Wireless World

VOL. LVI. No. 9. SEPTEMBER 1950

National Radio Exhibition

ECONOMISTS and sociologists tell us that over-centralization is one of the major defects in the organization of our national economy. *Wireless World* is hardly qualified to comment on that matter, but, if it be true, radio must indeed be in a bad way. With remarkably few exceptions, all purely radio manufacture and most industrial development work has long been concentrated in London or at least in a small part of the area known to weather forecasters as "S.E. England." True, as a result of post-war planning of industry a few radio factories have been set up in the North and West, but, rightly or wrongly, they are generally regarded as mere production units working under the direction of a central organization in London.

Now, for the first time, the annual National Radio Exhibition is to be held outside London. This departure from precedent will, we expect, have a salutary effect in showing that appreciation of the finer points of radio design is not confined to the Metropolis. The site of the show at Castle Bromwich is by no means ideal, but at least one of its defects has been overcome by making special arrangements for the transport of visitors from the centre of Birmingham. Consequently a good attendance can be expected.

Although the show is distinctly smaller than last year's Radiolympia—90 exhibitors compared with 172, occupying about two-thirds of the floor space—it is fair enough to call it representative. This is especially true in the field of domestic broadcast and television reception, in which the exhibits will typify fully present-day tendencies and practice. Though television will naturally predominate, few aspects of radio will be entirely unrepresented, except the "heavy engineering" side. In several branches of the art visitors will be able to examine new apparatus and techniques which have not hitherto appeared before the public.

In this issue of *Wireless World* we are publishing a guide to the Exhibition in the form that, we hope, will be found most convenient both to visitors and to others who wish to keep in touch with the present activities of the British radio industry.

Worth-While Tests

OVER two years ago *Wireless World* urged that the B.B.C. should not allow itself to be stampeded into initiating an e.h.f. broadcasting service until all the relevant factors had been investigated by means of a large-scale experiment. Naturally enough, we were highly gratified when the B.B.C. decided that both amplitude and frequency modulation should be tested simultaneously from the same site on high power. These tests have now started.

Although comparative f.m./a.m. tests are not new, we believe that they have not hitherto been conducted with such high power, or on such a favourable basis for comparison.

So far, little information is available as to the precise nature of the tests to be made, and the transmissions are not to a rigidly fixed schedule. No doubt, however, one of the first things to be determined will be the coverage obtainable from a high-power e.h.f. station of modern design, and secondly, to what extent, if any, coverage is dependent on the type of modulation.

Apart from matters mainly connected with transmission, there are many problems which concern the designers of receivers. For example, it has not yet been finally decided if a domestic f.m. set at a strictly economic price can be expected to maintain its alignment sufficiently well for the advantages of f.m. to be fully realized. If only to allow receiver designers to conduct large-scale field tests, a regular schedule of a.m./f.m. transmissions should be started as soon as possible.

17TH National Radio Exhibition

Classified Guide to the Principal Classes of Exhibits

Organized by the Radio Industry Council; Venue, B.I.F. Buildings, Castle Bromwich, Sept. 6-16; Admission, 2/6 (11-5 and all day Sat.), 1/6 (5-10)

PERHAPS it is fitting that Birmingham should be the chosen venue for the first national radio exhibition to be held outside the metropolis, in view of the position it now occupies as the centre of the Midlands television service.

In the following pages the products of the various firms exhibiting are tabulated in a similar manner to that adopted last year as it is believed this serves a very useful purpose by conveying the maximum amount of essential information in a way that is easy to follow. It also enables quick reference to be made when it is desired to trace all the makers of a particular class of equipment.

All the indications are that television will be the dominant feature, but perhaps this was to be expected in view of the recent opening of Sutton Coldfield, and the still further extension of the service in the near future. Indeed some makers of television sets are already catering for additional stations, particularly Holme Moss. In the majority of cases the provision is made as an alternative, effected either by an interchangeable r.f. unit or by suitable pre-set tuning adjustments.

Broadly speaking the television sets fall into three main categories, direct viewing, projection and television combined with all-wave radio. As the tables show direct viewing constitutes the largest class and nearly 40 firms are expected to show models of various kinds. They range from relatively inexpensive table models to quite elaborate consoles.

The popularity of the 9-in tube appears to be waning as, from the information available at the time of going to press, most makers of direct-viewing receivers have adopted the 12-in size as the standard whilst retaining a few 9-in models in order to provide a slightly cheaper set. Large 15-in tubes do not appear to have attracted much support and it is doubtful if more than two or three sets with them will be shown this year.

ALPHABETICAL LIST OF EXHIBITORS AND GUIDE TO THE STANDS

Name	Stand
A.R.B.M.	31
A.T.M.	41
Acrylite (Motor and Air Prods.)	14
Aerialite	76
Air Ministry	19
Alba (Balcombe)	54
Ambassador (Fitton)	68
Amplion	82
Antiference	18
Avo (Automatic Coil Winder)	26
B.C.L.	9
Baird (Scophony)	39
Barclays Bank	6
Belling-Lee	71
B.I. Callender's	80
"Birmingham Gazette"	27
British Railways	107
Brown Brothers	72
Bulgin	3
Bush	48, 105
Champion	73
Concord	5
Co-op.	61
Cossor	7, 52
Coulphone	97
"Daily Mail"	89
Decca	22, 37, 40
Domain	103
Dynatron	69
Econasign	13
Eddystone (Stratton)	83
Ediswan	33
Ekco (Cole)	11, 53, 92
"Electrical and Radio Trading"	106
Electro Dynamic	9
"Electronic Engineering"	15
English Electric	35
Etronic (Hale)	60
Ferguson	67
Ferranti	55
Fine Wires	101
G.E.C.	58, 77
G.K.N.	29
G.P.O.	21, 34
Garrard	32
Goodmans	85
H.M.V.	12, 65
Hobday	23
Invicta	46
J.B. Manufacturing	98
K.A. (Kimber, Allen)	99
K.B.	36
Kerry's	95
Lloyds Bank	30
McMichael	57
Magnavista (Metro Pex)	78
Marconiphone	51
Masteradio	28
Midland Auto Components	24
Midland Bank	91
Mullard	64, 74
Multicore	86
Murphy	44
National Provincial Bank	108
Peto Scott	84
Philco	38
Philips	42, 45
Pilot	56
Portogram	94
"Practical Wireless"	20
Pye	8, 49
R.G.D.	50
Radiomobile	70
Regentone	66
Romac	88
S.T.C.	43
Scott	104
Sobell	63
Taylor	2
Telcon (T.C.M.C.)	79
Telerection	100
"Television Weekly"	17
Trix	25
Ultra	59
Vidor	47
W.B.	62
Westerman	87
Westinghouse	16
Westminster Bank	75
Winter Trading	96
"Wireless & Electrical Trader"	93
"Wireless World" and "Wireless Engineer"	10
Wolsey	102
Wood	90

One or two makers are using a plastic filter to reduce the effects of ambient light and so enable viewing to be enjoyed in ordinary room lighting. Looked at in ordinary light with the set switched off the tube face has a distinctly dark shade and this has given rise to the description " dark screen " television set. One manufacturer is marketing a light filter as a separate unit.

The second largest category among television sets is the combined broadcast and television receiver. A wide variety of styles will be seen. Some manufacturers have striven to provide in one cabinet all the domestic radio entertainment likely to be desired. For instance, such combinations as an all-wave radio set, automatic electric gramophone having provision for the normal 78 r.p.m. discs as well as long-playing records and projection television.

Nothing very striking is forecast by the advance details in the realm of ordinary broadcast reception. The wider use of miniature valves and, in some cases, components, has led to an all-round reduction in the size of chassis, but this may not be reflected in the external appearance of the set, since the size of the cabinet is largely governed by the loudspeaker.

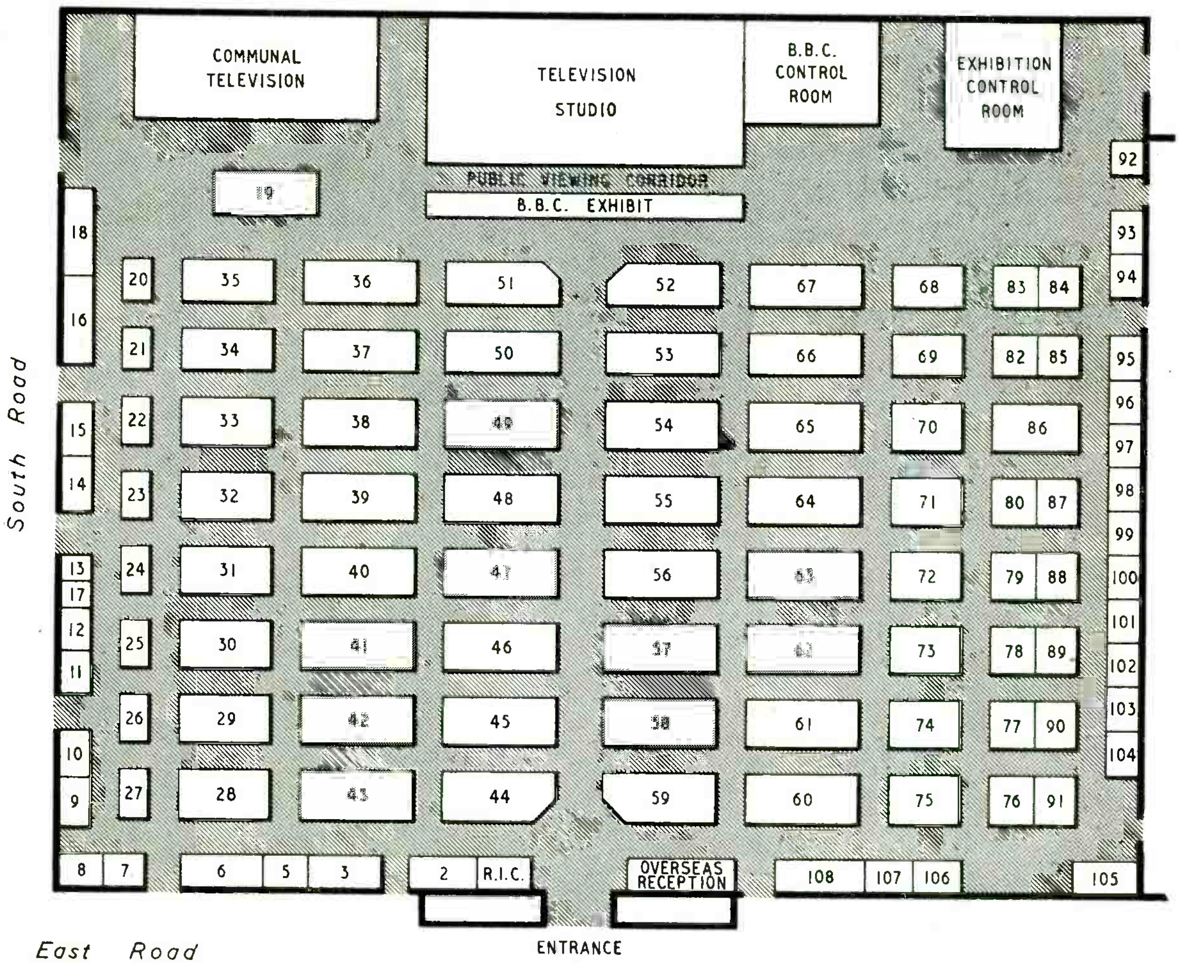
Portables have certainly benefited by the use of miniature parts and the division between ordinary portables and the so-called personal portables is now somewhat indefinite.

Conservation of battery power has come in for more attention and not only are there sets which are either mains or battery driven, but many makers are providing this feature in the form of an optional attachment. Another method of saving battery power is by substituting a small a.c. power unit, which occupies the same space as the battery, when the set is used indoors.

The advent of the long-playing record has had an inevitable repercussion on the design of new gramophone equipment. Almost all the latest radiograms are adaptable for either 78 r.p.m. or 33 1/3 r.p.m. operation and some also for 45 r.p.m. The pick-up has to be changed of course and one firm will be showing a tone arm with interchangeable heads; others use separate pick-up assemblies. These features will be seen embodied in some of the automatic record changers and record playing desks.

Although our classification of equipment is fairly broad it is inevitable that some apparatus will not readily fall within its scope. It must not be taken therefore that every piece of equipment is classified. There will, for instance, be examples of line transmission equipment and coil winding machines.

A noticeable omission at the show will be the lack of what can readily be called the " heavy engineering " side of radio. This is indicated by the scarcity of entries in the section of our tabular matter devoted



to transmitters. Moreover the entries in the section originally devoted to scientific and industrial equipment were so few that it has been omitted.

So far as the non-commercial exhibits are concerned there are three main exhibitors—G.P.O., Air Ministry and B.B.C. To emphasize the importance of a good aerial the G.P.O., who last year received 94,272 complaints of interference, of which over 15,000 were due to poor aerial-earth systems, will be demonstrating the advantage of increasing the height of the aerial and its distance from the house electrical wiring. They will also be demonstrating a 3-cm radio link using a lens-horn aerial. Another exhibit will show how repeaters are used when transmitting television video signals over the ordinary Post Office telephone cable.

The Air Ministry will be featuring a scale model showing how a chain of early-warning radar stations functions. Among the equipment to be seen will be the TR1934 ten-channel v.h.f. set which is the latest radio-telephone transmitter-receiver used by the R.A.F. for both air-to-air and air-to-ground communication. A synthetic radar trainer, used for training controllers in air-to-air interception techniques, will also be demonstrated.

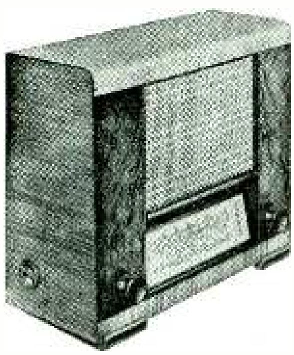
As at Radiolympia, provision is made for visitors to make comparative tests of television receivers in the Hall of Television where 85 sets will be working side by side throughout the greater part of each day. In addition 90 sets will also be in operation on individual stands.

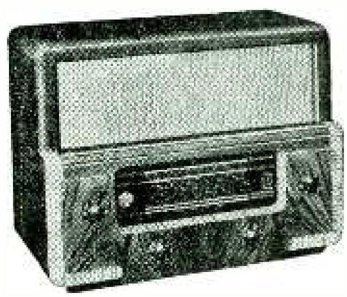
To enable sets to be demonstrated almost continuously and not merely during the normal B.B.C. transmitting hours arrangements have been made to instal a small transmitter working on a closed circuit, which, to avoid interference from Sutton Coldfield, will operate on the Alexandra Palace frequencies. The programmes will include, in addition to B.B.C. transmissions, performances in the exhibition studio, which will be open to the public, and also films.

When the Sutton Coldfield programme is being used it will first be demodulated, passed through a video fader for programme control purposes and will then re-modulate the exhibition transmitter. The film scanner and output from the exhibition studio will be handled via the fader at vision frequency. The wave form will conform to B.B.C. standards.

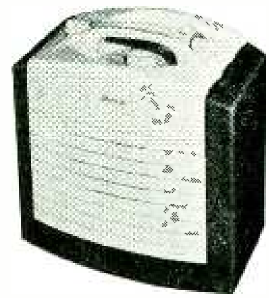
Broadcast receivers will not be demonstrated at the exhibition.

Ultra "Leader" five-valve a.c. superhet designed for ease of servicing.





The Pilot "Blue Peter" table receiver which covers the trawler band. It is a.c. operated.



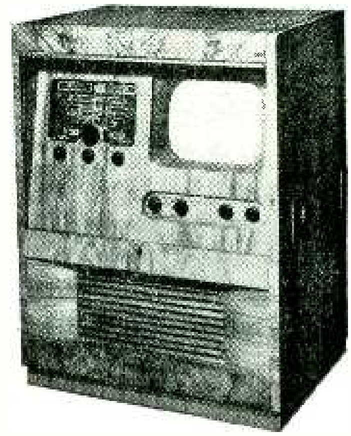
The Etronic "Rambler" EPZ4213 mains - battery portable.

Built-in aerials for long and medium waves are used in this Ferranti Model 005.

The Alba D611 has bandspread tuning on six short-wave bands and it incorporates an automatic record changer.

K.B. Model FP11 battery portable (below) with thumb controls.

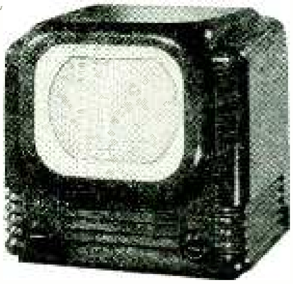
(Below) McMichael television-broadcast receiver fitted with 12in tube. It has two short-, medium- and long-wave bands.



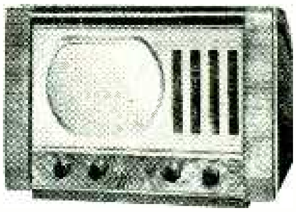
RECEIVERS : Broadcast, Television, Communications and Special Purpose

FIRM (Stand)	Broadcast: Mains	Broadcast: Battery	Broadcast: Mains/battery	Broadcast: Portable	Radio-gramophone	Direct-viewing television	Projection television	Television-broadcast	Special purpose
Alba ... ... (54)	●	●	●	●	●	●	—	—	—
Ambassador ... (68)	●	—	●	—	●	●	—	—	—
Amplion ... (82)	—	●	●	●	—	—	—	—	—
Baird ... ... (39)	—	—	—	—	—	●	—	●	—
Bush ... (48, 105)	●	●	●	●	●	●	—	—	—
Champion ... (73)	●	●	●	●	●	●	—	●	—
Co-op ... ... (61)	●	—	—	●	●	●	—	●	—
Cossor ... (7, 52)	●	—	●	●	●	●	—	●	—
Decca ... (22, 37, 40)	●	—	●	●	●	●	●	—	F
Dynatron ... (69)	●	—	—	—	●	●	—	●	—
Eddystone ... (83)	●	●	—	—	—	—	—	—	C, Y
Ekco ... (11, 53, 92)	●	—	●	●	●	●	—	—	S, M
English Electric (35)	—	—	—	—	—	●	—	—	F
Etronic ... ... (60)	●	●	●	●	●	●	●	—	—
Ferguson ... (67)	●	—	—	—	●	●	●	—	—
Ferranti ... ... (55)	●	●	—	●	●	●	●	●	—
G.E.C. ... (58, 77)	●	●	—	—	●	●	—	●	C
H.M.V. ... (12, 65)	●	●	—	—	●	●	—	●	F
Invicta ... ... (46)	●	●	●	●	●	●	●	—	T
K.B. ... ... (36)	●	●	●	●	●	●	—	●	—
McMichael ... (57)	●	●	—	●	●	●	—	●	T
Marconiphone ... (51)	●	●	●	●	●	●	—	—	—
Masteradio ... (28)	●	—	●	—	●	●	●	●	M
Midland Auto ... (24)	—	—	—	—	—	●	—	—	—
Mullard ... (64, 74)	●	—	—	—	—	●	—	—	—
Murphy ... ... (44)	●	●	—	●	●	●	—	—	—
Peto Scott ... (84)	●	—	—	●	●	●	●	—	—
Philco ... ... (38)	●	●	●	●	●	●	—	●	—
Philips ... (42, 45)	●	●	—	●	●	●	●	—	M
Pilot ... ... (56)	●	—	—	●	—	●	—	—	—
Portogram ... (94)	—	—	—	—	●	●	—	—	S
Pye ... ...(8, 49)	●	●	●	●	●	●	—	●	C,M S,T
R.G.D. ... ... (50)	●	—	—	—	●	●	●	●	—
Radiomobile ... (70)	—	—	—	—	—	—	—	—	M
Regentone ... (66)	●	—	—	—	●	●	—	●	—
Romac ... ... (88)	—	—	—	●	—	●	—	—	M
Sobell ... ... (63)	●	—	—	●	●	●	—	●	—
Trix ... ... (25)	—	—	—	—	—	—	—	—	S
Ultra ... ... (59)	●	—	●	●	●	●	—	●	—
Vidor ... ... (47)	●	●	●	●	—	●	●	—	—
W.B. ... ... (62)	●	—	—	—	—	●	—	—	K

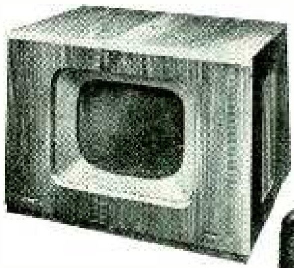
C, communications; F, f.m.; K, kit; M, car; S, schools; T, trawler-band; Y, yacht.



Adjustable tuning over the whole television band is provided in this Bush Model TV22 re-receiver, which incorporates a 9in tube.



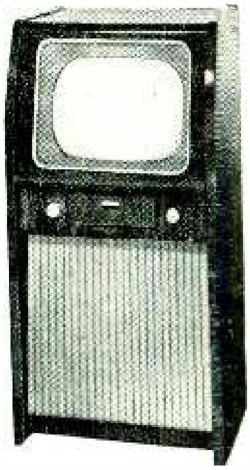
Baird portable television receiver, Model T165, which utilizes the mains lead as an aerial.

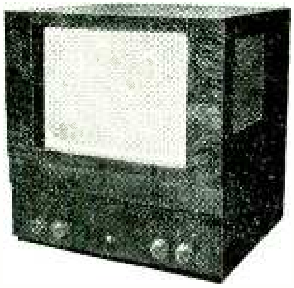


Pye "dark screen" television receiver, Model LV30, incorporating a 9in tube.

Flat-ended tube with aluminized screen and permanent-magnet focusing are features of the G.E.C. Model BT2147 receiver.

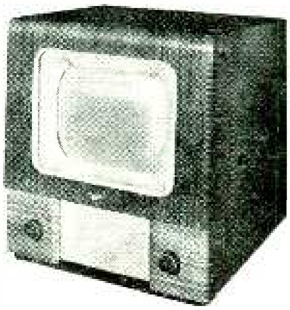
(Below) Vidor television receiver fitted with 12in tube. All controls are at the front.

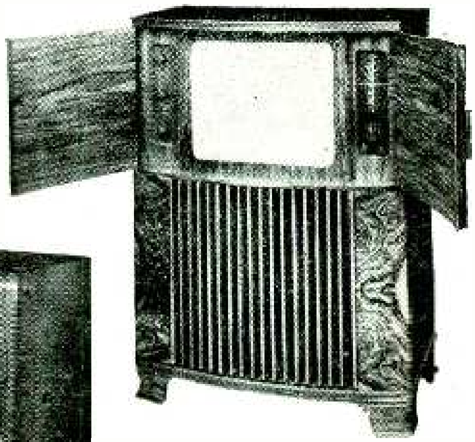




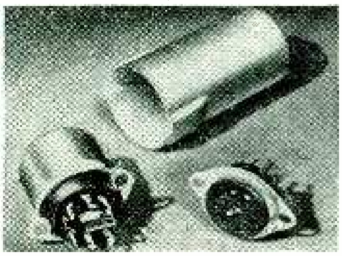
(Above) Philips projection television receiver, Model 600A, giving a picture $13\frac{3}{4} \times 10\frac{1}{4}$in.

(Right) Marconiphone, Model VT75A, table television receiver.



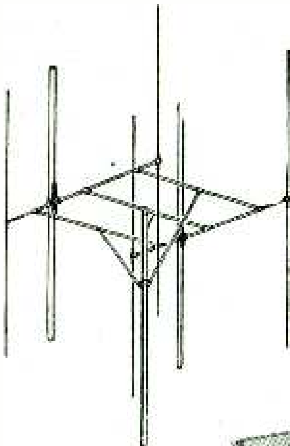


Decca projection television receiver incorporates a broadcast chassis covering eight wavebands.

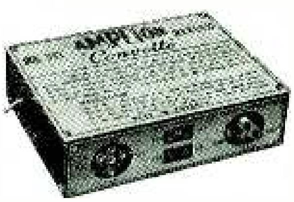


Belling-Lee B7G valve holders and screen.

Mullard "Noval-based" 9-pin television valves.



Wolsey six-element broad-side-array with two folded di-poles.



Amplion Model DB3 a.c. power unit for all-dry battery portables.

