.B.E., assistant chief engineer, B.B.C., has been nominated chairman of the I.E.E. Radio Section for 1949/50 and **D. C. Espley,** D.Eng., of the G.E.C. Research Laboratories, vice-chairman.

IN BRIEF

Licences.—An increase of 113,650 broadcast receiving licences (including 6,400 for television) during March brought the total to 11,753,150. The month's increase was a record; the increase for the whole of last year being only 400,000. The March total included 126,500 television licences.

B.B.C. Transmitters.—Two new air-cooled medium-wave transmitters have been ordered by the B.B.C. from Marconi's. By using forced-air cooling to dissipate the heat generated by the valves, it has been possible to considerably reduce the overall size of the equipment. Both 100- and 50-kW m.w. and s.w. transmitters are available with air cooling. The 120- and 150-kW sets in this range are water-cooled.

THE "BELLING-LEE" PAGE

Providing technical information, service and advice in relation to our products and the suppression of electrical interference

How is your earth ?

Only last month we received a letter in which the writer explained that as he lived in a block of flats, he could not do better than a tin seven inches square and three inches deep, full of earth. This was shown to our engineers, one of whom assured us that when investigating a recent case of interference, he found a radiogram "earthed" to a small flower pot, the soil of which was kept "suitably moist." We thought that everybody had grown out of this sort of thing, and we would like readers to emphasise to their friends that the use of a good efficient "solid" earth is highly desirable in the interest of reduction of interference and safety. Incidentally the earth pin of a three pin supply point is not the ideal earth for a receiver from the interference point of view, although it is the right way to "earth" an appliance and is often the most convenient to use.

Suppression of motor vehicles with magneto ignition.

We have been asked what to do in these circumstances. BS.CP.1001 recommends the use of a sparking plug suppressor L.1143 on each plug. Should you be so placed, for a four cylinder engine suppressors will cost you 4 at 1/6 = 6/- instead of 2/- for a "Belling-Lee" distributor suppressor L.630.

Protection of aerials.

There are only a few things to be said in favour of light alloy television aerials, they are light, they do not rust, and the raw material is readily available. Those of you with steel aerials, whether broadcast or T.V. should paint them every year or so. A good time to do this is when your house is being redecorated and there are ladders about the place. We repeat, even lamposts, park railings and bridges are painted regularly, and not for appearance.

P. S.

Did you know? A motor car can seriously interfere with electronic research and television reception.
Fit a "Belling-Lee" suppressor L.1274 or L 630 to the distributor lead, does not affect engine performance and helps an industry

This is a reproduction of a "Belling-Lee" letter sticker

We were very pleased to see so many old friends and to welcome new acquaintances at the B.I.F. and we look forward to meeting them all again at Radiolympia in the Autumn.

TELEVISION AERIAL LIST NUMBERS

The list numbers of television aerials have been subject to alteration and should be read as follows :—

MIDLAND FREQUENCY AERIALS

L652/LM Dipole, reflector and cross arm, 8ft. light alloy mast, chimney lashing and fabricated iron bracket (in 3 packs).

L652/C Dipole, reflector and cross arm with mast head adaptor L651 for 2½in. dia. wood mast (in 2 packs less mast).

L652/L As above but with lashings and brackets for customers own mast (in 3 packs). *See below.

LONDON FREQUENCY AERIALS

L502/L Dipole, reflector and cross arm with mast-cap, chimney lashings and brackets for customer's own mast (one package).
*A mast is not supplied, but a limited supply of poles, of slightly varying diameters is available, reference number Y7981. Die-cast wedges are supplied with masts, free of charge, to provide packing between mast and mast cap.

L502/C Dipole, reflector and cross arm with mast-cap. For customer's own mast (one package).

TYPES UNCHANGED

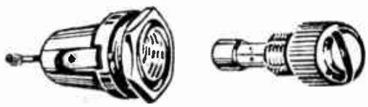
Midland Versions.	Description.	London Versions.
L647/T	Dipole with wall fixing bracket	L502/T
L647/L	Dipole with chimney lashings	L501/L
L646	"Veerod" attic aerial	L605
L635	"Veerod" chimney aerial	L606
L678	"Doorod" indoor aerial	L645

Cutting down London T.V. aerials to make them suitable for the Midland station.

No it won't do! We have said so before, and must repeat it, as so many people write and ask if they need only cut a piece off the element. The length of the crossarm is also a function of the wavelength, and this should be cut to the same length as the element, which raises all kinds of complications when you try to do it.

A reliable 10 m/A fuse.

We have perfected a method for the production of fuses rated at 10, 15 and 25 m/A blowing within one second on 100 percent. overload. The link is pure platinum wire, and complete cartridge is 5/8in. x 3/16in. corresponding to our list No. L.562. These fuses pass the bump test specified in R.I.C./11 for yellow and green component categories. The appropriate fuseholders are panel L.575, sealed panel L.565, open baseboard L.566. All these fuse-holders have Service reference numbers.



The illustration shows miniature panel fuseholder L.575. Regd. Design No. 843289.

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. . . **but there is a difference in VITAVOX sound equipment**

The GP 1 pressure Type Loudspeaker Unit is an outstanding example of advanced design and craftsmanship. Compact with high power handling capacity, efficient and economic in weight and cost, the GP 1 unit emphasises the quality of VITAVOX sound equipment.

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G.E.C.

QUARTZ CRYSTAL UNITS

FOR STABLE FREQUENCY GENERATION

FEATURES

Low temperature co-efficient — less than 2 in 10^6 per °C. Patented nodal suspension. Mounted in vacuum: performance independent of climatic conditions. Exceptionally high Q value. High stability. Small size, 3" x $\frac{5}{8}$" overall excluding pins. Fits standard miniature deaf aid valve socket.

FOR FREQUENCY SUB-STANDARDS

Type JCF/200, 100 KC/S. Available from stock adjusted to 0·01%. Higher accuracies supplied to special order.

The type JCF/200 unit illustrated is representative of the wide range of vacuum type unit available for low and medium frequencies.

PRICE **£2 - 15 - 0**

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PEEL WORKS, SALFORD 3, LANCS. *Telephone BLAckfriars 6688 (6 lines). Telegrams & Cables SPARKLESS Manchester*

Proprietors THE GENERAL ELECTRIC CO., LTD., OF ENGLAND

Exporting Television.—A receiver designed to American television standards (525 lines), was featured by Romac Radio Corporation at the B.I.F. It incorporates switch tuning covering twelve of the thirteen U.S. television channels (54 to 216 Mc/s).

SPECIALLY CONSTRUCTED housing for the image-orthicon camera outside the B.I.F., Birmingham, where 625-line television was demonstrated.

Centimetric Experiments.—In order to extend the quasi-optical path for experimental transmissions on centimetre wavelengths, the G.E.C. is to erect a 200-ft tower at the Company's research laboratories at Wembley. Two octagonal cabins, about 11ft across, will be fitted one above the other at the top of the lattice steel tower. A lift will give access to the cabins on the external balconies of which will be fitted parabaloidal aerials.

I.E.E. Growth.—In the annual report of the Council of the I.E.E. an increase during the past year of 1,464 in the membership is recorded. This brings the total to 34,371. Nearly 16,000 are Students and Graduates.

Sound Reproducing equipment, with individual volume control and selection of two programmes for each pair of headphones, is being produced by the Magneta Time Company for installation in hospitals.

P.A.—Two public-address installations have recently been undertaken by the Sound Amplification Division of E.M.I. Amplifying equipment giving an output of 400 watts to 53 loudspeakers has been installed at the Rugby Football Union ground at Twickenham. A contract to supply a complete p.a. installation for the mills of the Madura Mill Co. at Madura, Southern India, has also been placed with the company.

Ships' Aerials.—A centralized aerial system for the personal receivers used in various parts of the ship is being installed by E.M.I. in each of the five vessels now being built in Trieste for the Argentine Government.

"Try This One."—Don't read this until you have tried to solve the problem propounded by "Diallist" on p. 239. The answer is, the length of the line cord is five feet, the age of the elder brother being ten years.

Marine Radar.—The symposium of thirteen papers on the operational aspects of marine radar which was presented at a meeting of the Institute of Navigation in February is published in the April issue of the *Journal* of the Institute.

British Wireless Dinner Club.—The 25th annual dinner of the club was recently held in London. The guest of the evening was Lord Cherwell, P.C., F.R.S. The newly elected president of the club, which now has a membership of 450, is A.V-M. Lywood, C.B., C.B.E.

FROM ABROAD

French Television.—Demonstrations of 819-line television—the new French standard—were given throughout the recent Lyons Fair. Mobile equipment was used for the transmissions which were radiated on 213.25 Mc/s (vision) and 202.1 Mc/s (sound) with powers of 60 and 15 watts, resepectively.

North American Amateurs.—Canadian and U.S. amateurs are now permitted to use the 1.8 to 2-Mc/s band. It has been divided into bands of 25 kc/s and these have been allocated for use in individual States and Provinces. Transmission is permitted on both 'phone and c.w., but power is limited.

Newfoundland.—In order to link Newfoundland, which has recently become a Province of Canada, with the Canadian Broadcasting Corporation's network, an f.m. link has been established between the mainland and the island.

Ionosphere Data.—The U.S. National Bureau of Standards has issued a five-page booklet entitled "Absorption of Radio Waves Reflected at Vertical Incidence as a Function of the Sun's Zenith Angle" (RP1939) in which is analysed the diurnal variation of ionospheric absorption. It is obtainable, price 10 cents, from the U.S. Government Printing Office, Washington 25, D.C.

Pakistan.—The firm of Butler and Khan, importers and agents, of Muhamed Building, Bunder Road, Karachi, 1, invite manufacturers to send details of radio equipment which they are desirous of exporting to Pakistan.

"Broadcasting Yearbook," which is published by our Washington contemporary, *Broadcasting*, and is issued to subscribers to that journal, contains a wealth of information on broadcasting in the U.S.A. The 1949 edition includes complete lists of American a.m., f.m. and television stations.

INDUSTRIAL NEWS

De la Rue Plastics.—The two wholly owned plastics subsidiaries of Thomas De la Rue (De la Rue Installation, Ltd., and Hill, Norman & Beard Plastics, Ltd.) are no longer acting as individual companies, but will operate from 84, Regent Street, W.1 (Tel.: Regent 2901), as the plastics division of the parent company.

H. J. Enthoven & Sons have transferred all their departments to their new offices at "Enthoven House," 89, Upper Thames Street, London, E.C.4 (Tel.: Mansion House 4533).

Radio Industries Club.—In the annual report of the chairman of the Radio Industries Club the membership of the parent club is given as 673 and the total of the six affiliated clubs—Scotland, Merseyside, Manchester, Midlands, Wales and Monmouthshire, and West Riding of Yorkshire—as approximately 750. The new president is Lord Burghley, K.C.M.G., and W. E. Miller, Editor of our associate journal *Wireless & Electrical Trader*, who has been honorary secretary of the club for eight years, is this year's chairman and continues as secretary.

R.C.M.F. now R.E.C.M.F.—At the 16th annual general meeting of the R.C.M.F. it was agreed to amend the title to Radio and Electronic Component Manufacturers' Federation. The member firms and, in brackets, their representatives, elected to the council for 1949-50 are:—Antiference (N. S. Beebe); British Electrolytic Condenser (P. D. Canning); British N.S.F. (S. Wilding Cole); Ediswan (J. W. Ridgeway); Garrard (Hector V. Slade); Hellermann (J. Bowthorpe); A. H. Hunt (F. S. Richmond); Long and Hambly (G. G. Kent); Reliance Electrical Wire (C. H. Davis); Telephone Manufacturing (W. A. Jackson); Telegraph Construction and Maintenance (W. F. Randall); and Wingrove and Rogers (W. Holmes). The new chairman is C. H. Davis and the vice-chairman H. V. Slade.

C. H. DAVIS, chairman, R.E.C.M.F.

MEETINGS

Television Society

Midlands Centre. — "The V.H.F. Link," by A. H. Mumford (G.P.O.) at 7.0 on June 1st at the Chamber of Commerce, New Street, Birmingham.

Junior Institution of Engineers

Midland Section.—"The Manufacture of Gramophone Records," by H. W. Bowen, O.B.E., at 7.0 on June 4th at James Watt Memorial Institute, Great Charles Street, Birmingham.

Radio Controlled Models Society

London Group.—Second of three lectures on "Fundamentals of Radio Control," by P. A. Cummins at 2.0 on June 12th at St. Ermins Hótel, Caxton Street, London, S.W.1.

Institution of Electrical Engineers

Southern Centre.—Visit to the R.A.F. radar station at Poling, near Arundel, on July 1st.

"MIDGET A.C. MAINS RECEIVER"

Further Notes, and Answers to Some Queries

SINCE the appearance of this article in the March issue it has been found that the quality and undistorted power output of the receiver can be improved by the use of an output transformer different from the ex-Air Ministry type visible in one of the photographs. This component, which was originally designed for a rather different function, is to some extent responsible for the modulation of high notes by low, mentioned in the article. To obtain the best quality and the maximum output of which the receiver is capable, and in particular where a larger external speaker is used, a bigger output transformer with a core at least 2in × 1½in, having a centre cross-section of ½ sq in, should be used. The laminations in this size of transformer are normally butted together to give a small air gap in the magnetic circuit. By dismantling the transformer and reassembling it with the laminations interleaved, the inductance can be appreciably increased and the bass response correspondingly improved. This improvement in inductance is only possible, of course, because the anode current of the output valve is so small.

Nevertheless some constructors have found the quality quite adequate with the original output transformer, and details are given below for obtaining the ratios of 35:1 and 80:1 with this component.

35:1, primary TP and I4 with IP bonded to O4 secondary O3 and I3.

80:1, primary OP and I4 with IP bonded to O4 secondary O3 and T3.

It is regretted that an error occurred in the specification for the midget mains transformer. The core cross-section should be ¾ sq in not ¼ sq in as stated. A suitable component can be obtained from Stern Radio, 109, Fleet Street, London, E.C.4.

It should be pointed out that the reaction control is a pre-set adjustment intended to be set below the point of oscillation for all settings of the tuning control, and that this setting should be adjusted to give optimum sensitivity and selectivity. The brief period of oscillation during warming up of the receiver occurs only if reaction is pressed to the limit.

Some of the war-surplus EF50 valves are somewhat microphonic and give trouble in the detector position, particularly when the receiver is boxed. Care should therefore be taken to select a suitable valve for this position.—S. W. A.

MANUFACTURERS' LITERATURE

Four leaflets describing radio connecting wires, television down-lead cables, microphone and loudspeaker cables, and copper earth rods made by B.I. Callender's Cables, Norfolk House, Norfolk Street, London, W.C.2.

Illustrated guide to the products and resources of the British Thomson-Houston Co., Rugby, issued in connection with their exhibits at the British Industries Fair.

Leaflet in English, German, Spanish and French describing "Superspeed Special" activated solder made by H. J. Enthoven and Sons, 15-18, Lime Street, London, E.C.3.

Preliminary specification of "Sound Magnet" tape recorder made by General Lamination Products, 294, Broadway, Bexleyheath, Kent.

Leaflet describing a 20-watt, 12-inch Model R22/12 p.m. loudspeaker made by Goodmans Industries, Lancelot Road, Wembley, Middlesex. Alternative cones are available with fundamental resonances of 55 c/s or 75 c/s.

Illustrated leaflet of Model 72 table model receiver (export only) from Invicta Radio, Parkhurst Road, London, N.7.

List of quartz crystal units made by Salford Electrical Instruments, Silk Street, Salford, 3, Lancs.

