THE

WIRELESS ENGINEER

AND

EXPERIMENTAL WIRELESS

NUMBER 123 VOLUME X *DECEMBER 1933*

A JOURNAL OF

RADIO RESEARCH

AND

PROGRESS

3/6

2/6 NET

PUBLISHED BY

ILIFFE & SONS LTD.

DORSET HOUSE STAMFORD STREET LONDON S.E.1

SIGNAL - GENERATOR FOR SHORT WAVES.

We have pleasure to announce our new GR Type 604-B Standard Signal-Generator, which meets the exacting requirements of the Radio Industry for a reliable Generator covering the Short and Ultra-Short Wavebands.

The range covered is from 3 Megacycles (100 Metres) to 100 Megacycles (3·0 Metres). Design difficulties which are almost negligible at normal Broadcast Frequencies (200 to 600, and 1,000-2,500 Metres) become almost impossible of solution at the very high frequencies which the 604-B Generator covers, but by long and continued research all these difficulties have at last been overcome, and the new Generator is offered by us with complete confidence.

The instrument is completely portable, and covers its range of from 3·0 to 100·0 metres by a series of 13 interchangeable plug-in inductances, all of which are carried upon a special tray located under the hinged lid. Brief operational characteristics are quoted opposite.

Outputs: Two — by capacity attenuator and by rod-antenna. The former provides output of from 5 to 10,000 microvolts. The antenna is divided into 3 sections, the second and third being so chosen that the field strength is ×10 and ×100 that of the first. Maximum output 1·0 volt.

Modulation: Internal 400 cps., but plug-in units providing other frequencies can be obtained. There is also provision for external variable modulation.

Shielding: Particular attention has been paid to this feature, and this is absolutely adequate.

Price: Very reasonable—quoted on application only.

Those interested in this Type 604-B Generator should request "Engineering Bulletin No. 2339."

CLAUDE LYONS, LTD

Head Offices: 76 OLDHALL STREET, LIVERPOOL
London Offices: 40 BUCKINGHAM GATE, S.W. 1

"If a man write a better book, preach a better sermon, or make a better mouse-trap than his neighbour, though he build his house in the woods, the world will make a beaten path to his door."—RALPH WALDO EMERSON.

Does not this explain the outstanding acceptance and approval of our "G.R." Instruments?

A3

The
WIRELESS ENGINEER
and EXPERIMENTAL WIRELESS

A Journal of Radio Research & Progress

Editor
HUGH S. POCOCK

Technical Editor
Prof. G. W. O. HOWE D.Sc., M.I.E.E.

VOL. X. No. 123

DECEMBER 1933

CONTENTS

Published Monthly on the first of each month
SUBSCRIPTIONS Home and Abroad: One Year, 32/-, 6 Months, 16/-. Single Copies, 2/8 post free

Editorial, Advertising and Publishing Offices
DORSET HOUSE, STAMFORD STREET, LONDON, S.E. 1
Telegrams: "Experiwyr Watloo London" Telephone: Hop 3333 (50 lines)

Branch Offices

COVENTRY	BIRMINGHAM	MANCHESTER	GLASGOW
19 Hertford Street	Guildhall Bldgs., Navigation St., 2	260 Deansgate, 3	26B Renfield Street, C.2
Telegrams: "Cyclist, Coventry"	Telegrams: "Autopress, Birmingham"	Telegrams: "Iliffe, Manchester."	Telegrams: "Iliffe, Glasgow"
Telephone: 5210 Coventry	Telephone: Midland 2970 (3 lines)	Telephone: Blackfriars 4412 (4 lines)	Telephone: Central 4857

The Editor invites the submission of articles with a view to publication. Contributions which are not exclusive should be so described when submitted. MSS. should be addressed to the Editor, "The Wireless Engineer and Experimental Wireless," Dorset House, Stamford Street, London, S.E.1. Especial care should be taken as to the legibility of MSS. including mathematical work.