TRANSMITTERS: Including Low-power Transmitter/Receivers

FIRM (Stand)	Broadcasting	Point-to-point	Airborne	Marine	Mobile V.H.F.	Keying and Control
A.T.M. ... ... (41)	—	●	—	●	●	●
G.E.C. ... ... (58, 77)	—	●	—	—	●	—
Pye ... ... (8, 49)	—	●	—	●	●	—
Romac ... ... (88)	—	—	●	—	●	—
S.T.C. ... ... (43)	●	—	—	—	—	—
Wolsey ... ... (102)	—	—	—	—	●	—

TEST AND MEASURING GEAR: Including Signal Generators and Test Sets

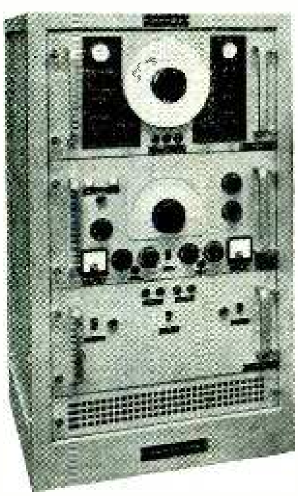
FIRM (Stand)	Single-range pointer meters	Multi-range meters	Bridges and accessories	Valve voltmeters	Test sets	Signal sources	Television signal sources	Oscilloscopes	Servicing tools and materials
A.T.M. ... (41)	—	—	●	—	●	●	—	—	—
Amplion ... (82)	—	●	—	—	—	—	—	—	—
Avo ... (26)	—	●	●	●	●	●	●	—	—
Bulgin ... ... (3)	—	—	—	—	—	—	—	—	●
Cossor ... ... (7, 52)	—	—	—	—	—	—	●	●	—
Eddystone ... (83)	—	—	—	—	●	—	—	—	●
Ediswan ... (33)	—	—	—	—	—	●	—	—	—
English Electric (35)	—	—	—	●	●	●	●	●	—
Kerry's ... ... (95)	—	●	—	—	—	—	—	—	—
Mullard ... (64, 74)	—	—	—	—	●	—	—	—	—
Pye ... ... (8, 49)	—	—	—	—	●	●	●	—	—
Taylor ... ... (2)	●	●	●	●	●	●	●	●	—

COMPONENTS: Excluding Accessories and Sub-Assemblies

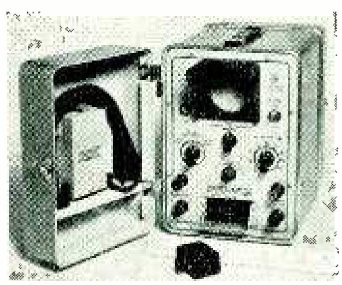
FIRM (Stand)	Capacitors: Fixed	Capacitors: Variable	Capacitors: Trimmers	Resistors: Non-ohmic	Resistors: Fixed wire-wound	Resistors: Variable	Switches	Coils, R.F.	Transformers, mains	Transformers, audio (inc. output)	Chokes	Plugs, sockets, connectors, adaptors	Chassis fittings (valveholders, etc.)	Cabinets, racks, chassis	Dials, drives, knobs	Relays	Vibrators	Television scan. components
A.T.M. ... (41)	●	—	—	—	—	—	—	—	—	●	—	—	—	—	—	●	—	—
Aeralite ... (76)	—	—	—	—	—	—	—	—	—	—	—	●	—	—	—	—	—	—
Amplion ... (82)	—	—	—	—	—	●	—	—	—	—	—	—	—	—	—	—	—	—
Antiference ... (18)	—	—	—	—	—	—	—	—	—	—	—	●	—	—	—	—	—	—
Belling-Lee ... (71)	—	—	—	—	—	—	—	—	—	—	—	●	●	—	—	—	—	—
B.I. Callender's ... (80)	●	—	—	—	—	—	—	—	—	—	—	●	—	—	—	—	—	—
Bulgin ... (3)	●	—	●	—	●	●	●	●	—	●	●	●	●	—	●	—	●	—
Bush ... (48, 105)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	●	—
Coulphone ... (97)	—	—	—	—	—	—	—	—	●	●	●	—	—	—	—	—	—	—
Dynatron ... (69)	—	—	—	—	—	—	—	—	—	—	—	—	—	●	—	—	—	—
Eddystone ... (83)	—	●	—	—	—	—	—	●	—	—	●	●	●	●	●	—	—	—
Ediswan ... (33)	●	—	—	—	—	—	—	—	—	—	—	—	●	—	—	—	—	—
G.K.N. ... (29)	—	—	—	—	—	—	—	—	—	—	—	—	●	—	—	—	—	—
J.B. Manufacturing ... (98)	—	—	—	—	—	—	—	—	—	—	—	—	—	●	—	—	—	—
Mullard ... (64, 74)	—	—	—	●	—	—	—	—	—	—	—	—	—	—	—	—	—	●
Pye ... (8, 49)	—	—	—	—	—	—	—	—	—	—	—	●	—	—	—	●	—	—
S.T.C. ... (43)	●	—	—	●	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Telcon ... (79)	—	—	—	—	—	—	—	—	—	—	—	●	—	—	—	—	—	—
W.B. ... (62)	—	—	—	—	—	—	—	—	●	●	●	—	●	●	—	—	—	—
Winter Trading ... (96)	—	—	—	—	—	—	—	●	●	●	●	—	—	●	—	—	—	●
Wolsey ... (102)	—	—	—	—	—	—	—	—	—	—	—	●	—	—	—	—	—	—

ACCESSORIES: Including Materials, Valves and Non-electronic Rectifiers

FIRM (Stand)	Aerials: Broadcast	Aerials: Television and E.H.F.	Aerials: Anti-interference	Aerials: Car	Valves	C.R. tubes	Photocells	Metal rectifiers	Crystal valves	Time switches	Batteries	Power units (inc. rotaries)	Interference suppressors	Magnets	Magnetic materials (inc. dust cores)	Wire and cable	R.F. cable	Insulants	Solder	Television pre-amplifiers	Television E.H.T units	Television lenses
A.T.M. ... ... (41)	—	—	—	—	•	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Acrylite ... ... (14)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	•
Aerialite ... ... (76)	•	•	•	•	—	—	—	—	—	—	—	—	•	—	—	•	•	—	—	—	—	—
Amplion ... ... (82)	—	—	—	—	—	—	—	—	—	—	—	•	—	—	—	—	—	—	—	—	—	—
Antiference ... ... (18)	•	•	•	—	—	—	—	—	—	—	—	—	•	—	—	—	—	—	—	—	—	—
B.C.L. ... ... (9)	—	—	—	—	—	—	—	—	—	—	•	—	—	—	—	—	—	—	—	—	—	—
Baird ... ... (39)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	•	—	•
Belling-Lee ... ... (71)	•	•	•	•	—	—	—	—	—	—	—	—	•	—	—	—	—	—	—	—	—	—
B.I. Callender's ... ... (80)	—	—	•	—	—	—	—	—	—	—	—	—	—	—	—	•	•	—	—	—	—	—
Concord ... ... (5)	•	—	—	—	—	—	—	—	—	—	—	—	—	—	—	•	—	—	—	—	—	—
Cossor ... ... (7, 52)	—	—	—	—	•	•	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Decca ... ... (22, 37, 40)	—	—	—	—	—	—	—	—	—	—	—	•	—	—	—	—	—	—	—	—	—	—
Eddystone ... ... (83)	•	•	—	—	—	—	—	—	—	—	—	•	—	—	—	—	—	—	—	—	—	—
Ediswan ... ... (33)	—	—	—	—	•	•	—	—	—	—	•	—	—	—	—	—	•	—	—	—	—	—
Electro Dynamic ... ... (9)	—	—	—	—	—	—	—	—	—	—	—	•	—	—	—	—	—	—	—	—	—	—
Ferranti ... ... (55)	—	—	—	—	—	•	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Fine Wires ... ... (101)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	•	—	—	—	—	—	—
G.E.C. ... ... (58, 77)	—	—	—	—	•	•	•	—	•	—	•	—	—	—	—	—	—	—	—	—	—	—
H.M.V. ... ... (12, 65)	—	•	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	•	—	—
K.A. ... ... (99)	—	•	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kerry's ... ... (95)	—	—	—	—	—	—	—	—	—	—	—	•	—	—	—	—	—	—	—	—	—	—
Magnavista ... ... (78)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	•
Marconiphone ... ... (51)	—	•	—	—	•	•	—	—	—	—	•	—	—	—	—	—	—	—	—	—	—	—
Masteradio ... ... (28)	—	—	—	•	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mullard ... ... (64, 74)	—	—	—	—	•	•	•	—	—	—	—	—	—	•	•	—	—	—	—	—	•	—
Multicore ... ... (86)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	•	—	—	—
Radiomobile ... ... (70)	—	—	—	•	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Romac ... ... (88)	—	—	—	—	—	—	—	—	—	—	—	•	—	—	—	—	—	—	—	—	—	—
S.T.C. ... ... (43)	—	—	—	—	•	•	—	•	—	•	—	—	—	—	—	—	—	—	—	—	—	—
Scott ... ... (104)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	•	—	—	—	—	—	—	—
Telcon ... ... (79)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	•	•	•	•	—	—	—	—
Telerection ... ... (100)	—	•	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Vidor ... ... (47)	—	—	—	—	—	—	—	—	—	—	•	•	—	—	—	—	—	—	—	—	—	—
W.B. ... ... (62)	—	—	—	—	—	—	—	—	—	—	—	—	—	•	—	—	—	—	—	•	—	—
Westinghouse ... ... (16)	—	—	—	—	—	—	—	•	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Winter Trading ... ... (96)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	•	•
Wolsey ... ... (102)	—	•	—	—	—	—	—	—	—	—	—	—	—	—	—	—	•	—	—	—	—	—



S.T.C. frequency-shift keying equipment for short-wave transmitters.



Telegraph distortion measuring set made by A.T.M.

Marconi Instruments (English Electric) television sweep generator, Model TF923, is shown below. It can be used for checking receivers, aerials and feeders.

(Right) Cossor, Model 1320, television alignment and pattern generator.

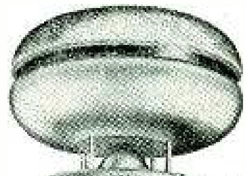
(Right) Avo universal bridge for measuring inductance, reresistance and capacitance.

SOUND REPRODUCING EQUIPMENT

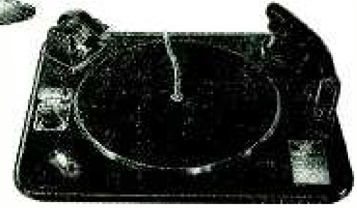
Audio-Amplifiers and Electro-Acoustic Apparatus

FIRM (Stand)	Microphones	Pickups	Amplifiers	Loudspeakers	Gramophone motors	Record changers	Electric gramophones	Record players	Recorders, magnetic	Hearing aids
Amplion ... (82)	—	●	—	●	—	—	—	●	—	—
Baird ... (39)	—	—	—	—	—	—	—	—	T	—
Co-op ... (61)	—	—	—	●	—	—	—	●	—	—
Coulphone (97)	—	—	●	—	—	—	—	—	—	—
Decca (22, 37, 40)	—	●	●	●	●	●	●	●	—	—
Dynatron ... (69)	—	—	●	—	—	—	—	—	—	—
Eddystone (83)	—	—	—	●	—	—	—	—	—	—
Ediswan ... (33)	—	●	—	●	—	—	—	—	—	—
G.E.C. (58, 77)	●	—	●	●	—	—	—	—	T	—
Garrard ... (32)	—	●	—	—	●	●	—	—	—	—
Goodmans (85)	—	—	—	●	—	—	—	—	—	—
H.M.V. (12, 65)	—	—	—	—	—	●	●	●	—	—
K.B. ... (36)	—	—	—	—	—	—	—	●	W	●
Marconiphone (51)	—	●	—	—	—	●	—	●	—	—
Peto Scott... (84)	—	—	●	—	—	—	—	—	—	—
Portogram (94)	—	—	●	—	—	—	●	●	—	—
Pye ... (8, 49)	—	—	●	—	—	—	—	—	—	—
R.G.D. ... (50)	●	—	●	●	—	—	—	●	T	—
Trix ... (25)	●	—	●	●	—	—	●	●	—	—
Vidor ... (47)	—	—	—	—	—	—	—	●	—	—
W.B. ... (62)	—	—	●	●	—	—	●	—	—	—
Westerman (87)	—	—	—	—	—	—	—	—	—	●

T, tape; W, wire.

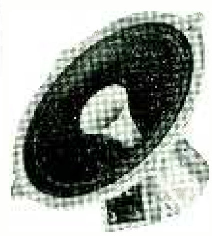


Goodmans omni-directional public - address loudspeaker, known as the Concentric Diffuser.



Garrard three-speed automatic record changer, Model RC72.

Model P358 three-speed "Trixette" electric gramophone (Trix).



(Below) Stentorian 12in Concentric Duplex loudspeaker (W.B.).

NUMERICAL LIST OF STANDHOLDERS WITH NAMES AND ADDRESSES

2 **Taylor Electrical Instruments**, 419, Montrose Ave. Slough, Bucks.
3 **A. F. Bulgin & Co.**, Bye-Pass Rd., Barking, Essex.
5 **Concordia Electric Wire & Cable Co.**, Long Eaton Nr. Nottingham.
6 **Barclays Bank**, 54 Lombard St., London. E.C.3.
7 **A. C. Cossor**, Highbury Grove, London N.5.
8 **Pye**, Radio Works, Cambridge.
9 **Electro Dynamic Construction Co.**, St. Mary Cray, Kent.
Battery Construction. Bristol Rd., Bridgwater, Som.
10 **"Wireless World" & "Wireless Engineer."** Dorset House Stamford St., London, S.E.1.
11 **E. K. Cole**, Ekco Works, Southend-on-Sea Essex.
12 **Gramophone Co.**, Hayes, Middx.
13 **Econasign Co.**, 92, Victoria St., London, S.W.1.
14 **Motor & Air Products**, 24, Bridge St., Leatherhead, Surrey.
15 **"Electronic Engineering."** 28, Essex St., London, W.C.2.
16 **Westinghouse Brake & Signal Co.**, 82. York Way King's Cross, London, N.1.
17 **"Television Weekly,"** 50 Old Brompton Rd., London, S.W.7.
18 **Antiference**, 67, Bryanston St. London, W.1.
19 **Air Ministry**, Parliament Sq. House, Parliament St. London, S.W.1.
20 **"Practical Wireless,"** Tower House Southampton St., London, W.C.2.
21 **General Post Office**, London, E.C.1.
22 **Decca Record Co.**, 1-3, Brixton Rd., London, S.W.9.
23 **Hobday Bros.**, 21-27, Gt. Eastern St., London, E.C.2.
24 **Midland Auto Components**, 58, Cambridge St., Birmingham.
25 **Trix Electrical Co.**, 1-5, Maple Place Tottenham Court Rd., London, W.1.
26 **Automatic Coil Winder & Electrical Equipment Co.**, Winder House, Douglas St., London, S.W.1.
27 **"Birmingham Gazette,"** Gazette Buildings, Corporation St., Birmingham, 2, Warwicks.
28 **Masteradio**, 10-20, Fitzroy Place, London, N.W.1.
29 **Guest, Keen & Nettlefolds**, Box No. 24 Heath St. Birmingham, 18, Warwicks.
30 **Lloyds Bank** 71, Lombard St., London, E.C.3.
31 **Association of Radio Battery Manufacturers**, 41 Gordon Square, London, W.1.
32 **Garrard Engineering & Manufacturing Co.**, Newcastle St., Swindon, Wilts.
33 **Edison Swan Electric Co.**, 155, Charing Cross Rd. London, W.C.2.
34 **General Post Office**, London, E.C.1.
35 **English Electric Co.**, Queens House, Kingsway, London, W.C.2.
36 **Kolster-Brandes**, Footscray, Sidcup, Kent.
37 **Decca Record Co.**, 1-3, Brixton Rd., London, S.W.9.
38 **Philco (Overseas)**, 204-206, Gt. Portland St., London, W.1.
39 **Scophony Baird**, Lancelot Rd., Wembley, Middx.
40 **Decca Record Co.**, 1-3, Brixton Rd., London, S.W.9.
41 **Automatic Telephone & Electric Co.**, Strowger House, Arundel St., London, W.C.2.
42 **Philips Electrical**, Century House, Shaftesbury Ave., London, W.C.2.
43 **Standard Telephones & Cables**, Connaught House, Aldwych, London, W.C.2.
44 **Murphy Radio**, Welwyn Garden City, Herts.
45 **Philips Electrical**, Century House, Shaftesbury Ave., London, W.C.2.
46 **Invicta Radio**, Parkhurst Rd., Holloway. London N.7.
47 **Vidor**, West St., Erith, Kent.
48 **Bush Radio**, Power Rd., London, W.4.
49 **Pye**, Radio Works, Cambridge.
50 **Radio Gramophone Development Co.**, Pale Meadow Works, Bridgnorth, Salop.
51 **Marconiphone Co.**, Hayes, Middx.
52 **A. C. Cossor**, Highbury Grove, London, N.5.
53 **E. K. Cole**, Ekco Works, Southend-on-Sea, Essex.
54 **A. J. Balcombe**, 52, Tabernacle St., London, E.C.2.
55 **Ferranti**, Hollinwood, Lancs.
56 **Pilot Radio**, 31-33, Park Royal Rd., London, N.W.10.
57 **McMichael Radio**, 190, Strand, London, W.C.2.
58 **General Electric Co.**, Magnet House, Kingsway, London, W.C.2.
59 **Ultra Electric**, Western Ave., Acton, London, W.3.
60 **Hale Electric Co.**, Radio Works, Talbot Rd., West Ealing, London, W.13.
61 **Co-operative Wholesale Society**, 1, Balloon St., Manchester, 4, Lancs.
62 **Whiteley Electrical Radio Co.**, Victoria St., Mansfield, Notts.
63 **Sobell Industries**, Langley Pk., Nr. Slough, Bucks.
64 **Mullard Electronic Products**, Century House, Shaftesbury Ave., London, W.C.2.
65 **Gramophone Co.**, Hayes, Middx.
66 **Regentone Products**, Eastern Ave., Romford, Essex.
67 **Ferguson Radio Corpn.**, 105, Judd St., London, W.C.1.
68 **R. N. Fitton**, Princess Works, Brighouse, Yorks.
69 **Dynatron Radio**, Perfecta Works, Ray Lea Rd., Maidenhead, Berks.
70 **Radiomobile**, Cricklewood Works, London, N.W.2.
71 **Belling & Lee**, Cambridge Arterial Rd., Enfield, Middx.
72 **Brown Brothers**, Gt. Eastern St., London, E.C.2.
73 **Champion Electric Corpn.**, Champion Works, Seaford, Sussex.
74 **Mullard Electronic Products**, Century House, Shaftesbury Ave., London W.C.2.
75 **Westminster Bank**, 51, Threadneedle St., London E.C.2.
76 **Aerialite**, Castle Works, Stalybridge, Cheshire.
77 **General Electric Co.**, Magnet House, Kingsway, London, W.C.2.
78 **Metro Pex**, 38, Gt. Portland St., London, W.1.
79 **Telegraph Construction & Maintenance Co.**, 22, Old Broad St., London, E.C.2.
80 **British Insulated Callender's Cables**, Norfolk House, Norfolk St., London, W.C.2.
82 **Amplion**, 230, Tottenham Court Rd., London, W.1.
83 **Stratton & Co.**, Eddystone Works, Alvechurch Rd., West Heath, Birmingham, 31, Warwicks.
84 **Peto Scott Electrical Instruments**, Addlestone Rd., Weybridge, Surrey.
85 **Goodmans Industries**, Lancelot Rd., Wembley, Middx.
86 **Multicore Solders**, Mellier House, Albemarle St., London, W.1.
87 **F. Westerman** (Wholesale), 94, Dale End, Birmingham, 4, Warwicks.
88 **Romac Radio Corpn.**, The Hyde, Hendon, London, N.W.9.
89 **"Daily Mail,"** Northcliffe House, E.C.4.
90 **E. A. Wood**, 100, Aston Rd., Birmingham, 6, Warwicks.
91 **Midland Bank**, Poultry, London, E.C.2.
92 **E. K. Cole**, Ekco Works, Southend-on-Sea, Essex.
93 **"Wireless & Electrical Trader,"** Dorset House, Stamford St., London, S.E.1.
94 **Portogram Radio Electrical Industries**, Priel Works, St. Rule St., London, S.W.8.
95 **Kerry's (G.B.)**, Warton Rd., Stratford, London, E.15.
96 **Winter Trading Co.**, 6 Harrow Rd., Paddington, London, W.2.
97 **Coulphone Radio**, 53, Burscough St., Ormskirk, Lancs.
98 **J. B. Manufacturing (Cabinet) Co.**, 86, Palmerston Rd., Walthamstow, London, E.17.
99 **B. Kimber, Allen & Co.**, Myron Works, Myron Place, Lewisham, London, S.E.13.
100 **Telerection**, 12, Suffolk Parade, Cheltenham, Glos.
101 **Fine Wires**, Grove Rd., Castle Boulevard, Nottingham.
102 **Wolsey Television**. 75, Gresham Rd., Brixton, London, S.W.9.
103 **Domain Industries**, Domain Works Barnby St., London, N.W.1.
104 **Geo. L. Scott & Co.**, Cromwell Rd., Ellesmere Port, Cheshire.
105 **Bush Radio**, Power Rd., London, W.4.
106 **"Electrical & Radio Trading,"** 96, Long Acre, London, W.C.2.
107 **British Railways**, 222, Marylebone Rd., London, N.W.1.
108 **National Provincial Bank**, 15 Bishopsgate, London, E.C.2.

Flyback E.H.T.

(*Concluded from page 282, August Issue*)

2—Characteristics of the Circuit

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

THE general argument leads to the conclusion that the requirement for good regulation is a high ratio of energy in the deflector-coil circuit to the energy drawn from the e.h.t. system by the tube. It tells us nothing about how big the ratio must be for a given regulation, however, nor does it indicate how the magnitude of the damping affects matters. The detailed analysis of the Appendix is necessary for this and its results are presented in Figs. 5, 6 and 7. The damping is here indicated by the Q of the circuit ($Q = R\sqrt{C/L}$). It is interesting to notice that the Q has very little effect on the regulation. For values of $LI^2/V_{HT}i_{HT}$ over 4.5×10^{-3} the effect of varying Q is indistinguishable on the curves. For smaller values, Q does have a noticeable effect, but it is still very small.

This at first seems surprising for the power dissipated in R increases as Q is lowered and one would expect the ratio of circuit volt-amperes to e.h.t. power to increase to make up for this loss. This would occur if the curves were plotted in terms of $Li_0^2/V_{HT}i_{HT}$ instead of $LI^2/V_{HT}i_{HT}$ for the value of I/i_0 depends very much upon the Q.

The peak-to-peak current I is regarded here as more fundamental than the peak current i_0; I must be provided for deflection, i_0 depends on I and Q, and Q depends on what is practicably obtainable and upon what is usable in a given type of circuit. The relation between I and i_0 is dependent on scanning requirements only and is either settled by the Q available or Q is chosen to provide the required relation. Of course, I/i_0 is affected somewhat by the load of the e.h.t. supply, but this is taken into account in Fig. 5.

The measure of volt-amperes in the deflecting circuit is made LI^2 because this is also a convenient measure of deflector-coil characteristics. It is not actually a volt-ampere product; to be this it would have to be divided by the repetition period of the saw-tooth. Time does come into the expression used in computing Fig. 5, but it has been included as a numerical figure of 98.77 μsec.

A typical deflector coil has an LI^2 figure of 1.3 mH-A² with a tube operating at 5 kV. A transformer may have a field efficiency of 70 per cent. The effective LI^2 figure at the primary then becomes $1.3/0.7 = 1.86$ mH-A². With a current of 120μA at 5 kV, $V_{HT}i_{HT}$ is $5 \times 0.12 = 0.6$ watt and so $LI^2/V_{HT}i_{HT} = 1.86 \times 10^{-3}/0.6 = 3.1 \times 10^{-3}$. Reference to Fig. 5 shows $V_{HT}/V_m = 0.88$, about. The zero to full-load regulation is thus $100(1 - 0.88) = 12\%$. With $V_{HT} = 5$ kV, V_m becomes $5/0.88 = 5.68$ kV and the change of voltage is 680 V; therefore, the internal resistance of the supply is $680/120 = 5.7$ MΩ.

If better regulation is needed, then it is necessary to increase LI^2. This means, of course, that a less efficient deflector coil or transformer must be used. The pursuit of efficiency in these components may, therefore, be a waste of time when e.h.t. is taken from the fly-back!

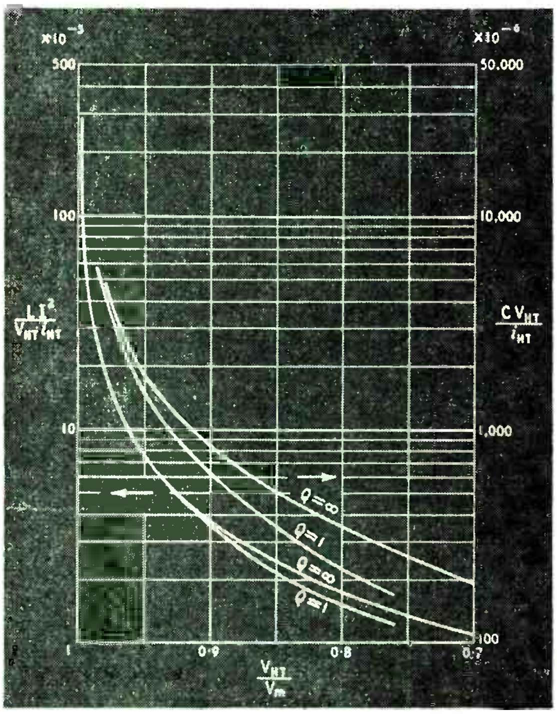


Fig. 5. Variation of $LI^2/V_{HT}i_{HT}$ and CV_{HT}/i_{HT} with V_{HT}/V_m for Q values of 1 and ∞.

In the case quoted the LI^2 figure was taken as a reasonable one for good components and it led to a usable figure for the regulation. Suppose now that the tube voltage is doubled so that V_{HT} becomes 10 kV, the current remaining unchanged. LI^2 is also doubled, because the current needed for deflection increases as $\sqrt{V_{HT}}$, so that $LI^2/V_{HT}i_{HT}$ is unchanged and the regulation is unaffected. This is very important because it means that the regulation is independent of the voltage.

The LC product needed in the circuit is also independent of voltage (Equ. 24 in the Appendix) but depends on the fly-back time, the Q and the regulation. For a given Q, if LC is chosen to give the required fly-back time at full current, then at lower current the fly-back will be a little quicker. The change is not large because the conduction time of the diode is only a small fraction of the total fly-back time and it is the conduction time which is directly affected by the current.

For a given maximum current, the voltage obtainable is inversely proportional to the circuit capacitance. As capacitance cannot be reduced indefinitely this sets a limit to the maximum voltage obtainable.

For the case of $LI^2 = 3.1 \times 10^{-3}$ and $V_{HT} = 5$ kV, we see from Fig. 5 that for a low-Q circuit $CV_{HT}/i_{HT} = 480 \times 10^{-6}$ and for a high Q it is 670×10^{-6}. With $i_{HT} = 120\ \mu A$, we have 5.86×10^{-8} and 8.2×10^{-8} respectively for CV_{HT} and so C becomes 11.9 pF and 16.4 pF. A high-Q circuit has an advantage in permitting a higher circuit capacitance. In both cases the circuit capacitances are low and may be impracticably low. Certainly, appreciably smaller values, and hence much higher e.h.t. voltages, would be impossible.

If the circuit Q is large so that the losses in R are negligibly small the equations in the Appendix can be greatly simplified for then $\omega t_1 = \sin^{-1} V_{HT}/V_m$ and $I/i_0 = 1 + V_{HT}/V_m$. Then

$$\frac{LI^2}{V_{HT} i_{HT}} = 2\tau \frac{1 + V_{HT}/V_m}{1 - V_{HT}/V_m}$$

$$\frac{CV_{HT}}{i_{HT}} = 2\tau \frac{(V_{HT}/V_m)^2}{1 - (V_{HT}/V_m)^2}$$

Eliminating i_{HT} between the two equations we get

$$C = \frac{LI^2}{V_{HT}^2} \cdot \left(\frac{V_{HT}/V_m}{1 + V_{HT}/V_m}\right)^2$$

which shows that for a given regulation and deflector-coil energy the capacitance required is inversely proportional to the square of the voltage. If LI^2 is fixed at the requirements for scanning there is a decided limit to the e.h.t. voltage obtainable because there is a physical limit to the extent to which C can be reduced. However, this limit of voltage is only for a given type of rectifier. If a voltage-doubler rectifier is substituted for a half-wave, then in the ideal case the rectifier output voltage V_T and input current i_{HT} are doubled. Since i_{HT} does not appear in the above equation and V_{HT} still refers to the circuit voltage, the permissible capacitance is increased four times or, for the same capacitance the tube voltage is doubled. Voltage-multiplying rectifiers are thus essential for high tube voltages.