Catalogue of "Stanelect" public address loudspeakers for all purposes, from the Standard Electrical Engineering Co., 16, Heneage Lane, London, E.C.3.

Leaflet describing Models CN385 and CN386 a.c./d.c. superhet receivers (export only), from Vidor, West Street, Erith, Kent.

Catalogue of radio components and kits of parts from Coulphone Radio, 58, Derby Street, Ormskirk, Lancashire.

Technical details of the G.E.C. "Overseas" bandspread auto-change radiogram, from the General Electric Co., Magnet House, Kingsway, London, W.C.2.

Leaflet describing the universal oscillograph mounting made by Nagard, Ltd., 245, Brixton Road, London, S.W.9.

Technical details of Eddystone Model 680 communications receiver from Stratton and Co., Eddystone Works, West Heath, Birmingham, 31.

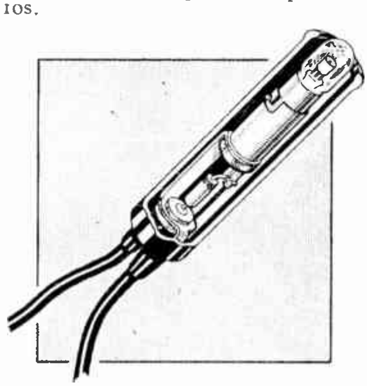
MULLARD VALVE DATA

THE information contained in the wall chart of Mullard receiving valves has now been incorporated in a pocket-size booklet for the convenience of servicemen. In addition to full characteristics, operating data and base connections, there is a comprehensive list of equivalents and near equivalents of valves of other makes. Copies are obtainable from Mullard Electronic Products, Century House, Shaftesbury Avenue, London, W.C.2.

NEON TEST PROD

AN insulated test prod containing a small neon lamp which can be used on either a.c. or d.c. circuits of 200 volts and over has been introduced by A. F. Bulgin & Co., Ltd., By-pass Road, Barking, Essex. It gives polarity indication on d.c. and enables a.c. or d.c. supplies to be identified by the nature of the glow. Its many uses comprise means of locating a blown house fuse, testing motor car sparking plugs, leakage tests on capacitors, continuity of supply circuits and for identifying transformer windings. The prod is very sensitive and gives an indication of leakage through several megohms.

A standard size neon bulb is used so it is easily replaceable if necessary. The whole is fully shrouded in rubber and has semi-flexible P.V.C.-covered prod leads terminating in ferruled tips. The price is 10s.



Bulgin insulated neon test prod.

ELECTRONIC CIRCUITRY

Selections from a Designer's Notebook

By J. McG. SOWERBY (Cinema Television Ltd.)

THOSE readers fortunate enough to have visited the Physical Society's exhibition last April will probably have noticed the large number of instruments involving electronic counters. These circuits were first widely used in nuclear physics research for counting the individual pulses derived from Geiger-Muller tubes, and other devices.[1] Since then the field of application of counters has been greatly extended, and numerous counting circuits have appeared in the technical literature.

Electronic Counters

Electronic counters may be used for recording and controlling the flow of articles past a given point—as in the manufacture of buttons and cigarettes—when the counting rate is in excess of that which can be handled by a mechanical counter. In such industrial applications the articles are often made to interrupt a beam of light falling onto a photocell, and then each interruption produces a pulse which is counted as one integer. Of course, other means are available for deriving the required pulses from the passage of an article. Counters are also used for recording the number of revolutions executed by a piece of rotating machinery in a given time, for recording the number of cycles executed in a given time (e.g., measuring cycles per second), for the accurate measurement of intervals of time, and for frequency division. The electronic counter is also the basis of the well-known ENIAC computing machine.

Probably one of the simplest forms of counter is the so-called scale of two which usually consists of two valves so connected that the circuit has two similar stable states, and which will change from one to the other each time it receives a pulse of predetermined shape and amplitude. Such a scale of two circuit is shown in Fig. 1, and this represents a simple reliable design.[2] It will be seen that the circuit is entirely symmetrical, and that each anode is connected through a resistive network to the other valve's grid. If the R_2 and R_3 resistances are chosen correctly, it is possible to arrange matters so that when one valve is conducting, the drop across its anode load is partially transferred to the other's grid, so that the latter is cut off. Since the circuit is entirely symmetrical it is a matter of chance which valve becomes conducting when power is first supplied to the circuit; let us arbitrarily assume that it is A which is conducting, and go round the circuit to see how the standing voltages are distributed.

Since A is conducting and B is not, the anode of A will be negative with respect to B's, and the difference may well be anything between 20 and 100 volts in a practical design. Consequently the grid of A will be more positive than that of B by $R_3/(R_2 + R_3)$ times the difference in the anode potentials. Provided R_k is made sufficiently large, no grid current will flow, and the anode current of A will be nearly its grid potential divided by R_k. When B is conducting all the foregoing will again be true if A and B are interchanged, and the function of all the resistors and the valves is apparent. We have not yet discussed the function of the two condensers C_A and C_B—which are equal in value.

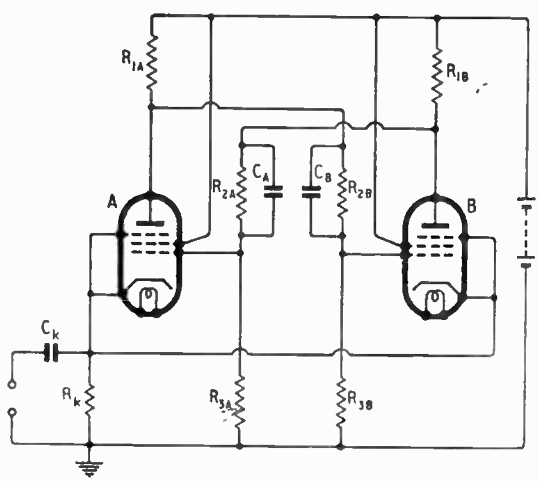


Fig. 1. Scale of two counter circuit.

To appreciate the need for the two condensers, we must now enquire how the scale of two is made to change from one stable state (A conducting) to the other (B conducting). In this circuit positive pulses of short duration are applied to the cathode, so that for the whole or part of each pulse both A and B are cut off. This pulse may last anything between 0.1 and 50 μsec, according to the particular design and the requirements, but its length must be properly related to the short time-constant formed by C_A and C_B and their associated resistances. To show how essential are these condensers, assume first that the input positive pulse is indefinitely long. This cuts off both valves and before very long the circuit is in an entirely symmetrical state, since C_A and C_B will assume equal charges. If the pulse now returns to zero both valves conduct, and the circuit is in a state of unstable equilibrium. By regeneration one or other will soon become fully conducting and the other will cut off. But there will be nothing to decide *which* valve shall become fully conducting (except, of course, any small practical lack of sym-

[1] "Electrical Counting," by W. B. Lewis, C.U.P., 1942.

[2] T. C. Nuttall, Brit. Pat. No. 572884.

L

Electronic Circuitry—

metry) and the circuit will not behave as a scale of two.

But now suppose the input pulse to be very short in duration compared with the time-constant of C and its associated resistances. As A is initially conducting there is a greater potential across (and so more charge stored in) C_A than C_B. Consequently, when both valves are first cut off the grid of B moves positively with respect to A's. The grid potential of B then reverts exponentially with time towards that of A, but before equality is attained the input pulse collapses leaving B passing a greater anode current than A—or the conditions may be such that A is cut off. Consequently, the circuit locks into its second stable state with B alone conducting. Thus we see that the condensers C_A and C_B form an essential feature of the design, and that the circuit cannot be expected to function correctly without them. They form a kind of "memory" which enables the circuit to remember, for a short time after the onset of the energizing pulse, which state it was in last, and ensures that it shall change to its other state. The function of the condensers has been discussed at some length because they are often wrongly described as being merely "sharpening" condensers to compensate for the stray grid-cathode capacitance of the valves, or to make the anode-grid transmission independent of frequency.

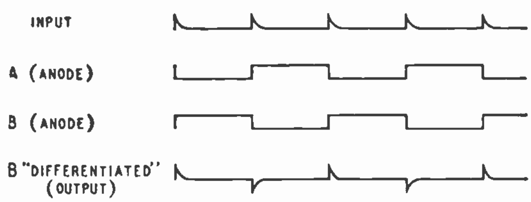


Fig. 2. Simplified waveforms in the scale of two counter.

In the scale of two circuit shown in Fig. 1 the energizing pulse is coupled into the cathode through C_k, and it is generally not necessary for this pulse to be anything more precise than the positive "spike" resulting from the differentiation of a square wave. Fig. 2 indicates the general shape of the relevant waveforms in the circuit, and also the waveform obtained by differentiation of the anode potential changes of one valve. From this one sees that one output positive spike is obtained for two at the input, so that the circuit divides pulses by two. Obviously if we can arrange that the unwanted negative spikes are not transmitted, we can use the remainder to operate another scale of two. This is conveniently done by means of a buffer stage as shown in Fig. 3.

This consists simply of a short time-constant differentiator C_gR_g, and a cathode follower biased to cut-off by the current through R_k caused by the return of R to the h.t. supply. If this stage is fed with square waves—or the anode waveform of the scale of two circuit—the positive and negative spikes in the last waveform of Fig. 2 will appear at the grid of the valve, but the negative ones will be largely suppressed, and the positive ones may be used for driving the next scale of two, or for any other purpose. Hence with this design three valves constitute a complete scale of two, and any number of them may be arranged in cascade. The division ratio of such a cascade is 2^n, where n is the number of scales of two. Thus we may easily obtain division ratios (or scaling factors) of 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048 . . . and so on.

It must be emphasized at this stage that the circuits shown in Figs. 1 and 3 are not by any means the only ones available, and that a large number of variations is possible. For example, the input pulses do not necessarily have to be applied to the cathodes, nor do they always have to be of one sign, and counters can be designed to accept mixed positive and negative pulses but to respond only to those of one sign. They may be fed into the circuit in many ways—at the control, screen, or suppressor grids, or at the anodes—provided the pulses are supplied symmetrically to the circuit. Again, various circuits have been designed using diodes as part of the input coupling, in which the aim is to apply the input pulses alternately to the two valves. Triodes or pentodes may be used, but generally speaking pentode circuits are easier to design owing to the absence of Miller effect. The "memory" need not consist of a condenser

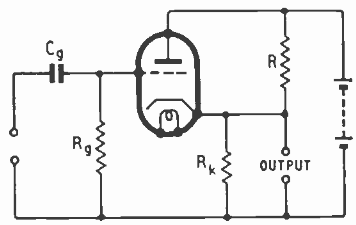


Fig. 3. Cathode-follower buffer circuit.

and associated resistances; circuits have been designed in which inductances were used. However, if the mode of operation of the circuit of Fig. 1 is remembered the reader should have no difficulty in following the action of more complicated circuits.

So far, then, we have seen how a simple scale of two operates, and how any pulse repetition frequency may be divided by any number N in the series given by $N = 2^n$, where n is the number of scales of two used. Next month we shall make some observations on methods of obtaining division ratios not included in this series, and we shall see how N can be given any integral value.

NEW DOMESTIC RECEIVERS

A THREE-WAVEBAND receiver, Model BC5050, introduced by the General Electric Co., Magnet House, Kingsway, London, W.C.2, employs a four-valve, plus rectifier, superhet circuit with a single KT61 output tetrode feeding a sensitive p.m. loudspeaker, and is designed to give better-than-average quality of reproduction. It is available for a.c. mains only (£21 14s 4d including tax) or for a.c./d.c. operation (Model BC5055), price £22 7s 2d including tax.

Five wavebands are a feature of the H.M.V. Model 1120 superhet (four valves, plus rectifier), which has a 5-watt output and is fitted with spin-wheel tuning. In addition to the usual medium- and long-wave ranges, there are short-wave ranges covering 15.5-20.5 m, 20.5-33 m and 33-100 m. The price, including tax, is £26 16s 7d and the makers are the Gramophone Co., Hayes, Middlesex.

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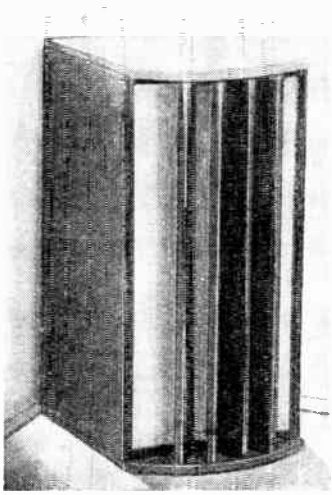

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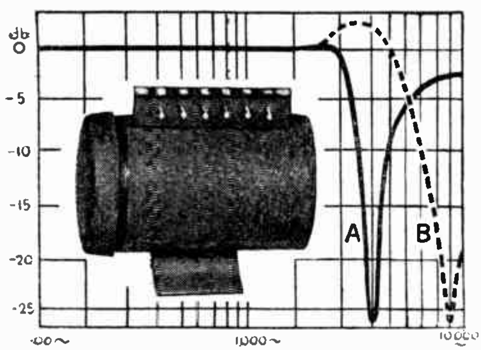

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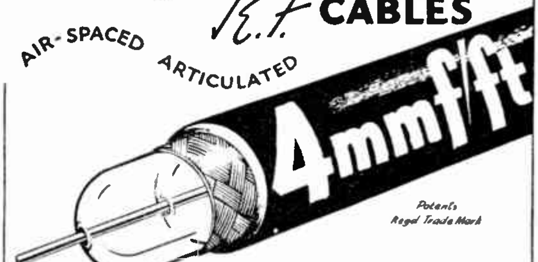

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RECTIFIER VOLTAGE CONTROL

Using Saturable-Core Reactors

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

APART from barretter lamps and gas discharge tubes, static voltage - control systems may be divided into two principal classes, one using electronic valve regulation, the other employing the properties of saturable-core reactors or transformers. D.c. power supply units operating on a.c. mains commonly employ electronic regulators to stabilize the output voltage against load current and supply voltage changes, and designs for an extensive range of such units have been published. Close regulation and rapid response are secured at the expense of some circuit complexity.

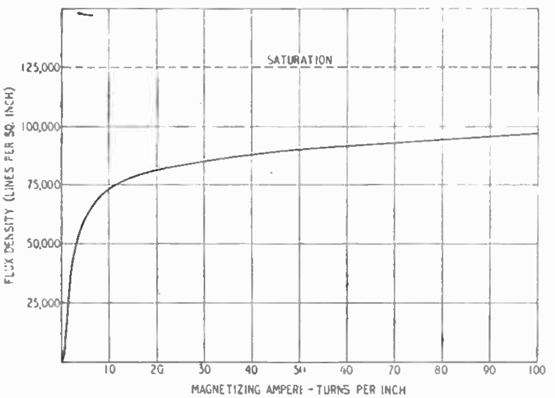

Fig. 1. Typical initial magnetization curve for transformer steel.

Regulators employing magnetic saturation of an iron core are much less complicated and are preferable for use in industrial equipment where reliability is essential. They can be applied equally well to a.c. voltage regulation and to the stabilization of the d.c. output from rectifier sets. In both cases the regulator action depends on the non-linear relationship which exists between the magnetizing ampere-turns and the flux density in the iron core of a transformer or reactor. The observed non-linearity accounts for the variation of the inductance of iron-cored coils under different conditions of a.c. and superimposed d.c. magnetization. It is well known that the primary inductance of an output or inter-valve transformer is profoundly modified by the flow of d.c. anode current to the associated valve. Because of this effect, when measuring the inductance of the windings of such transformers, it is necessary to select standard values of d.c. and a.c. excitation in order that the results should correspond to some definite value for the incremental permeability of the core material.