645

THE

WIRELESS ENGINEER

AND

EXPERIMENTAL WIRELESS

VOL. X. DECEMBER, 1933. No. 123

Editorial

Electrical Interference with Broadcast Reception

ABOUT six months ago the Institution of Electrical Engineers appointed a committee to inquire into the subject of Electrical Interference with Broadcasting, and some of the sub-committees of this committee have recently issued a preliminary report. Our readers will be interested in the parallel activities of the "Kommission für Rundfunkstörungen" set up by the Verband Deutscher Elektrotechniker. This committee has, through two of its sub-committees, issued two draft regulations, which were published in the *E.T.Z.* of 28th September, with the request that any objections should be lodged with the V.D.E. before 30th November. These draft regulations cover six pages of the *E.T.Z.*, and go into considerable detail. The first draft deals with the precautions to be taken in lines and networks, and in the receiving set and aerial; the second, which is much longer, deals with the steps to be taken to render electrical apparatus non-disturbing. In each case there is a preliminary statement that the regulations are intended to indicate how, in the present state of the art, interference can be reduced, with due regard to price, practicability and reliability. The draft dealing with networks is subdivided into four sections dealing respectively with power networks, trolley wires, signalling networks and the radio receiving apparatus itself. In the case of power networks it recommends that all straight-through and tee connectors should be firmly secured, that all contact with tree branches, straw, etc., should be avoided, as should also all sharp points on high voltage wires, clamps, etc. That insulators should be kept clean and replaced if damaged, and that the lines should be run underground wherever possible, especially in thickly populated districts. It recommends that the aerial should be erected as remote as possible from the wiring system of the premises. In connection with trams it points out the necessity of good mechanical construction of the collecting wheel or bow so as to maintain steady pressure and contact, and also the use of materials which do not tend to spark production. It also emphasises the importance of maintaining the overhead wire and the track in good condition in order to avoid sudden blows on the collector with consequent vibration and intermittent contact. A further point is the necessity for maintaining good conductivity at the rails joints to prevent the flow of high-frequency currents through the earth. The recommendations for signalling networks are almost identical with those for low-voltage power networks. For aerials it is recommended that they be as high as possible and kept as far as possible from the house and any disturbing wiring;

it is also suggested that the lower part may be screened and in some cases the screen used as a counter-capacity instead of employing an earth connection. If an earth connection is used, it should be as short as possible, and not parallel to interfering leads. Little is said about the receiving set beyond suggesting screening and the insertion of filters in the supply leads.

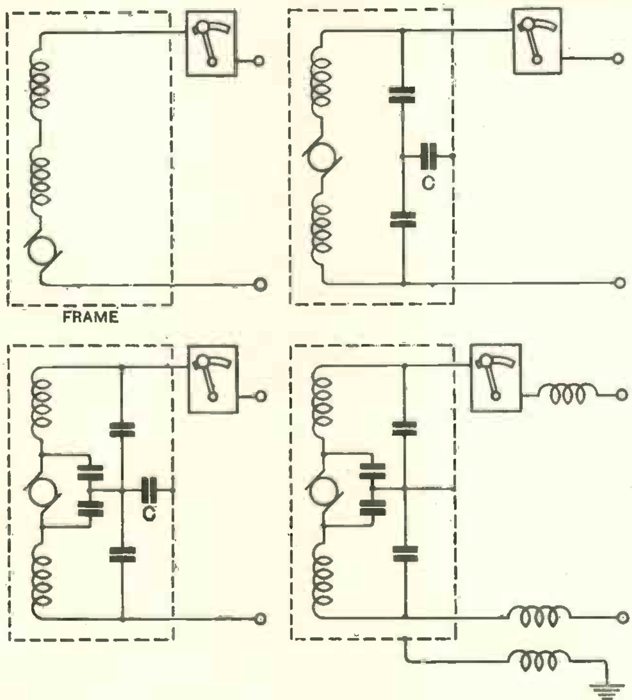


Fig. 1.—*If the frame is earthed, the condenser C is replaced by a direct connection.*

The second draft dealing with the steps to be taken to render electrical machines and apparatus innocuous gives a great many diagrams showing how the condensers and choke coils may be connected. It is emphasised that the condensers and coils must be so constructed that they do not decrease the efficiency or the reliability of the apparatus to which they are fitted. Special stress is laid upon the importance in all new construction of the symmetrical distribution of the field windings with respect to the armature. If in a series motor the field winding is divided into two parts with the armature connected between them, they will serve as chokes and protect the external circuit from disturbances arising at the commutator. Further protection is then obtained by connecting condensers of about 0.1 μF across the whole machine and, if this proves insufficient, other such condensers across the armature. Finally, if all these prove insufficient, choking coils should be inserted in the supply wires. In all the diagrams the steps are numbered in the order in which they should be applied. Diagrams are given for series and shunt motors, motors with commutating poles and for rotary converters. If the frame of the machine is not earthed, a condenser should be connected between it and some point of the winding to provide a path for high-frequency currents. As an example of the successive application of protective devices diagrams are given for a series motor. As a final step a choking coil is even inserted in the earthing lead from the frame of the motor.