The regulation is unaffected by the use of such a rectifier for although the input voltage and current are changed their product is constant. This is, of course, in the ideal case. In practice, the regulation of a voltage-multiplying rectifier is itself poorer than that of a half-wave because there is a greater power loss within it. Where it is practicable to use a half-wave rectifier, therefore, this kind should be used.

We have seen that the regulation is hardly affected by the Q of the circuit. This does not mean, however, that the effect of the regulation on the width of the picture is unaffected by Q. The deflection D is inversely proportional to the square root of the tube anode voltage and directly proportional to the deflecting current I; that is,

$$D \propto 1/\sqrt{V_T} \propto 1/\sqrt{V_{HT}} \text{ and } D \propto I$$

Now $I = i_0\left(1 + \frac{V_{HT}}{V_m}\epsilon^{-\pi\delta/\omega}\right)$ where i_0 is the peak current in the circuit at the start of fly-back and is constant because it is supplied by the driving valve. We get, therefore,

$$D = k\left[\sqrt{\frac{V_{HT}}{V_m}}\epsilon^{-\pi\delta/\omega} + \sqrt{\frac{V_m}{V_{HT}}}\right]$$

where k is a constant, and $\alpha/\omega = 1/[2Q\sqrt{1 - 1/4Q^2}]$. Writing for simplicity x_1 for any given value of V_{HT}/V_m, Δx for a small change from this value, D_1 for the picture width at x_1 and ΔD for the change of picture width corresponding to Δx we get

$$\frac{\Delta D}{D_1} \approx -\frac{1}{2}\cdot\frac{\Delta x}{x_1}\cdot\frac{1 - x_1\epsilon^{-\pi\alpha/\omega}}{1 + x_1\epsilon^{-\pi\alpha/\omega}} + \frac{1}{8}\left(\frac{\Delta x}{x_1}\right)^2\frac{3 - x_1\epsilon^{-\pi\alpha/\omega}}{1 + x_1\epsilon^{-\pi\alpha/\omega}}$$

For a given $\Delta x/x_1$ it is clear that $\Delta D/D_1$ becomes smaller as $x_1\epsilon^{-\pi\alpha/\omega}$ approaches unity; if $Q = \infty$, $\epsilon^{-\pi\alpha/\omega} = 1$ and $\Delta D/D_1$ is at its minimum. Therefore, in order to minimize the effect of the regulation on picture width the circuit Q should be as large as possible. As an example, consider two limiting cases with $x_1 = 0.9$ and $\Delta x = \pm 0.1$. If $Q = \infty$ the above expression gives $\Delta D/D_1 = -0.0012$ and 0.0046 whereas if $Q = 1$ we find $\Delta D/D_1 = -0.037$ and 0.046. The high Q circuit is thus at least ten times as good as the low Q.

It seems, therefore, that the use of a high-Q circuit offers a very considerable advantage. In fact, any reasonably good regulation of the e.h.t. supply is sufficient for the effect on picture width to be negligible.

Unfortunately, this is only part of the story. The frame-scanning current is constant so that picture height will be proportional to $1/\sqrt{V_{HT}}$. The picture height will, therefore, change more than the picture width and the aspect ratio will be affected by the regulation of the e.h.t. supply. With a low-Q circuit this effect will not be appreciable.

Also, variations of V_{HT} affect the focus and the compensating action of a high-Q circuit does nothing to reduce this. The best results are thus clearly obtained by using a low-Q circuit and making the regulation adequate by keeping LI^2 large. This is an uneconomical condition, however, in that it leads to a line-scanning stage which demands a large power input from the h.t. supply.

From the technical point of view, the right answer to all these problems is to keep the load on the e.h.t. system constant, so that V_{HT}/V_m and I remain constant. The tube current necessarily changes, so that the maintenance of a constant load on the e.h.t. circuit demands the connection to the output of a shunt circuit having special characteristics. It must absorb little or no current when the tube is drawing full current, and the full tube current when the tube ceases to take current.

The obvious thing to use is a shunt valve stabilizer, but this is ruled out by the absence of a suitable valve. A high-g_m triode or pentode is required which is capable of withstanding the full e.h.t. voltage on its anode.

It is, however, possible to approach the regulated

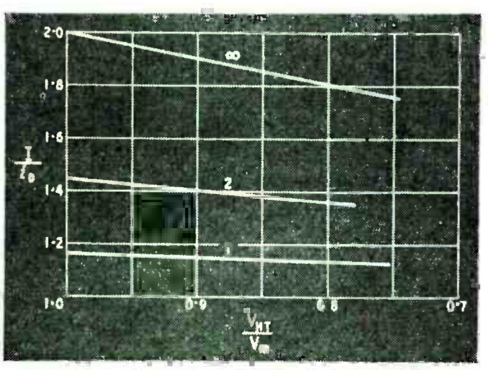


Fig. 6. Variation of I/i_0 with V_{HT}/V_m for Q values of 1, 2 and ∞.

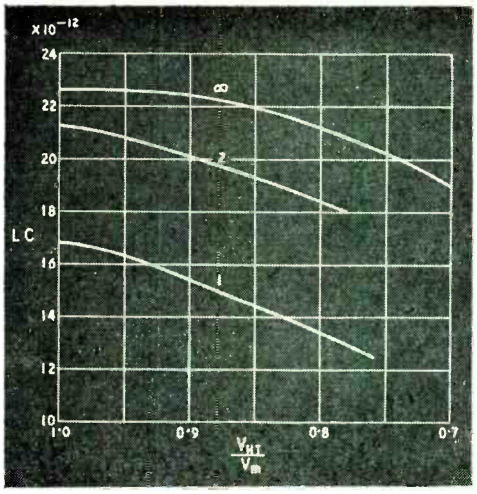
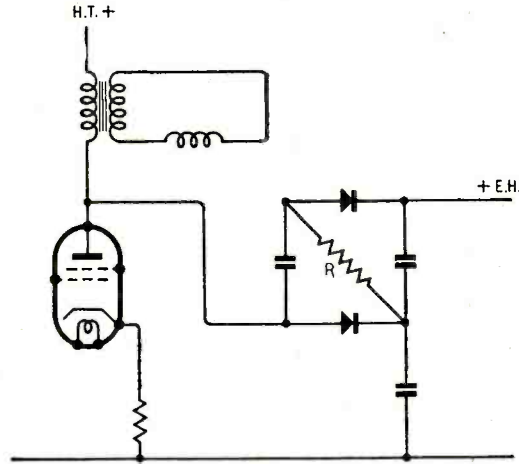


Fig. 7. Variation of LC with V_{HT}/V_m for Q values of 1, 2 and ∞.

Fig. 8. Typical voltage-doubling e.h.t. rectifier system.



condition by shunting the output by a suitable semiconductor. Such materials have a resistance which, above a certain applied voltage, decreases rapidly with an increase of voltage. The back resistance of selenium rectifiers is an example and a considerable improvement in regulation is possible if a suitable rectifier is connected across the e.h.t. supply.

Since the back resistance of the e.h.t. rectifier is in shunt with the supply during the " non-conductive " period, this rectifier can provide the stabilizing action as well as the rectifying. By careful choice of the operating conditions, therefore, it should be possible to obtain better regulation with metal rectifiers than with thermionic rectifiers.

Since these rectifiers need no filament supply they are especially convenient in voltage-multiplying circuits. These circuits have a bad reputation for regulation, but this has been acquired in mains-supply service where the source is of low impedance and the rectifier itself is the major cause of poor regulation. In fly-back systems it is the source which is mainly responsible for the regulation with the result that the greater power loss in a voltage-doubler has relatively little effect.

Most of the regulation effects of the voltage-doubler are due to the series resistance R of Fig. 8 and this is usually around 1-2 MΩ. It can be taken into account by adding it to the effective internal impedance of the source, viewed from the output.

Thus, suppose $V_{HT} = 3$kV, $i_T = 200\ \mu$A and $V_{HT}/V_m = 0.9$ at full current. Then $\Delta V_{HT} = 300$V and the source impedance is $300/200 = 1.5$ MΩ. The equivalent impedance viewed from the output is four times this, or 6 MΩ, because the voltage is doubled and the current halved in the voltage-doubling rectifier system. This is also the impedance of a half-wave system suppying 6 kV at 100 μA.

Taking the feed resistor of 1 MΩ into account the impedance becomes 7 MΩ. For a change of current of 100 μA in the output (200 μA at the input of the voltage-doubler), the change of voltage is 700 V instead of 600 V and so the regulation is $100 \times 700/6{,}000 = 11.6\%$ instead of 10%. In fact, it is slightly worse than this for there are two rectifiers in series instead of one only. It can, however, be made still better by replacing the resistance by a third rectifier, since this will have a lower forward resistance. The gain is not usually sufficient to justify this, however.

In conclusion, the main properties of fly-back e.h.t. systems can be summarized as follows :—

(1) With a given deflector coil, transformer and rectifier system the regulation is independent of the tube operating voltage because $I \propto \sqrt{V_{HT}}$ and $LI^2/V_{HT}i_{HT}$ is, therefore, constant. This assumes that the changes of tube current are independent of the tube anode voltage.

(2) The regulation is nearly independent of the Q value of the circuit comprising the deflector coil and transformer.

(3) With a given deflector coil, transformer and rectifier system the maximum tube voltage is limited by circuit capacitance. The circuit Q also has an appreciable effect and a very high-Q circuit enables about 40% more voltage to be obtained than with a very low-Q circuit for the same capacitance.

(4) The capacitance limit to the voltage can be overcome by using a voltage-multiplying rectifier system. The circuit regulation is unaffected by this if the power loss in the rectifier system is negligible.

(5) With a very low-Q circuit the regulation affects picture width and height nearly equally and the aspect ratio is hardly affected. With a high-Q circuit the regulation affects I and this largely compensates for the effect on picture width. Picture height is directly affected by the regulation and so with a high-Q circuit the regulation affects the aspect ratio.

(6) In all cases the regulation affects the focus.

(7) Because of the high source impedance the regulation with a voltage-doubling rectifier is only slightly poorer than with a half-wave.

For the benefit of those who like to know how results are derived a full analysis of the circuit is given in the Appendix. It leads to the results which, for the British 405-line system, are summarized in Figs. 5, 6 and 7.

APPENDIX

Referring to Fig. 1 let the initial circuit in L be i_0. The instantaneous current i_L resulting from its decay is the same as that which would be obtained if i_0 were maintained indefinitely and a unit impulse of current $i_0\mathbf{1}$ were applied to the circuit so that the current in L resulting from it is in opposition to i_0. Then

$$v = i_0 Z \mathbf{1} \quad \ldots \quad (1)$$

$$i_L = i_0 - i_0(Z/pL)\mathbf{1} \quad \ldots \quad (2)$$

where $p = d/dt$

$$Z = \frac{1}{pC + \frac{1}{R} + \frac{1}{pL}} = R\,\frac{2\alpha p}{p^2 + 2\alpha p + \omega_0^2}$$

$$\alpha = 1/2RC\,; \quad \omega_0^2 = 1/LC$$

Whence

$$v = i_0 R \frac{2\alpha p}{p^2 + 2\alpha p + \omega_0^2}\mathbf{1} \quad \ldots \quad (3)$$

$$i_L = i_0 \frac{p^2 + 2\alpha p}{p^2 + 2\alpha p + \omega_0^2}\mathbf{1} \quad \ldots \quad (4)$$

Writing $\omega^2 = \omega_0^2 - \alpha^2$ these equations have the following solutions when $\omega_0 > \alpha$

$$v = i_0\, R \frac{2\alpha}{\omega} \sin \omega t\, \epsilon^{-\alpha t} \quad \ldots \quad (5)$$

$$i_L = i_0 \left[\cos \omega t + \frac{\alpha}{\omega} \sin \omega t\right] \epsilon^{-\alpha t} \quad \ldots \quad (6)$$

If V_2 is disconnected, the voltage v across the circuit reaches a maximum value V_m when $dv/dt = 0$. By differentiating Equ. (5) and equating to zero this is found to occur when $\omega t_m = \tan^{-1}(\omega/\alpha)$ and so*

$$V_m = i_0\, R \frac{2\alpha}{\omega_0} \exp\left(-\frac{\alpha}{\omega}\tan^{-1}\frac{\omega}{\alpha}\right) \quad \ldots \quad (7)$$

When V_2 is connected the reservoir capacitance is charged to V_{HT} and so V_2 becomes conductive at some instant t_1 when $v = V_{HT}$ $(0 < t_1 < t_m)$; writing i_1 for the current at this instant we get

$$V_{HT} = i_0\, R \frac{2\alpha}{\omega} \sin \omega t_1\, \epsilon^{-\alpha t_1} \quad \ldots \quad (8)$$

$$i_1 = i_0 \left[\cos \omega t_1 + \frac{\alpha}{\omega} \sin \omega t_1\right] \epsilon^{-\alpha t_1} \quad \ldots \quad (9)$$

After t_1 Equs. (3) and (4) no longer apply because the ideal diode V_2 keeps the voltage constant at V_{HT}. Therefore, C no longer draws current and R draws a constant current V_{HT}/R. The current in L must fall linearly with time because V_{HT} is constant and becomes $i_1 - V_{HT}t/L$, time now being reckoned from t_1 as zero. The current i_v through the diode V_2 is the current in L less the current in R, therefore

$$i_v = i_1 - V_{HT}\frac{t}{L} - \frac{V_{HT}}{R} \quad \ldots \quad (10)$$

This current flows until $i_v = 0$ at $t = t_2$, therefore,

$$t_2 = \frac{L}{V_{HT}}\left(i_1 - \frac{V_{HT}}{R}\right) \quad \ldots \quad (11)$$

Since i_v varies linearly from $i_1 - V_{HT}/R$ at $t = 0$ to zero at $t = t_2$ its mean value is one-half of its initial value. The total charge conveyed through V_2 into C_r during the conducting interval t_2 is thus

$$q = \frac{t_2}{2}\left(i_1 - \frac{V_{HT}}{R}\right) \quad \ldots \quad (12)$$

This charge must, in the equilibrium state, equal the charge withdrawn from C_r by the constant current i_T of the c.r. tube during the whole interval τ between successive fly-backs. Therefore,

$$i_T\,\tau = \frac{t_2}{2}\left(i_1 - \frac{V_{HT}}{R}\right) = \frac{L}{2V_{HT}}\left(i_1 - \frac{V_{HT}}{R}\right)^2 \quad \ldots \quad (13)$$

After t_2 the diode becomes non-conductive again and the performance is that of an LCR circuit having for initial conditions a current V_{HT}/R in L and a voltage V_{HT} across C. Time is now to be reckoned from t_2 as zero. From Equ. (6) the current in L due to the initial current is

$$i_{L1} = \frac{V_{HT}}{R}\left[\cos \omega t + \frac{\alpha}{\omega} \sin \omega t\right] \epsilon^{-\alpha t} \quad \ldots \quad (14)$$

The current in L due to the charge on C is calculated with the aid of Fig. 2. By inspection.

$$i_{L2} = \frac{V_{HT}}{\frac{1}{pC} + \frac{pLR}{pL + R}} \cdot \frac{pLR}{pL + R} \cdot \frac{1}{pL}\mathbf{1}$$

$$= \frac{V_{HT}}{L} \cdot \frac{p}{p^2 + 2\alpha p + \omega_0^2}\mathbf{1}$$

$$= \frac{V_{HT}}{\omega L} \sin \omega t\, \epsilon^{-\alpha t} \quad \ldots \quad (15)$$

The total current after t_2 is, therefore,

$$i_L = \frac{V_{HT}}{\omega L}\left[\frac{\omega L}{R}\cos \omega t - \left(1 - \alpha\frac{L}{R}\right)\sin \omega t\right]\epsilon^{-\alpha t} \quad \ldots \quad (16)$$

This has a maximum negative value, found by differentiating and equating to zero, at t_3, or

$$\omega t_3 = \tan^{-1}\left(-\frac{\omega}{\alpha}\right) = \pi - \tan^{-1}\frac{\omega}{\alpha} \quad \ldots \quad (17)$$

Therefore, the negative current maximum is

$$i_{Lm} = -\frac{V_{HT}}{\omega_0 L}\exp\left[-\frac{\alpha}{\omega}\left(\pi - \tan^{-1}\frac{\omega}{\alpha}\right)\right] \quad \ldots \quad (18)$$

and the peak to peak scanning current is

$$I = i_0 - i_{Lm} = i_0 + \frac{V_{HT}}{\omega_0 L}\exp\left[-\frac{\alpha}{\omega}\left(\pi - \tan^{-1}\frac{\omega}{\alpha}\right)\right] \quad (19)$$

The total fly-back time is

$$\tau_2 = t_1 + t_2 + t_3 \quad \ldots \quad (20)$$

The ratio of the voltage on full load to the voltage on open circuit is a design factor of major importance; it is given by the ratio of Equs. (8) and (7).

$$\frac{V_{HT}}{V_m} = \frac{\omega_0}{\omega}\sin \omega t_1 \exp\left[-\frac{\alpha}{\omega}\left(\omega t_1 - \tan^{-1}\frac{\omega}{\alpha}\right)\right] \quad \ldots \quad (21)$$

Now $\omega_0 = 1/LC$ and we define Q as $R/\omega_0 L$; therefore, $Q = R\sqrt{C/L}$ and so

$$\frac{\alpha}{\omega_0} = \frac{\sqrt{LC}}{2CR} = \frac{\sqrt{L/C}}{2R} = \frac{1}{2Q}$$

$$\omega = \omega_0\sqrt{1 - \alpha^2/\omega_0^2} = \omega_0\sqrt{1 - 1/4Q^2}$$

$$\frac{\alpha}{\omega} = \frac{1}{2\,Q\sqrt{1 - 1/4Q^2}}$$

From Equs. (7) and (8)

$$\frac{V_{HT}}{V_m} = \frac{\exp\left(\frac{\alpha}{\omega}\tan^{-1}\frac{\omega}{\alpha}\right)}{\sqrt{1 - 1/4\,Q^2}}\sin \omega t_1\, \epsilon^{-\frac{\alpha}{\omega}\cdot\omega t_1} \quad \ldots \quad (22)$$

From Equs. (8), (9) and (11)

$$\omega t_2 = \sqrt{1 - 1/4\,Q^2}\left(\cot \omega t_1 - \frac{\alpha}{\omega}\right) \quad \ldots \quad (23)$$

$$\omega t_3 = \pi - \tan^{-1}\frac{\omega}{\alpha} \quad \ldots \quad (17)$$

From Equs. (17), (20) and (23)

$$LC = \frac{\tau_2^2\,(1 - 1/4\,Q^2)}{(\omega t_1 + \omega t_2 + \omega t_3)^2} \quad \ldots \quad (24)$$

From Equs. (8), (19) and (22)

$$\frac{I}{i_0} = 1 + \frac{V_{HT}}{V_m}\epsilon^{-\pi\alpha/\omega} \quad \ldots \quad (25)$$

From Equs. (8), (9) and (13)

$$\frac{LI^2}{V_{HT}i_T} = 2\tau\left[\frac{I/i_0}{\left(\cot \omega t_1 - \frac{\alpha}{\omega}\right)\sin \omega t_1 \epsilon^{-\omega t_1 \alpha/\omega}}\right]^2 \quad \ldots \quad (26)$$

From Equs. (8) and (26)

$$\frac{CV_{HT}}{i_T} = \frac{2\tau}{(1 - 1/4Q^2)\left(\cot \omega t_1 - \frac{\alpha}{\omega}\right)^2} \quad \ldots \quad (27)$$

The units are ohms, henrys, farads, volts, amperes, seconds.

* The expression exp $(-x)$ is merely an alternative way of writing ϵ^{-x} and means exactly the same; it is a convenient one when the index is at all complicated.

WORLD OF WIRELESS

Anti-interference ✦ Beveridge Committee ✦ Views on Television ✦ U.R.S.I. Meeting

Interference Suppression

PROVISION was made in the Wireless Telegraphy Act, 1949, for the setting up of an Advisory Committee with which the Post-master General will consult before making regulations prescribing such requirements as he "thinks fit for the purpose of ensuring that the use of the apparatus does not cause undue interference with wireless telegraphy."

The committee has to be appointed from a panel of persons nominated by the Institution of Electrical Engineers, who either "possess expert knowledge of the matters falling to be dealt with" or "represent persons whose interests are likely to be affected" by the regulations. The I.E.E. has now nominated 45 people to constitute the panel from which the P.M.G. has appointed an advisory committee of seventeen members to consider the question of ignition interference and another of eighteen members to deal with refrigeration.

The "ignition systems" committee, of which Sir Stanley Angwin is chairman, and the "refrigeration" committee, include a number of well-known radio personalities and embrace a very wide variety of interests.

It would appear, from the names of the remaining thirteen members of the panel on whose services the P.M.G. will be able to call when regulations in respect of other types of apparatus are to be framed, that electro-medical equipment will be considered at a later date.

B.B.C. Enquiry

THE Broadcasting Committee, which was set up last year under the Chairmanship of Lord Beveridge, to "consider the constitution, control, finance and other general aspects of the sound and television broadcasting services in the U.K. . . . and to advise on the conditions under which these services and wire broadcasting should be conducted after December 31st, 1951 [when the present Charter of the B.B.C. ends]," completed the hearing of evidence at the end of July.

The first meeting of the Committee was held on June 24th, 1949, and during the past 13 months some one hundred organizations and individuals have given oral evidence before the Committee. It is understood that four members of the Committee are visiting North America to obtain additional information on the services in the U.S.A. and Canada.

The Lord President of the Council, Mr. Morrison, recently stated that he hoped the report of the Committee would be presented to him by the end of the year.

European Television

FOLLOWING the meeting in London of the Television Study Group of the International Radio Consultative Committee (C.C.I.R.), at which a preference for a 625-line standard was expressed by the majority of delegates, a meeting was held in Geneva in July.

At this meeting, attended by delegates from Belgium, Denmark, Italy, the Netherlands, Sweden, Switzerland, France, the U.S.A. and the U.K., it is understood detailed standards were established which are to be recommended to countries wishing to adopt a 625-line system.

Television: U.S. Opinion

THE Editor of our U.S. contemporary, *Electronics*, who as a member of the C.C.I.R. Television Study Group recently inspected the television systems of Europe and the United States, gives some general impressions of the visits in the July issue of his journal.

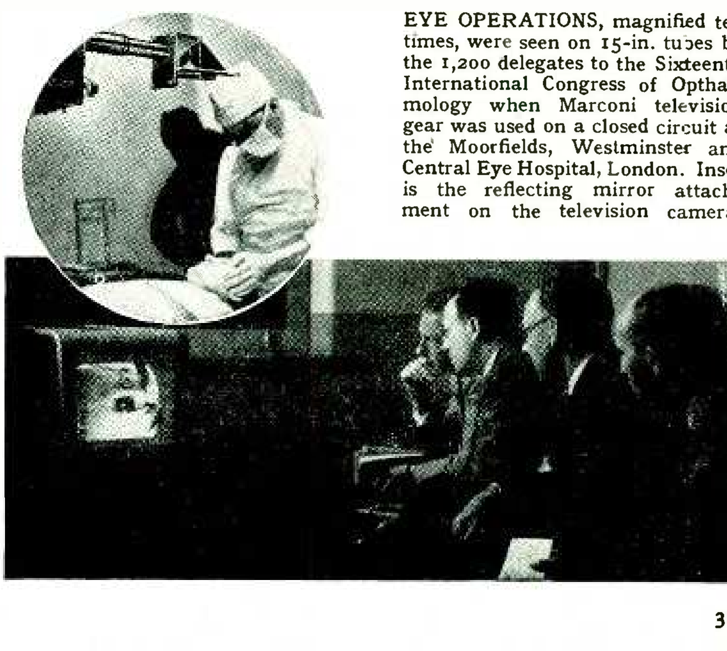
After stating that many of the delegates considered that the U.S. standard of 525 lines, 60 frames, with a 4.25-Mc/s vision bandwidth "is the happiest compromise among the systems demonstrated," he adds "this is not to say that the American television industry leads the world in all respects." He considers that British manufacturers are ahead of the American industry in these respects: First, "the transient response of British television studio equipment, co-axial cables, radio relays and transmitters is much superior"; secondly, in the use of the flying spot method of scanning films; thirdly, the C.P.S. camera has several advantages over the image orthicon; and fourthly, in the use of high-power transmitters such as that at Sutton Coldfield.

Among criticisms of the British system are (a) that the use of positive modulation, resulting in white ignition-interference spots on the screen "is more annoying than the black spots of the American system" which, of course, employs negative modulation; and (b) that the use of a.m. rather than f.m. for sound is apt to be noisy.

Scientific Radio

BETWEEN the meetings of the General Assembly of the International Scientific Radio Union (U.R.S.I.), of which Sir Edward Appleton is the President, the work is continued by seven commissions. In addition, at each general assembly national committees submit progress reports on the work undertaken in their own countries in the various fields of scientific radio. The British National Committee for Scientific Radio, which is organized under the auspices of the Royal Society, has nominated seven delegates to the ninth general assembly of the U.R.S.I. which meets in Zurich from September 11th to 22nd.

The British delegates and commissions to which they are especially responsible are: C. W. Oatley (measurements and standardization), who is in the Engineering Laboratory, Cambridge University; Dr.



EYE OPERATIONS, magnified ten times, were seen on 15-in. tubes by the 1,200 delegates to the Sixteenth International Congress of Opthalmology when Marconi television gear was used on a closed circuit at the Moorfields, Westminster and Central Eye Hospital, London. Inset is the reflecting mirror attachment on the television camera.

R. L. Smith-Rose (troposphere and wave propagation), Director of Radio Research, D.S.I.R.; Dr. W. J. G. Beynon (ionosphere and wave propagation), Dept. of Physics, Swansea University; Dr. J. W. Findlay (terrestrial atmospherics), who, during the war, was in the M.A.P. Directorate of Communications Development and is now at Cambridge University; Dr. A. C. B. Lovell (extra-terrestrial radio noise), who was at T.R.E. and is now at Manchester University; W. Proctor Wilson (waves and oscillations), Head of the B.B.C. Research Dept., and Prof. J. Sayers (electronics), who with Prof. Randall and Dr. Boot developed the cavity magnetron.

Meeting Cancelled

IN view of the international situation the Extra-ordinary Administrative Radio Conference which, as mentioned last month, was to be held at the Hague from 1st September, has been cancelled.

Educational Opportunities

PROSPECTUSES and information on special radio and electronics courses are sent to us by a number of educational institutions prior to the opening of the academic year. Among those recently received is the prospectus of the evening courses in telecommunications, and television and radio servicing, issued by the Electrical Engineering Department, of the Polytechnic, Regent Street, London, W.1.