Fig. 1 shows the relationship between the magnetizing ampere-turns per inch length of magnetic circuit plotted against the resulting flux density in lines per square inch of core cross-section.

The data refers to a particular sample of transformer steel (Stalloy). For a given coil the ampere-turns will be proportional to the current. From the figure, it can be seen that at different points on the curve, equal increments in magnetizing current cause widely differing flux variations. In the case of a coil carrying a fixed alternating current superimposed on a variable d.c. biasing current, there will be different alternating fluxes corresponding to each level of direct current. If the frequency of the alternating current is fixed, there will be differing back e.m.f.s corresponding to the changing rates of flux linkage and there is thus a particular value of coil inductance corresponding to each d.c. bias level. This variable-inductance feature is the basis of design of magnetic amplifiers and control equipment using saturable reactors or transformers.

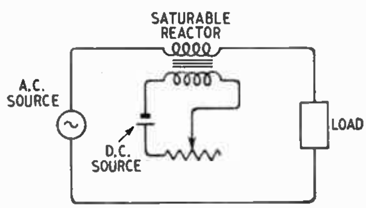

Fig. 2. Simple variable-reactance regulator.

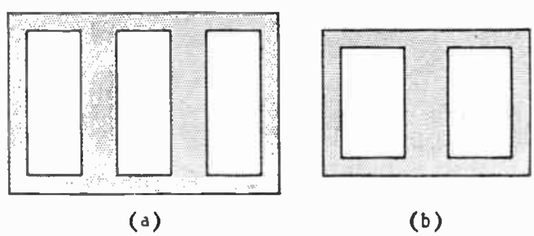

Fig. 3. (Right) Core shapes suitable for use in saturable reactors.

Fig. 2 shows the most elementary form of regulator using the principle of reactance variation by auxiliary d.c. bias control of the steady flux.

It can be seen that the control reactor forms a variable impedance in series with the load. Practical circuits differ from the simple arrangement shown in that there is some transfer or coupling device connected between the load circuit and the d.c. control section so as to effect the desired automatic control. In certain cases, the interconnection is by means of current transformers and auxiliary metal rectifiers. With equipment incorporating rectifiers, it may be sufficient to divert the d.c. output and employ it to exercise the required magnetic bias control.

It will be clear that the elementary design of the reactor core and windings shown in Fig. 2 has some obvious disadvantages. Normally, the d.c. control winding has a large number of turns and a high induced voltage will be developed in it. Alternating

Rectifier Voltage Control—
current will also flow in the control circuit. Core designs which eliminate these defects are shown in Fig. 3.

The type shown in Fig. 3 (a) is to be preferred since the leakage flux is small. Separate a.c. windings are placed on the two centre limbs, while the d.c. coil embraces the pair. By proper connection of the two a.c. windings, either in series or in parallel, it is possible to cancel the undesired induced voltage in the d.c. coil. With laminations of the type shown in Fig. 3 (b), the control winding is carried on the central limb and the two a.c. coils are wound on the outer cores. Again, care is necessary when joining the a.c. windings in series or in parallel, so as to avoid induced voltages in the d.c. coil. Several published papers give a discussion on the choice of core shapes. Making use of standard shell-type transformer laminations, the best scheme is to use two stacks of the form shown in Fig. 3 (b), assembling them with non-magnetic separators, winding the a.c. coils on the centre limbs and arranging the d.c. winding so as to encircle both central cores.

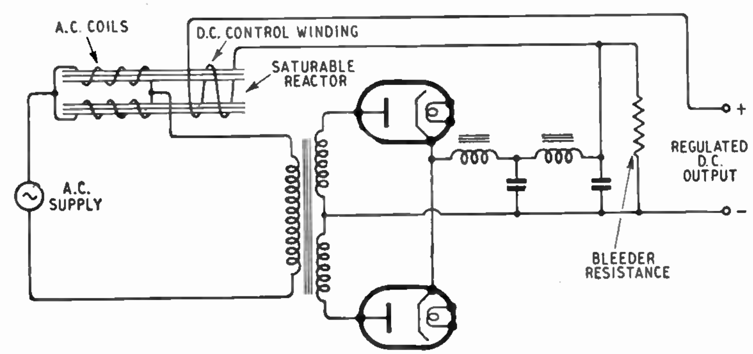

Fig. 4. Application of saturable reactor control in a mercury-vapour rectifier designed for feeding Class B modulators.

More details will be given later regarding winding particulars and core constructon. Due to the many variables involved, it is difficult to give design information to cover a wide range of use. Instead, details will be given of one specific application.

A standard medium - power single-phase, full-wave mercury vapour rectifier set, using a choke-input filter, has a a voltage regulation, between light and full load, of about 15 per cent. This is particularly objectionable when supplying Class "B" modulators, and it is responsible for causing a large percentage of the total audio distortion. The circuit of Fig. 4 shows how complete compensation may be secured; in fact, it is possible to provide a rising characteristic so that there is an increase in output voltage consequent upon an increase in load current.

The action of the controlling reactor is as follows. Its a.c. windings are so proportioned that when the sole load on the rectifiers is the normal bleeder resistor (essential to prevent a dangerous rise in no-load voltage) the potential dropped across the reactor is 20-25 per cent of the supply voltage. The load and reactor voltages combine vectorially to give the supply voltage and under certain conditions, the first two voltages are approximately in phase quadrature. As soon as additional load current is demanded, a polarizing current flows in the d.c. winding of the reactor. There is a fall in its reactance and a change in its phase angle of impedance, so that there is a reduction in the voltage drop across it and a corresponding increase in the rectifier transformer primary voltage. The full d.c. output voltage is thus sustained or it may actually be increased. The following results were obtained during practical trials of one regulated power unit:—

D-C. output voltage . .	970	985	995	1000	990
Load current (mA) . .	0	100	150	200	400

Particulars of the saturable reactor used in this case are given below:—

Lamination size (external = 5in × 4¼in.
Window area = 3in × 1¼in.
Depth of stack = 1⅜in.
Cross-section of centre core = 1¼in × 1⅜in.

The identical stacks are required to the above dimensions spaced by non-magnetic separators about 1in thick.

A.c. windings (2) each 300 turns, 18 s.w.g.
D.c. winding 1,200 turns, 24 s.w.g.

The general assembly and method of coil winding and connection are shown in Fig. 5. The construction of a similar unit was described by T. A. Ledward in *Wireless World*, June, 1943.

The performance figures given show that there is no difficulty in securing close voltage regulation using the circuit shown in Fig. 4. At the same time, it is necessary to keep in mind a number of factors which, under some circumstances, can prove objectionable. In the first place, non-linear devices using magnetic saturation must cause some waveform distortion. This effect is not serious in the present application. The high operating flux density necessarily increases the iron losses, but again, in this case, the requisite small change in controlled voltage permits operation at high efficiency, and the losses in the reactor vary with the output load. There is a relatively high stray field surrounding the saturable reactor, which must therefore be shielded magnetically or well spaced from low-level audio stages.

Returning to the question of waveform distortion, considerably different results are obtained in the two cases of series and parallel connection of the a.c. coils. In general, parallel connection is to be preferred, though in this case the response to load changes is rather more sluggish than for the alternative series connection. The response time is, of course, principally affected by the time constants of the smoothing filters, and no speeding-up of reactor response can do much to alter this characteristic. It is of advantage to increase the capacitance of the final filter capacitor as much as possible within economic limitations.

Since it is possible so to proportion the control reactor that there is a rising characteristic of output voltage versus load current, it might appear that there is some risk of a cumulative form of positive feed-back or over-control instability, but in practice, this is not experienced. At the same time, it must be recognized that the normal effects of supply voltage changes are enhanced, and if very high stability is essential, it may be necessary to supply the entire equipment from a constant-voltage transformer, though in most practical cases there is no need to go to this extreme.

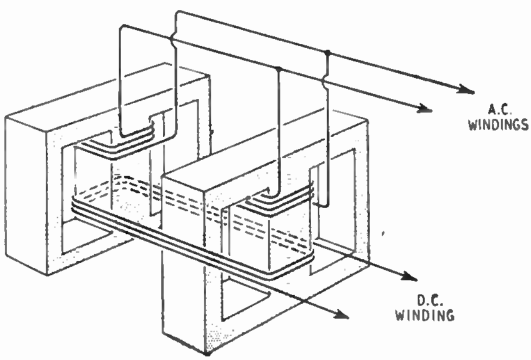

Fig. 5. Arrangement of cores and windings used in the reactor shown in Fig. 4.

The control system described has applications in both radio and industrial electronic equipment, and for these purposes its reliability and extreme simplicity are in marked contrast with the complexity of alternative regulation systems, though its inherent limitations must be recognized.

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HIGH-QUALITY REPRODUCER

Details of the Vitavox "Klipschorn"

TO meet the demand of the connoisseur for a really high-grade reproducer capable of doing justice to recent advances in recording technique and amplifier design, Vitavox, Ltd., Westmoreland Road, London, N.W.9, have introduced a "corner cabinet" loudspeaker with many interesting features.

Two driving units are employed, a Type S2 pressure unit for frequencies above 500 c/s, and a special 15in cone for lower frequencies. Frequency division is effected in a single-section, series-connected, cross-over network.

Both units work into true horn loading and the bass horn is of complicated construction. It is of the folded re-entrant type with divided outlets emerging at the two sides of the cabinet. The walls of the room form an extension to the horn, and special provision is made to get an air-tight seal between the cabinet and walls, which may not be perfectly flat or at exactly 90 deg. The internal divisions of the cabinet are all of ½in plywood, and great care is taken to ensure perfectly air-tight joints bonded with synthetic resin glue. The acoustic design is due to P. W. Klipsch,* and the exterior design is due to F. C. Ashford.

We have had an opportunity of hearing this reproducer on a wide variety of test records and radio programmes (f.m. and a.m.) and the outstanding impression is one of power and solidity There seems to be an unlimited capacity for delivering acousic watts without the slightest suggestion of wilting either in the driving units or the cabinet work, and the electro-acoustic efficiency is such that a 10-watt amplifier provides all the volume necessary, not only for the home but for, say, a gramophone recital to an audience of several hundred people

The bass response is outstandingly good and there is no lack of top of a quality which does full justice to the brass section of the orchestra. We could detect no flaw in the transition at the cross-over frequency of 500 c/s.

For its size the "Klipschorn" gives a very impressive performance, and a power and depth of bass response that is usually found only in cinema reproducers. The cabinet stands approximately 4ft 2½in high and extends 27½in from the corner of the room. The whole instrument weighs 210 lb, and the price is £135.

* *J. Acous. Soc. Amer.*, Jan., 1946; *Electronics*, Feb., 1946.

Vitavox high-quality reproducer based on the design of P. W. Klipsch.

NEW RADIO-GRAMOPHONE

IN the design of the Murphy A138R radio-gramophone particular emphasis has been placed on the reproduction of gramophone records and a moving-coil pickup has been developed specially for use in conjunction with the automatic record changer. Two Pen44 valves in push-pull, with negative feedback, deliver 12 watts to two loudspeakers with diaphragms of 10in and 8in diameter.

The three-waveband radio receiver follows the conventional arrangement of frequency changer, i.f. amplifier, diode detector, and a.f. amplifier, but it is interesting to note that the earlier stages have their heaters fed in series from a mains auto-transformer.

An edge-lit Perspex tuning scale projecting from the front of the cabinet is a distinctive feature, and the whole of the front panel, carrying the receiver chassis and loudspeakers, hinges forward, giving accessibility for servicing.

The price, including purchase tax, is £92 8s 11d, and the makers are Murphy Radio, Welwyn Garden City, Herts.

BLOCKING OSCILLATORS

Improving Performance at High Frequencies

By W. T. COCKING, M.I.E.E.

ON account of its simplicity and reliability the blocking oscillator is one of the most attractive circuits for generating saw-tooth waveforms or narrow pulses. It is by no means a new circuit for it was commonly employed in pre-war television sets and was very widely used during the war as a pulse generator and as a frequency divider in radar equipment. It is now almost the standard method of generating saw-tooth waves in television.

In spite of this, and of its apparent advantages for the purpose, the blocking oscillator is rarely used in oscilloscopes. Having searched the literature and found few references to this application, the writer decided to try it out, and it then soon became apparent why it is not often so used. Although not far from ideal at low and medium repetition frequencies, a serious fault made its appearance at high frequencies.

As no published reference to this defect could be found, the writer was led to investigate it in some detail. In its turn this led to the development of a more or less satisfactory remedy.

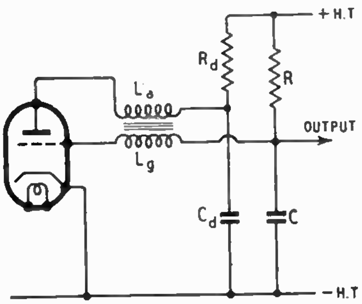


Fig. 1. The usual blocking-oscillator saw-tooth generator.

The usual blocking oscillator circuit is shown in Fig. 1; R_d and C_d are merely voltage-dropping and decoupling components. In all that follows it is assumed that C_d is so large that the voltage across it remains constant and for ease of reference this voltage will be termed V_d.

The saw-tooth appears across C. When the valve is conductive C is charged by grid current and the output terminal goes very rapidly negative with respect to cathode. It reaches a maximum negative voltage V_c which is very approximately $V_d/3$ in magnitude.

When the valve is non-conductive C discharges through R until the voltage falls sufficiently for the valve to conduct again or until an external trigger pulse makes the valve conduct. If the h.t. supply voltage is V_{ht} the voltage acting in the discharge circuit is $V_{ht}—V_c$. As V_c is negative this voltage is greater than that of the h.t. supply.

In most, if not all, other circuits the capacitor is charged positively with respect to negative h.t. and so the initial voltage acting on discharge is less than that of the h.t. supply. This fact is one of the great advantages of the blocking oscillator, for the higher voltage acting in the discharge circuit means that the discharge is more linear. For a given supply voltage and saw-tooth amplitude, the blocking oscillator gives better linearity than other circuits.

This alone is, of course, far from being a decisive factor, for unless the output amplitude required is very small the linearity of even the blocking oscillator is not adequate for oscilloscope purposes. It is usually necessary to adopt one of the well-known linearizing circuits in any case.

The mode of operation of the blocking oscillator is very simple in principle but very complex in detail. It is easiest to start by supposing C to be so charged that the valve is beyond cut-off. This means that the upper plate (on the diagram) is negative with respect to the lower. The capacitance then discharges through R and the voltage across it falls, so bringing the grid of the valve nearer to the cathode in potential. This goes on until the grid-cathode voltage falls within the grid base of the valve, which

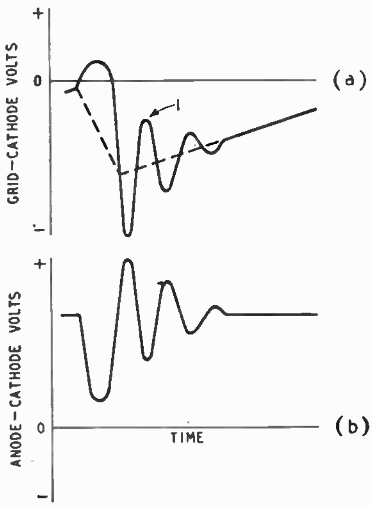


Fig. 2. Grid (a) and anode (b) voltage waveforms in the circuit of Fig. 1 when the transformer losses are only moderate.

then starts to draw anode current. This produces a back-e.m.f. in L_a in a direction to oppose the current and the anode voltage of the valve falls.