It is suggested that switches need only be considered when they are operated very frequently. If the switch arcs on break it causes little interference, but if it only sparks it is much more troublesome and should be shunted with a condenser; if necessary, a damping resistance should be inserted in series with the condenser. Still further protection is obtained by inserting choke coils on either side of the switch as shown in Fig. 2. This applies also to signalling apparatus in which contacts are made and broken. It is stated that the values of the condensers lie between 0.1 and 2.0 μF and of the resistances between 5 and 500 ohms, the best values being determined by experiment in each case.

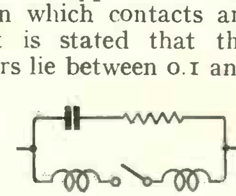


Fig. 2.

In the case of electric bells the contact should be connected between the windings of the two magnet cores, in addition to being shunted by a condenser and resistance. In extreme cases, choking coils may have to be inserted in the leads and a condenser connected across them as in the series motor. Somewhat similar precautions should be employed with vibrating contact rectifiers.

Special arrangements are necessary with rotary rectifiers for supplying X-ray and dust depositing plant. High resistances or choke coils of low capacity should be inserted in the leads from the contacts, in addition to filters on the primary side of the transformer. Filters should also be fitted to the primary side of the filament-heating transformer for hot cathode X-ray tubes. If these precautions are insufficient the whole apparatus should be metallically screened in a Faraday cage. It is stated that large mercury rectifier plants do not as a rule cause any disturbance, but that in small ones condensers should be connected between the cathode and the anodes, and, if necessary, high-frequency chokes inserted in the anode leads between the anodes and the condenser tappings. The same applies to any form of gaseous rectifier. In the case of Tesla coil medical apparatus, filters should be inserted between the apparatus and the mains, and the open oscillatory circuit should be " closed " by bringing out a connection from the other terminal of the Tesla coil—if necessary, through a condenser—and using it to screen the working electrode.

Diathermy apparatus is very troublesome, and a filter of several sections should be inserted in the supply wires and kept remote from the high-frequency apparatus and operating leads. If necessary, the high frequency part of the apparatus, including the patient, should be enclosed in a metallic screen.

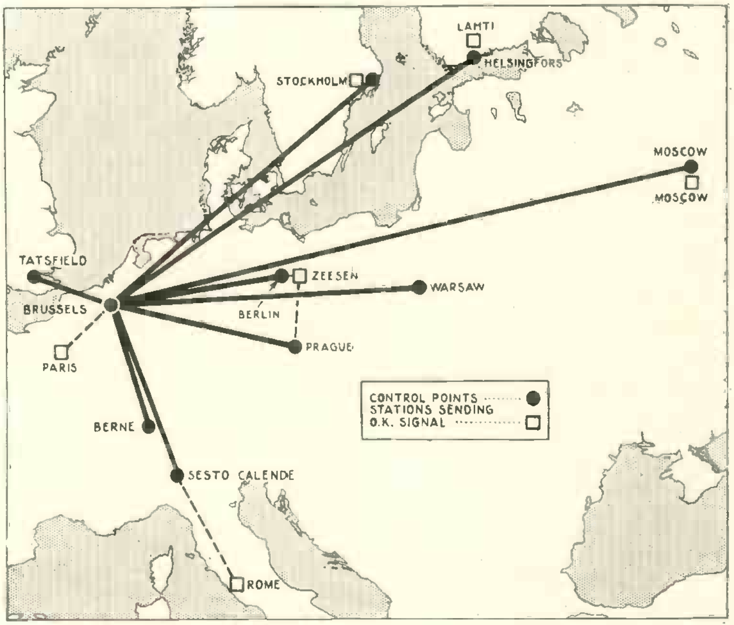
It is pointed out that radio-receiving sets may themselves be the source of interference, not only due to the well-known oscillations set up by excessive back-coupling, but also due to faulty connections in the set or aerial and contact between the aerial and surrounding bodies. It is stated that the latter can cause wide-reaching interference. It is also stated that excessive back-coupling may cause interference in neighbouring receivers even if it is not carried to the point of oscillation. Another cause of interference is the modulation at the supply frequency of the carrier frequency picked up by the supply leads and passed into the rectifier unit.