The prospectus from the Northern Polytechnic, Holloway, London, N.7, gives details of both full-time courses in radio and television technology, and evening courses in servicing, telecommunications engineering and electronic measuring instruments.

At the University College, Southampton, the full-time courses include radar, radio engineering and radio operating. There are also part-time day and evening courses in telecommunications engineering and radio and television servicing.

B.B.C. APPOINTMENTS

R. T. B. Wynn, C.B.E., M.A., M.I.E.E., who has been Asst. Chief Engineer of the B.B.C. since 1943, becomes Deputy Chief Engineer responsible under the Chief Engineer (Harold Bishop) for the general control and direction of all the corporation's engineering departments. He joined the B.B.C. as Head of the Engineering Information Department in 1926 after four years at the Marconi experimental transmitting station at Writtle, Chelmsford. He was chairman of the I.E.E. Radio Section for 1949-50.

H. L. Kirke, C.B.E., M.I.E.E., who succeeds R. T. B. Wynn as Asst. Chief Engineer, was also among the Writtle pioneers. He joined the Marconi Co. in 1920 and in 1924 went to the B.B.C. to become, in the following year, Head of the Development Dept., which later became the Research Dept. He will now be responsible for the co-ordination and direction of the technical work of the departments concerned with research, design, planning and installation.

W. Proctor Wilson, C.B.E., B.Sc., M.I.E.E., is the new Head of the Research Dept. of which he was appointed Asst. Head in 1945 on his return from war service. He joined the B.B.C. in 1927, having previously been with the Western Electric Co. He is one of the British delegates to the next meeting of the U.R.S.I.

E. C. Drewe, M.I.E.E., is now Asst. Head of the Research Dept. During his twenty years with the B.B.C. he has successively been Engineer-in-charge of the Brookmans Park transmitter, Senior Asst. to the Supt. Engineer (Transmitters), Asst. Head of the Engineering Secretariat and Research Manager.

IN BRIEF

Licences.—12,251,350 broadcast receiving licences, including 406,600 television licences, were current in Great Britain and Northern Ireland at the end of June.

Interference Suppression.—According to our associated journal *Motor Transport*, the principal operators of goods and passenger vehicles have taken the lead in fitting interference suppressors. All petrol-engined vehicles used by British Railways within 60 miles of Alexandra Palace and Sutton Coldfield have been fitted with suppressors—diesel engines do not cause interference. London Transport now employs only 30 petrol-driven buses and these have been suppressed.

B.V.A.—The chairman, J. W. Ridgeway (Ediswan), and vice-chairman, G. A. Marriott (G.E.C.), of the British Radio Valve Manufacturers' Association have been re-elected for the current year.

Canadian Television.—In addition to the equipment which Marconi's are supplying for two television studios in Toronto and two in Montreal the company has been awarded the contract to supply two specially designed television outside broadcasting vehicles for the Canadian Broadcasting Corporation. Each vehicle will be a complete television station equipped with three cameras and providing a radio link with the main transmitter. The total value of the equipment to be supplied by Marconi's is $875,000. Canadian television will operate on American standards; some thousands of Canadians within range of American stations have already purchased receivers. The number of sets sold in Canada during the first half of the year exceeded 15,000.

Duddell Medal for 1950 has been awarded by the Physical Society to D. W. Fry who during the war was at the Telecommunications Research Establishment working on the problems of centimetre-wave techniques. Since the war he has been at the Atomic Energy Research Establishment.

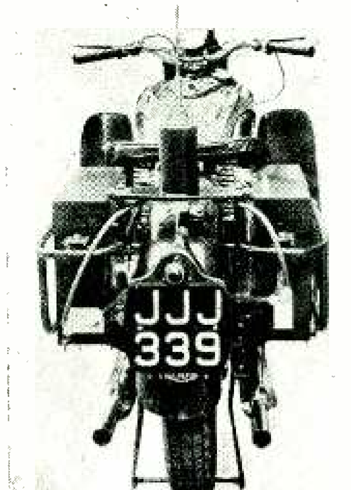
"Heaviside Centenary Volume" to be issued by the I.E.E. will contain a complete record of the proceedings of the meeting of the Institution in May to commemorate the centenary of the birth of Oliver Heaviside. The volume, which will be available to non-members at 10s, will also include "Some Unpublished Notes on Oliver Heaviside."

Reunion.—We are asked to announce that the reunion dinner for those who served in the Test Dept. No. 1 Signals Depot, R.A.F., West Drayton, will be at the Lotus Restaurant, Norris Street, Haymarket, London, W.1, on October 21st. Details are obtainable from H. Coker at 5, Turnpike Parade, London, N.15.

Haifa Volunteer Fire Brigade is seeking quotations from U.K. manufacturers for a 50-watt fixed transmitter and two 20-watt sets for installation on fire appliances. The quotations and descriptive literature should be sent to the Taylor Transport Co., 35, Kingsway, P.O. Box 162, Haifa, Israel.

Valve Vade Mecum.—Copies of the Brans "Vade Mecum" reviewed in our July issue are obtainable from Peter Armstrong, 136 Bickenhall Mansions, London, W.1, at 21s including postage.

Cable Centenary.—The submarine cable, which we would have described in the old days of intense competition between wire and wireless as "our poor relation," is celebrating its centenary. Now that co-operation has largely replaced competition in this field of communications, and radio-like techniques are widely used in all, we can properly offer our congratulations. To mark the event, an exhibition, opening on August 28th, is being staged at the



PLESSEY f.m. transmitter-receivers are being fitted on motor cycles used by the London Metropolitan Police. The equipment is housed in two cases carried on either side of the rear wheel above which is mounted the telescopic aerial. A selective calling system permits any one, or all, of 90 units to be called by the central station which is also being equipped by the Plessey Co.

There has been no change in the position with regard to the withdrawal of overtime working by a section of the printing industry. A slight reduction in the number of pages in "Wireless World" is still unavoidable. All journals printed in London are similarly affected, to a greater or lesser extent, but journals printed in the provinces are not affected. It is greatly regretted that publication of our last issue was delayed.

Science Museum, South Kensington. An interesting and highly informative handbook, "One Hundred Years of Submarine Cables," written by G. R. M. Garratt, of the Museum, is on sale there, or from H.M. Stationery Office, price 2s 6d.

ECHO-FREE ROOM at the G.E.C. Research Laboratories the walls, floor and ceiling of which are covered with nearly 3,000 "Fibreglass" wedges, each 3-ft long. The sound-"transparent" floor can be seen in this illustration showing a television set undergoing audio tests.

BUSINESS NOTES

Decca Radar, Ltd., has been formed as a subsidiary of the Decca Record Co., to undertake the design, manufacture and sales of Decca marine radar, which in addition to receiving the Ministry of Transport's Certificate of Type Approval has the distinction of being the only British equipment to be approved by the American Federal Communications Commission. The head office is at 1-3, Brixton Road, London, S.W.9, and the factory at Shannon Corner, Kingston By-Pass, New Malden, Surrey. Grp. Capt. E. Fennessey is managing director.

D. W. Heightman, the well-known amateur, G6DH, has, as a result of a divergence of views on a matter of policy, resigned from the board of Denco (Clacton), Ltd., of which he was the founder in 1938 and has been managing director since 1946 when it became a limited company. A. N. Heightman, who was works manager, has also resigned.

Co-ordination of Resistance Production was the theme of a meeting earlier this year in the Philadelphia office of the International Resistance Co. of representatives of resistor manufacturers from Australia, Canada, Denmark, Italy and the U.K. who operate under I.R.C. licence. The U.K. representative was John Goodman (Dubilier).

Marconi's W.T. Co. and Marconi Instruments have now issued a house magazine the title of which is self-explanatory—"The Marconi Companies and their People." It is stated that this will not in any way supersede the "Marconi Mariner" issued by the Marconi International Marine Communication Co.

Ekco search radar equipment, which serves not only for the location of storm clouds but also as an aid to navigation, is to be installed by the British Overseas Airways Corporation in the de Havilland "Comet" and other aircraft operated by the corporation.

R. F. Gilson.—In the report on iron-cored components shown at the B.S.R.A. Exhibition (p. 257, July issue), we regret the mis-spelling of the name of R. F. Gilson, Ltd., 11a, St. George's Road, London, S.W.19.

S. American Market.—Empiria Products, Ltd., of 229, High Holborn, London, W.C.1, manufacturers representatives and exporters, will be interested to hear from British manufacturers of radio components who are anxious to extend their connections in South America. A director of the firm is visiting Venezuela, Colombia, Peru, Chile, Brazil and Uruguay in September.

A New Zealand client of Jepson, Bolton & Co., of 120, Moorgate, London, E.C.2, is visiting this country and is interested in the purchase of radio equipment other than domestic receivers. Further information is obtainable from the company.

Appointment of Philip Hickson as Director of Buying (radio and television) is announced by the John Lewis Partnership, Ltd. He was for many years technical director of Ardente Acoustic Laboratories.

NEW ADDRESSES

A.B. Metal Products, Ltd., have opened a new factory at Ynysboeth, Abercynon, Glam., South Wales.

Bonochord, Ltd., manufacturers of hearing aids, are now operating from their new factory in Lancaster Road, High Wycombe, Bucks. (Tel: High Wycombe 2136.) The London office is moving from 48, Wigmore Street, W.1, to 48, Welbeck Street, W.1. (Tel.: Welbeck 8245.)

G.R.S.E.—The registered office of the Guild of Radio Service Engineers has been transferred from Bank Chambers, 6, Station Road, Clacton-on-Sea, to 2, Stevenson Street West, Accrington, Lancs. The new general secretary is H. Hill.

"Q-Max" (Electronics), Ltd., are moving on September 1st from 10, Little Turnstile, London, W.C.1, to 95, Villiers Road, London, N.W.2.

Radar Association.—The address of the head office of the association is now 83, Portland Place, London, W.1. (Tel.: Langham 8183.)

T.R.D.—The head office of the Television Retailers' Development Co., and the Midlands T.R.D. Service, Ltd., which were formed as non-profit making organizations to provide dealers with an aerial installation service and advice bureaux, has been transferred from 47, Maddox Street, London, W.1, to 63, Portobello Road, London, W.11. (Tel.: Park 4491.)

MEETINGS

British Institution of Radio Engineers

Twenty-fifth annual general meeting at 6.30 on 27th September at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1, followed at 7.15 by the presidential address of Paul Adorian.

British Sound Recording Association

Presidential address of C. E. Watts at 7.0 on 29th September, at the Royal Society of Arts, John Adam Street, London, W.C.2.

Society of Relay Engineers

"Medium Voltage Feeders and their Associated Transformer Equipment for Long-distance Transmission of A. F. Power" by K. A. Russell, B.Sc., at 2.30 on 3rd October at the Engineers' Club, 17, Albert Square, Manchester, 2.

Hull Electronic Engineering Society

Details of the new Mullard c.r. tube for television projection systems and a description of the associated optical system, coil unit and e.h.t. supply will be given by E. Jones, B.Sc., A.M.I.E.E., at 7.30 on 8th September at the Y.E.B. Showrooms, Ferensway, Hull.

"Frequency Modulation" by E. D. Hart, M.A., A.M.Brit.I.R.E., A.Inst.P., and A. G. Wray, M.A. (Marconi Instruments), at 7.30 on 29th September, at the Y.E.B. Showrooms, Ferensway, Hull.

Measurements with Simple Apparatus

Potentialities of a Common-or-garden Voltmeter

By DONALD ROBINSON (*Londex, Ltd.*)

IN his article "Solving Parallel Problems," in the March issue of *Wireless World*, Mr. D. A. Pollock describes a method of thinking which can be developed and used to solve many other problems besides the particular ones he mentions. He gives an excellent example of how to produce one's own formulae instead of always relying on the text-book and also illustrates the really useful "ratio idea." It is, in fact, this "ratio idea" which enables us to make our measurements with simple apparatus.

Before going any further, it is worth pointing out that the method Mr. Pollock gives for calculating the combined value of two resistances in parallel can be extended by the same reasoning to deal with the much more trying case of three or more resistances in parallel. The formula then becomes:

$$R = \frac{R_1}{1 + \frac{R_1}{R_2} + \frac{R_1}{R_3} + \frac{R_1}{R_4} + \ldots \text{ etc.}}$$

As an example, let us take 3, 4, 6 and 12 ohms. In this case it is easiest to take the highest value, 12, as R_1, and then:

$$R = \frac{12}{1 + 2 + 3 + 4} = \frac{12}{10} = 1.2\Omega$$

It is sometimes best, however, to take one of the lower values as R_1. For instance, with 3, 6 and 20 ohms it would be best to take 6.

Measuring Resistance

There are at least two ways by which the "ratio idea" enables resistance to be measured with little more than a voltmeter. One of them is as follows.

Let us first measure some convenient source of volts and then connect the unknown resistance, R, in series with the meter, as in Fig. 1. Clearly, providing R is not inductive and the source impedance is not too high, its value will be in the same proportion to the resistance of the meter (R_m) as the voltage across R is to the voltage across the meter (E_m).

Now we know R_m: it is the "ohms-per-volt" figure of the meter multiplied by the full-scale reading of the range in use—although it would probably be best if the opportunity presented itself to measure

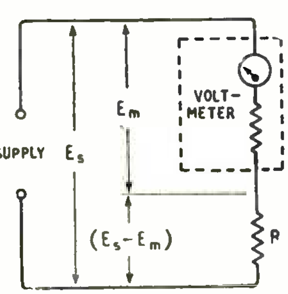
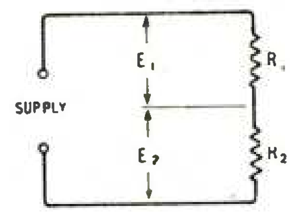


Fig. 1. Simple method of measuring resistance employing a voltmeter.

Fig. 2. Measuring resistance by comparison; an alternative method to that in Fig. 1, for low values.



the resistance of each range accurately, once and for all. We also know E_m: it is what the meter is saying. The voltage across R is the source volts (E_s) minus E_m. Therefore:—

$$\frac{R}{R_m} = \frac{(E_s - E_m)}{E_m}$$

$$\text{or} \quad R = R_m \times \frac{E_s - E_m}{E_m}$$

This is well worth remembering, if only for those occasions when the ohms-range battery dies unexpectedly!

It is advisable to select the meter range that has an R_m nearest to the suspected value of R, and then to find a source that gives a voltage near to, but below, the full-scale reading of the range. It must not, of course, be affected by the load of the meter.

The h.t. and bias voltages of a receiver often provide a good choice of E_s, but if R is not significantly reactive and a meter with a.c. ranges is available the mains can be used, either direct or from between suitable taps on the primary of a mains transformer.

Thus, if the meter resistance is 1,000 ohms-per-volt and R is non-inductive and believed to be between about 50kΩ and 250kΩ you might use the 100-volt a.c. range and the 50 volts obtainable from between the 200- and 250-volt taps on a mains transformer.

Before using a low a.c. range—say under 12 volts—it is best to take into account the method the meter manufacturer has used to minimize the inaccuracy that can arise on these ranges as a result of the variation in the resistance of metal rectifiers at low currents. Some makers avoid the effect by providing a special non-linear scale for low a.c. volts, but this means that the variation in rectifier resistance is high enough compared with the multiplier resistance to affect R_m significantly. Such ranges should not be used for this method below about two-thirds of full scale.

Other makers, however, overcome this difficulty and are able to use one linear scale for all ranges by reducing the ohms-per-volt figure for the low a.c. ranges, often to a tenth of the figure for other ranges. No difficulty will be experienced with these meters, provided the lower ohms-per-volt figure is used in working out the answer and the increased possibility of loading down the source is considered.

Otherwise, the limit of useful accuracy is perhaps reached when R is either about a fifth, or five times, R_m. A 1,000-ohms-per-volt meter of the latter type with ranges running from 10 to 1,000 volts can thus be used to check resistors between 2kΩ and 5MΩ.

Comparison Method

An alternative method that can be used for lower values and which gives a greater accuracy up to perhaps 100kΩ is that shown in Fig. 2.

In addition to a voltmeter and some volts, a known resistor, R_1, is needed. If R_1 and the unknown resistor, R_2, are connected in series across the supply and the voltage across each is, respectively, E_1 and E_2 and the current is I, then :—

$$R_2 = \frac{E_2}{I} = \frac{E_2}{E_1/R_1}$$
$$= R_1 \times \frac{E_2}{E_1}$$

A noteworthy feature is that the accuracy is but little affected by the shunting effect of the meter or by the accuracy, or otherwise, of its calibration. In fact an uncalibrated meter can be used provided it has an evenly divided scale.

The nearer R_1 is to R_2 the greater the accuracy. If their ratio is not more than 2 or 3 and neither is more than about a quarter of the resistance of the meter, considerable reliance can be placed on the result.

Checking Impedance

The comparison method can also be used to check impedance, and it is generally more accurate than the two-meter method (one for E and one for I) as it is not dependent on the accuracy of calibration. This is particularly likely to be so at 400 c/s or more when the accuracy of many meters falls off.

The accurate measurement of impedance needs careful precautions and finer measuring devices than the ordinary moving-coil meter, but the method we are dealing with has wide use for rough practical checks—for such purposes as testing a transformer for shorted turns by finding its impedance at 50 c/s., and for obtaining an idea of the impedance of a group of loudspeakers in a factory or public building in order to check the matching and see that there are no line shorts or reversed transformers.

As loudspeaker impedance is mostly reflected resistance, the waveform or frequency of the test signal is not of great importance, provided it is steady and well away from the upper and lower resonant frequencies. I have often used one of the whistles with which most radio receivers are only too well endowed.

If the loudspeaker system normally operates at the usual figure of 100 volts, this test can be made at a level hardly audible to any possible listener, and because of this low level a one-watt resistor can be used for R_1, even when the amplifier is rated at hundreds of watts. This is perhaps the most useful test that can be made on a big amplifier system.

An inexpensive and readily obtainable resistor for use as R_1 is the half- or one-watt, 1% accuracy, cracked-carbon type. A set of four—10, 100, 1,000, 10,000—will meet most needs, though for greater accuracy a set of seven—10, 33, 100, 333 . . . etc. —is better.

They can be usefully made up into a small adaptor, wired as in Fig. 3. Switch S_1 selects R_1 and also has two extra positions, E_s and E_m to facilitate tests by the series-voltmeter method.

Thus, if it is found that 10kΩ is not high enough for R_1 the switch can be moved in succession to the next two positions and the value found by the series method. It is best to use for S_2 a push-button or a non-locking key, spring loaded to the E_1 position. It can then be left alone when making a test by the series method.

When first using this adaptor one is inclined to select a hopelessly unsuitable supply voltage, value of R_1 and/or meter range, but as one has then to think in ratios in the way shown by Mr. Pollock to find which way to alter the constants, one soon becomes able to handle with facility both this unit and any other ratio problem that comes along.

Internal Resistance

The internal resistance of a battery, h.t. supply, valve stage or other source is often found by dividing the change in volts by the change in current that occurs when two values of load resistor are connected in turn, i.e. $R_i = \Delta E/\Delta I$. A method of doing this is illustrated in Fig. 4. Here :

$$E_s = I_1(R_1 + R_i) = I_2(R_2 + R_i)$$
$$\therefore \quad I_1R_i - I_2R_i = I_2R_2 - I_1R_1$$
$$\therefore \quad R_i(I_1 - I_2) = E_2 - E_1$$
$$R_i = \frac{\Delta E}{\Delta I}$$
$$\text{or } R_i = \frac{E_2 - E_1}{\frac{E_1}{R_1} - \frac{E_2}{R_2}}$$

Accuracy is likely to be greatest when E_2 is about twice E_1, but it should be remembered that internal heating may change R_i if the current is excessive.

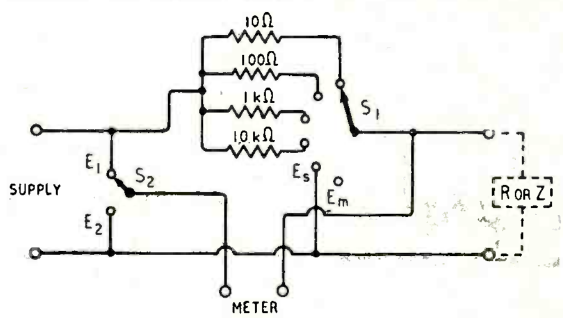
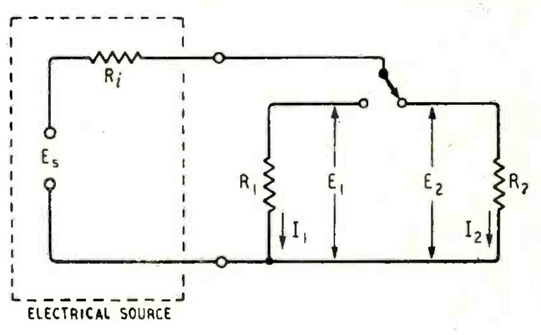


Fig. 3. Adaptor for measuring a wide range of resistance or impedance with the aid of a voltmeter.

Fig. 4. Method of measuring the internal resistance (R_i) of an electrical source, using two load resistors.



It often happens that the internal resistance to be measured is high enough for the open-circuit voltage indicated on one range of a meter to be distinctly different from that shown on another range. In such cases the internal resistance is best found from these two readings only, without the use of load resistors. R_1 and R_2 are then the ohms-per-volt figure multiplied by the full-scale reading of each range.

Amplifier Power Output

Although the rated output of an amplifier or receiver—the so-called "maximum undistorted output"—can only be measured with accuracy if complex apparatus is available, there is a method whereby it can be checked to a practical degree of accuracy with very simple apparatus.

I have found that, except in some special cases we shall come to later, the accuracy is of the same order as that obtainable from visual examination of the output wave-form on an oscilloscope; that is, within about 10%. This order of accuracy cannot always be reached, however, with fixed bias and other special types of amplifiers, so we will begin by considering first the most common class of amplifiers, those employing auto-bias.

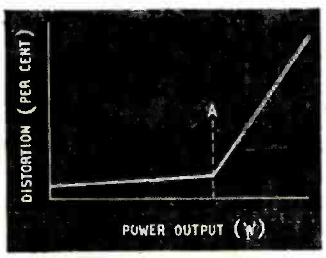


Fig. 5. Curve showing the relationship of percentage distortion to power output in amplifiers using auto-bias.

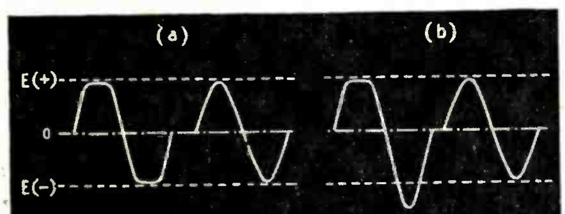
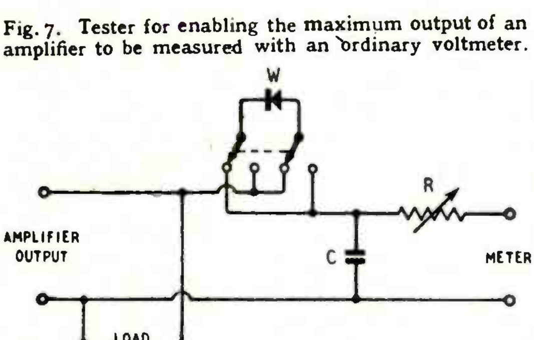


Fig. 6. Amplifier output waveforms, (a) flattening on both peaks, (b) flattening on the positive peak first. E is the peak voltage available at point A in Fig. 5.

Fig. 7. Tester for enabling the maximum output of an amplifier to be measured with an ordinary voltmeter.



Now what is the relationship of percentage distortion to output in such amplifiers? Except in some special cases dealt with below it is always much as shown in Fig. 5. Distortion stays at a reasonably low level until the peak input voltage to the grids of the output valves exceeds the auto-bias voltage. After this point distortion increases quickly, producing the knee shown at point A in the curve. The power at this point can conveniently be termed the maximum output.

The factor used to check this quantity is that the peak output voltage never exceeds that available at point A, i.e., for maximum output. As shown in Fig. 6(a) (we will come to 6(b) later) the waveform at any level above point A is flattened, due to grid current, and there is no increase in the peak value. In fact it often falls.

If therefore we can measure the highest peak voltage obtainable, E, and then find the r.m.s. value of the sine wave with the same peak value ($= E/\sqrt{2}$), square it, and finally divide by the value of the load resistor, R, we obtain the maximum output, i.e.:

$$P_{out\ max} = \frac{(E/\sqrt{2})^2}{R} \text{ watts}$$

The components used in practice are shown in Fig. 7. W is a small stick-type metal rectifier with a voltage rating at least twice the amplifier's output voltage; and, assuming the amplifier's output voltage is in the normal range of 100-120 volts and the meter resistance is 100 ohms-per-volt, C can be about 2μF.

To set up the unit, a source of sinusoidal a.c. (the mains will often, but not always, do) has to be set to the amplifier's nominal output voltage, which is usually 100 volts. The output tester is then connected to this supply and to a meter set to the d.c. range nearest to 250 volts. The resistor R is then adjusted until the meter reads exactly 100 volts. The meter will now indicate the r.m.s. value of a sine wave of the same peak value as whatever voltage is applied to the tester; i.e., $1/\sqrt{2}$ or 0.707 of the peak value.

In use, the unit is connected to the amplifier's output, to the meter and to a suitable load resistor. The last-mentioned can be a heater element adjusted to have a resistance of E^2/W where E is the nominal output voltage and W is the rated output; (don't use lamp bulbs, their R varies with E). The amplifier is now driven by any continuous tone which, it may be interesting to note, need *not* be sinusoidal. The input is increased until the maximum possible reading is obtained on the meter with the switch in Fig. 7 first in one position and then in the other. The square of the lower of these two readings divided by the value of the load resistor can then be taken as equal to the maximum output.

The need for the two readings is shown by Fig. 6(b); if there is any appreciable amount of even harmonics it is necessary to use the reading taken on the half wave that flattens first. Incidentally a difference in these readings indicates a defect if the amplifier is push-pull, for such amplifiers should not have a noticeable amount of even harmonics.

Unless alternative values of R, and perhaps C, are provided, the unit can only be used with the type of meter on the particular range with which it was first set up. In addition the accuracy deteriorates below about half the voltage at which the setting up was done. This matters little, however, as the amplifier would then only be giving a quarter of its rated power.