A similar e.m.f. appears by induction in L_g. Its magnitude is modified by the turns ratio but, in practice, this is usually 1 : 1. The transformer is so poled that this secondary e.m.f. acts to drive the grid in a positive direction and it consequently results in an increase of anode current. This in turn drops the anode voltage further and results in the grid becoming more positive, still further increasing the anode current. It is a regenerative action.

In an exceedingly short space of time the grid-cathode voltage falls enough for grid current to start. This flows through L_g and produces a back-e.m.f. in opposition to that induced from L_a. However, the latter greatly predominates and the main action is carried on, the grid being carried well positive to cathode and the anode voltage falling to a low figure.

The grid current flows into C to recharge it. The voltage across C increases rapidly in a negative direction, the output terminal being carried well below cathode potential. The voltages across L_a and L_g are equal with a 1 : 1 ratio transformer. The grid is positive with respect to cathode by this voltage less that across C, and the anode-cathode voltage is V_a less the transformer voltage.

After a time the rate of change of anode current decreases, so reducing the e.m.f. in L_a and hence that in L_g. The grid voltage rises less and so further reduces the anode current rise. Again the effect is cumulative and the valve is rapidly cut off, the voltage in the transformer disappears and the circuit is left quiescent with C charged. Nothing further happens except for the slow discharge of C through R until the voltage across C falls sufficiently to initiate the whole cycle again.

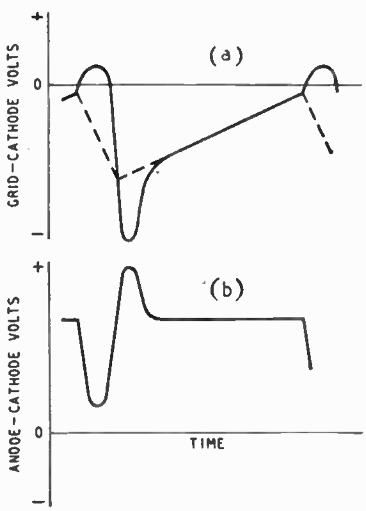


Fig. 3. Grid (a) and anode (b) voltage waveforms with heavy transformer losses. The dotted curve shows the voltage across C.

However, this account of the operation of the circuit is really over-simplified. The various stray capacitances have an important effect and instead of L_a and L_g forming the windings of an ideal transformer they really form the inductance of a Hartley oscillator.

An equivalent circuit showing

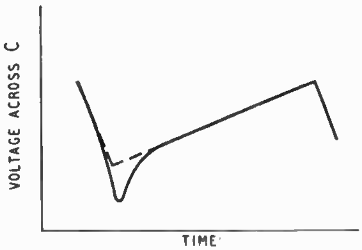


Fig. 4. The solid line shows the wave actually obtained across C when its capacitance is small and the dotted line indicates the required wave.

the stray capacitances appears in Fig. 5. In addition to the valve capacitances there are the winding capacitances C_a and C_g and the inter-winding capacitance C_1. The main effect of these capacitances is to cause oscillatory voltages to appear across, and oscillatory currents to appear in, L_a and L_g when the valve is cut off.

Instead of the voltages in the inductances disappearing quickly when the valve is cut off they execute damped oscillations. The grid voltage swings below the voltage on C and the anode swings above the supply voltage. These voltages have the form shown rather exaggerated in Fig. 3. The voltage on C has, or should have, the form shown dotted in (a).

For proper operation under these conditions it is essential that the first positive half-cycle after the valve is cut off should not be of sufficient amplitude to bring the valve within its grid base. Point 1 in Fig. 2(a) must not rise above the cut-off voltage of the valve. If it does it will restart the regenerative action of the valve and the stage will operate as a class C " sine-wave " oscillator and will not block.

The effect is avoided by making the resonant circuit of low Q. This is usually done by using an iron-cored component with fairly heavy core losses but, if necessary, a damping resistance can be

Blocking Oscillators—

connected across a winding. In practice with the proper damping the waveforms are more like

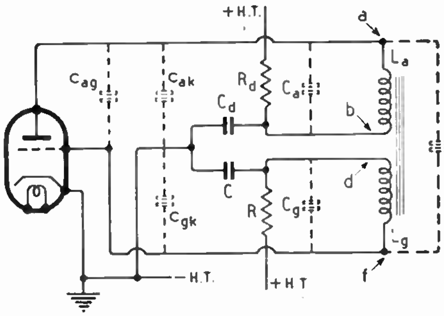


Fig. 5. Blocking oscillator circuit with the stray capacitances added.

those of Fig. 3 than those of Fig. 2.

It is observed in practice that at low recurrence frequencies the voltage wave across C really has the dotted form of Fig. 3(a) except that the fly-back is so rapid that it appears vertical. As the frequency is increased by reducing C, however, an overshoot appears at the end of the fly-back. In the writer's experience this becomes detectable when C is reduced to 0.01μF but is small enough to be unimportant. With smaller values it becomes more prominent and when it is 100 pF the overshoot may equal the scan amplitude. In addition, the overshoot persists well after the nominal end of fly-back and so occupies a good deal of time which should be devoted to a linear sweep. The form of the wave is sketched in Fig. 4 in which the desired wave is shown dotted.

The overshoot arises because C forms part of the oscillatory circuit. It has been shown in Figs. 2 and 3 that there are voltages of oscillatory form across the inductances during and immediately after the fly-back. Now if there is an oscillatory voltage across an inductance there must be an oscillatory current in it and there must be a closed path in which that current can flow. The closed path is provided by the stray capacitances and these are shown in Fig. 5, which is Fig. 1 with the capacitances added.

When the valve is cutting off, the anode is going positive and the grid negative; that is, point *a* is going positive with respect to *b* and *f* is going negative with respect to *d*. The current in the inductances, therefore, must be an electron current flowing upwards and increasing with time. It flows through L_g in the same direction as the grid current. The current oscillates so that it is proportional to the integral of the voltage across the inductance; that is, if the voltage is roughly sinusoidal, the current is roughly cosinusoidal.

It is important to notice that this oscillatory current in the circuit persists after the grid current has ceased and the valve has been cut off. It lasts as long as the anode and grid oscillations of voltage shown in Figs. 2 and 3 persist and in high-frequency operation they can last for at least half the sweep period.

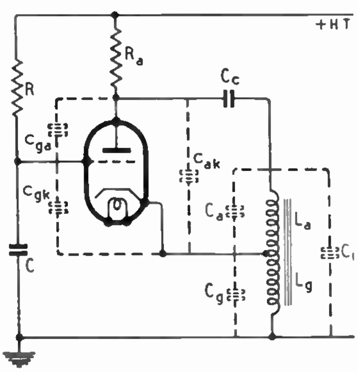


Fig. 6. Cathode-tapped blocking-oscillator circuit.

Inspection of Fig. 5 shows clearly that except for a relatively small part in C_a and C_g the whole of this current flows through C. The closed circuit is L_a, C_d, C, L_g and the combined value of C_1, c_{ag}, c_{gk}, c_{ak}. The mutual inductance between L_a and L_g complicates the matter somewhat but does not affect the main conclusion.

Conditions during fly-back are largely independent of C; they are governed mainly by the transformer characteristics and stray capacitances. As long as this is true the oscillatory current in C is independent of its capacitance but the voltage which it develops across C is inversely proportional to its capacitance. When C approaches the stray capacitances in magnitude its value does affect the fly-back and the current, but the oscillatory voltage across it is then very large.

There appears to be no way of avoiding the effect with this form of blocking oscillator. However, there are other forms of the circuit. One modified form is shown in Fig. 6. It functions in much the same way as the other circuit, but is modified somewhat by negative feedback from the cathode inductance. Since C is no longer included within the oscillatory circuit it would at first appear that the circuit would be free from the overshoot in the voltage across C. In practice it is not. The overshoot is still present.

When the circuit is examined in more detail, however, it can be seen that C is actually coupled to the tuned circuit by the grid-anode and grid-cathode valve capacitances and so a part of the oscillatory current must flow in C. In order to prove this the experiment was tried of operating at a low recurrence frequency with a large value of C. Overshoot was unobservable. The grid-anode capacitance was then artificially increased by adding external capacitance and the overshoot then appeared as expected.

The advantage of this circuit over the earlier one is that it

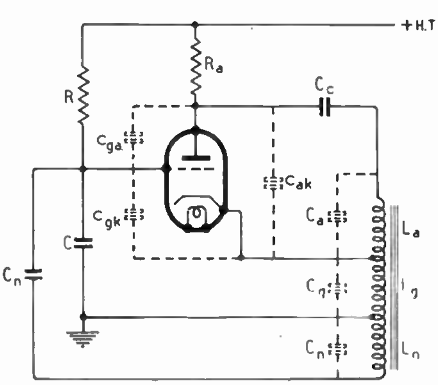


Fig. 7. Basic form of the cathode-tapped circuit with neutralizing components L_n and C_n added.

lends itself to a method of overcoming the defect. If an additional winding L_n and capacitance C_n are added, Fig. 7, the coupling through the valve capacitances can be neutralized. C_n is connected to a point which undergoes voltage variations in opposite phase to those of the grid and cathode. The current through it is then in opposition to those through c_{ga} and c_{gk} and can be adjusted to equal their sum.

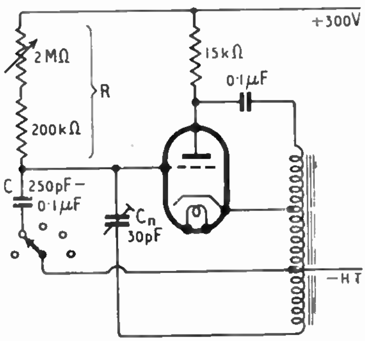


Fig. 8. Practical form of neutralized cathode-tapped blocking oscillator. The valve can be one section of a 6SN7.

One can then consider the currents in c_{ga} and c_{gk} as returning to the tuned circuit through C_n and so missing C completely. Alternatively one can regard the valve capacitance currents in C as being cancelled by an equal and opposite current in C from C_n.

If L_a, L_g and L_n all have equal turns and are very tightly coupled so that the leakage inductance is negligible, it is easy to work out the required value of C_n. The first step is to resolve c_{ga} and c_{gk} into a single equivalent capacitance. Since $L_a = L_g$ the anode voltage swing is twice that of the cathode and so c_{ga} can be regarded as absent if c_{gk} has added to it a capacitance $2c_{ga}$. Then neutralization is complete if C_n equals this effective grid-cathode capacitance; that is $C_n = c_{gk} + 2c_{ga}$.

In its practical form the circuit is shown in Fig. 8 and it is convenient to make C_n a 30-pF trimmer. The value to which it is actually set is of the order of 15 pF. It should be adjusted at the highest sweep frequency for the most linear sweep as observed on an oscilloscope and the setting is moderately critical.

It is not, of course, practicable to obtain perfect neutralization, for the inevitable leakage inductance of the transformer prevents this. It is however, possible to reduce an overshoot of 50 per cent to perhaps 2 or 3 per cent only and so to turn an unusable saw-tooth into one which is quite adequate for many purposes. The main practical drawback lies in the need for an oscilloscope in order to carry out the neutralizing adjustment.

NEW BOOK

Television. By M. G. Scroggie, B.Sc., A.M.I.E.E. 2nd edition. Pp. 77+ix, with 28 illustrations. Blackie & Sons, Ltd., 17, Stanhope St., Glasgow, C.4. Price 6s.

THIS book gives a very simple and lucid explanation of how television works. Originally written in 1935, this post-war edition has been very thoroughly revised.

In his first chapter the author explains what is involved in television. He shows why a scanning process is necessary and in turn why this involves high frequencies. In the next chapter he goes on to describe briefly some of the methods by which television has been attempted, and in Chapter III he turns to the cathode-ray tube as applied to television, and good elementary descriptions are included.

Subsequent chapters deal with television standards and present-day transmitters and receivers, while broadcasting technique and future developments receive some attention.

The book covers the whole field of television in only 77 pages, so that details of methods and equipment are necessarily scanty. It is not intended to supply such detail, however, for the book is really an introduction to television and meant for those who know nothing about it. The author claims also that: "Although some knowledge of radio will help here and there, the reader with only a general interest in modern invention should be able to follow all the essentials." In the reviewer's opinion a little more prior knowledge of radio than this is needed, but there is no doubt that, given this rather elementary knowledge, the book does form an excellent introduction to television.

W. T. C.

Unbiased

By FREE GRID

Mr. Punch Nods with Homer

ONE of the weaknesses of the flesh to which we are all heir is the taking of a sadistic delight in saying "I told you so" whenever opportunity offers. The temptation to say this gathers strength in proportion to the eminence of the person to whom we are able to say it. This desire becomes so overmastering that we yield to it regardless of all consequences and despite all the warnings of prudence and common sense. A notable instance of this was Cardinal Wolsey's fatal inability to refrain from reminding Henry VIII that he had anticipated by several months the Royal remarks about Anne Boleyn's behaviour. The result of this, of course, was a regrettable gap in the ranks of the Freemen of Ipswich, although actually kindly nature mercifully forestalled Henry.

Therefore, even at the risk of a vacant chair among the Burgesses and Aldermen of my own city, I cannot refrain from pointing out to Mr. Punch his unconscious plagiarism. He reminds householders struggling to keep up appearances that a licence is not necessary for just a television aerial (13.4.49). It is just ten years ago that I gave a full account in the pages of this journal (8.6.39) of the doings of the new "snobocracy." Mindful of their poverty, and at the same time of the necessity of keeping up what the late Sir Arthur Quiller-Couch called "Cumeelfo," the "snobocrats" have erected on their chimney-stacks what are best described as television aerials without portfolio.

Aerials Without Portfolio.

As Mr. Punch has so belatedly discovered, this pernicious practice is still going on; in my opinion pernicious is undoubtedly the *mot juste* to use in spite of the fact that the king of laughter makers takes a more kindly view of the practice than myself, and sees behind it the more worthy motive of keeping up appearances.

I am happy to record that Mr. Punch makes no claims that his discovery is an original one; which is more than can be said of certain inventors. I would go so far as to say that there are few major inventions in the realm of radio and electronics which have not been anticipated in these columns; in fact, many large corporations are jealously guarding patents which would be rendered quite worthless were I minded to drop a line to the Comptroller of the Patent Office calling his attention to my prior publication.

Were it not against my principles I could, without doubt, make a considerable income by accepting under-the-counter royalties from these firms. Moreover, it could be free of income tax, as they would most certainly not risk offending me by notifying the Inspector.

Midsummer Menace

DURING the murky days of "drear December," as we sat round the electric fire which Mr. Gaitskell had cut off, and drew our overcoats and the encircling gloom of our own thoughts a little more closely around us and solemnly munched a benzedrine tablet to raise our blood pressure, we not unnaturally indulged in escapist thoughts. We sighed for the long, lovely and languorous summer days which lay ahead when our tired and sweat-soaked bodies will straphang twenty-to-the-compartment on our annual pilgrimage to the sea.

This year, alas, such comforting thoughts failed to cheer my winter gloom, for I have been faced with the fearful menace of the over-loud loudspeaker bellowing through the too-open window. My only weapon of counter-offensive appears to be useless, its sting having been drawn by a callous government, aided and abetted by the opposition, by means of the new "anti-interference" Bill.

Hitherto I have been able to secure some measure of peace in my neighbourhood by letting Mrs. Free Grid run amok with her so-called violet-ray beautifier. With this aid she endeavours, will-o'-the-wisp fashion, to recapture the pristine glamour that was hers when she made her *debutante* bow before Queen Victoria in the days when knights were bolder and nights were kinder than nowadays, when the gentle glow of Queen Spermaceti has given place to the harsh glare of King Neon.

Not Dingley Dell.