What legal force, if any, will be given to these regulations when they have been approved we do not know, but they will certainly be useful to any other body, such as our own Institution of Electrical Engineers, which is considering this important question.

G. W. O. H.

Lucerne Wavelength Plan

At 11 p.m. on 14th January all European broadcasting stations will close down. Then, one by one, in each of seven main groups, they will resume transmission according to special schedules, their new wavelengths being checked at the control points shown in the map. Certain high-power stations, also shown, will broadcast the results of each calibration. The centre of operations will be the Brussels checking station of the International Broadcasting Union.



High Power Pentode as an Electron Coupled Transmitter*

By J. C. W. Drabble and R. A. Yeo, B.Sc.

SUMMARY.—Experiments on electron coupled transmitters, using a silica pentode capable of dealing with an input of 4 kW. are described. Conditions for most efficient working are obtained. Both efficiencies and stability are comparable with those of a two-stage master oscillator transmitter. A method of modulating this pentode is investigated and it is found that it would be possible to modulate this 4 kW. pentode by means of a small receiving valve and transformer. The short wave limitations are discussed and found to be about 15 metres.

Introduction

A CERTAIN amount of work has been done by Lt. J. B. Dow† in America on electron coupled oscillators, that is, oscillators in which the coupling to the output or load circuit is provided by the electron stream reaching the anode of a four-electrode or screen grid valve, the output circuit being connected to the anode and the oscillatory circuit to the two grids of such a valve. This type of circuit has certain disadvantages, the two most important being :—

(1) The proximity of a high potential screen to the anode gives rise to secondary emission effects which are likely to cause considerable trouble.

(2) In order to prevent feed back from the driven to the driver circuit through the anode-screen capacity neutralisation is necessary unless an inverted type of circuit in which the screen is at zero high frequency potential is used.

Preliminary Experiments

The following investigation employing a pentode as an electron coupled oscillator was suggested from consideration of the fact that the earthed or suppressor grid of such a valve would act as an electrostatic screen and make neutralising unnecessary and secondary emission impossible. The work was started before it became known that Lt. Dow had continued his research, using the pentode, but so far as is known none of his results in that connection has yet been published.

The circuit used for the greater part of these experiments is shown in Fig. 1, where it will be seen that the driver circuit is of the Hartley type and is connected between the first and second grids, the output circuit being connected between anode and filament.

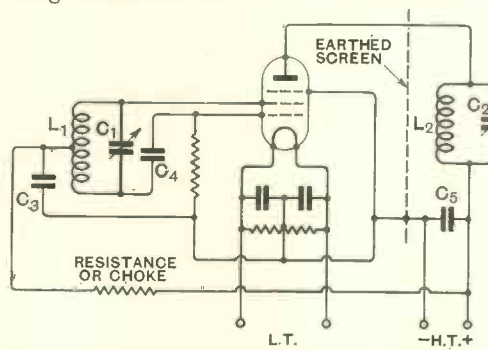


Fig. 1.—*Pentode connections for C.W. working.* $L_1 = 14\ \mu H$; $L_2 = 18\ \mu H$; C_1 *and* $C_2 = 0.0001\ \mu F$ (*max.*); $C_3 = 0.0002\ \mu F$; $C_4 = 0.0001\ \mu F$; $C_5 = 0.001\ \mu F$.

In the original experiments small receiving pentodes were used. Very promising results were obtained using a Marconi PT2, a two-volt pentode which works with a maximum potential of 150 volts on screen and anode when used as an output receiving valve. In these tests the potential used was never increased beyond 100 volts on both anode and screen.

With the driver circuit oscillating at a wavelength of 80 metres (3.75 megacycles/sec.) it was noticed that considerable changes in the applied H.T. voltage and in the tuning of the output circuit could be made without seriously affecting the generated frequency of the driver circuit. A 28 per cent. change in H.T. caused a change of 100 cycles/sec. in the driver frequency, representing a frequency change of one part in 37,500. Con-

* MS. received by the Editor August, 1933.