The accuracy is also reduced if the distortion/output curve is smooth and without a definite knee. This occurs in varying degree with fixed-bias amplifiers and with auto-bias amplifiers with such defects as an early stage or transformer overloading before the output valves. It is, however, quite easy to detect this state of affairs, as the output meter will not then come to a definite stop as it does with a good auto-bias amplifier.

Readings taken by this method on an auto-bias amplifier exhibiting such properties, or on a class AB_2 or class B amplifier with positive drive, are of little value ; but a reasonable indication can be obtained with fixed-bias amplifiers that are not meant to be driven positive by looking for the point at which the rate of movement of the pointer—normally in proportion to the increase in the input level—suddenly slows down considerably. That is, with such amplifiers the pointer does not so much hit the buffers as run into a heap of sand !

I have found it valuable to make up the circuits of Figs. 3 and 7 with some load resistors into one unit for checking R, Z and maximum output.

Recording Air Traffic Control Telephony

Equipment Adopted by the Ministry of Civil Aviation

AIRPORTS coming within the jurisdiction of the Ministry of Civil Aviation are shortly to be provided with sound recording equipment for all radio-telephone communications between air traffic control officers and pilots of aircraft in flight. Development work initiated by the Directorate of Telecommunications, M.C.A., and implemented by recommendations of the International Civil Aviation Organization has been carried out by the Royal Aircraft Establishment, Farnborough, in association with Simon Sound Service who were given the development and production contract. Initially, about 100 installations will be required and the actual manufacture is being carried out by an associated company, Simon Equipment, Ltd. The first production model is already undergoing trials at Prestwick.

The system of recording adopted complies with I.C.A.O. recommendations that the recording medium shall not be capable of being erased or altered without leaving visual evidence of interference (which rules out magnetic recording). Accordingly a direct-recorded embossed track with lateral modulation on standard 35-mm uncoated cellulose acetate film stock is used.

The recording and reproducing heads are of the moving-iron type with replaceable styli. The pickup head can be traversed by hand to select any part of the track, and passages can be played back while recording is in progress.

Approximately eight hours' recording time is provided by one loading of film, which is formed in a continuous loop with a reversed butt joint. After passing the recording stylus, a given point on the film is turned through 180 degrees so that, after traversing the loop, it comes up for recording on the reverse side. In this way both sides of the film are filled with the recorded track, which, incidentally, has a pitch of 0.007in. There are 120 tracks in the width of each side of the film and the time taken from the start to the reappearance of the groove alongside the starting point (after two revolutions from joint to joint) is four minutes.

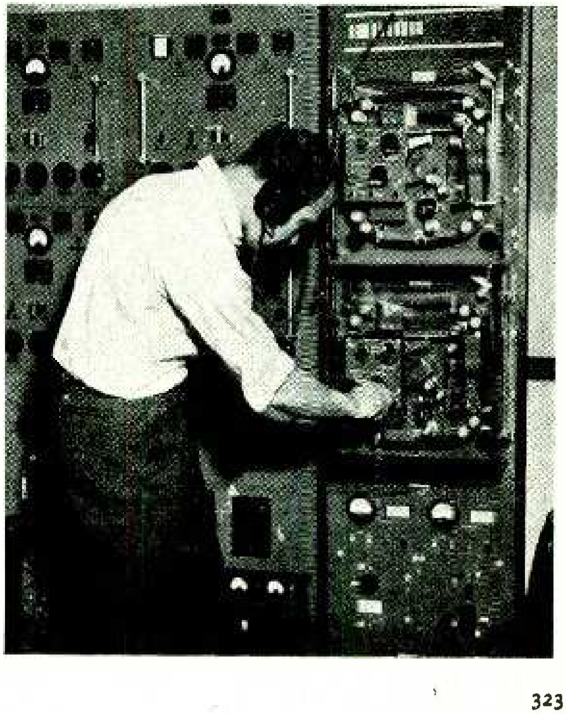
The linear speed is 40ft/min, and, although this may seem low by normal recording standards, the quality and intelligibility of speech recorded by the 0.0015-in radius stylus is more than adequate for the operational requirements of air traffic control The overall frequency response is within ±4 db over the range 200-3,000 c/s; ultimately only the band 500-3,000 c/s, carrying the principal elements of intelligibility, will be used, and coded time signals will be superimposed on the speech track at 300 c/s.

Duplicate recorders are provided and a relay mechanism gives an "instantaneous" changeover (of the order of milliseconds and well within the duration of a single syllable) in the event of breakdown or when the film is full ; normally a recorded overlap of about four minutes is allowed.

A voice-operated clutch mechanism can be used to economize film when traffic is slack.

The equipment will be shown working on the Ministry of Civil Aviation's stand at the S.B.A.C. exhibition at Farnborough (5th-10th Sept.).

Sound-recording equipment at Prestwick Airport for continuous monitoring and recording of all radio-telephone conversations between the Control Unit and pilots.



NEW BOOKS

Radio Servicing: Theory and Practice. By Abraham Marcus. Pp. 775; figs. 400. George Allen & Unwin, Ltd., Ruskin House, 40, Museum St., London, W.C.1. Price 35s.

FROM the title the reader might expect a description of the art of repairing radio receivers. What the author presents here is a very comprehensive survey of domestic radio receiver practice, with some notes on faults and service methods. It is all very useful indeed to the novice entering the field of radio service work, but a better title would have been "Domestic Radio Receiver Circuits."

The opening chapter is a "refresher" course on electrical and radio theory, followed by another on components and one on the valve, tracing its development from the diode to multi-electrode and multiple valves. This provides the raw material, as it were, for several following chapters on various aspects of valves. Three chapters on circuitry round off the receiver design section at page 560. Each chapter is followed by a list of revisionary questions.

The chapter on servicing instruments is a curious mixture of academic meter sketches and modern commercial equipment. Three chapters on servicing methods (88 pages) complete the text.

A servicing flavour is introduced into the body of the book by the addition of a section of "Service Notes" at the ends of appropriate chapters, although they are rather in the nature of an afterthought than the primary purpose of the chapter. They summarize the probable faults that can occur in the stage concerned, and are frequently repetitive and generally of a simple nature.

This repetitive tendency pervades the final chapters, which seem to rush through the processes of fault-finding at a breathless speed. A primary dictum that certainly would not be endorsed by a practising serviceman is: first test all valves, irrespective of the symptoms.

The treatment throughout the book is mainly descriptive, with a minimum of mathematics, and the author has a very readable and easily assimilated style, but whereas radio theory is explained in a thoroughly practical manner, the essentially practical subject of service work gives the impression of being treated somewhat theoretically. No attempt has been made to Anglicize the Americanese for this English edition.

Despite the size of this volume, the number of subjects dealt with is so great that some of them receive hardly more than a passing mention, although it is difficult to think of anything that is not mentioned at all.

To the servicing improver who wishes to familiarize himself with receiver design this book contains as much as he can expect to find between two covers. To the student who requires a good readable, descriptive introduction to receiver design it can be recommended.

E. A. W. S.

Sound Reproduction. By G. A. Briggs. Second edition. Pp. 248; figs. 193. Published by Wharfedale Wireless Works, Bradford Road, Idle, Yorks. Price 10s 6d.

THE first part of this book deals with loudspeakers and is an extension of the author's earlier work "Loudspeakers."

He has carried out a large number of experiments with loudspeaker cabinets and provides in this volume a wealth of figures and curves relating to every size and shape of baffle—plane, enclosed, vented, pipe, horn, etc. For the most part the results are given in terms of the peaks produced in the speech-coil impedance characteristic, which is not always a criterion of acoustic output; but if one cannot always agree with his conclusions, one is grateful for the evidence, which is not to be found elsewhere in the literature on anything like this broad basis.

Up-to-date information has been added to this second edition and includes such items as the slant-plate divergent lenses of Kock and Harvey for h.f. diffusion. There is also a good new chapter on cross-over networks, with practical design data.

Part II, which deals with recording, has been extended, and more information has been included on magnetic recording, and also on long-playing records. New evidence is produced on the relative merits of sapphire, tungsten carbide and diamond as stylus materials. Questions of stylus and record wear are viewed from all angles and beautifully illustrated by the photomicrographs of C. E. Watts. Surface noise, hum and motor rumble are investigated on a quantitative basis, and the author has something to say on every aspect of recording and reproduction.

Summarizing, this work may be regarded as the personal notebook of a loudspeaker manufacturer of nearly 20 years' standing who has succeeded in retaining the fresh and enquiring outlook of the amateur on high-quality reproduction—the term amateur being used in its original derivation of one who loves his subject.

What the book may lack in the rigour or orderliness of subject treatment usually demanded in a textbook is more than compensated by the writer's entertaining and forthright style. One thing is certain: no reader, whatever his height of brow, will fail to find something instructive or stimulating to thought in this generous collection of facts, dicta and opinion on the reproduction of sound.

F. L. D.

Communication Circuit Fundamentals. By Carl E. Smith. Pp. 401 + x. McGraw-Hill Book Co. Price in U.K. 42s 6d.

THIS book is the second in a series by the same author, intended as a course in radio and other communication engineering. It is self-contained, however, and covers the basic principles of circuits and valves, beginning with matter and energy, electricity, and d.c. circuits, continuing through a.c. circuits, and ending with an introduction to valves and cathode-ray tubes. The treatment is on the whole quite simple, and, being intended especially for home study, each chapter includes examples and exercises, and is followed by a summary of the main points. Nearly 50 pages at the end of the book are devoted to appendices, including lists of symbols and abbreviations, tables, useful formulæ (mathematical and electrical), and analysis of waveforms. There is a good index and full answers to all the exercises.

It would have been a pleasure if it had been possible to record that a book so well and carefully organized for its purpose of instructing beginners had been equally well written. Unfortunately, however, it is very uneven and contains many unnecessary difficulties for the student, of which the following are one or two examples.

"A resistance is said to have one ohm when an emf of one volt causes a current of one ampere to flow. This is a statement of Ohm's Law." In fact, of course, it is a statement concerning a particular system of units. As regards units, the book starts with the hitherto usual mixture of practical and c.g.s. units; then on p. 102, in the middle of a paragraph on skin effect (of all things!) one finds a short table headed "Reduction of Quantity in C.G.S. Units to M.K.S. Units." Neither here nor anywhere else is there an explanation of what this means, but a few pages later there is a sudden transition from maxwells to webers (incorrectly defined), and from centimetres to metres. After some pages of mixed m.k.s. and c.g.s. units, inductance and capacitance formulæ are given in inch units. The subject of units in general is not included.

The author does not hesitate to use terms and ideas to which the reader has not been introduced. In the paragraph on skin effect just mentioned, at least five important new terms are used, which are defined or explained only in later chapters. The treatment of magnetism is very confusing; and the chapter on series resonance leads to the conclusion that "with a given value of Q, the selectivity will increase as L is made larger." For the most part the treatment is by numerical example, avoiding anything but the simplest algebra; then, without warning, the circuit containing R and L is solved in the most uncompromisingly mathematical manner by differential equations; but in the corresponding R and C circuit in the next chapter the author reverts to elementary school methods. Consequently, whereas the current in the inductive circuit keeps on growing for ever, the current in the capacitive circuit soon reaches a definite zero.

It must be recorded, however, that the sections and chapters on circuit networks and theorems are excellent; the treatment is simple yet concise, and includes important matter that is not always attempted at all in elementary books. The use of reactance sketches for qualitative study is a good feature. The chapters on valves and the brief one on the cathode-ray tube are also reasonably free from the type of flaw referred to above.

The imperfections would be less marked if the reader could be assumed to have some knowledge of the subject, and it is suggested therefore that the book would be a good one for students' *revision*. One would, however, also venture to recommend some author's revision.

M. G. S.

Gramophone Speed Conversion

Possibilities of Adapting Existing Types for Long-playing Records

By R. L. WEST, B.Sc., A.M.Brit.I.R.E.

THE recent release of LP records in this country has aroused considerable interest among experimenters. The most expensive single item in the changeover is undoubtedly the motor. Some people feel they would like to try out LP before scrapping their existing motor and buying a new dual-speed type. Others just can't afford it after buying a new pickup and a couple of LP records! Either way, the idea of converting the existing motor appeals, so here are a few notes on the subject.

Only simple modifications are envisaged in this article and only simple hand tools will be needed. Readers with well-equipped workshops have unlimited scope for their talent, and I expect their projects are already well under way.

All governor-controlled types should be convertible to dual-speed operation. This covers the commutator types—d.c. and universal, as well as the brushless induction motors and the eddy-current motor. Theoretically the commutator type would be the better, since the torque is almost independent of speed, whereas most induction motors show rather less torque at the lower speed.

Those without governors are generally synchronous motors, and speed, usually 3,000 or 1,500 r.p.m., depends on the supply frequency. Rim-driven synchronous motors can be converted to $33\frac{1}{3}$ r.p.m. by fitting a smaller motor pulley, but dual speed involves skilled engineering design.

With a $33\frac{1}{3}$ r.p.m. stroboscopic disc on the turntable (a stop watch for the unfortunates on d.c.), see if the speed adjuster will go far enough to reach the low speed. This may entail grub screw adjustments beneath the turntable, or may necessitate moving the whole governor bodily along its spindle a short distance *towards* the friction pad, or even forcing the pad through its holder to make it, say $\frac{1}{16}$ inch longer. It is usually just possible to get both speeds within the limits of travel of the speed regulator arm or screw. If this cannot be done, then the remainder of this article acquires only academic interest!

At $33\frac{1}{3}$ r.p.m. the turntable speed will probably prove to be far from steady. A number of causes can be found, but first a little theory, starting with the formula

$$\text{Change of angular velocity} = \frac{\text{Driving torque} \times \text{time}}{\text{Moment of inertia}}$$

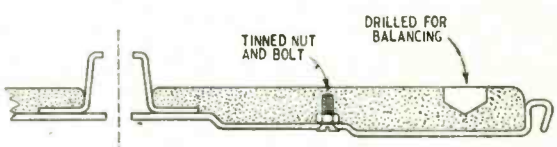
At $33\frac{1}{3}$ r.p.m. each tooth is transmitting the drive for 2.34 times as long as at the higher speed. The driving torque is more or less the same, the inertia identical, hence much larger speed changes due to imperfections of gear shapes or meshing are to be expected.

When rotating, the turntable has kinetic energy proportional to $(\text{r.p.m.})^2 \times$ moment of inertia. At the lower speed this is reduced to less than $\frac{1}{5}$th of its 78-r.p.m. value.

Regular and irregular abstractions of energy take place due to variations in friction of the governor bearings, gears, and the pickup itself, thus producing further speed changes. This can be countered by increasing the moment of inertia of the turntable by a factor of 2·34 times from the first point of view, and 5.5 times from the second—hence 5.5 times, to be on the safe side!

Now the moment of inertia of a circular flat disc—our turntable—equals $\frac{1}{2}\,mr^2$ where m is its mass and r its radius. To increase its inertia either m, r, or both can be increased. If the loading is evenly distributed and the diameter unchanged, the new

Fig. 1. Section of inverted turntable, showing effect of surface tension in holding the level of lead above the height of the rim.



weight will have to be 5.5 times the old. If the loading is arranged mainly near the outside of the turntable, less will be needed since 1lb, 4in from the centre, is as effective as 4lb, 2in from the centre. I favour, however, the first way, since the heavier turntable will be relatively immune from vibration in any other direction as well.

Adding the Weight

Lead is probably the most useful material for this purpose, since it can be melted quite easily over a gas-ring. A layer on top of the turntable is attractive, since it puts the magnetic pickup farther from the steel turntable. This will need machining on the upper face and the spindle will have to be lengthened —a major engineering feat. It is quite easy, however, to put 8-12 lbs of lead underneath the standard 12in turntable.

First, drill the turntable to take six 6 BA countersunk brass bolts. Use the radial ribs and then there is no fear of the heads projecting. Tin the visible part of the bolt and the nut, and when cool smear on more flux to make sure the lead will adhere properly. Invert the turntable and level it carefully on a stone or concrete floor—firmly, because it is very heavy once the lead is poured in. If a blowlamp is available the lead need only be just above its melting point when poured. The blowlamp is to keep the surface molten long enough to allow it to run perfectly level. The lead will finish neatly at the edge of the turntable (*not* tinned) up to ¼in above the level of the rim, due to surface tension. This neat

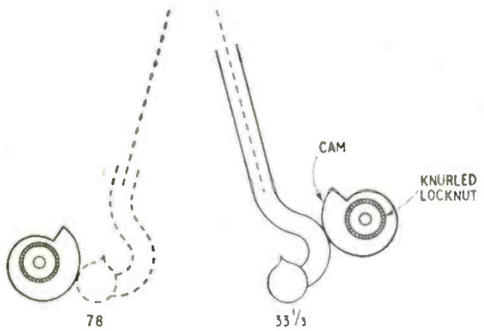
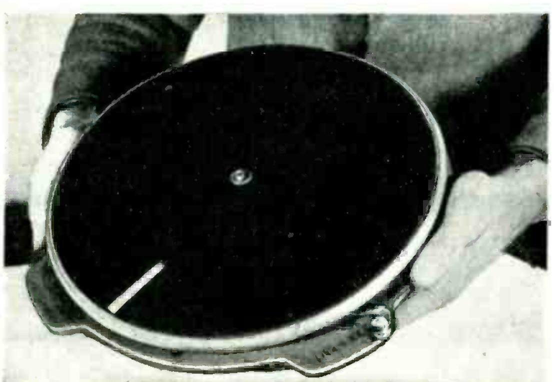


Fig. 2. Pre-set cam stops facilitate a quick and accurate change of speed.

Illustrating the method of testing the turntable for balance.



finish minimizes the amount of balancing necessary. If the centre boss is an alloy casting, be careful not to overheat it. In the absence of a blowlamp, the lead must be made much hotter, skimmed more thoroughly, and poured as quickly as possible. Preheating the turntable would obviously help too.

After cooling, place on the spindle, rotate and check for flatness. If out of true, remove, invert on to a firm surface and a judicious hammer blow on the lead, about a third of the way out from the centre, on the correct radius, will do the trick.

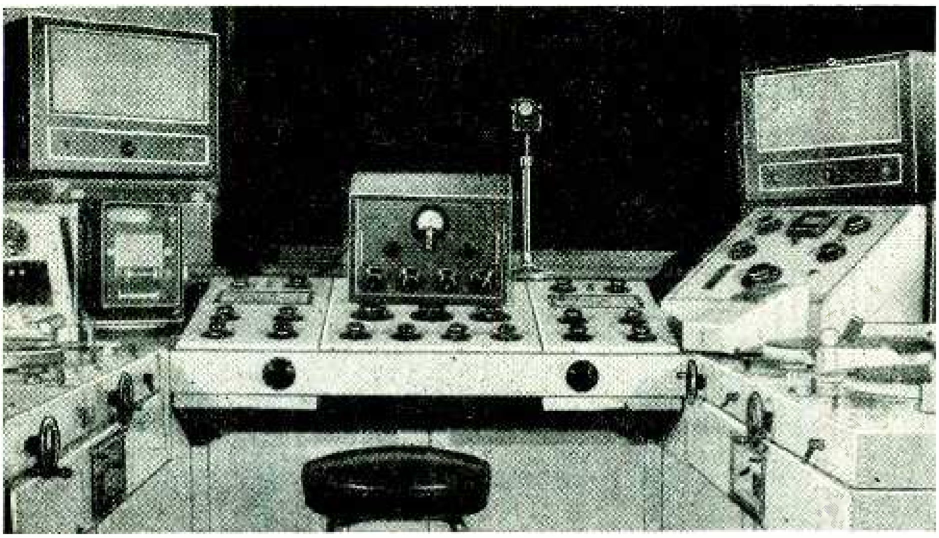
Balance is important since it will affect the speed unless the spindle is perfectly vertical. Even then, it may rock the motor on its rubber mounting, producing an effect like a " swinger " record. Mount the turntable on its spindle and tip the whole motor till the spindle is approximately 45° to the vertical. Holding the motor in both hands, rock it to and fro sharply about the axis of the turntable. This leaves the turntable almost stationary in space, but rotating in its own bearings. The heaviest point gradually finds its way to the bottom. Mark it with chalk. Check it by causing it to descend from either side in turn. This will give a more accurate position. In order to decide roughly how much lead to remove, stick various lumps of lead, in turn, on to the turntable with Plasticine, at a point diametrically opposite the mark and repeat the rocking process. Finally drill out some lead and repeat. If persevered with, it shows a sensitivity of less than 1 gram at the periphery, even if 13 lb of lead are run in.

Success will also depend upon very careful attention to the lubrication of governor, gears and bearings. Some concern was felt for the extra loading of the turntable vertical thrust bearing, particularly the type that sits on a $\frac{1}{16}$in ball. No evidence of failure of the lubricant has been observed, but the addition of colloidal graphite, or replacement by one of the extreme-pressure car rear axle lubricants is recommended.

Whilst on the subject of lubrication, a further point arises. Due to the increased weight, the turntable tends to jam on the taper seating of the spindle, making removal difficult and increasing the risk of distorting it during removal. A smear of graphite-loaded grease covering the full length of the taper will be found advantageous.

Due to the increased inertia, the turntable takes quite a time to settle at the selected speed, so that some system of pre-set stops could be devised with advantage. For the moving-arm type of speed adjuster, a couple of snail-shaped cams anchored down to the motor baseplate with knurled nuts is one simple solution.

Really accurate assessment of the final result is quite complicated and something on the lines of the method described by E. W. Berth-Jones in the December 1949 issue of *Wireless World*, or the method described in *Electronics*, July 1950, would be necessary. A useful estimate of success or otherwise can be obtained by setting the speed to 33⅓ r.p.m. and placing on the turntable any 78-r.p.m. frequency record having bands of constant frequency in the range 1,000–2,000 c/s. Centralize the record accurately by watching carefully for lateral motion of the pickup. When satisfied with the centring, listen to the reproduced tone. If no " wow," flutter, or irregular waver is audible, then it is safe to assume that no trouble from this source will be experienced when listening to music.



Control cabin for stereophonic transmission. The only equipment additional to that of a standard cabin consists of the two loudspeakers on the right and left and the central control desk between them.

Improved Stereophony

French Broadcast Using Extra Facilities for Simulating Displacement

By **E. AISBERG** (Editor, *Toute la Radio*, Paris)

THE first broadcast of stereophony, the system in which sources of sound are restored to their relative positions in space, took place in France on June 19th, 1950. The transmission was made simultaneously by two chains of French broadcasting stations, the Parisian and the Paris-Inter.

To make use of this transmission two receivers were needed. For some days before it took place, the broadcasting authorities made frequent announcements, urging friends to join forces in small groups so as to receive it under optimum conditions. To obtain these, it was explained that two receivers should be placed from 5 to 7 feet apart, with the axes of their loudspeakers converging at a very small angle; the listeners should be at the apex of an isosceles triangle with the sides some 7 to 10 feet long, the base being a straight line joining the two loudspeakers. It was also necessary that the receivers should be adjusted to give the same volume of sound and that their response should be matched as nearly as possible by means of the tone controls.

Lastly, it was strongly recommended that listening should be done in a darkened room, or at any rate, with the eyes closed, in order to prevent any conflict between aural and visual impressions. This point was found to be of very great importance.

At 8.50 p.m., the programme began with an opening speech by René Clair, of French film fame, who had undertaken the task of producing it. After briefly reminding listeners of the conditions required for hearing the transmission properly, he went on to the reproduction of a series of sounds, which showed the acoustic possibilities of the new technique.

The listener's ears could follow a train as it started, gathered speed and crossed from left to right; troops, headed by a band, appeared to march from one side to the other of the room in which he was sitting; the sounds of footsteps going quickly up a spiral staircase could be followed. In each of these examples the ears "pin-pointed" the source of sound readily and very exactly. The impression of movement was strikingly realistic.

Next, listeners were regaled for more than an hour by the production of an unpublished play of Théophile Gautier's, *Une Larme du Diable*. The new technique proved particularly suitable for the reproduction of this piece, in which the author gives speaking parts not only to men and women, but also to God, the Virgin Mary and a number of inanimate objects. The sounds were heard coming now from one direction, now from another, exactly as the author had intended. It must be recorded that the success of this part of the programme was due in no small measure to René Clair's personal touch.

The idea of making reproduction reconstitute the spatial relations of sources of sound is by no means new. It is well known that, provided it does not come from a point immediately in front of or behind the head, the brain determines the direction from which a sound arrives mainly through its differing intensity at the two ears. In other words, the appreciation of what we may term acoustic depth is essentially a product of binaural hearing. In the same way, the visual sensation of depth, which allows us to see objects standing out in relief, depends chiefly upon the simultaneous use of two eyes, the

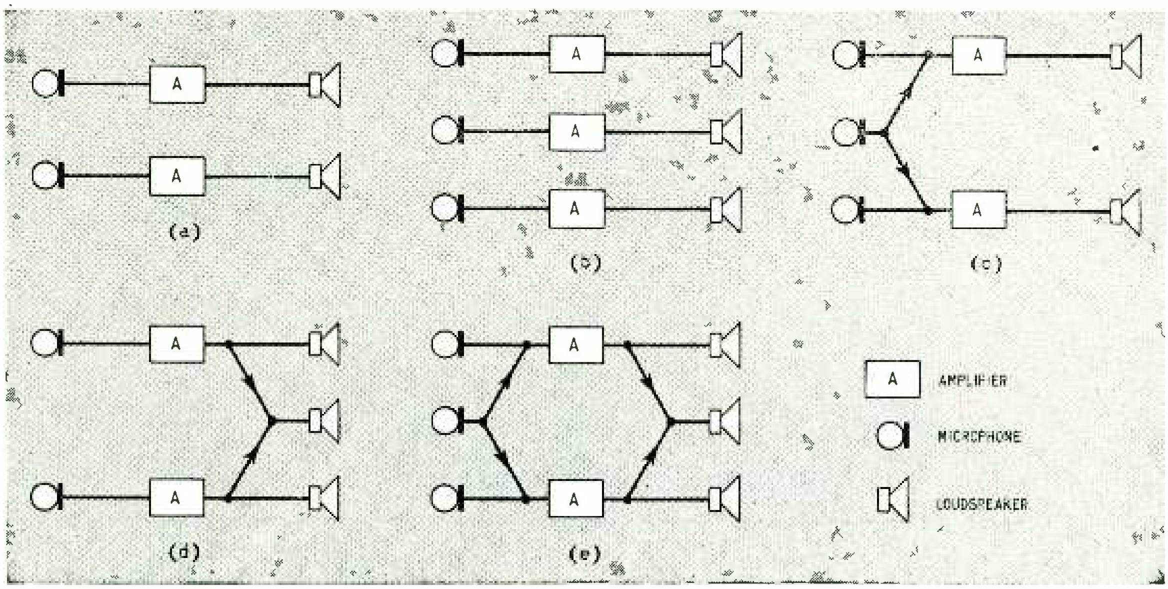
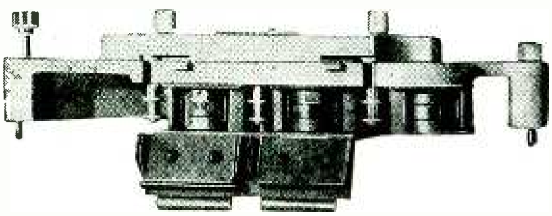


Fig. 1. Various arrangements used in stereophony : (a) the most widely used two-channel system ; (b) three-channel system designed to avoid the dead-spot found mid-way between the outer microphones or loudspeakers ; (c), (d), (e) two-channel systems using three microphones and three loudspeakers either separately or at the same time.