I have been hard put to it to evolve a legally permissible way of getting round the "anti-interference" Bill, for to break the law deliberately would be abhorrent to me. I have, I think, solved the problem, but my legal learning is admittedly not in the K.C. class, and I shall feel very gratified if any of your Portias of either sex can point out the flaws, if any, in my scheme, and, moreover, suggest remedies.

Briefly, I have fitted Mrs. Free Grid's beautifier with all the suppressors which the law requires, but have, in addition, fitted a relay which, on being actuated, switches them out of circuit. This relay is operated from a suitable amplifier which is controlled by microphones placed at strategic points round my garden wall so that offending loudspeakers themselves trigger-off the reprisals; it is, in fact, a sort of inverted I.F.F. or Vogad circuit. The owner of the offending loudspeaker is himself (more usually herself) morally responsible for causing the interference, and it is my firm belief that in a test case he, or she, would be held legally liable and be quite justly fined for the offence.

Fiat justitia.

LETTERS TO THE EDITOR

Economics of Interference Suppression • Simple E.H.T. Supply • Television Lines and Picture Quality • Time-base Circuit Characteristics

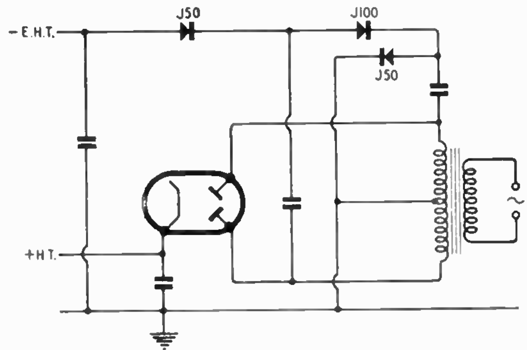
Interference versus *Signal*

IT occurs to me that economically the proposed legislation for the compulsory suppression of electrical interference is in a sense unsound. The total cost, I would imagine, will considerably exceed the amount required to provide greater signal strength (voltage at aerial) by increasing the number of transmitters and/or their radiated power. In any event, as you have pointed out, there are types of interference which it will be most difficult to suppress.

Great Yarmouth. S. WEST.

E.H.T. for VCR97 Tubes

THE accompanying diagram shows how a 2-kV supply may be obtained from a standard 350-0-350 mains transformer, which is at the same time providing normal h.t. The principle is that of the "Westeht" unit, fully described in your May, 1948, issue. I am using the method with a 400-0-400 transformer, with the VCR97 in an oscilloscope. The e.h.t. peak value is then 2.4 kV. The rectifiers used are Westinghouse J50 (two) and J100—available cheaply on surplus market. The tube filament is best supplied from one of the filament windings via an isolating transformer which may easily be wound by hand on an old output transformer core.



C. J. McCUBBIN.

Cambridge.

"Television Goodness Factor"

IN the above article (your March issue) the writer claims that there is no advantage to be gained from an increase in the number of lines above 405 until the transmitting, relaying and receiving equipment are all capable of handling a 5-Mc/s bandwidth. I fail to agree with this.

When calculating f_{min} to give equality in horizontal and vertical definition one should use a utilization factor. All the elements of the object being scanned do not coincide with a scanning line, and so some of the picture elements are distorted or missing; this reduces the effective number of scanning lines. Utilization factors of between 0.6 and 0.95 have been suggested and D.G. Fink. puts 0.75 "as a convenient basis for calculation." Hence, for the present B.B.C. system:

$$f_{min} = \frac{405^2 \times 25 \times 5 \times 93 \times .75}{2 \times 4 \times 84.5} = 2.12 \text{ Mc/s.}$$

$$\text{And so } D = \frac{f_{mod}}{f_{min}} = \frac{2.7}{2.12} = 1.27$$

$$\text{Also for } D_{opt} = 1.5;\ f_{mod} = 1.5 f_{min} = 3.18 \text{ Mc/s.}$$

In a system with 525 lines, 25 pictures/sec., 5 : 4 aspect ratio, 94 per cent. vertical and 84 per cent. horizontal activity and a utilization factor of 0.75

$$f_{min} = \frac{525^2 \times 25 \times 5 \times 94 \times .75}{2 \times 4 \times 84} = 3.62 \text{ Mc/s.}$$

$$\therefore \text{ for } D_{opt} = 1.5;\ f_{mod} = 1.5 f_{min} = 5.43 \text{ Mc/s.}$$

From this it can be seen that with the present B.B.C. system any increase in transmitted bandwidth beyond 3.18 Mc/s, while giving an improvement, will not give optimum conditions if unaccompanied by an increase in the number of lines. Also the 5-Mc/s bandwidth suggested by R. W. Hallows would give a d.f. of 1.38 on a 525-line system.

I should also like to point out what I believe to be an error in Fig. 2 in the same article. Three peak blacks and two peak whites occur at (a) represented in the voltage waveform by three peak negatives and two peak positives at (b). However (c), the reproduction on the screen, shows five peak blacks and four peak whites. The second and fourth blacks should,

Letters to the Editor—

I believe, be whites. [*Yes, this error is regretted.*—ED.]

DENIS E. URRY.

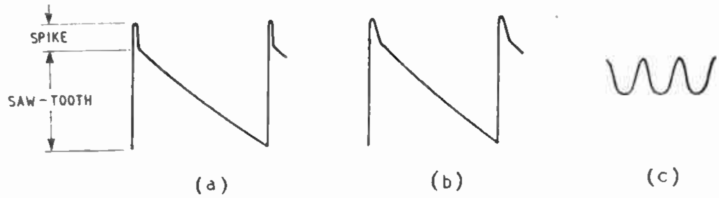
London, S.E.23.

Time-base Circuit

IN his note on a time-base circuit in the May issue of *Wireless World*, J. McG. Sowerby does not refer to one of its characteristics which may well make it unsuitable for some purposes. The saw-tooth is preceded by a spike of considerable amplitude. With small values of capacitance, this spike merges into the saw-tooth and causes serious non-linearity at its start.

The accompanying table shows the effects of varying the capacitance.

With large capacitance values, corresponding to low repetition frequencies, the fly-back is very rapid and the spike is accordingly very narrow. With small capacitances, however, the waveform changes from the form (*a*) to (*b*), while the anode waveform deteriorates from a very narrow pulse to something approaching a sine wave (*c*).



Capacitance	Saw-tooth Amplitude (V p-p)	Spike Amplitude (V p-p)	Per cent. Overshoot	Anode Pulse (V p-p)
100pF	17.6	3	17	6.5
0.01μF	23.4	4.15	17.8	26.6
0.1μF	23.4	4.15	17.8	26.6

They are for a 6SN7 double-triode with a 200-V h.t. supply and operating with a 1-kΩ cathode resistor for one valve and a 2-MΩ for the other, the anode coupling resistor being 15 kΩ.

The spike is, of course, inherent and brought about by the charging current in the cathode resistor on fly-back. Its presence is most unfortunate, because it mars what would otherwise be a most excellent circuit, having the great practical merit of being exceptionally easy to put into operation. As both sweep and fly-back times are controlled by the same capacitance there is almost nothing to go wrong.

It is, perhaps, worth pointing out also that the peak cathode voltage may, and usually will, greatly exceed the peak-to-peak amplitude of the waveform, because the fly-back starts long before the capacitor is fully discharged. This must be taken into account when choosing the operating conditions, otherwise the heater-to-cathode voltage rating of the valve may be exceeded. W. T. COCKING.

Drawing Circuit Diagrams

I WISH to endorse the remarks in his article on the above subject by L. H. Bainbridge-Bell in the May issue of *Wireless World*. I am more used to the conventions he prefers and whilst I have no difficulty in understanding bridged cross-overs, I am often confused by the use of cross-over connections.

I would like *Wireless World* to consider abandoning cross-over connections in favour of staggered connections, but still retaining bridged cross-overs. This action would render diagrams easily understood by people used to both sets of conventions. J. I. COLLINGS.

Broadstone, Dorset.

Hum in High-gain Amplifiers

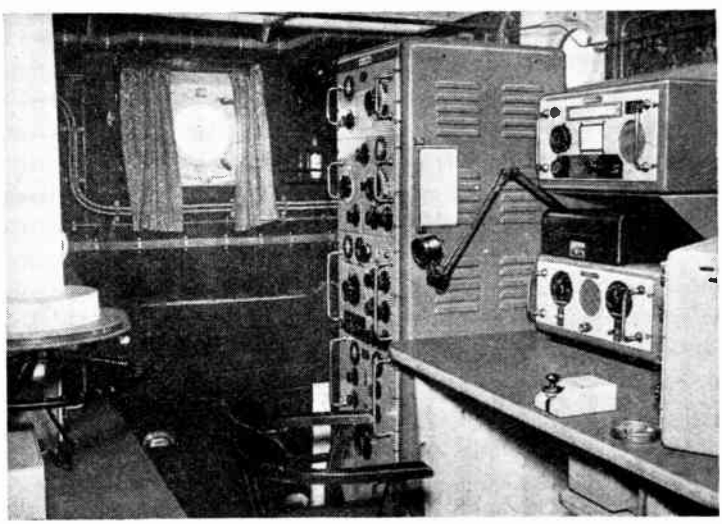
WHEN experimenting with high-gain amplifiers I have found "hum" to be reduced considerably if the "earth" connection is made through a capacitor of value 0.005 μF, but when larger or smaller capacities or direct earth connections are used they have increased the hum. Alternatively, connection through a variable resistor of 0/250,000Ω has given a very sharp "dead spot." I should be interested to know if other readers have found this effect. I have my own theories, but would be glad to know the exact reason.

I have never seen this mentioned in print, but perhaps it has missed my attention.

GEOFFREY P. DENNY.

Worthing.

TRAWLER RADIO



DESIGNED specifically to meet the requirements of trawler owners and skippers, this new "Redifon" equipment, installed in the trawler *Thuringia*, has a working range on telephony of the order of 1,000 miles. Facilities for simplex, duplex or voice-operated relay working are provided. A special direction-finding equipment enables "snap fixes" to an accuracy of 1° to be taken on transitory speech code messages of only a few syllables. The makers are Rediffusion Ltd., Broomhill Road, London, S.W.18.

SHORT-WAVE CONDITIONS

April in Retrospect : Forecast for June

By T. W. BENNINGTON and L. J. PRECHNER (Engineering Division, B.B.C.)

DURING April, maximum usable frequencies for this latitude decreased considerably by day, and increased somewhat at night. Thus the 28-Mc/s band in the last two weeks was no longer always reliable for daytime eastward and westward communication during the second half of the month. These are normal seasonal variations, and a similar trend should continue towards midsummer.

The month was somewhat less disturbed than March, ionosphere storms being observed on 5th-6th, 8th-9th, 11th, 13th, 19th, 22nd, 26th-27th and 29th-30th. The 8th-9th was exceptionally disturbed.

Apart from the disturbed period early in the month, conditions were on the whole very good on most circuits. 50-Mc/s amateur transmissions from South Africa were again received in England on a number of occasions early in the month. During the night frequencies of the order of 11 Mc/s continued to be workable.

The rate of incidence of Sporadic E was about the same as in March, and it was of the usual order for this time of the year.

Eight "Dellinger" fadeouts were recorded in April (three on 5th, one on 10th, one on 11th, two on 13th and one on 26th). Two fadeouts on the 5th were particularly violent.

Sunspot activity in April was somewhat less than in March. Only one large group crossed the central meridian of the sun (on 16th), and it was very probably associated with severe reception disturbances which occurred before that period.

Owing to the favourable weather conditions, long-range tropospheric propagation was observed on a number of occasions, particularly towards the end of the month.

Forecast.—During June the daytime m.u.fs should continue to decrease, and may probably reach their annual minimum values. On the other hand, night-time m.u.fs will continue to increase, probably reaching their highest values for the year.

Although daytime communication on very high frequencies (like the 28-Mc/s band) is not likely to be very frequent, over many circuits fairly high frequencies like 15 and 17 Mc/s will remain regularly usable until midnight. During the night frequencies lower than 11 Mc/s will be seldom required.

For medium distances up to about 1,800 miles the E and the F_1 layers will control transmission for considerable periods during the day, and in such cases daytime as well as night-time frequencies should be higher than in May.

Sporadic E is usually very prevalent in June, and communication over distances up to 1,400 miles may be possible by way of this medium on frequencies greatly in excess on the m.u.fs for the regular E and F layers. Frequencies as high as 60 Mc/s may be occasionally reached for a short time. However, it is impossible to predict when such communication may occur, owing to the irregular behaviour of Sporadic E.

Below are given, in terms of the broadcast bands, the working frequencies which should be regularly usable during June for four long-distance circuits, running in different directions from this country. (All times G.M.T.) In addition, a figure in brackets indicates the highest frequency likely to be usable for about 25 per cent of the time during the month, for communication by way of the regular layers:—

Montreal :	0000	15Mc/s	(19Mc/s)
	0100	11 ,,	(15 ,,)
	1200	15 ,,	(19 ,,)
Buenos Aires :	0000	17Mc/s	(22Mc/s)
	0100	15 ,,	(19 ,,)
	0500	11 ,,	(16 ,,)
	1000	17 ,,	(23 ,,)
	1500	21 ,,	(26 ,,)
	1900	17 ,,	(22 ,,)
Cape Town :	0000	15Mc/s	(20Mc/s)
	0100	11 ,,	(15 ,,)
	0600	17 ,,	(24 ,,)
	0800	21 ,,	(28 ,,)
	1800	17 ,,	(22 ,,)
	2100	15 ,,	(19 ,,)
Chungking :	0000	11Mc/s	(14Mc/s)
	0500	15 ,,	(20 ,,)
	2300	11 ,,	(14 ,,)

Ionospheric storms are not very common in June, and relatively undisturbed conditions may be expected. At the time of writing it would appear that storms are more likely to occur during the periods 2nd-5th, 8th-10th and 28th-30th, than on the other days of the month.

MORE LOUDSPEAKERS

THE new range of Plessey loudspeakers has been further extended by the provision of alternative magnet assemblies in the 6½in and 8in models; thus manufacturers can avail themselves of higher sensitivity and damping where this is particularly required. All p.m. speakers with the exception of the 3-in model are now available with 3-ohm as well as 5-ohm voice coils.

RANDOM RADIATIONS

By "DIALLIST"

Fringe-area Television

IN LAST MONTH'S ISSUE of *Wireless World*, W. Gearing-Sherratt asked why our makers of television aerials have not done more to develop multi-element arrays, designed to make the most of weak signals at distances of 100-150 miles from the transmitting station. He states correctly that any American radio magazine contains numbers of advertisements of high-gain three-element or four-element arrays of folded dipoles markedly directional and of very high performance. He laments the absence of similar arrays from the advertisement pages of our wireless magazines. A short time ago this was true; but now more than one firm of manufacturers caters for fringe-area television reception. There's no question that if you put up a receiving aerial array, strongly directional and of very high gain, you can receive television broadcasts far beyond their normal range. One of the most convincing proofs of this was the success of the array erected on Beachy Head during the war to receive television from Paris. The Germans kept the Paris transmissions going after the occupation and used them for propaganda purposes. The big idea was to broadcast to the French populace horror pictures of the damage wrought by allied bombers in the attacks that they had to make on French factories engaged in turning out war material for our enemies. As there were then not more than a few hundred receivers in use in the Paris area, this object was not attained. But a high-gain aerial array erected on the cliffs near Dover enabled these broadcasts to be received by our people and gave them invaluable up-to-the-minute information. The demand for multiple aerial arrays is likely to grow rather than to decrease as new transmitters come into operation and interest is widespread.

For the Soldering Iron

EVERYBODY, I SUPPOSE, who uses an electric soldering iron makes (or is always promising himself that he will make, one of these days) some kind of prop, enabling the hot iron to be put down anywhere on bench or table without the risk of "frying" valuable bits and pieces. I've never been quite satisfied with any of my own contraptions and have for long been intending to make something of superlative excellence. One somehow never seemed to find time to do the job; but the other day I had, like friend Murdoch, an idea, which I pass on for the benefit of any who are as good at putting things off as I am. Cost, threepence or fourpence; time required, about the same number of minutes; performance, eminently satisfactory. You know those paper clips (Bulldog, I think they're called) which open a pair of jaws when you squeeze a couple of lugs sticking out at the top? Get a small one of those; mine has 1¼-inch jaws. If need be, shape the jaws with a pair of pliers. Then slip it on to the body of the iron about 4 inches above the tip of the bit and bend the lugs outwards to form "feet." This prop stays put, doesn't get in the way and doesn't upset the balance of the iron. What's wrong with ready fitted props or feet?

Big Business

USED AS PACKING in a parcel which I received a short while ago from the U.S.A., came a copy of an American "tabloid" illustrated daily newspaper. Having almost forgotten what even our dailies used to be in days gone by, I examined it with awe, amazement and a modicum of regret. Seventy-two pages: price two cents! My regrets were occasioned by the reflection that each page of this not very valuable publication was about four times the size of those of an average book; hence each issue contains enough paper to make a 288-page book. It seems a queer business that at a time when one part of the world is so short of paper that it can't supply students with sufficient text books, either new or reprinted, another part should think nothing of squandering vast masses of paper every day on the publication of so much stuff that isn't worth either writing or reading. However, I did cull one little gem from this particular tabloid. It concerned the opening of a new radio and television shop at a place called Englewood in New Jersey. Everyone who bought a television set on the first day was presented with two tickets for a Broadway music hall show, a voucher covering dinner for four at a New York night club, a portable radio receiver and a magnifying lens for the televisor. Business, I gather, was brisk—as well it might be!

The Customer can be Wrong!

IT'S almost an axiom of the side of Big Business devoted to retail distribution that the salesman must take the view that the customer must be right. Actually, as Big Business jolly well knows, half the cost of high-pressure salesmanship lies in making the customer do the silliest things without realising that they are silly. What the poor mutt seldom grasps is that somebody has to pay for "free gifts" and that somebody won't be the vendor. One is glad to think that, on this side of the Atlantic at any rate, television has had little need to boost sales by offering purchasers of receiving equipment gifts, apparently free, which have to be paid for in the end.

Try This One

Below is a horrible problem which members of the Slade Radio Society of Birmingham were recently asked to solve. I've written to the Secretary to ask for the official answer and I only hope he is kind enough to let me have it before this appears in print and readers start sending in solutions! Twisters of this kind in which someone is three times as old as someone else was . . . always drive me to the verge of insanity if I let myself be tempted into tackling them. You, I'm sure, will do it on your head—or in it. Well, here it is if you care to have a go.

A line cord is centre-tapped to form two arms of a bridge, Y and Z. The other arms comprise a resistance X and a small boy with a thirst for experiment.

The bridge is balanced and there is the same amount of line cord in each of the arms Y and Z.

The line cord has a resistance of 1 ohm to the foot and the ages of the small boy (S.B.) and his elder brother (E.B.) are together 16 years. The resistance of the S.B. is as many ohms as the E.B. is years old.

The E.B. is twice as old as the S.B. was when the E.B. was half as old as the S.B. will be when he is three times as old as his E.B. was when the latter was three times as old as the S.B.

The resistance C and the resistance of the line cord is half as much again as the difference between the resistance X and the resistance X and the resistance of the S.B.

What is the length of the line cord?

[For solution see page 223.—Ed.]

M

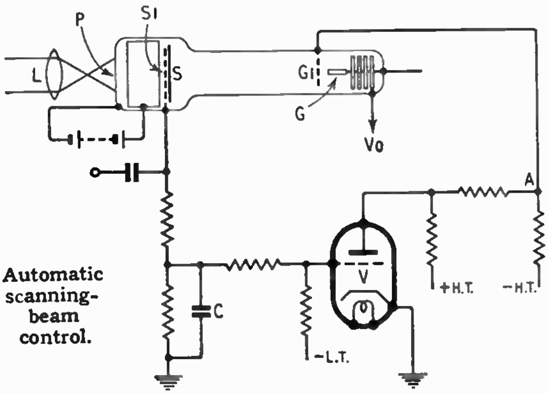
RECENT INVENTIONS

A Selection of the More Interesting Radio Developments

Television Cameras

THE intensity of the scanning beam in a television tube of the so-called "Orthicon" or low-velocity type is automatically controlled in accordance with the average overall illumination of the scene being televised.

In the diagram, which only shows such details as are essential to the invention, a lens L projects the scene on to a photoelectric cathode P to release a stream of electrons, which are focused on to a mosaic screen S. Here they liberate secondary electrons, which are collected by a grid S1 in numbers proportional to the prevailing brightness of illumination. The grid is connected to earth through the resistances shown, and the resulting current builds up a negative charge on a condenser C. This is translated, by means of a valve V, into a corresponding rise in the positive potential of a point A in the anode circuit, which in turn is transferred to a grid G1 controlling the "gun" of the tube. The network of resistances shown ensures that the bias applied to the grid G1 is such as to maintain the scanning beam full modulated at all times; irrespective of variations in the background illumination. The final video signal VO is developed by a group of electron-multipliers in known manner.



Automatic scanning-beam control.

Marconi's Wireless Telegraph Co., Ltd. (assignees of R. R. Thalner). Convention date (U.S.A.), January 9th, 1945. No. 610288.

Variable Permittivity

A CERAMIC dielectric, made of a mixture of barium and strontium titanites in the proportion of 95 parts to 5, possesses a permittivity which increases with the applied alternating voltage. Advantage is taken of this fact to make condensers which are inherently "voltage sensitive," and so can be used to secure automatic selectivity control and other desirable results.

If, for instance, the two circuits of an intervalve coupling of the bandpass type are arranged to be exactly in tune for a predetermined level of signal strength, the inclusion of a voltage-sensitive condenser will cause progressive detuning of the circuit as the signal increases in strength; this automatically widens the acceptance band of the filter. Again, if a similar type of condenser is used to couple an aerial to the tuned input circuit of a wireless receiver, its initial low permittivity will ensure high selectivity for weak signals; though for stronger signals the resulting increase in the capacity coupling automatically acts as a damping factor on the input.

P. R. Coursey, L. J. Snell, Steatite & Porcelain Products, Ltd., and Dubilier Condenser Co. (1925), Ltd. Application date, October 2nd, 1945. No. 609824.

Television Suppressor Circuit

A KNOWN circuit for eliminating disturbances that exceed the peak white signals consists in connecting the anode lead from the amplifier to earth through a condenser and a diode, both of these being shunted by a resistance of such value that the time-constant of the combination is longer than that of the disturbing impulse.

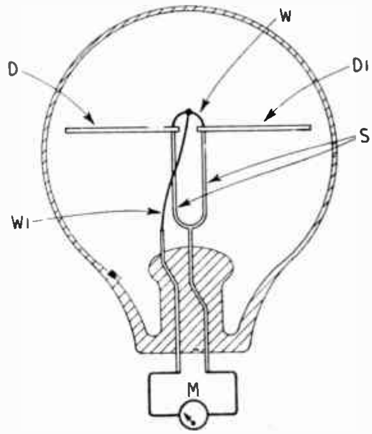
According to the invention, the above circuit is made more effective by connecting the anode of the suppressor diode to the control grid of the amplifier, so as to apply negative reaction to the latter. Under normal conditions, the degree of reaction will be determined by the peak-white signal voltage, and is small. When a disturbing pulse arrives, it acts to open the diode and so automatically reduces the amplification of the main valve. This, in turn, serves more efficiently to eliminate the effect of the disturbance upon the received picture.

E. R. Blackler and Pye, Ltd. Application date, February 28th, 1946. No. 608710.

Measuring Radiation Fields

AN appliance for taking field-strength measurements of energy radiated on wavelengths of the order of centimetres comprises a pick-up dipole D, D1, which is mounted inside an evacuated bulb on a metallic stub support S, which also serves as a quarter-wave "insulator." The adjacent ends of the dipole are joined together by a fine wire W of Constantan alloy, the centre point of which is connected to a fine wire W1 of copper or Chromel alloy. The two wires form a thermocouple having its hot junction located at the point of maximum pick-up current. The voltage developed across the sensitive couple is indicated on an external meter M connected to the pair of lead-in wires.

In an alternative arrangement, the simple dipole is replaced by the two halves of a split waveguide stub of rectangular cross-section. These are separately mounted, side by side, and the collected energy is fed to a thermocouple situated midway between the centres of their two opposite faces.



Thermocouple for centimetre field-strength measurement.

Philco Radio and Television Corpn. (assignees of W. E. Bradley). Convention date (U.S.A.), December 31st, 1943. No. 610024.

Radio Cabinets

TO allow convenient access to the circuit components, for renewal or repair, the cabinet is moulded in two parts, each having the form of an open box. The edges of the open sides are flanged and recessed, so as to make a tight joint when the two parts are clamped together by long screws.

The chassis of the set is mounted on a pair of skid-like members, which fit into grooves along the base of the cabinet and are held in position by screws, preferably passing through the bottom of the front moulding. The rear moulding is more than half the depth of the complete cabinet, so as to expose the greater part of the chassis to inspection. A plug-and-socket switch automatically breaks the mains supply lead, when the two parts of the cabinet are separated.

De La Rue Plastics, Ltd.; F. E. Middleditch and S. R. Hawkins. Application date, December 7th, 1945. No. 606817.

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permalloy permendur

STANDARD MAGNETIC MATERIALS have the unique advantage of being produced by a Company which itself is a large scale user of these materials, as a result of which a vast amount of direct experience in the use of magnetic alloys has become available. Permalloy Nickel/Iron Alloys are particularly suitable in cases which demand high permeability and low losses—especially low hysteresis loss: they should, however, be selected according to individual requirements. V-Permendur, one of the Cobalt/Iron alloys, should be employed where high permeability throughout a wide range of flux densities is called for, and it finds special application in diaphragms for high quality telephone receivers.

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PERMALLOY B. Lower initial permeability than "C," but higher flux densities possible.

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V-PERMENDUR. A Cobalt/Iron alloy with unusually high flux density. **It can be rolled to .010 in. strip** and exhibits high permeability up to high flux densities.

	Permalloy "B"	Permalloy "C"	Permalloy "D"	V. Permendur
Specific gravity	8·3	8·6	8·15	8·2
Electrical resistivity, microhms per cm. cube ...	55	60	90	26
Temperature for heat treatment C°C ...	900	1,050	900	790
Initial permeability μ... ...	1,800 to 2,400	10,000 to 30,000	1,500 to 2,000	700 to 1,000
Maximum permeability μ_{max}	10,000 to 20,000	50,000 to 100,000	6,000 to 8,000	3,000 to 5,000
Magnetising force for μ_{max} oersteds	0·30 to 0·60	0·025 to 0·04	0·5 to 1·0	2·0 to 6·0
Maximum flux density, gauss ...	16,000	8,000	13,000	23,000
Coercive force in oersteds for B_{max} = 5,000 gauss	0·25	0·03	0·5	—
Remanence in gauss for B_{max} = 5,000 gauss	4,000	3,500	3,500	—
Hysteresis loss in ergs per c.c. per cycle for B_{max} = 5,000 gauss ...	300	45	550	—
Total loss in watts /lb. B = 5,000 gauss, 50 c/s 0·015 in. sheet	0·11	0·04	0·2	—

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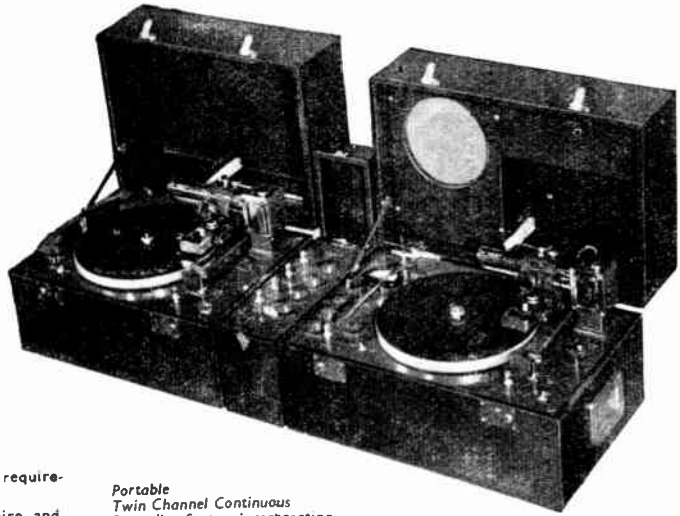

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High cathode current – Stability – Long life

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(1) *High continuous and instantaneous cathode current.*

(2) *Consistent striking characteristics.*

(3) *Higher stability and freedom from photoelectric and temperature effects.*

(4) *Reliability and long life resulting from improved cathode activation.*

These features make the 1267 ideal for a great number of industrial electronic applications, the more important of which include :—

- *Welding and industrial engineering timers.*
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PRINCIPAL CHARACTERISTICS	
*Max. Operating Anode Voltage	225V peak
Trigger Voltage for firing (Pos.)	70V. min. to 90V. max.
Trigger Current at Striking Point (V_a=140)	100μA max.
Valve Voltage Drop	70V. approx.
Max. Continuous Cathode Current	25 mA
Max. Peak Cathode Current	100 mA

* Above this voltage the valve may break down at Vg=0.

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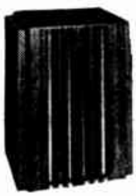
An indoor loudspeaker for schools, hospitals, restaurants, hotels, public buildings, etc. In effect a quarter segment of a circle 18in. radius which, when used in the corner of a room provides the equivalent performance of a 3 foot circular baffle. Independent wattage adjustment, etc.

£4. 12. 6d. List.



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Heads are available, made to fit standard auto-changer arms. They cost £3.0.0 plus £1.6.8 tax.

Miniature steel or thorn needles fit the pick-up and special sapphires costing 10/- plus 4/5d. tax are available.