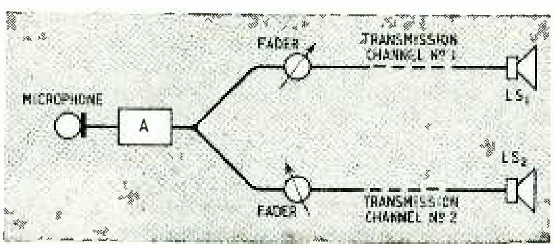
angle of convergence enabling the brain to determine distances.

When listening to broadcasts made by ordinary methods we would be quite satisfied if we used only one ear, because all the sounds which reach the microphone are reproduced by the single small surface of the loudspeaker diaphragm. The use of a number of loudspeakers connected to the same output would make no difference. There is only one way of restoring the directions of sound-sources in reproduction and that is to use two loudspeakers fed by the outputs from two separate channels ; the differences between their respective volumes then serve to "place" the sounds.



The two recording heads and the erasing head for double-track tape. One track "lags" 14 cms behind the other, and this relationship remains constant both during the recording and during the play-back.

Fig. 2. An electrical method of simulating displacement of a sound-source in the process of reproduction.



The problem of stereophony (Greek *stereos*, solid) has provided material for a vast amount of research work. Clément Ader, who did such fine pioneering work in the field of aviation, made one of the first practical attempts as long ago as 1881, when he used his "*théâtrophone*" for the transmission of operas over telephone lines. But one of the most striking experiments was that made by the American Telephone and Telegraph Company on April 27th, 1933, when a concert given at Philadelphia was reproduced in a Washington hall by means of a two-channel system. Sounds were picked up by two microphones on the right and left of the orchestra and sent, with suitable amplification, to two loudspeakers similarly placed in the Washington hall.

What may be termed the acoustic perspective was faithfully restored in the reproduction. When the producer walked across the stage, speaking as he went, from one microphone to the other, the listeners in Washington could follow his movements as easily as if a single loudspeaker had been moved about on the stage of the hall in which they were sitting.

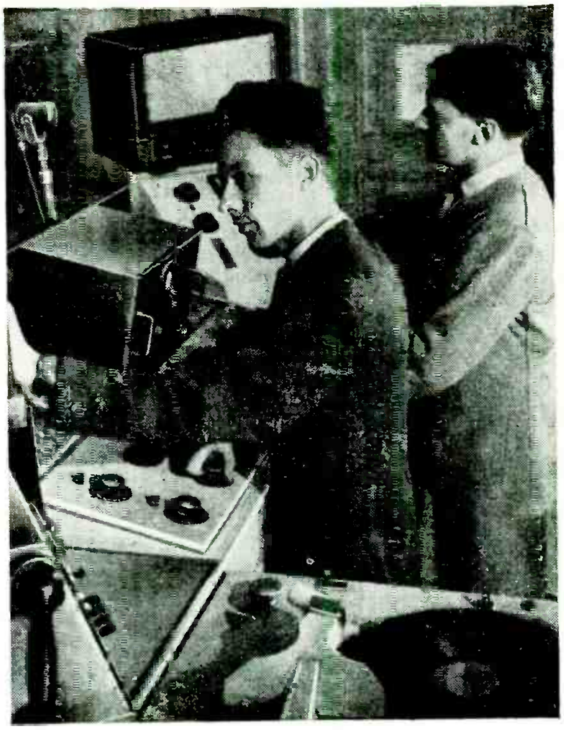
An analysis of the technical details of the experiment and of the conclusions which might be drawn from it formed the subject of a series of articles in the *Bell System Technical Journal* for April, 1934. An important point emerging from these is that a number of transmission links of different kinds (see Fig. 1) were tried out. The best results, however, appear to have been obtained with a two-channel system. With its faithful reproduction of the constantly changing positions of the sources of sound, such a system is perfectly adapted to all direct transmissions from theatres or concert halls ; but it does not lend itself to those electrical artifices to which the presentation of items specially prepared for broadcasting owes so much of its flexibility.

A completely different system can be conceived in 'hich sound-sources would be made to change their positions by artificial methods of an entirely electrical nature. As shown in Fig. 2, a system of this kind uses only one microphone, the resulting modulation being distributed to two transmitting links by means of suitable faders. At the receiving end two loudspeakers are required, placed at a suitable distance from one another. The source of sound will then appear to move, in accordance with the relative volume from each loudspeaker, to points on an imaginary line between the two. When one loudspeaker is silent and sounds are coming only from the other, the listener's ears place their source at the position occupied by the latter. When the volume from both loudspeakers is equal, the source of sound appears to be at a point midway between the two. Any other variation in their relative volumes makes the source of sound appear to be at a corresponding point between the two loudspeakers.

Working on these lines, a controller with his fingers on the knobs of the faders can, at will, make the voice of a broadcaster not moving an inch from one position in the studio, seem to the listener to come from any point between his two loudspeakers. It is not difficult to see that the system lends itself readily to the production of a vast variety of sound effects; in particular the position of the source of sound may be changed instantly from right to left, or *vice versa*. On the other hand, such a system can make no worthwhile use of a number of sources of sound in different positions, for all sounds, no matter whence they originate, are picked up by one single microphone.

The outstanding merit of the improved system of stereophony, due to José Bernhart and Jean Wilfrid Garrett, with which the French broadcasting authorities have recently experimented, is that it combines all the advantages of that tried out some years ago by the American Telegraph and Telephone Company with the facilities for deceiving the ear offered by the system using a single microphone and two transmission channels.

In the improved system a number of microphones



J. W. Garrett (left) and J. Bernhart (right), the engineers responsible for the system, at the control desk.

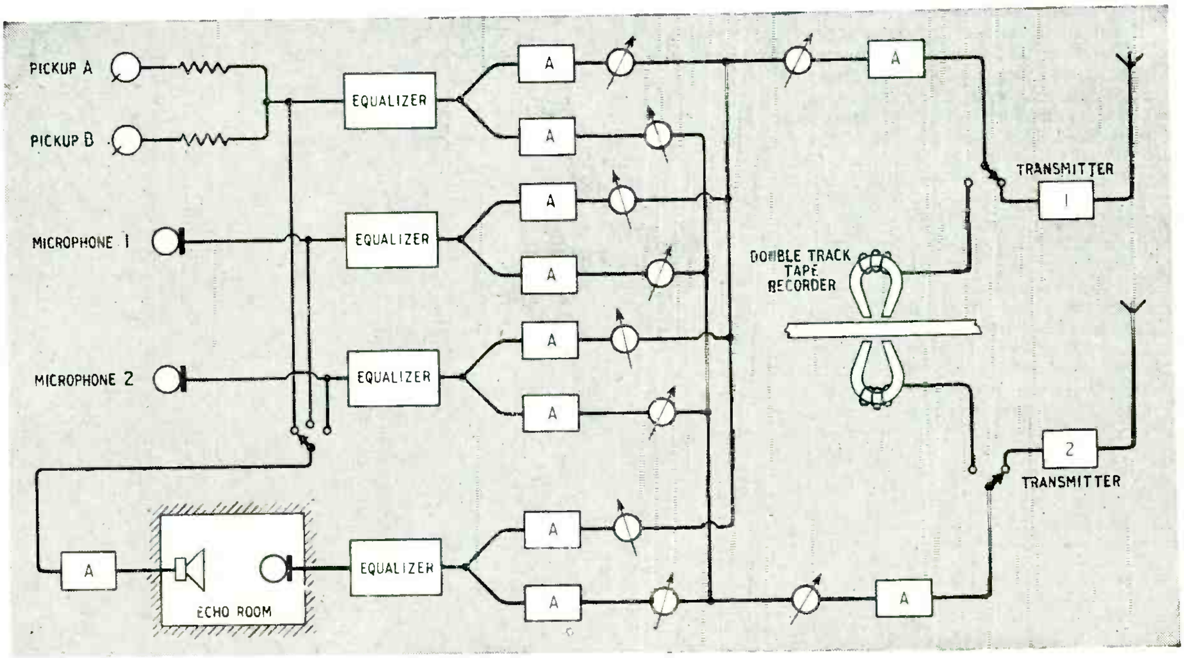


Fig. 3. Block diagram showing the complete layout used in the Bernhart-Garrett process. The number of pickups and microphones may be increased as required. It will be seen that sound effects from the pickups, as well as the outputs of the microphones, are fed to both channels on the principle of Fig. 2.

may be used ; but transmission takes place on two channels only. The basic feature of the system is that the output of every microphone is fed through faders to both channels. Thus either of the listener's loudspeakers can be made to receive at will a suitable "ration" of the output of any microphone.

The less active the controller, the more closely does the working of the improved system resemble that of the old A.T.T.C. stereophonic system. Hence, it is readily adaptable to direct transmission from theatres and concert halls. On the other hand, when the controller wants to show what he really can do, he can make sound-sources which are in fact fixed, appear to move about it any way that he fancies—and he can do this with speed and flexibility that it would be difficult to match.

During the transmission of *Une Larme du Diable* four microphones were in use. The effect of "depth" was produced by means of an echo room. By these means an utterly amazing acoustic perspective was brought into being, with no sacrifice whatever of classic production methods.

The broadcast on June 19th was recorded. With this in view the modulation of the two channels was recorded simultaneously on two sound-tracks on the same magnetic tape. In this way perfect synchronization was ensured during the replay.

It is to be hoped that further experimental transmissions will take place to assist the development of the new system. In this way listeners will make the pleasant discovery that it is not for nothing that Nature has provided them with two ears.

SHORT-WAVE CONDITIONS

July in Retrospect : Forecast for September

By T. W. BENNINGTON

(Engineering Division, B.B.C.)

DURING July the average maximum usable frequencies for these latitudes were slightly lower, both by day and night, than they were during June.

Day-time working frequencies for long-distance communication were relatively low, and conditions were very seldom favourable on the higher short-wave frequencies. The 28-Mc/s amateur band, for example, was almost unusable for communication to North America, and even in more southerly directions did not appear to give very good results. Frequencies somewhat lower than this were, however, very frequently usable in north-south directions, though 20 Mc/s was about the highest useful frequency for east-west communication. Medium-high frequencies were usable over a large part of the day and over most paths, 15 Mc/s was regularly receivable till well after midnight.

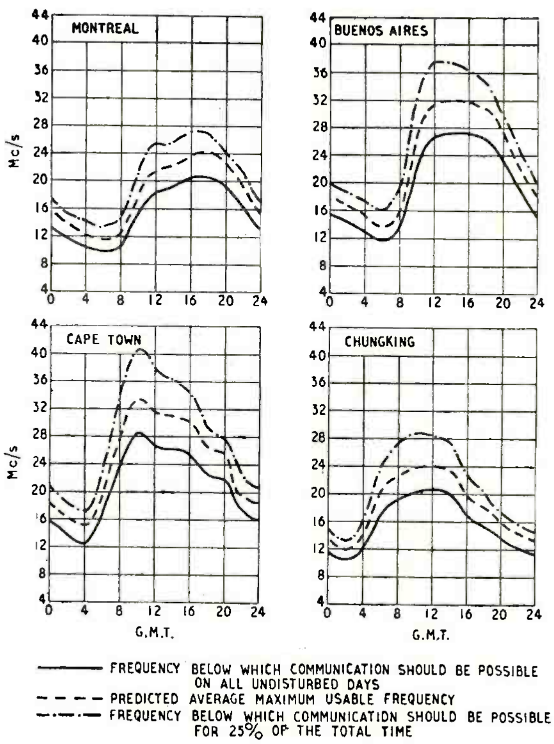
Sporadic E continued to be prevalent, though that with high critical frequency seemed somewhat less prevalent than during June. On the 28-Mc/s band "short skip" contacts with European countries appeared somewhat less frequent than during June. Occasionally, however, distant Continental stations on frequencies up to 50 Mc/s were heard here, and their signals no doubt came in by way of Sporadic E. On a few occasions, nearer Continental stations on 90 Mc/s and on 40-46 Mc/s were heard, most probably by means of tropospheric refraction.

Sunspot activity was about the same average level as during last month, and has now decreased by approximately one-third since sunspot maximum.

There was more ionospheric disturbance during July than during the past few months. Of the several prolonged periods of disturbance which occurred the most severe were those of 4th-6th, 12th-14th and 25th-26th. Only two Dellinger fadeouts were reported, the most severe of these occurring at 1610-1705 on 12th.

Forecast.—There should be a considerable increase in the day-time m.u.fs and a small decrease in the night-time m.u.fs during September, as compared with those for August.

Day-time working frequencies for long-distance communication should, therefore, be fairly high, though it is not expected that frequencies as high as 28 Mc/s will often be usable over east-west paths except, perhaps, towards the end of the month. Over north-south paths, however, such frequencies should be usable almost regularly. Medium-high frequencies should remain usable for a large proportion of the total time and frequencies below about 10 Mc/s should seldom be really necessary at night.



Working frequencies for medium-distance communication will be somewhat lower than during August, both by day and night, and such communication will be by way of the E and F_1 layers for only a short daily period. There should be a considerable decrease in the prevalence of Sporadic E, though some medium-distance communication on the higher frequencies by way of this medium may still be possible. There is often an increase in ionospheric storms during September, and periods of disturbed conditions are, therefore, to be expected.

The curves indicate the highest frequencies likely to be usable over four long-distance circuits during the month.

RC Oscillators

Explaining Why They Are Not Just the Poor Relations of LC Oscillators

By "CATHODE RAY"

MOST of the books on radio explain inductance-capacitance (or LC) tuning at great length and either omit resistance-capacitance (RC) tuning altogether or give it rather scanty notice. Consequently some readers, who are more or less familiar with the theory of the normal LC tuned circuit, are somewhat mystified that apparently similar results are obtainable without inductance. The puzzling aspect is that in the LC circuit these results depend on the peculiar ability of inductance to store energy and to cancel or neutralize capacitance at one particular frequency, whereas resistance can do neither of these things.

The resemblance between the two systems is, in fact, only partial. One cannot with RC circuits do everything that one can with LC circuits. On the other hand, for some purposes RC tuning has advantages over LC tuning. They are not simple equivalents. The fact that there is a resemblance at all is very interesting, but it should not be pressed too far.

The use of RC circuits for obtaining selectivity has been explained quite recently by J. McG. Sowerby† so we shall concentrate now on oscillators. The essential heart of an oscillator is an amplifier, because of its being able to give an output at least as powerful as the input, so that by connecting one to the other in a suitable manner the amplifier can be made to keep itself going; in other words, can oscillate. A transformer by itself, for example, is unable to do this; because the output power is always less than the input. The first condition for keeping oscillation going, then, is *output at least as great as input.*

The second is that the *output must be in phase with the input.* The output at the anode of a single-valve amplifier is in phase opposition to the input at its grid, so connecting anode straight back to grid does not make an oscillator. Some device such as a transformer is needed for reversing the phase. The tuned-anode tuned-grid oscillator is only apparently an exception; actually the phase reversal system is there, though it is mixed up with the frequency-determining parts of the circuit.

The two conditions for oscillation are not necessarily confined to one frequency at a time, but it is usual for them to be. The LC tuning circuit is particularly effective in keeping oscillation definitely to a single frequency, because it exerts a very strong control on both the conditions for oscillation. Both amplitude and phase are altered more or less sharply when the frequency is shifted from resonance, as shown in Fig. 1.

Fig. 2 is a simple and well-known example of how the LC circuit can be incorporated in the amplifier, with a back-coupling or retroaction coil L_r to apply part of the voltage developed across LC to the grid in opposite phase. If L_r is adjusted so that the two conditions are only just fulfilled at the frequency of resonance, then it is clear from Fig. 1 that at any other frequency, even if it is only slightly different, the output is likely to fall below the critical amount

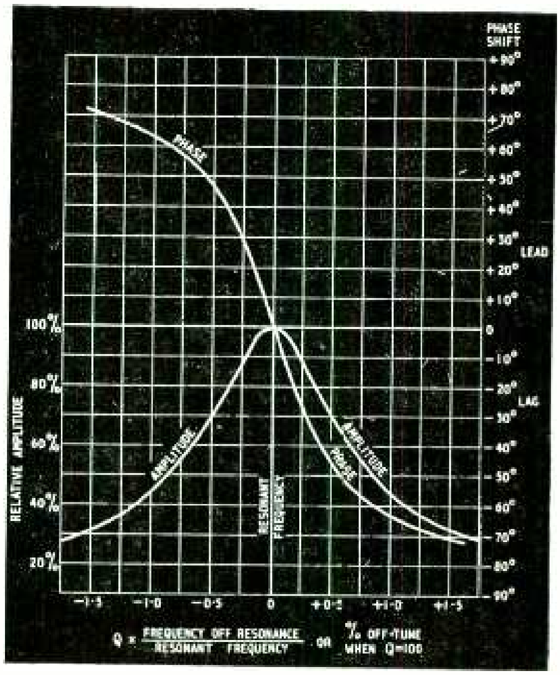


Fig. 1. Graphs of amplitude and phase angle of voltage developed across a parallel resonant LC circuit when fed from a source having infinite resistance. They approximately represent the results in a circuit such as Fig. 2 when the valve is an r.f. pentode.

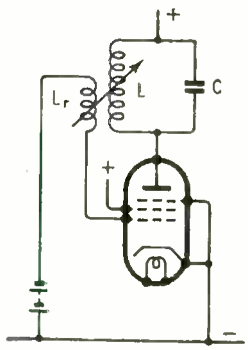


Fig. 2. Very simple LC oscillator circuit, in which the purpose of L_r is (i) to reverse the phase and (ii) to reduce the voltage developed across LC by the same factor as the valve amplifies, making the voltage received by the grid equal to that necessary to produce the voltage.

† *Wireless World*, June 1950, p. 223.

needed to maintain oscillation, and the phase will be right off.

Fig. 2 and its modifications are very simple and convenient, except that at low frequencies the amount of inductance required demands an enormous number of turns of wire and/or an iron core which introduces the objectionable feature of non-linearity. So at the low end of the frequency scale it is much better to use resistance, which is cheap, linear, easy to vary, and does not pick up hum so readily. But at first sight a ban on inductance seems to raise considerable difficulties. Gone is the convenient transformer method of phase inversion. Gone, too, are the sharply discriminating characteristics shown in Fig. 1. Connecting the output device on the cathode side of the valve instead of the anode would certainly make the phase right for the grid, but would also reduce the output voltage below the input voltage (see theory of cathode follower), so is ruled out on that ground.

If we are obliged to stick to a single valve, then the qualifications of our RC system must be these: it must be capable of shifting the phase of the valve's output by 180° without attenuating it more than the valve amplifies.

A simple combination of one R and one C can be used to cause a phase shift of anything between (but not including) 0° and 90°. In Fig. 3, if R and X_C (the reactance of C) happen to be equal, then the voltage V_R across R is 45° ahead of V, the applied voltage, and V_C is 45° behind it. And V_R and V_C are both $1/\sqrt{2}$ (about 71 per cent) as large as V. If R is made smaller relative to X_C, say by reducing C or the frequency, the phase lead of V_R is increased, but the magnitude of V_R is inevitably reduced. The lead can only be increased to 90° by making V_R zero, when it isn't any good to anybody. Similarly with V_C.

Suppose, however, that we apply V_R (say) to another RC circuit; the output across R in that circuit will lead V_R, and hence lead V by a greater angle, at a further sacrifice in voltage. Obviously even this cannot give us a total phase shift of 180°, but we can get it by using three "stages" of RC, each with a 60° shift, or four stages each giving 45°, and so on. Only very elementary a.c. theory is needed to calculate the phase shift and voltage reduction at any frequency due to one RC stage (as we have just done); but the total shift due to n equal stages is not n times that of one stage, nor is the total voltage ratio equal to the nth power of that of one stage. Connecting a second stage upsets the impedance of the first stage; and the third upsets both. The calculation of n stages is quite a difficult mathematical problem, but here is a table of the attenuation of 3 to 6 stages at the frequency at which the total phase shift is 180°:

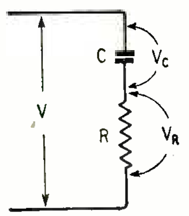
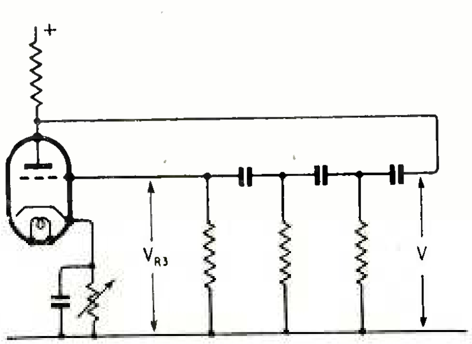


Fig. 3. Basic RC phase-shifting circuit.



Below: Fig. 4. How a 3-stage phase shifter can be connected to the single-valve amplifier to make it an oscillator. The variable cathode resistance acts as an oscillation control.

Number of Stages n	Attenuation α
3	29.0
4	18.4
5	15.4
6	14.1

The figure $\alpha = 29$ for 3 stages means that the voltage across the final R or C is 1/29th of that put in across the first pair. So to obtain oscillation it is necessary for the voltage amplification of the valve to be 29 times. A 4-stage system allows a valve with a lower μ and higher power output to be used, if that is wanted. As we have seen, anything less than 3 stages is insufficient to give the required 180°; and the above table makes it seem (as is indeed the truth) that increasing the number of stages above 3 or 4 is unlikely to reduce the attenuation enough to be worth the extra components. Actually the amplifier input and output impedances generally introduce phase shifts that modify the above figures. Fig. 4 is a simple example of this type of oscillator.

Before going on, it may be as well to make sure that we are quite clear why such an oscillator oscillates at one frequency at a time, and why varying C or R varies that frequency. The answer, of course, is that there is only one frequency which makes the total phase shift through the RC "ladder" equal to the 180° necessary for bringing the oscillatory voltage at the grid into the correct phase to maintain itself. (To be strictly correct, other frequencies are possible, but only with an abnormally large number of RC stages, and in any case voltages at these frequencies are too heavily attenuated to cause oscillation.)

With the Fig. 4 type of circuit, in which the series elements are C and the shunt elements R, there is hardly any phase shift at very high frequencies, because the capacitances are almost short-circuits; and at very low frequencies the shift approaches 90° per stage. But whereas with a high-Q LC circuit the phase changes very rapidly indeed in the region of resonance (see Fig. 1), with the RC system the shift is spread gradually over the frequency range. In other words, it behaves in this respect like an LC circuit with very low Q. And whereas the amplitude falls off more or less steeply on both sides of an LC resonance peak, on one side of the working frequency of an RC system the amplitude actually increases. With the Fig. 4 arrangement, this is obviously the high-frequency side; but if the R's and C's were interchanged the slopes of both phase and amplitude graphs would be reversed. Fig. 5 shows the graphs for the Fig. 4 system, on the assumption that the

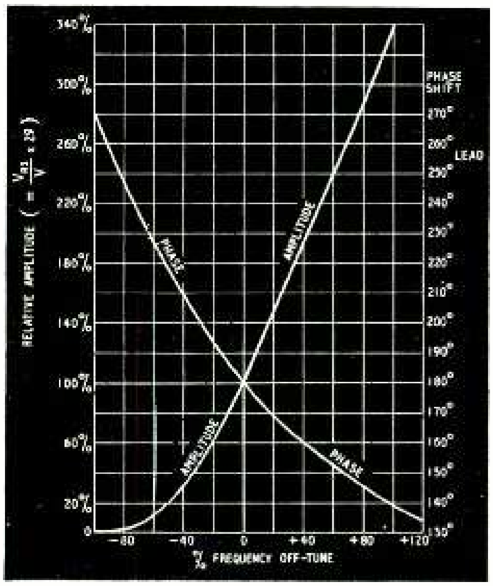
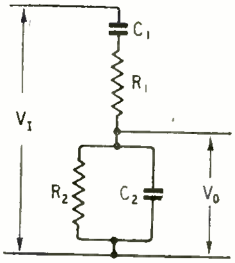
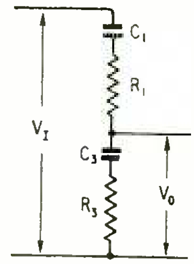


Fig. 5. Phase and amplitude graphs for 3-stage RC circuit as in Fig. 4, assuming negligible valve output impedance. When comparing with Fig. 1, note change of scale.





Left : Fig. 6. Series-parallel frequency-discriminating circuit for obtaining a phase shift of 0° or thereabouts at only one frequency.

Right : Fig. 7. At any one frequency, Fig. 6 is equivalent to this.

output impedance of the valve is negligible. The relative voltage figures (V_{R3}/V) have been multiplied by 29 (the correct valve amplification) so as to make the figure at the 180°-shift point equal to 1, or 100 per cent. Comparing Fig. 5 with Fig. 1 we see that for a given phase shift near the oscillation point the corresponding frequency shift is 200 times as great with the RC circuit as with a 100-Q LC circuit, so on this basis the RC circuit can be reckoned to have a "Q" of 0.5.

In short, the control of frequency by phase shift, with this type of RC circuit is very much less keen than that of any reasonable LC circuit, while its control by amplitude is entirely one-sided.

If two valves can be spared for the amplifier, then with the normal type of resistance coupling the output is in phase with the input, so the RC tuning circuit is relieved from the duty of creating a phase reversal. All it has to do is to satisfy the conditions for oscillation (in this case, to transmit the necessary amplitude with *no* phase shift) at the desired frequency, and fail as thoroughly as possible to satisfy them at all other frequencies.

There are various ways of arranging resistances and capacitances to achieve this, but the simplest is to have one of each in series and another of each in parallel, as in Fig. 6, where V_I means input voltage and V_0 output voltage. It is going to be simplest to calculate, and satisfactory in practice, to make $R_1 = R_2$ and $C_1 = C_2$. Then it turns out that at the frequency which makes V_0 in phase with V_I the reactance of C_1 (or C_2) is equal to the resistance R_1 (or R_2). It also turns out that the impedance of the $R_2\,C_2$ pair is half that of $R_1\,C_1$, so V_0 is one-third of V_I.