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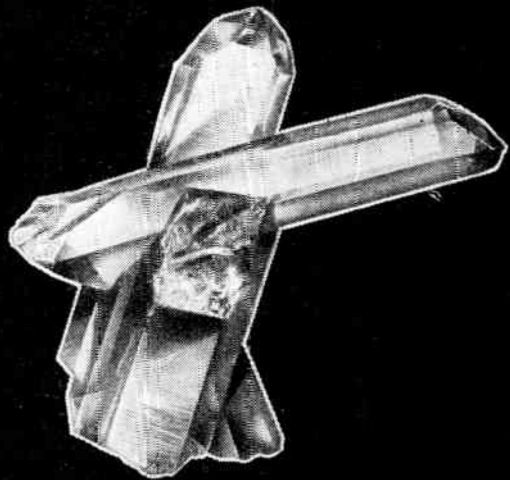

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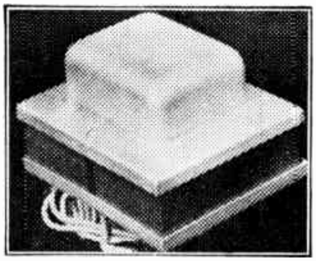

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(b) 250-0-250 v. 60 mA. 4 v. 4 A., 4 v. - A.	16 6
(c) 250-0-250 v. 80 mA. 0/4/6.3 v. 4 A. C.T. 0/4/5 v. 2 A.	19 0
(d) 300-0-300 v. 80 mA. 0/4/6.3 v. 4 A. C.T. 0/4/5 v. 2 A.	19 0
(e) 350-0-350 v 80 mA. 0/4/6.3 v. 4 A. C.T., 0/4/5 v. 2 A.	19 0
(f) 250-0-250 v. 100 mA. 0/4/6.3 v. 4 A. C.T. 0/4/5 v. 2 A.	22 0
(g) 300-0-300 v. 100 mA. 0/4/6.3 v. 4 A. C.T. 0/4/5 v. 2 A.	22 0
(h) 350-0-350 v. 100 mA. 0/4/6.3 v. 4 A. C.T. 0/4/5 v. 2 A.	22 0
(i) 350-0-350 v. 150 mA. 0/4/6.3 v. 6 A. C.T. 0/4/5 v. 3 A.	39 0
(l) 425-0-425 v. 180 mA 6.3 v. 4 A. C.T., 6.3 v. 4A. C.T., 5 v. 3 A.	44 6
(k) 425-0-425 v. 180 mA. 4 v. 8 A. C.T., 4 v. 4 A. C.T., 4 v. 4 A.	44 6
(l) 425-0-425 v. 180 mA. 6.3 v. 4 A. C.T. 4 v. 2 A. C.T., 4 v. 2 A. C.T., 5 v. 3 A.	47 0

Types (a) (b) (c) (d) (e) (f) (g) (h (k) illustrated on left. Types (i) (j) (l) upright shrouded type.

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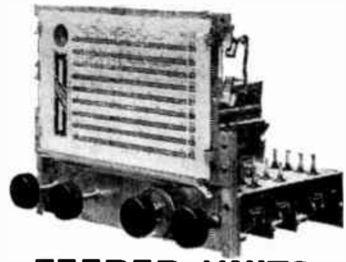

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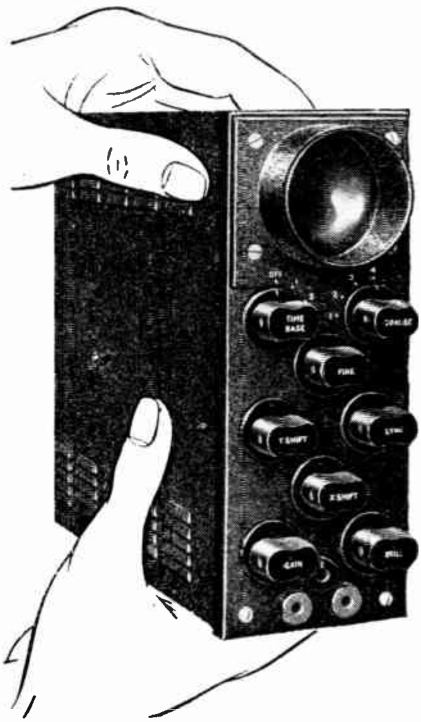

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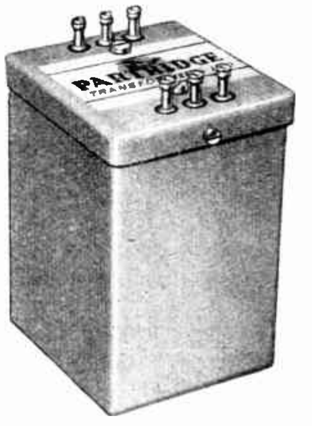

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HALLICRAFTER'S Skyrider Marine S22R, 8 valves, BFO, switched avc; seen Worthing; offers.—Box 5466. [3323

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FOR sale, Marconiphone Model T14A, 5-valve superhet table receiver, as new; £25, or offer.—Write Box 6079. [3424

DENCO 6-valve export receiver, 1946, unusual short wave capabilities; £20.—Gilbert, 8a Portinscale Rd., Putney. [3397

A.R.88 chassis 540kc/s, 32mc/s with instruction manual, perfect working condition; £55, or offers.—Box 6092. [3450

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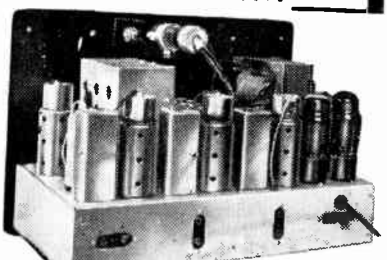

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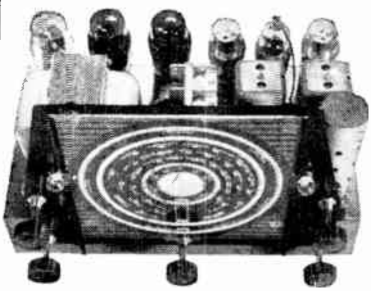

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AMAZING radio surplus bargains! Lawrences, 61, Byrom St., Liverpool, 3; searchlight radar receivers (Elsie), nineteen valves, EF54, SP61, Pen46, MU14, etc., freq. 200mc/s, I.F. 11mc/s, broadband, splendid cabinet, a superb job for long range TV or amateur band conversion, 60/-; American Command receivers, completely modified to 12v medium wave car radio receivers, 6 valves superhet, ready to instal in your car, complete with speaker, only £7; receivers R4/ARR2, freq. approx. 148mc/s, miniature valves: 3 6AK5, 7 9001, 1 12A6, similar in size BC453, 65/-; control cables, 7/6; above sets ideal for mobile operation, dynamotors type PE94, these superb American machines, fitted with robust ½in shaft, easily convert to 230v a.c. ⅛hp motor, full instructions and diagram supplied, 22/6; filters 1-L2/15C 870, this well known unit is a genuine bargain at only 8/6; inertia switches, micro action, 5/6; control cables for Bendix BC433 and MN26, 7/6; new and unused R.C.A. quality amplifiers 230 a.c., output 20watts, from 4 6J7, 2 6L6, 1 5U4G, handsome cabinet, £16/5; unused 3cm radar scanning units, AS12/APS3, parabolic reflector, dipole and waveguide, two powerful d.c. motors, precision gearing, 25/-; new American star identification instruments, complete with charts for all latitudes, in leather cases, 3/-; new American box kites, M357A, large size, originally intended for elevating 200ft antenna, 15/6; aerial tuning units type 126, rotatable inductance, RF ammeter, tune 2.5-13mc/s, 7/-; Genemotors, type 33, ideal for car radio, input 12-6v, output 200v, fully suppressed, 11/-; Bendix compass receivers MN26: valves, 1 6L7, 2 6N7, 1 6b8, 2 6J5, 5 6K7, 1 6F6, freq. 150-695kc/s, 3.4-7mc/s, complete with circuits, 90/-; control panels for receivers: RU19, 7/6; BC966/IFF, 3/6; BC453-4-5, 8/6; BC453 dynamotors, genuine plug-on type 28v in, 250v out, 12/6; brand new and unused, in makers' cartons, finest quality combination headsets, moving coil mike and earpieces, large rubber ear cushions, 10/-; new M.O.P.A. tuning units CAY47155, freq. 1.5-3mc/s, precision micro vernier dials, ceramic switches, instrument cabinet, 17/6; oscilloscope units BC929, tube 3BP1 3in, seven valuable valves, panel controls for focus brilliance, shift amplitude, etc, convert to efficient test scope, 70/-; American aerial tuning units BC306A, variometer type S.M. dial, ceramic switch, 11/-; just arrived! a vast consignment of aircraft instruments from 2/6; numerous types for pressure, speed, vacuum, direction, etc., etc.; send only 2½d for illustrated lists; new Marconi Dynamotors, input 6v, output 200v, 80ma, small dimensions, 18/6; Octal plug-in coils for Birmingham TV, air trimmers, screened, 3/6; new 15h, 100ma chokes, shrouded, 7/-; a 2½d stamp brings you our latest illustrated lists, describing countless bargains from 5kva petrol generators to diminutive components; terms, c.w.o., prices include carriage.
LAWRENCE'S, 61, Byrom St., Liverpool 3. Cen. 4430. [3589

G. A. RYALL, "Utopia," Mayfield Rd., Herne Bay, Kent; mail order only; postage or carriage extra; c.o.d. £1 or over; special list for the trade; U.S.A. tubular metal cased wire ended 0.1m.f. 350v. 6/- doz., 350v 5/6 doz., U.S.A. tubular metal cased wire ended 0.5m.f. 350 7/6 doz.; Mansbridge 1m.f. 500v wkg. 3-2/-; Mansbridge 4m.f. 400v wkg. 2/3 each; silver mica 10 p.f. 40p.f., 200p.f., 300p.f., 400 p.f., 500p.f. 3/6 doz.; mica 0.01m.f. 3-1/3; all condensers guaranteed; Amphenol type British 5-pin chassis valve holders, 3/6 doz.; international octal chassis valve holders, paxolin, 4/- doz.; bar type 3-gangs 5/-; bar type 4-gangs 5/-; resistors ½watt and ¼watt assorted 100 ohms to 2 meg. level assortment 40-5/-; switches, SB, 2P 6w miniature 1/6, 3B, 2P 6w five poles total 2/3 each; SB, 9w 2/-, 2B SP 6w 1/6, SB, SP, 3w 1/-, 2B, 3P, 3w 2/-, SB, 2P, 4w 1/3; twelve-way group boards with 9-1w and ½w resistances, etc., 2/-, all new; twenty other types in stock; octal plugs, cap and chassis socket, 3-3/-, with tags 3-3/6; Paxolin panels ¼in size 12×8 5/6, 12×12 7/6; meters 0-1ma. scaled 0-100, 2½in, 3¼in overall 15/6 and 18/6, details on request, first class instruments; metal boxes, black finish with quarter inch paxolin panel, fixing lugs and corner sockets, size 8½×7½×3½ deep, 6/9 each new; 10,000 ohm bakelite cased volume controls medium spindle 1/6; metal cased miniature depth ¼meg vols., short spindle 1/6 each; special list for trade. [3485

GENUINE bargains by post; potentiometers wire wound 1k, 2k, 5k, 10k, 20k, 25k, 2/-; Selenium rectifiers h/wave 375v, 80ma, 3/9; condensers ali. can., 16mfd 350v 2/3, 32mfd 350v 2/3; 25mfd 25v 1/3; 16 plus 8mfd 450v 4/-; card. tub. 8mfd 500v 3/9; 2mfd 350v 1/3; .0005 twin gang 7/3; P.M. speakers, 3½in 18/6; 5in 13/6; 8in 16/-; output transformers pentode 4/6; multiratio (6 ratios) 8/6; filament transformers 6.3v 1.5amp 7/6; 3amp 9/-; l.f. chokes 20henries 50ma 7/6; 10h 100ma (ex-Govt.) 4/-; 10h 150ma 14/-; 5h 250ma 18/-; volume controls ¼, ½, 1meg (with switch) 5/11, (less switch) 4/-; 2½d stamp for complete lists; c.w.o. (mail order only); please cover cost of postage and packing.—A.R.K., 4 Queen Square, Brighton, Sussex. [3423

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NEW STC selenium rectifiers, largest 1.t. range in Gt. Britain, all makers' current products, not surplus; selections from our stock: H4/200 for "W.W." televisor, 28/- p.f.; half-wave 16v ¾a, 6/8; 1a, 8/-; 2a, 9/6; 3a, 16/6; all p. 6d; 16v 4a, 18/-, p. 10d; 30v 1a, 12/-; 2a, 14/-; 4a, 26/-; 48v 2a, 21/-; 4a, 35/-; 100v 2a, 34/6; 4a, 65/-; all p. 1/-; H.D type with 7in sq. Al cooling fins, 16v 5a, 21/6; 6a, 22/6; 10a, 24/6; all p. 10d; 30v 5a, 35/-; 6a, 36/6; 8a, 38/6; 48v 5a, 48/-; 8a, 54/-; all p. 1/-; full-wave bridge conn., 17v 7.5a, 12/1; 2a, 15/6; 2.5a, 20/6; 3a, 21/6; 4a, 25/-; 5a, 27/-; all p.f.; 33v ¾a, 18/6; 1a, 21/3; 1.5a, 28/6; 2a, 29/6; 3a, 35/-; 4a, 42/-; 5a, 43/6; all p. 10d; 54v 1.5a, 39/-; 2a, 47/6; 4a, 65/-; 72v 2a, 61/-; 100v 1.5a, 72/-; 136v 4.5a, 168/-; all p. 1/-; H.D. type with 7in sq cooling fins, 17v 6a, 34/1; 10a, 43/8; 12a, 72/-; 20a, 80/-; 33v 6a, 64/-; 10a, 71/-; 12a, 124/-; 20a, 140/-; 54v 6a, 90/-; 10a, 100/-; 72v 10a, 130/-; 100v 10a, 190/-; all p. 1/4; industrial rects., funnel cooled, 17v 12a, 76/-; 20a, 87/-; 30a, 122/-; 50a, 188/-; 33v, 6a, 69/-; 30v 10a, 80/-; 33v 12a, 124/-; 20a, 144/-; 54v 6a, 92/-; 10a, 108/-; 72v 6a, 114/-; 10a, 136/-; 100v 6a, 160/-; 10a, 192/-; all p. 1/6; replacements for valve-type chargers, Philips 328 and 367, Tungar 68504, 68530 and U600, etc., fitted in 5 min without alteration to wiring; tropically rated rectifiers from stock; rectifiers supplied by us are giving unfailing service in many countries; specialised rectifier equipment supplied to specification for schools, laboratories and industrial use; kits, trans., rect. and rheo., 33v 6a, £7/10 (incl. tap switch), 16v 10a, 6/12/6; 17v 6a, £4/12/6; both with 10v output tap; following with fused voltage adjuster for 2-6-12v batts, 16v 5a, £3/10 (vent steel case 7/6 extra); 16v 4a, £3, case, 7/6; 16v 2a, 38/6, case, 7/6; transformers, 200/250in 18v 10a, 65/-, p. 1/4; 18v 6a, 47/6, p. 1/4; 17v 5a, 41/6, p. 1/-; 16v 4a, 35/-, p. 1/-; 16v 2a, 25/6, p. 10d; slider res, all values from 24/6, p. 1/-; ammeters, 1-6a M.I., 12/6; 0-5a M.C. 15/-, both p. 6d; 0-14a M.C., 5in dia., 32/6, p. 1/4; see under "Dynamos" for larger charging equipment, etc.; terms, c.o.d. post goods only; c.w.o. or pro forma all others; wholesale and retail.
PEARCE, 66, Gt. Percy St., London, W.C.1; off Pentonville Rd., between King's Cross and Angel. Est. 17 years. [3574

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TELEBOOSTER for long range television, type R.F.2, slug and variable tuned, input 40-48m/cs, 2 valve, 3 stage, co-axial plugs and sockets, size 5½in long, 2½in wide, 2in deep; h.t. and l.t. from receiver chassis, V.R.91 valves (EQ to EF50), gain approx. 30, price £3/12/6; R.F.1 as above but single valve, 2 tuned circuits, price £2/12/6; power units can be supplied, same size as chassis, price £4; s.a.e. for leaflet.—Boscombe Radio, 595, Christchurch Rd., Boscombe, Hants. [3587

STOP press bargains offered by Radio Unlimited, 16, Carnarvon Rd., Leyton, E.10.—Impedance matching unit for television, transmitter, etc., 5/-; m/iron 0-25 ampmeter, 2½in flush mounting, 2/11; miniature m/coil speaker, 1¾in diam, 3/6; extn spkr vol control, 2/-; Loud Tone buzzer, in bakelite case, 2/3; send/receive microphone units for indoor telephone, 2/- each; twin connecting wire, 2½d yd; heavy duty 5amp panel switches, 9d; sp/st toggles, 1/6. Detailed list 1d stamp. [3303

H.R.O. Senior receivers complete with valves, crystal and s. meter less coils, £17/10 ea.; few coils available; several other communication sets; R.C.A. crystal cal wavemeters, 250kcs to 25mcs, complete with valves, crystal, 'phones and instruction book, as brand new, £6/15 ea.; indicator units, type L, with v.c.r. 97 and 7 valves, brand new, £4 ea., carr. 10/- plus £1 dep. on crate; others in stock; Tannoy 20w P.A. pressure units, as new, £2 ea.; ditto Vitavox, £3; elec. light meters, 230v 5a a.c., 12/6 ea.; R.F. units, type 24, 10/- ea., c.p. 24, mod. 27 and type 25, 12/6 ea.; type 27, 21/6 ea.; all complete and perfect; most types of W.D. plugs and sockets in stock; wavemeters W66, absorbtion, 4 range, 3-15mcs., 30/- ea. c.p.; signal generators, 100-155mcs, with field strength meter and test meter and batt. box, American, £15; compasses, motors, rotary convertors, magnetrons, klystrons, Elec and radio gear of all types; s.a.e. will bring you our 12-page list, including optical gear and lens, etc.
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SUPREME RADIO, 746b, Romford Rd., Manor Pk., London, E.12. Tel. Ilf. 1260; est. 15 yrs. Radio and television component part specialists at the right price.—E.H.T. 4kv or 5kv, 2v fil., 55/- ea.; 2.5kv E.H.T. 4v fil., tapped at 2v, 27/6 ea.; line and frame scanning coils, 25/6 ea.; line trans. 21/- ea.; both items matched focus coils, 30/- ea.; h.t. transformer, 350-0-350v, 6.3v 6amp, 4v 8amp, 4v 3amp, 0-2v, 6.3v 2amp, 250ma, with screen, 70/- ea.; 5hy 250ma choke, 17/6 ea.; 10hy 80ma choke, 9/6 ea.; ceramic E.F.50 valve holders, 6d. ea.; retaining rings for same, 8d. ea.; bakelite E.A.50 valve holders, 6d. ea.; anode clips for same, 2d. ea.; Anti-Corona caps, 8d. ea.; co-axial cable or twin balanced feeder, screened 80ohm, 1/- yd., 4/6 doz. yds. only; special offer, balanced feeder 5d. yd., 4/6 doz. yds. only; co-axial plug and socket, 1/- complete; revised edition of E.E. home-built televisor handbook, 2/6 copy; layout plan and wiring diagram for E.E. televisor, 3/6 copy; all parts in stock for E.E. televisor; ¼watt resistances, 10Ω, 22Ω, 27Ω, 47Ω, 82Ω, 120Ω, 180Ω, 390Ω, 820Ω, 2.2kΩ, 11kΩ, 39kΩ, 470kΩ, 10kΩ, 1/9 doz., 18/6 gross only or assorted; ½watt resistances, 100Ω, 150Ω, 200Ω, 400Ω, 500Ω, 2kΩ, 2.2kΩ, 10kΩ, 16kΩ, 18kΩ, 20kΩ, 150kΩ 500kΩ, 1.5mΩ and 5meg, 2/- doz., 21/- gross, or assorted; most other values at 3/- doz., 30/- gross only; 1watt resistances, 470Ω, 1kΩ, 3.3kΩ, 8.2kΩ, 18kΩ, 33kΩ, 56kΩ, 75kΩ, 68kΩ, 1mΩ and 2meg, 4/- doz., 45/- gross only, or assorted; 2watt resistances, 2kΩ, 18kΩ, 1mΩ, 5/6 doz., 60/- gross only; mains transformers, 350/0/350v 120ma, 6v, 5v and 4v, 32/6 ea.; metal tubular midget tag-end condensers, 25mfd 25v, 1/2 ea., 13/- doz; 50mfd 50v and 50mfd 12v can-type condensers, 1/- ea., 11/- doz.; 0.01mfd 1,000v, 0.02mfd 750v, 0.05mfd, 500v and 0.1mfd, 350v, 5/6 doz.; 0.1mfd 500v, 6/6 doz.; midget mica condensers, 0.001mfd, 0.0003mfd and 0.0005mfd, 5/6 doz.; metalmite condensers, 0.01mfd 350v and 0.002mfd 500v, 9d. ea., 8/6 doz.; can-type condensers, 8mfd 450v, 2/9 ea.; 16+32mfd 350v, 4/3 ea.; 16+8mfd 450v, 4/3 ea.; 30+30mfd 350v, 425v surge, 6/6 ea.; 16+24mfd 450v, 5/6 ea.; 32mfd 350v, 3/- ea.; 32mfd 500v, cardboard drylitic condensers, 6/6 ea.; 16mfd metal can drylitic condensers, 350v, 1/9 ea.; midget can condensers, 16+8mfd and 8+8mfd 450v, 3/9 ea.; 16+16mfd 450v, 5/6 ea.; 8mfd 450v, 2/6 ea.; 4mfd 550v screw base tubular metal condensers, 1/3 ea., 14/- doz.; 0.01mfd 5kv metal tubular condenser, 3/6 ea.; 2mfd 350v metal and cardboard wire end electrolytic condensers, 1/- ea., 11/- doz.; fixed mica condensers, 3ppf, 30ppf, 60ppf, 65ppf, 70ppf, 180ppf, 305ppf, 307ppf, 500ppf, 570ppf, 590ppf, 700ppf, 4,550ppf, all at 2/6 doz., or assorted doz., 28/- gross; 0.01mfd 3kv and 0.005mfd mica, 3/- doz.; metal rectifiers, selenium type, 230v R.M.S. 120ma, 4/- ea. —Terms, c.w.o., no c.o.d.; send 6d. extra for postage orders under £5; 2½d. s.a.e.; all enquiries and list. [3569

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G. HENSON LITTLEWOOD & Co., 27, Ballards Lane, Finchley, N.3. Fin. 3060. [3567

CONDENSERS, Midget, 0.1mfd, 150v, d.c., wka, 1/3 doz., 9/6 100; chassis M.t.a. metal, tubular, 0.25mfd, 500v d.c., 5/- doz.; single pole chassis mounting fuse holders, 6/- doz.; selection components; enquiries invited.—3, Western Drive, Shepperton, Middx. [3391

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VACUUM gauge or gauges reading 10 to 10-4 mm Hg. also Pyrex domed chamber suitable blooming; no fancy prices.—Box 6072.

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CARRIER telephone and telegraph equipment of all types in any condition wanted; also teleprinter and teletypewriter apparatus.—Harris & Gillow, 93, Wardour St., W.1. [3036

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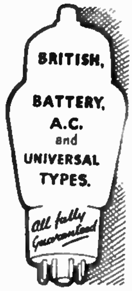

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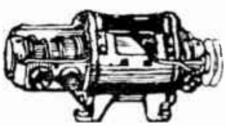

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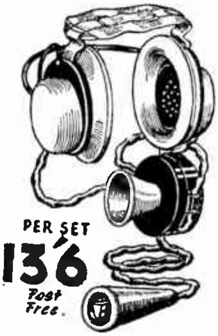

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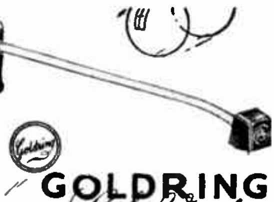
YOUTH, keen on radio, required as junior assistant in radio mail order firm, N.W. London; write.—Box 6177. [3536

APPLICATIONS are invited for electronic engineers and mechanics for reconditioning v.h.f. wireless equipment, Wellington, Salop, area.—Box 6360. [3583

NEWSPAPER wire room requires young assistant experienced in electronics and maintenance of 5-unit telegraphic equipment.—Full details to Manager, Westminster Press Provincial Newspapers, 167 Fleet St., E.C.4. [3601

TECHNICAL correspondence clerk required by radio component manufacturer to handle technical and other correspondence, only fully qualified applicants can be considered; state age, experience and salary required to Box 6176 [3531



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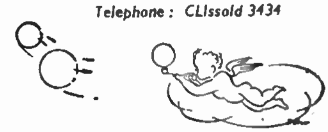

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Further particulars and forms on which to apply for admission may be obtained from the Secretary.

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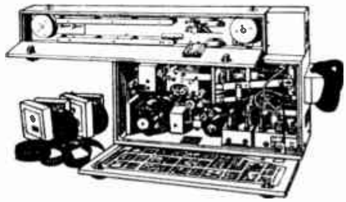

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CROWN Agents for the Colonies.—Applications from qualified candidates are invited for the following posts:—
AERADIO mechanicians required by Government of Northern Rhodesia for one tour of 24-36 months with possibility of further employment. Commencing salary according to age and experience in the scale £490 rising to £840 a year. Gratuity payable on satisfactory termination of engagement. Free passage. Candidates, over 25, must have had at least four years' experience in radio engineering, including not less than two years' experience on maintenance and installation of medium power transmitter and v.h.f. ground station equipment. A knowledge of accumulator charging required.—Apply at once by letter, stating age, whether married or single, and full particulars of qualifications and experience, and mentioning this paper, to the Crown Agents for the Colonies, 4, Millbank, London, S.W.1, quoting M/N/24675(3B) on both letter and envelope. [3585

TELEVISION service engineer required for mid-Kent area; prospects of supervisory position for man with suitable qualifications.—Give particulars to Box 6071. [3407

CHIEF draughtsman required with experience in electrical instruments and test equipment design; excellent prospects for man with suitable experience.—Box 5443. [3250

RADIO-TELEVISION service engineer, experienced, starting £7 p.w.—Write or 'phone Ley. 1362 for appointment to interview.—Frooms, Ltd., 226, High Rd., Leyton, E.10. [3383

SPECIALITY salesmen required for new moving coil pick-up with permanent needles; samples available—sells on test; most districts vacant; generous commission and expenses.—Box 6090. [3446

CABLE makers require sales representative with experience in telecommunications and radio; age 25 to 35 years preferred; superannuation scheme and good prospects; full particulars to Box 5438. [3244

RADIO technician, B.Sc. standard. Requirements: good general education and sound training in fundamentals of radio; some experience; capability for clear technical writing.—Apply Box 6270. [3581

WANTED, test gear maintenance engineer for large manufacturing concern in radar and radio products; only men with previous experience and knowledge of this branch of industry need apply.—Box 6085. [3434

THE Ministry of Supply invites applications for a limited number of unestablished posts in the Technical Class Grade II for Electronic and Radio inspection duties in the Aeronautical Inspection Directorate.
APPLICANTS, who must be of British Nationality, born of British parents (see detailed Nationality regulations, a copy of which can be obtained on application to Ministry of Supply, Room 432, Adelphi, John Adam Street, London, W.C.2), should have had sound practical training and experience, have received a technical education up to the standard equivalent to National Certificate (Electrical), have had inspection experience in the particular sphere of manufacture, and have good knowledge of A.I.D. procedure; duties include inspection and the supervision of contractors, inspection of all items handled in the Radio and Radar branch, both during and after manufacture. Applicants must be prepared to serve in any part of the United Kingdom. Salary ranges: £500 (linked to entry at age 30) to £625 (London); £485 (linked to entry at age 30) to £610 (Intermediate); £470 (linked to entry at age 30) to £595 (Provincial). Hours of work, 44 nett weekly. Applications should be made by letter only, giving full details of age, education and experience, and the names and addresses of present and all previous employers in chronological order, with particulars of the posts held. These should be addressed to London Appointments Office, Ministry of Labour and National Service, 1-6, Tavistock Sq., London, W.C.1, quoting the reference K.I.272. Copies only of testimonials should be forwarded with applications. [3599

VALVE manufacturing company in S.E. England require a design engineer with experience of mercury vapour rectifier valves.—Graduates aged 25-35 should apply, quoting Ref No. C.6/234, to Box 6361. [3593

TELEVISION engineer required for factory production, area South of London.—Write stating age, experience and salary required, to Box No. 126, S. T. Garland Advertising Service, Ltd., 52, Mount St., London, W.1. [3425

SENIOR draughtsmen required; must have experience in detailing radio or electronic equipment; North London district.—Write, stating experience and salary, to Box U1522, A.K. Advg., 212a, Shaftesbury Ave., W.C.2.

FOREMAN to take charge of transformer division of West Country manufacturers. Experience of coil winding and assembly of transformers up to 50kVA essential, and some previous executive experience desirable. Give details of experience, with dates, to Box 5435.

INTERMEDIATE and senior grade draughtsmen required by large radio manufacturing company in S.E. England; draughtsmen with experience of development or installation D.O. work on telecommunication equipment are asked to send details quoting ref. D.O.42 to—Box 4766. [3074

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LABORATORY assistant, with experience or interest in electrical instruments or radio required for electronic work; Inter. or National Certificate standard expected.—Apply to Secretary, British Rayon Research Association, Bridgewater House, Whitworth St., Manchester.

APPLICATIONS are invited from engineering and physics graduates by the Research Laboratories of The General Electric Co., Ltd., East Lane, North Wembley, Middx., for work on telecommunications equipment and radio navigation aids; details of age, academic record and experience should be sent to the Personnel Officer. [3515

ASSISTANT to service manager of radio manufacturing firm required in London; technical radio experience in Forces or with radio manufacturers or large group retailers' organisation, and ability to deal with correspondence essential; suitable to ex-Service radio officer of secondary school educational standard.—Box 6070. [3406

WIREMEN for radio and electronic apparatus required to wire from circuit diagrams and models, various intricate units of television transmission apparatus; ability to carry out modifications or to build new types from verbal instructions or diagrams only, and to carry out stage by stage test and inspection would be an advantage.

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REQUIRED, technical cost engineer, must have full experience of development and production D.O.s, tool design and production planning; experienced in the complete estimating for factory engaged in the light engineering and radio industry.—Write in confidence, giving full particulars of experience, qualifications and salary required, to Box 6073. [3410

ELECTRONICS laboratory assistant required Reading-Newbury area, for work on design and construction of all types of electronic equipment; practical experience essential.—Apply in writing, giving full particulars, to Manager, Associated Electrical Industries Research Laboratory, Aldermaston Court, Aldermaston Berks. [3468

ENGLISH ELECTRIC Co., Ltd., Stafford, require urgently electronic draughtsmen of all grades for research development and production drawing offices; experience in this field essential; good conditions and prospects.—Please quote Ref. D.O.53 when sending full details to Central Personnel Services, English Electric Co., Ltd., 24-30, Gillingham St., London, S.W.1.

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THE FAIREY AVIATION Co., Ltd., Hayes Middx requires engineers with experience of electro mechanical servo mechanism control circuits or auto-pilot design for research divisions U.K. and Australia; applicants should be capable of undertaking research and development work on the above; university degree or equivalent an advantage.—Apply to Personnel Manager. [3369

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LARGE electrical engineering firm in South London with international connections, has vacancy for responsible senior design engineer; applicants must have first-class experience in developing 50 cycle and A.F. electronic equipment to production stage and a feeling for light mechanical designs; University degree preferred; very interesting permanent appointment; state age and salary required.—Box WW80, L.P.E. 110, St. Martin's Lane W.C.2. [3426

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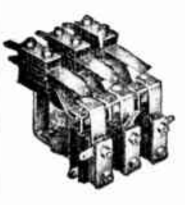

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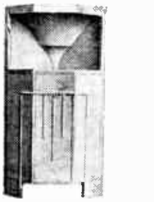

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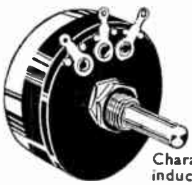

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