One way of seeing how Fig. 6 functions is to compare it with Fig. 7. If we assume first that $R_3 = R_1$ and $C_3 = C_1$, then the impedance of the $R_3\,C_3$ pair is in every respect the same as that of $R_1\,C_1$. The current flowing through $R_1\,C_1\,R_3\,C_3$ leads V_I by some angle between 0° and 90°, but the angle is the same for $R_3\,C_3$ as for $R_1\,C_1$. So obviously V_0 is in phase with V_I and is half its magnitude. Now suppose R_3 is reduced to half R_1, and C_3 is doubled, so that its reactance is half that of C_1. The phase angle of the $R_3\,C_3$ pair will be unchanged, but its impedance will be halved, so that V_0 will now still be in phase with V_I but equal to only one-third of V_I in magnitude. Next, replace R_3 and C_3 by their parallel equivalents, given by the standard formulae :

$$R_p = \frac{R_s^2 + X_s^2}{R_s} \text{ and } X_p = \frac{R_s^2 + X_s^2}{X_s}$$

where the subscripts *p* and *s* indicate, as you have no doubt guessed, "parallel" and "series" respectively. If we assume that the frequency is such as to make X_s (which is the reactance of C_3) equal to the resistance R_s (which is R_3), then they become delightfully easy to work out : the results are $R_p = 2R_s$ and $X_p = 2X_s$. So, since $R_s = R_3 = R_1/2$, $R_p = R_1$ and is the same thing as R_2; and similarly X_p is equal to the reactance of C_2. We have therefore proved that when $R_1 = R_2$ and is equal in magnitude to the reactance of C_1 and of C_2, V_0 is in phase with V_I and one-third its voltage. So if we make V_1 the output of our 2-stage amplifier, V_0 will supply the necessary input voltage, provided that the total voltage amplification is 3. That is not much to ask of a 2-stage amplifier ; in fact it will almost certainly be far less than the amplifier gives, so it will be necessary to lose most of the amplification somehow—a point we shall take up in a few moments.

In the meantime, note that if Fig. 6 were equivalent to Fig. 7 at all frequencies it would be unable to discriminate between one frequency and another, so that if the conditions for oscillation were satisfied at one frequency they would be at all frequencies. The object of connecting one RC pair in parallel is of course to introduce frequency-discrimination. If the frequency is raised, X_{C1} falls, R_1 becomes the dominating partner, and the current through $R_1\,C_1$ comes more nearly into phase with the voltage across them. X_{C2} also falls, but that fact makes it dominate R_2, because the greater part of the current flows through it, and being 90° out of phase with V_0 it widens the phase difference. So on both counts the phase of V_0 departs from that of V_1. Similarly (but in the opposite direction) if the frequency is reduced.

It is also pretty clear that whether the frequency is increased or reduced it will reduce the magnitude of V_0 relative to V_I. At zero frequency, the reactance of C_1 is infinitely large, so V_0 is nil. At infinitely high frequency the reactance of C_2 is zero, so again V_0

is nil. In this respect Fig. 6 is closer than Fig. 4 to the LC circuit with its resonance peak. But it still has a very low "Q" compared with any reasonable LC circuit. This is shown in Fig. 8, which can be compared with Figs. 5 and 1.

An advantage of Fig. 6 is that there are two RC pairs instead of three or four, so a 2-gang capacitor (or rheostat) is sufficient as an effective variable frequency control.

Now the question of surplus amplification. What would happen if nothing were done about it? If the back-coupling of an LC oscillator is increased beyond the point at which oscillation starts, it makes the oscillation grow, and in so doing it drives the valve into heavy grid current or anode-bend cut-off, until its amplification is reduced sufficiently to restore the balance. In this process the oscillation is distorted. The same happens with an RC oscillator if the amplification is at first too great: the oscillation grows until the amplification is sufficiently reduced. But the distortion is very much worse, because in the LC oscillator the sine waveform is shaped mainly by the LC circuit itself, and is not very much dented even when the current through the valve consists of square waves or pulses. But the RC circuit lacks this flywheel or pendulum effect; if the amplification is increased even moderately beyond the necessary minimum the waveform goes all to pieces. That is why practical RC oscillators nearly always have an automatic device to keep them only just oscillating.

A 2-stage resistance-coupled amplifier of normal design is likely to have a voltage gain of several hundred times, even when no particular effort is exerted to make it large. In order to maintain good waveform this must be reduced to 3; but we can make a virtue of necessity, by using negative feedback for the purpose. This means applying such a large amount of back-coupling in the direction tending to stop oscillation that it is only at the very peak of the RC "resonance" curve that it is counteracted and oscillation is possible. The very flat RC peak and gradual phase curve can thus be geared up until they compare with those of a typical LC circuit.

Fig. 9(a) is the skeleton of a 2-stage amplifier. Positive feedback, to make it oscillate, can be introduced at one particular frequency by feeding one-third of the output back to the grid by means of Fig. 6. At the same time the large surplus gain of the amplifier can be neutralized at all frequencies by tapping off very nearly one-third of the output and feeding it back in opposite phase to the cathode. The complete circuit is then as in Fig. 9(b). Drawn like this, it can be seen in another light—as a Wien (pronounced "Veen") Bridge. A and B are the "generator" terminals, receiving the output from the amplifier; whilst C and D are the "detector" terminals, connected to the input of the amplifier. If the bridge is balanced (which can be done at only one frequency) there will obviously be no signal input and therefore no oscillation. Assuming, as we have done, that $R_1 = R_2$ and $C_1 = C_2$, perfect balance is obtained by making $R_3 = 2R_4$. Points C and D then both receive one-third of any output voltage there might be, in the same phase, so both are at the same potential. If R_3 is made less than $2R_4$, there is a net voltage between C and D, but in the opposite phase for maintaining output. If R_3 is greater than $2R_4$, there is a net voltage tending to maintain output, and if sufficient it will cause continuous oscillation. The greater the gain of the amplifier, the less the bridge has to be unbalanced to produce oscillation, and the easier it is to apply an automatic control to keep the system just oscillating and no more. The simplest method is to make R_3 a thermistor, as described in the August, 1949, issue, page 296.

Before superhets came into general use, the most-used method of obtaining r.f. selectivity was positive feedback ("reaction") just short of the oscillation point. In the same way this RC oscillator system, if set just short of oscillation, can be used for getting a.f. selectivity. And that is the point where readers who want to pursue the subject farther can be handed over to J. McG. Sowerby (June, 1950, page 223).

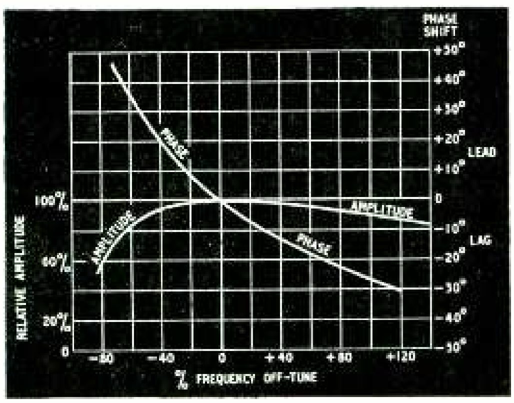
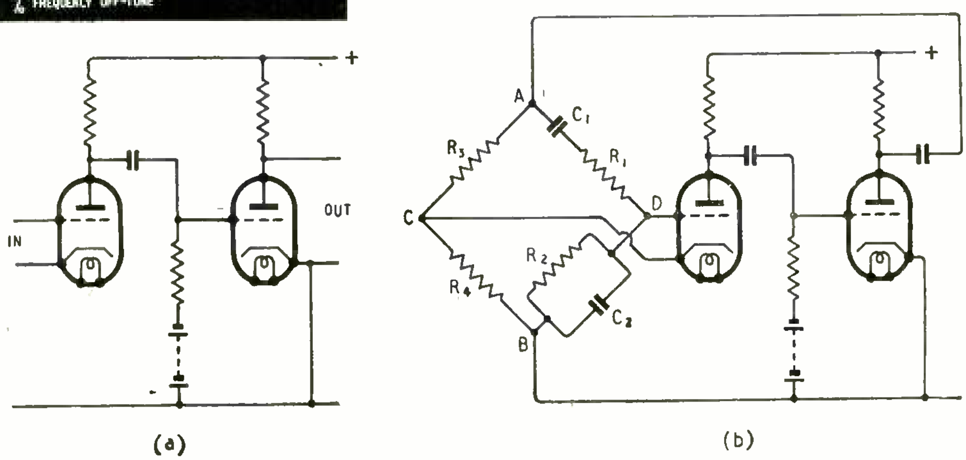


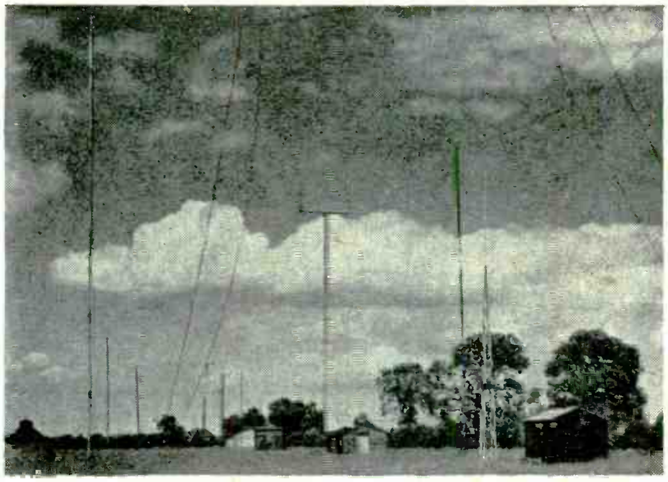
Fig. 8. Phase and amplitude graphs for Fig. 6 circuit, for comparison with Fig. 5.



Right: Fig. 9. (a) 2-stage amplifier alone, and (b) with output connected to input by Wien bridge circuit.

Monitoring Airways Radio

Frequency Measuring Station Established by the Ministry of Civil Aviation



The aerials at the M.C.A's. frequency checking station at Pailton. (*Photo: Courtesy Ministry of Civil Aviation.*)

THE photographs on this page show the imposing array of aerials and some of the precision measuring apparatus used at the M.C.A.'s frequency measuring station set up at Pailton, near Rugby.

Regular checking of the frequency and field strength of all airways navigational aids and communication sets, together with measuring the frequencies of all quartz crystal oscillators used in the various air and ground transmitters and receivers of civil airways, constitute the work of the station.

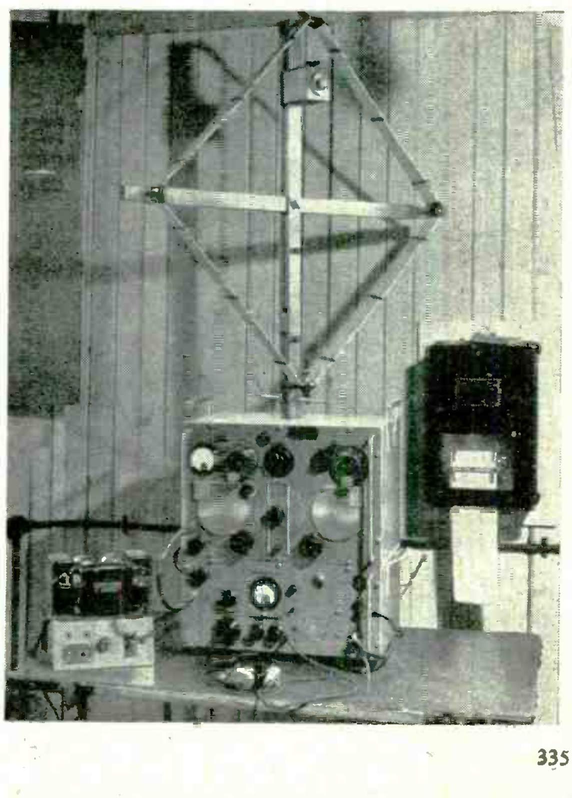
Pailton being roughly in the centre of England, most of the U.K. beacons, which operate in the 250- to 400-kc/s band, are received well enough for frequency and field strength measurement purposes. But the station has also some mobile equipment which makes on-the-spot measurements to supplement those taken at Pailton.

Records are kept of all routine measurements and a monthly graphical chart is prepared showing the day-to-day behaviour of all the navigational beacons. By international agreement these have to keep within ±0.05 per cent of their allotted frequencies. Checks are also made on all airport h.f. transmitters operating in the 3- to 11-Mc/s band.

Whilst the foregoing represents the principal activities at Pailton, numerous other tasks are also performed. For example, the frequency meters used by civil airways stations are periodically checked and re-calibrated if necessary and radio flight-tests are carried out with aircraft for the Ministry certificate of airworthiness.

Future plans envisage investigation into interference problems, measurement of harmonic and parasitic radiation from transmitters and a programme of work covering v.h.f. measurements.

Left: With this equipment regular measurements are made on beacons and ground transmitters used by civil airways. Right: The field strength measuring equipment used at Pailton. It is the Marconi Instruments type TME18 covering 150 kc/s to 25 Mc/s with interchangeable loops. (*Photos: Courtesy Ministry of Civil Aviation.*)



UNBIASED

By FREE GRID

Meteorology for the Million

SPEAKING as one of the "countless others" whom the Editor mentions in the July issue as being "more than usually dependent on sudden changes of weather," I cannot too warmly endorse his plea for the restoration of the discontinued "Airmet" meteorological broadcasting service and for its extension to cover the whole twenty-four hours of the day.

I have always made a point of carrying my umbrella, no matter how favourable the forecast; not because I lacked faith in it, but merely to safeguard my legal position lest at any time a "common informer," inspired by greed of gold, caused me to be arraigned before the Court on a charge of "aiding and abetting," since I have always understood that it is an offence against the law to "profess to tell the future." I am sure that, on paper at any rate, the learned scientist feeling his seaweed on the roof of the Air Ministry is equally guilty in this respect with Madame Estelle gazing into her crystal. If any of you who are

Further Outlook Unsettled.

learned in the law are of a different opinion perhaps you will quote chapter and verse to show me exactly when the law was altered to show discrimination between meteorological and matrimonial forecasts.

But while I whole-heartedly endorse the Editor's appeal for a 24-hour "Airmet" service, we part company when he lends support to a suggestion that the Third Programme channel should be employed during those hours of the day when it is normally not in use. To myself and other Third Programme listeners, among whom I am sorry to say it seems clear that the Editor is not numbered, such a sacrilege can only be compared to a suggestion that the nave of Canterbury Cathedral be employed as a dance hall at such times as it is not in use for ecclesiastical purposes.

To my mind the obvious solution of the difficulty would be to use the Light Programme channels by putting the words of the forecasts into the mouths of dance band crooners. These songsters (?) have but a limited vocabulary consisting of words like "blue" and "true" and "you," and no doubt they would be glad of something fresh to sing, such as "the north wind doth blow and we shall have snow." Dancers and others who enjoy these programmes would be only too glad if their favourite fare were to be continued throughout the 24 hours, and dance band leaders would be glad of the extra money.

Bob Allen Up to date

ENTERPRISE and initiative are qualities that have invariably appealed to me, and I am always pleased when I find outstanding instances of them in which radio plays a part. I was, therefore, agreeably surprised to see a television set in operation in the waiting room of a seaside doctor at whose surgery I called one evening in August to get something to ease the pain caused by a crab seizing my big toe when enjoying the delights of paddling.

The waiting room was crammed to the doors by patients, and it was obvious that most of them had only imaginary complaints and had come mainly to see the television programme, since the town was on a part of the coast well outside the nominal range of Alexandra Palace, and a television set in operation was a comparatively rare sight; indeed, it was only by the use of an elaborate aerial array and a super-sensitive pre-amplifier that it was possible to get and hold the programme.

At first I assumed that the only credit for enterprise was due to the dealer who had put in the installation and had affixed an artistic and yet conspicuous nameplate to it giving his name and address. I learned differently, however, when a fee was demanded of me for examining my toe, as I had expected to get it all free under the National Health Service as an emergency case, since I was well away from the area of my own doctor. Unfortunately, however, the seaside medico was not a member of the Service.

Subsequent enquiries laid bare the enterprising nature of this doctor, who had, without breaking any of Mr. Bevan's regulations or infring-

Enjoying the delights of paddling.

ing any of the strict rules of professional etiquette about advertising, built up quite a lucrative practice. It was, in fact, fully up to the standard of permissible medical advertising set by Dickens' Bob Allen.

Autophone Service Wanted

CAR radio is now regarded as indispensable by all self-respecting motorists. In a few years it will be considered equally indispensable for a car to be on the telephone. Nobody, however, seems to be interested in the idea to-day, although it is technically possible by means of a micro-wave link to the nearest telephone exchange. Such a system is, in fact, in actual operation in certain "furrin parts."

It should be easy to stimulate interest in this country since, as is well known to people who matter, one of the big motoring organizations has in operation a radio patrol-car service whereby you can ring their H.Q. from the nearest telephone box and get a first-aid car directed by radio to your broken-down vehicle.

It would be quite easy to improve on this. Members of the organization could be provided with small fixed-frequency micro-wave transmitter-receivers to link up with a counterpart on the roof of the telephone kiosk which would connect the caller by landline to H.Q., without the necessity of getting out of his immobilised car and trudging wearily to the 'phone box. This roof-top link would be completely automatic in operation like the chain of stations between Sutton Coldfield and the Alexandra Palace. Once get motorists used to this and they would soon demand a fully fledged telephone service. Centimetre wavelengths and a chain of roadside pick-up stations would probably be necessary.

LETTERS TO THE EDITOR

The Editor does not necessarily endorse the opinions expressed by his correspondents

Spot Wobble

THE letter of H. S. Chadwick in your July issue queries a previous statement of E. G. O. Anderson in the May issue that "the light output is increased" by the use of spot wobble. If Mr. Anderson will permit, I would like to enter the fray on his behalf, and also because I find that the inability to appreciate that conditions of scanning and focus can affect the total light output is widespread. The following may help.

Given a fixed set of scanning conditions but always maintaining optimum focus there are two main considerations affecting brightness.

(1) Final anode voltage (affecting depth of electron penetration into the screen) will increase the light output progressively with voltage increase. The upper limit of brightness is a function of the screen thickness.

(2) Current increase affects brightness by putting more electrons on to the screen. The upper limit of brightness is when the individual electrons are so crowded that they fall only on screen material which is already excited to saturation by the previous electrons.

Now the light output from a screen as measured by a photo-cell and galvo does not increase in a direct ratio to an increase of beam current, due to the current saturation conditions of the screen.

As can be seen from the curve extracts below, doubling the beam current gives *less* than double the brightness. The higher the current the less efficient the screen becomes.

Beam Current (μA)	50	100	200	400
Brightness	0.6	1.1	1.9	3.15

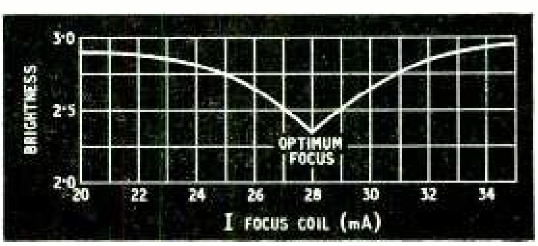
But if in doubling the beam current the scanned area is also doubled then the brightness is maintained.

Now look at it another way.

If we scan the whole of the screen as in television practice, then about one-third of the screen (between the lines) is not being excited at all. The two-thirds of the screen being excited, is, for modern conditions of daylight viewing, working well up the current/brightness curve where the efficiency is reduced. If we now fill between the lines either by defocusing or by spot-wobble we reduce the current on the two-thirds previously bearing all the current, and we work on a more efficient part of the current/brightness curve.

The accompanying curve shows what can happen to brightness with changes of current through the focus coil, all other conditions remaining constant. S. F. NUTKINS.

Hayes, Middx.



Record and Stylus Wear

I FEEL that Mr. Wood, in his article in the July issue, did not sufficiently bring out the main advantage of the cantilever pickup, namely, its ability to "iron out" the distortion due to pinch effect. I have myself recently constructed a pickup of this type with a moving-iron movement, and find that it is now possible to obtain excellent results from records which previously I considered virtually unplayable. Since many of these are of excellent musical quality it is satisfying to hear these performances unmarred by "pinchy" recording. Possibly this is the reason for the great vogue enjoyed by cantilever pickups in America.

My own experience as regards life of styli shows that a sapphire or ruby may be expected to play 150 sides in a 14-gm non-cantilever pickup, and 300 in a 7-gm cantilever pickup. This requires qualification, in that the records used were by no means all new; some, indeed, are still showing signs of the use of fibre needles in the "pre-sapphire era!" (It is significant that "fibre-wear" will, in the course of later playings with sapphires, gradually heal up, due to the burnishing action of the stylus.)

Using brand new discs only, these figures might be doubled; but most collectors have a large proportion of older discs, and the already-mentioned superiority of the cantilever types makes it probable that these will be played still more.

I also feel that Mr. Wood's curves, showing the deterioration of quality due to stylus wear, are misleading. The test discs used at present invariably start with the highest frequency on the outside rim (groove velocity 47 in/sec). This highest-frequency band is shown as falling off by some $2\frac{1}{2}$ db at 10 kc/s after 2,000 sides at $7\frac{1}{2}$ gm, and 5 db at 10 kc/s, at $14\frac{1}{2}$ gm. However, at the inner rim the groove velocity may fall as low as $15\frac{1}{2}$ in/sec, and one may therefore expect a loss of $2\frac{1}{2}$ (or 5) db at 3,300 c/s and correspondingly more at higher frequencies. In actual fact, a falling off in clarity towards the end of a side is just about audible after 200 sides, and becomes troublesome after 300; although these figures only represent averages, the behaviour of sapphires being decidedly unpredictable. Unless a very high degree of magnification is available, wear is audible long before it becomes visible. S. C. HINE.

Harrow, Middx.

Nomenclature

FOR some considerable time now the words "capacitor" and "resistor" have been used to replace the original designations of "condenser" and "resistance." These designations I consider a great improvement. There is, however, another designation which I think is in need of alteration—"intermediate frequency." This should, in my opinion, be called "resultant frequency" or "resultant sub-frequency." It is not an intermediate frequency, but a sub- or lower-frequency created by the mixture of the signal frequency and the oscillator frequency.

Ormskirk, Lancs. F. B. RUDD.

MAY I recommend to television manufacturers the discontinuance of the term "brightness control." "Brightness" on a knob tempts viewers to advance this control when contrast adjustment is actually needed.

The chief results are pictures which do a disservice to the television industry's future, and reduction of the life of the tube.

A change of name, plus improved instructions from some manufacturers on the use of their receiver controls, would go a long way to overcoming these troubles. Perhaps someone will complete the idea by suggesting a new word for the offending one.

W. P. ROWLEY.

East Molesey, Surrey.

Reducing Television Interference

THOSE who have to deal with complaints of interference radiated by the line time-base circuits of the modern television receiver might be interested to hear that some U.S. radio manufacturers make a practice of coating the inside of the cabinets with graphite in order to reduce this effect.

The mixture employed is a dispersion of colloidal graphite in water or other volatile base which is easily brushed or sprayed on glass, bakelite, wood or rubber as required. There are several variations of the mixture available which will form a fairly low-resistance skin and act as an electrostatic screen. In cases where an "uncoated" tube is used, the outer surface of the flared part of the glass envelope should also be coated in order to complete the screening in the forward direction, i.e., from the front of the receiver. Contact is made between chassis and "screens" by means of strips of aluminium foil attached by gum prior to the application of the graphite.

From observations made during tests carried out on a typical receiver after the application of a coating of Acheson's colloidal graphite ("dag"), it should prove possible to reduce unwanted radiations by at least ten times (20db). In applying this remedy to a.c./d.c. receivers, care must be taken to restrict the coating to the internal parts of the cabinet in order to eliminate the possibility of leakage paths to the live chassis.

G. T. CLACK.

London, S.W.12.

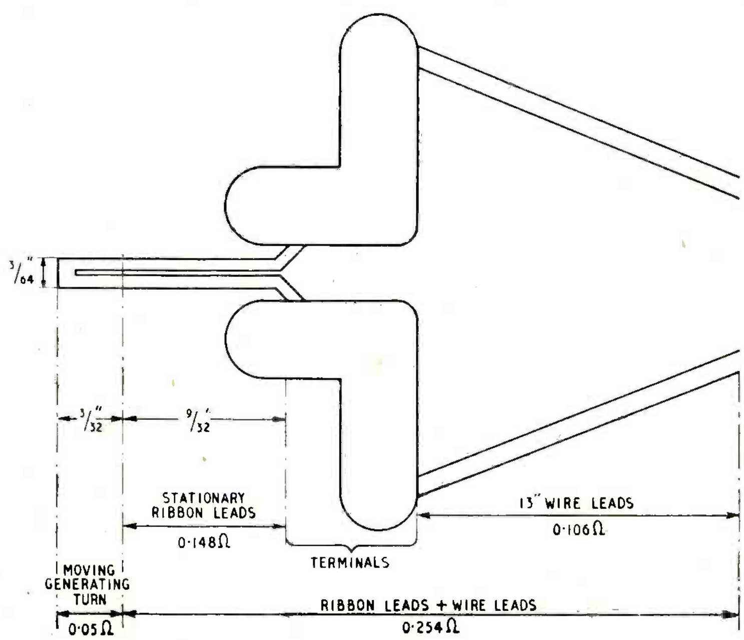
Pickup Design

MY letter in your July issue mentioned the mass of the moving parts of the single-turn pickup under consideration. A typing error converted the measured mass of 3.5 milligrams into the incorrect figure of 35 milligrams. I greatly regret the error, which many readers must have spotted, for it is widely known that single-turn pickups have been available for a considerable time where the moving parts have a mass of the order of 3 milligrams.

An objection has been made to my use of the word "new" to describe the pickup on which tests were made. The word was used to indicate that the pickup was in an unused condition. It was the latest model of which I had cognizance, and though I read the technical press thoroughly I have been unable to trace any announcement of a later model.

My statement regarding the proportions of resistance in a single generating turn and the leads has also been challenged. In confirmation of my statement I give a detailed drawing showing the relative resistance of the single generating turn, the remainder of the ribbon (ribbon leads), and the lead-out wires. The total resistance of the ribbon was measured as 0.198 ohm, the resistance of the moving part and the fixed part being calculated therefrom.

The drawing is approximately to scale, and it gives confirmation to my statement that the active signal-generating part of the ribbon is small compared with the rest of the loop formed by the remainder of the ribbon, the terminal connections and the leads running along the arm. This large non-signal-generating part of the loop is the main reason why



single-turn pickups tend to give higher hum/signal ratios than multi-turn generators. H. J. LEAK.
H. J. Leak and Company,
London, W.3.

American Insularity

I AM in entire agreement with Keith Henney (your July issue) that it is as a result of ignorance that the majority of American writers on technical subjects fail to give credit to foreign writers and inventors. In these circumstances, we must ask why this ignorance exists. The reason surely is that those writers who are aware of the facts do not all take the trouble to give credit, with the result that their readers are mis-informed, or not informed, as to the true situation. For example, Professor Maclaurin is in an exceptionally favourable position in that he writes from the Massachusetts Institute of Technology, whose library is obviously extremely well stocked and which, to my knowledge, contains many unpublished documents describing the work of foreign engineers. There is thus no excuse for his omission of this essential part of the story of the invention and development of ideas. Attention to details of this sort is a duty which an author must accept. The inclusion of these names is a courteous and pleasant way of acknowledging one's indebtedness to others both as an author and as one who has benefited by their work. It is interesting and instructive for the reader, and it rounds off a book which, without it, can cause much irritation to readers who know the true facts. O. S. PUCKLE.
Beaconsfield, Bucks.

MANUFACTURERS' LITERATURE

Marine radar activities described in a review (No. 5) issued by Cossor Radar, Ltd., Highbury Grove, London, N.5.

High-vacuum pumps and allied equipment described in a "digest" catalogue from W. Edwards & Co., Worsley Bridge Road, London, S.E.26.

Ex-Government Equipment List No. 7 (price 6d) from Clydesdale Supply Company, 2, Bridge Street, Glasgow, C.5.

Process timers described in List 120/B from Londex, Ltd., 207, Anerley Road, London, S.E.20.

Laboratory equipment, including resistors, capacitors and inductors, bridges, oscillators, magslips and servo components are covered in the latest series of bulletins from Muirhead & Co., Beckenham, Kent.

Hospital Patient-call system; details of the equipment in a leaflet from Ardente Acoustic Laboratories Ltd., Guildford, Surrey.

RANDOM RADIATIONS

By "DIALLIST"

Preferred Valve Types

No one could agree more heartily than I with the suggestion made by James Franklin in the correspondence columns of last month's *W.W.* that we should adopt a small number of preferred types for valves. The saving to manufacturers of resistors brought about by the general acceptance some time ago of preferred values must be enormous. Not so many years have gone by since one could readily buy resistors marked, or colour-coded, 40,000, 45,000, 50,000 and 55,000 ohms. Comparatively few purchasers realized that there was a ± 10 per cent tolerance in the values of standard grade resistors. But there was—and still is. Hence a resistor marked 45,000 ohms might have a true resistance of anything between 40,500 and 49,500 ohms; again, the genuine value of the resistor correctly marked 50,000 ohms could vary from 45,000 to 55,000 ohms. Except in certain precision circuits, such as those of the time-constant type, it does not greatly matter as a rule whether a resistor, specified by the designer as one of 50,000 ohms, has a real value as low as 50,000 − 10 per cent = 45,000 ohms or as high as 50,000 + 10 per cent = 55,000 ohms. Adopt a preferred value of 47,000 ohms and you assure the purchaser, if the tolerance is ± 10 per cent, that the true value lies between 42,300 and 51,700 ohms; with a ± 5 per cent tolerance it is between 44,650 and 49,350 ohms. The tolerances stipulated and accepted for valve characteristics are very much greater; it would seem, therefore, that the task of drawing up a short list of preferred valve types should not present any insuperable difficulties from this point of view.

The Price Question

Everyone with whom I discuss the subject (not excluding some big noises in valve manufacturing concerns in their calmer and more human moments!) is of opinion that the prices of "replacement" valves are too high; replacement valves being those that the experimenter or constructor buys over the counter for his work, and those bought in the same way by John Citizen to fill the gaps caused in his radio or television receiver by burn-outs, wear-outs or breakages. The style of both experimenter and would-be constructor is cramped. To my knowledge, the sales of radio receivers containing more than a modest number of valves—and still more so those of television sets necessarily sporting from 18 to 30—are restricted by the quite natural fear that some untoward happening involving his valves may land him in a position presenting two most disagreeable alternatives. Either he must spend on valve replacements an amount as great as, or even more than, the present value of his receiving apparatus, or he must be deprived of its services. One of the reasons given by valve manufacturers for the high prices charged for replacements is that they have to keep so many types on the market. The adoption of preferred types should help enormously here.

A Golden Opportunity

If ever the radio industry is to adopt preferred valve types, the present affords a golden opportunity. We're told (and I've no doubt about it myself) that the miniature valve will rapidly supersede the old "bottle." There are comparatively few types of miniature now being made and one kind of base is suitable for all of them. Were the problem energetically tackled *now*, it should be possible to guard against any runaway increase in the types of miniature valves like that which has occurred to the disadvantage of everyone, in those of the now more familiar size and shape. A firm foundation could be laid by agreement on the part of radio manufacturers to use only the B7G base for miniatures for, say, the next five years. Nor should it be unduly difficult to work out a range of preferred characteristics for a.c., a.c./d.c. and battery valves. Curiously enough, one of the biggest difficulties might be to agree on the preferred battery types, for with the coming of the "all-dry" radio receiver and of the mains/battery set this kind of valve has gained a new importance. The filament current has already been brought down to 50 mA and many of these valves will continue to function when the l.t. voltage has dropped to 1.1.

The Set of the Future?

It wouldn't surprise me if the broadcast receiving set of the near future was normally a universal affair, based on miniature battery valves. I see it incorporating lightweight dry h.t. and l.t. accumulators of types yet to be developed. In my vision of things to come both batteries are served by a.c. and d.c. trickle-chargers, the appropriate one being brought into action when required by a 3-position switch, marked "a.c.," "d.c." and "off." When the user has no mains supply, but can get his accumulators charged, he will have duplicate batteries, both with "plug-in" connectors and easily removed from, or inserted into, the cabinet. Should there be no charging station available, he will run his receiver from dry batteries of the inert type. These are already well known. They live fully up to their name, for they are genuinely dry when purchased and remain chemically and electrically inactive until water is supplied to their cells. The set owner who has either a.c. or d.c. supplies available will use just the opposite of the present mains set procedure. He will switch *off* the mains supply when he wants to use his set and switch it *on* when the programme comes to an end. In other words, the h.t. and l.t. accumulators will take charge of the receiver when it is in use and the a.c. or d.c. mains will take charge of the accumulators when it isn't. Fantastic? I don't think so. Remember, I'm thinking only of the domestic broadcast radio receiver. In the small living room of to-day—and probably to-morrow—no great output is required from the loudspeaker. The latter is, from one point of view, a most inefficient instrument, with a very low input/output ratio. Nor, again, does the compact, lightweight "dry" accumulator exist to-day. But I firmly believe that both the efficient loudspeaker and the small, light secondary battery with its electrolyte in semi-solid form are not too far away. Could these things be realized, as I am sure that they will one day, one single range of radio valves would fulfil the needs of the great majority of broadcast listeners.

Wireless World

DELAY IN PUBLICATION

The main body of this issue of "Wireless World" went to press before the recent printing trade dispute reached an acute stage. We apologize to readers for the long delay in publication, and also for the fact that certain matters referred to are no longer current. On this and the succeeding three pages we have endeavoured to bring the issue up to date by giving information on more recent events.

Restoring Airmet

AT a conference convened in October by the Royal Meteorological Society, strong demands were made by spokesmen of many diverse interests for early restoration of the Airmet weather broadcasts. As readers will remember, the 245-kc/s channel on which these detailed and frequent bulletins and forecasts were transmitted was allocated under the Copenhagen Plan for other purposes, and the transmissions stopped abruptly last March.

It was agreed at the conference to present a petition to the Government, and this is being organized by the Society's journal *Weather* (49, Cromwell Road, London, S.W.7) from where copies of the petition form can be obtained.

Wireless World's pleas for restoration of the service have been well supported by readers, but the official attitude is that no channel is available. There also seems to be the further difficulty that the responsibility for the service cannot be definitely allocated to any particular Ministry or department; in fact, the service benefits nearly all of us, and not mainly air navigators, for whom it was originally mainly intended.

That being so, *Wireless World* contends that the responsibility for distributing Airmet should be passed to the B.B.C. Space for it could be found in the channels allocated to the Third Programme, which, until they were annexed quite recently for overseas propaganda broadcasting, were idle until 6 p.m. The amount of time and ether space given to propaganda seems to us to have become quite disproportionate. It is not generally realized that one of our two exclusive medium-wave channels is used entirely for propagating the British way of life overseas—instead of improving the British way of life at home.

CURRENT TOPICS

A.M./F.M. Tests

IN the September issue we appealed editorially for a regular schedule of a.m./f.m. transmissions from the experimental v.h.f. station at Wrotham "if only to allow receiver designers to conduct large-scale field tests," and we are now glad to be able to give some details of the transmissions.

The two transmitters are radiating the same programme simultaneously. The 25-kW f.m. transmitter is at present tuned to 91.4 Mc/s and the 18-kW a.m. station to 93.8 Mc/s. The outputs are fed into a horizontally polarized omni-directional slotted aerial. It is understood that the main object of the tests is not so much to prove that one method of modulation is better than the other, but rather to ascertain whether e.h.f. broadcasting is a practical possibility.

At present the transmissions are being broadcast from Monday to Friday from 11 a.m. to 4.30 p.m. with an hour's interval at noon, and each week-day from 6.0 p.m. until the close of the programme—either the Home or Third—being radiated.

U.S. Colour Television

FOR months past the American Federal Communications Commission has been considering the claims of various methods of colour television in the course of an investigation into the allocation of frequencies in the 475 to 890-Mc/s band to television stations. It will be recalled that there has been a television "freeze" in the U.S. since September, 1948, stopping the licensing of new stations until the whole question of frequency allocation—at present limited to the 12 channels between 54 and 216 Mc/s—had been thrashed out. On 1st September the F.C.C. issued a report on colour television, giving its approval to the frame-sequential system developed by the Columbia Broadcasting System and regular transmission will begin on 20th November.

In the C.B.S. system the colours are changed after each vertical scanning period. There are 144 frames per second and, as in black-and-white, 2 to 1 interlacing is employed. The number of lines per picture is 405, or 202.5 per frame (262.5 in black-and-white). Thus, the total number of lines per second, or horizontal line frequency, is $72 \times 405 = 29{,}160$ c/s.

Each colour—red, blue, and green—lasts for 1/144th of a second, and the colour sequence repeats itself after 1/48th of a second. This period is called a three-colour frame interval. Since only one-half the number of lines will have been scanned in all colours in 1/48th of a second, twice this period, or 1/24th of a second, is required for all lines to be scanned in all colours. This period of 1/24th of a second is called a colour picture interval.

The C.B.S. frame-sequential system is the only one of the colour systems so far demonstrated which can utilize electronic or mechanical means for colour selection. The simplest and least expensive method is the use of a colour disc. The disc rotates in front of the receiver tube at the rate of 1,440 r.p.m. When six colour filters are employed, two sets of red, blue, and green filters are used. In addition to the tube size, the shape of the filters determines the size of the colour disc.

The colour transmission process works as follows: At the camera, which is more or less of conventional design, a single image is produced by means of a lens on the light-sensitive surface of the pickup tube. A colour filter disc, fully enclosed, rotates in front of this pickup tube and contains a series of colour filters in the order of red, blue and green. If the camera disc has 12 filters (4 red, 4 green and 4 blue), the disc rotates at 720 r.p.m.

C.B.S. has developed a series of devices, among which is an attachment permitting the viewing in black-and-white on a colour receiver of both tricolour and monochrome transmissions. A convertor is also available for use with monochrome receivers permitting the reception of transmissions in colour. This colour convertor slides on tracks and when pushed aside, monochrome transmissions can be received.

It will be recalled that the colour system developed by Pye at Cambridge is based on the C.B.S. system.

Amateur Exhibition

THE fourth annual amateur radio exhibition to be organized by the Radio Society of Great Britain will be held at the Royal Hotel, Woburn Place, London, W.C.1, from November 22nd to 25th.

Among the exhibitors are: Air Ministry, Avo, Berry's, C. H. Davis, Decca, Easibind, E.M.I., G.E.C., G.S.V. Marine and Commercial, Imhof, Oliver Pell Control, Philpotts Metalworks, Post Office, Q-Max, Salford Electrical Instruments, Sangamo-Weston, *Short Wave Magazine, Short Wave News*, Taylor Electrical Instruments, Westinghouse, Woden, *Wireless World* and *Wireless Engineer*.

The exhibition will be opened at 2.30 on the first day and at 11 a.m. on subsequent days. It will close daily at 9 p.m. Admission to the show, which will be opened by Hugh S. Pocock, will be by catalogue price 1s.

Records: E.M.I. Policy

IN a letter to gramophone traders, E.M.I. Sales and Service, who issue H.M.V., Columbia, M.G.M., Parlophone and Regal-Zonophone records, state that until further notice they will continue to supply standard (78 r.p.m.) records only. They affirm their belief in the principle of a universal single turntable speed and state that if for any reason they consider that records should be played at any speed other than the present standard of 78 r.p.m., record dealers will be given a minimum of six months' notice of their intention to introduce such records.

Amateur Television

WHEN asked in the House of Commons why he would not permit amateurs to transmit television as is done in the U.S.A. and the Netherlands, the Postmaster General announced that the question had again been reviewed and that arrangements were being made for licences to be issued.

The bands to be used will be 2,300-2,450, 5,650-5,850 and 10,000-10,500 Mc/s and special licences will be issued as soon as the detailed conditions have been worked out.

OBITUARY

Sir Frank Gill, K.C.M.G., O.B.E., died on October 25th, at the age of 84, whilst attending meetings of the International Telephone Consultative Committee (C.C.I.F.) in Geneva. At the time of his death he was chairman of Standard Telephones & Cables, the International Marine Radio Co., and Standard Telecommunication Laboratories. He was a past president of the I.E.E.

W. H. Peters, O.B.E., M.I.E.E., Assistant General Manager of the G.E.C.'s Coventry group of works, died recently at the age of 52. He joined the Company's Research Laboratories in 1925. In 1930 he was appointed Chief Engineer of the Radio Group at Coventry, and nine years later he became Manager of the Radio and Television Works. He had been Assistant General Manager of the Coventry group, in charge of its radio activities, since 1943.

IN BRIEF

Licence Figures.—As is to be expected during the summer months when viewing and listening are not so popular, the increase during August in the number of receiving licences—both sound and vision—current in the U.K. was only 9,050. In September the increase was 35,550. The total at the end of the third quarter was 12,305,200. The quarter's increase in television licences was 64,200, bringing the total to 470,800.

British Television in Berlin.—Eight British television manufacturers—Bush, Cossor, Ekco, G.E.C., Marconiphone, Murphy, Pye, and Ultra—demonstrated receivers during the Industrial Fair in Berlin in October. The studio equipment, cameras and transmitters, which operated on a closed circuit, were supplied by Pye.

"Engineers in the B.B.C."—A booklet with this title, describing what the Engineering Division of the B.B.C. is doing, the types of men it wants and its conditions of service, has been prepared by the Corporation for distribution to Universities and Training Colleges as a guide to graduates and undergraduates contemplating careers as engineers.

Decimetric Communication—Two-way telephony communication on 1250 Mc/s over a distance of 75 miles for approximately one hour was achieved by two British amateurs—R. Tunney, G8DD, at Worcester Beacon, nr. Great Malvern, and C. Edlin, G3QC, at Merryton Low, nr. Leek, Staffs.

Twenty-week Courses of lectures on electro-acoustics and pulse techniques are being held on Monday and Thursday evenings, respectively, at the Technical College, Beaconsfield Road, Southall, Middlesex. Applications for enrolment should be made immediately to the Secretary (Tel.: Southall 3448). The fee for each course is £1.

BUSINESS NOTES

Exporting Television Kits.—An enquiry has been received from the Anglo-Netherland Technical Exchange, Ltd. (Antex) of 3, Tower Hill, London, E.C.3, for kits of parts for television receivers operating on 625-lines for use on the Continent.

Television Repeaters.—The G.E.C. is providing the four amplifiers—one working in each direction of transmission and a stand-by for each direction—required for each of the nineteen repeaters to be employed in the television cable link between Birmingham and Holme Moss. They have a gain of 52db at 4.4 Mc/s—the upper limit of the specified frequency coverage.

Concert Hall S.R.E.—Standard Telephones & Cables have been awarded the contract for installing the sound reproducing equipment in the Royal Festival Hall on the South Bank of the Thames. The installation, which covers the main auditorium, smaller hall and ancillary rooms, includes hearing-aid outlets fitted into the arms of seats in the main hall.

Austrialian Agency for magnetic-tape recorders and inter-office communication equipment is required by Austral Impex to whom particulars should be sent direct. Their address is G.P.O. Box 5067, Sydney, N.S.W., Australia.

MEETINGS

Institution of Electrical Engineers

Radio Section.—Informal lecture on "The Nervous System as a Communication Network," by J. A. V. Bates, M.A., M.B., at 5.30 p.m. on November 20th.

Symposium of Papers on "Radiation Monitoring Apparatus," at 3.30 and 5.30 p.m. on November 28th.

The above meetings will be held at the I.E.E., Savoy Place, London, W.C.2.

Cambridge Radio Group.—"Frequency-Modulated Broadcasting," by W. P. Wilson, C.B.E., M.Sc.(Eng.), on November 27th (Joint Meeting with Cambridge University Wireless Society).

North-Eastern Radio Group.—"A New Precision A.C. Voltage Stabilizer," by G. N. Patchett, B.Sc., Ph.D., at 6.15 p.m. on November 20th at King's College, Newcastle-on-Tyne.

North-Western Radio Group.—"Crystal Diodes," by R. W. Douglas, B.Sc., and E. G. James, Ph.D., and "Crystal Triodes," by T. R. Scott, B.Sc., at 6.30 p.m. on November 29th at the Engineers' Club, Albert Square, Manchester.

Television Society

"Feedback Methods of Scan Linearization," by A. W. Keen (E.M.I.), at 7 p.m. on November 24th at the Cinema Exhibitors' Association, 164, Shaftesbury Avenue, London, W.C.2.

British Sound Recording Association

"Some Features of Amplifier Design for Recording Equipment," by H. D. McD. Ellis, M.A., M.I.E.E., at 7 p.m. on November 24th at the Royal Society of Arts, John Adam Street, London, W.C.2.

British Institution of Radio Engineers

London Section.—"Ultrasonic Generators for High Powers," by B. E. Noltingk, Ph.D., at 6.30 p.m. on November 20th at the London School of Hygiene and Tropical Medicine, Gower Street, W.C.1.

West Midlands Section.—Discussion on "The Quality of Electrical Reproduction and its Effect on Receiver Design," at 7 p.m. on November 22nd at the Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton.

Radio Society of Great Britain

"Electronic Computing," by F. Aughtie, D.Sc., A.M.I.E.E., at 6.30 p.m. on November 17th at the I.E.E., Savoy Place, London, W.C.2.

SHORT-WAVE CONDITIONS

September in Retrospect : Forecast for November

By T. W. BENNINGTON, (*Engineering Division, B.B.C.*)

THE average maximum usable frequencies for these latitudes during September decreased slightly during the daytime, and decreased considerably during the night. The latter was in accordance with the normal seasonal trend, but the daytime variation was the opposite of what would have been expected. It was probably due to the exceptional amount of ionospheric storminess which occurred during the month.

Daytime working frequencies for long-distance communication were rather low, the 28-Mc/s amateur band, for example, being seldom usable. Frequencies of the order of 21-24 Mc/s were about the highest generally usable during the day, and of the order of 10 Mc/s during the night.

There was a very considerable decrease in the rate of incidence of Sporadic E, and not much communication on high frequencies occurred by way of this medium.

Sunspot activity was, on the average, very much lower than during the previous month, and was, in fact, at its lowest level since 1946.

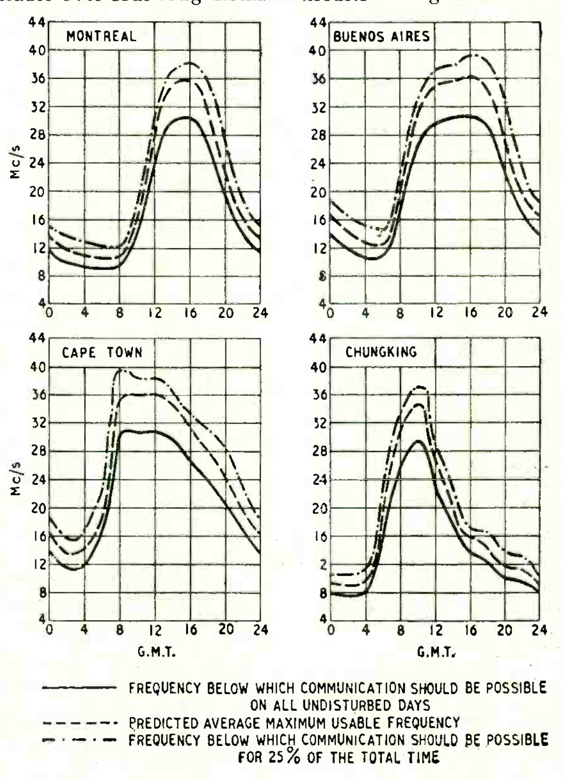
Some severe and prolonged ionospheric storms occurred during the month, the most disturbed periods being 3rd-12th, 18th-21st, 25th-28th and 30th. Only one Dellinger fade-out was reported; at 1715 on 19th.

Forecast.—During November daytime m.u.fs should continue to increase, and, perhaps, will reach their highest values for the present winter season. Night-time m.u.fs should continue to decrease.

Long-distance working frequencies should therefore be high by day, and frequencies as high as 28 Mc/s should be regularly usable over most circuits at the appropriate times of day. At night frequencies as low as 7 Mc/s will almost certainly be necessary in order to maintain communication over certain long-distance circuits.

Sporadic E is unlikely to be very prevalent, and, therefore, medium-distance communication on very high frequencies is unlikely to occur. It is likely that there may be some decrease in ionospheric storminess, though those storms which do occur are likely to be troublesome, particularly at night.

The curves indicate the highest frequencies likely to be usable over four long-distance circuits during the month.



Projection *versus* Direct-viewing Television

I.E.E. Discussion on Which is Better in the Home

AT the I.E.E. on October 30th, an informal discussion on the above subject was opened by W. T. Cocking, who gave a short introductory talk to bring forward some of the relevant points at issue. The first, which occupied the meeting for a large proportion of the time, was the question of desirable picture size. Many speakers were of the opinion that we need bigger pictures than are at present given by the average television receiver, and it was suggested at the outset by a representative of the B.B.C. that the most suitable size would be about 20in by 15in. At the usual home-viewing distance of about 8ft this would subtend a viewing angle of 10°, corresponding to a back seat at the average cinema, and would be such that the line structure on 405-line definition would be not quite discernible. One argument put forward for this order of size by an advocate of projection television was that television producers would not be so limited to close-up shots as they are at present. Other speakers thought that the large picture was more restful to the eyes, which had freedom to move about over it, but this opinion was disputed by two supporters of direct-viewing. One of them said that because the maximum acuity of the eye existed over a very small angle, parts of the large picture could only be seen out of the corner of the eye, where vision was poor. The other speaker thought that a big picture caused eyestrain because, with the present definition, the eyes were continually trying to focus on to details which seemed to be there but actually were not.

Viewing Distance

Apart from this, the question of size did not provoke a very sharp division of opinion, since both sides were more or less agreed on the desirability of big pictures. There was, however, some argument on the relative merits of projection and direct-viewing tubes for producing these big pictures. The opinion was expressed, for instance, that really large direct-viewing tubes could not possibly be mass-produced at low prices, and so installation and replacement costs would be too high. Moreover, although there were no official figures on the lives of projection tubes—nor on direct-viewing tubes, for that matter—there was no evidence to show that they had shorter lives. In reply to this, it was stated that manufacturers are hoping to produce 20in tubes at lower prices within a few years, and that, although projection tubes were certainly small, they could not be produced cheaply because of the large amount of precision work involved.

Several speakers referred to the use of front projection on to reflecting screens to obtain even larger pictures, but it was pointed out that the optical focus would be upset by any alteration in the position of the screen and such a system would always necessitate a darkened room.

On the subject of optimum viewing distance, several speakers agreed that this had less to do with the size of the picture than was generally thought. A representative of the B.B.C. said it was the absolute size of the picture that was important subjectively, not its apparent size due to different viewing distances. Mr. Cocking had stated that the optimum viewing distance for a projection picture 14in wide was about 10ft, and had suggested that for this reason the public might be disappointed with projection television in the home where the convenient viewing distance was limited to about 6 or 8ft. Commenting on this, a speaker thought that figures for optimum distance could not be relied upon, as he found that it was a matter of personal preference and different people selected different distances. This opinion was supported by several others, who quoted various distances, ranging from 3ft to 9ft, taken up by people when viewing. In reply, Mr. Cocking stressed that his figure of 10ft was obtained from tests in a room without chairs, so that people were not influenced in any way by the existing seating arrangements.

Picture Quality

Dealing with comments on comparative picture quality, a speaker said that the rough matt appearance of some projection pictures was due to the screen being too thick or having lenticular rulings which were too coarse. The fact that the line structure of the raster could not be seen was criticized by engineers. Other supporters of projection pointed out that although the high-light brightness of projection was lower than that of direct-viewing tubes, projection television gave a better contrast ratio in a lighted room because of the directional effect of the viewing screen. This resulted in a viewing angle of about 20° vertical and 60° horizontal, and light originating outside these angles had negligible effect on the picture. The use of a tinted screen on the direct-viewing tube did not, however, balance this advantage because of specular reflections from the polished surface of the screen.

Several speakers were of the opinion that although the directivity of projection television was a help towards good brightness, more could be done by improving the optical system, which was stated to be only 4 or 5 per cent efficient at the moment. In response to Mr. Cocking's suggestion that saturation effects in the fluorescent screen were perhaps responsible for limiting brightness, those supporting projection television stated that saturation effects were small, whilst the opinion of those on the other side was that saturation was important. A further speaker added that it was difficult to measure saturation anyway. It was agreed that saturation effects could be reduced by using a bigger projection tube, for this would decrease the brightness per unit area required on the tube face; this was not recommended, however, because it would increase the size of the optical system and so its cost.

Reference was made to spot wobbling as a means of obscuring the lines so that large pictures could be closely viewed, although it was pointed out that this did not help with the horizontal resolution in any way.