† "A Recent Development in Vacuum Tube Oscillator Circuits."—J. B. Dow, *Proc. I.R.E.*, December, 1931. "Electron Coupled Oscillator Circuits."—J. B. Dow, *Q.S.T.*, January, 1932.

siderable changes in output tuning were made without causing a greater change than 500 cycles/sec. in the master frequency. It was noticed with these small receiving pentodes that the optimum value of the grid leak was somewhat critical, for the PT2 being about 5,000 ohms. The Mullard PM22 would not work satisfactorily with this value of grid leak, but the investigation was not pursued to any extent with these valves as it was desired to proceed to high power as soon as it was ascertained that the circuit functioned as anticipated. A rough comparison was carried out with 100 volts H.T. between the pentode circuit using a PT2 and a two-stage master oscillator transmitter using PM202 valves both as master and output. The efficiency of the pentode circuit appeared to be slightly less but the frequency stability slightly better than the two-stage transmitter.

It should be understood that these tests were only considered to be in the nature of preliminary experiments and no elaborate precautions were taken to obtain the best working conditions with these small valves. The input and output circuits were arranged as far apart as practicable and the coils placed at right angles to each other, but no screening was used. This precaution would possibly have given still further improvement to the frequency stability and possibly to the efficiency. The use of one of the more recent screened pentodes in which the anode is brought out to a terminal on the top of the envelope offers further possibilities for improved working owing to the absence of capacity between screen and anode leads in the pinch.

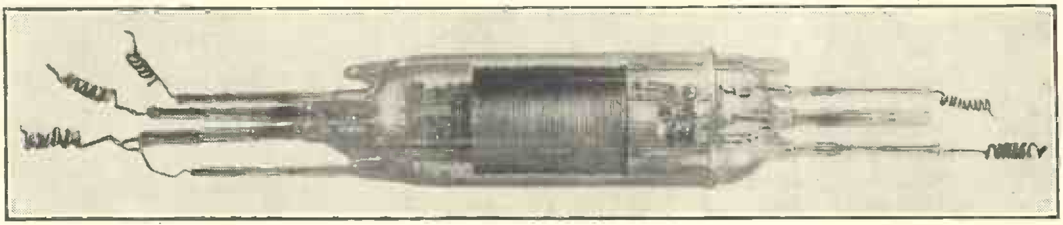


Fig. 2.—*Silica Pentode constructed in H.M. Signal School, Portsmouth.*

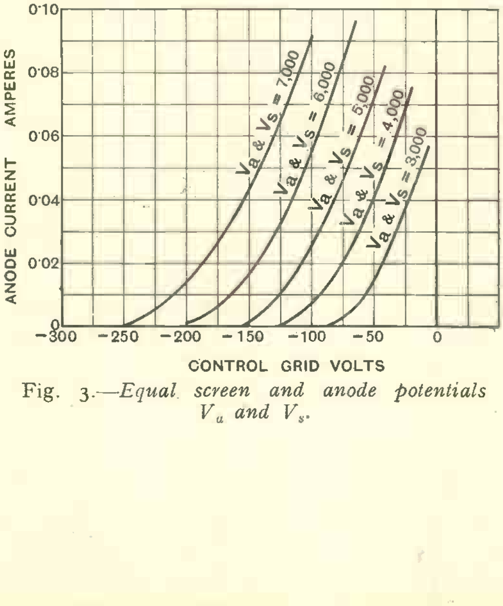


Fig. 3.—*Equal screen and anode potentials* V_a *and* V_s.

The work with the small receiving pentodes appeared to be so promising that it was decided to proceed to high power experiments with the largest pentode available.

Description of Silica Pentode

This valve which was constructed in H.M. Signal School, Portsmouth, is illustrated in Fig. 2. The envelope is made of transparent fused silica and is 10 cms. in diameter and 32 cms. in length. Including seals, the overall length of the valve is 60 cms. All seals are of the lead plug type with molybdenum rods as internal conductors and flexible stranded copper external conductors.

The anode and high tension screen seals are brought out at one end, and suppressor screen, grid and both filament seals at the other.

The filament is a loop of pure tungsten wire kept in tension by a spring and has a total length of 30 cms. and diameter of 0.7 mm. This requires a heating current of 28 amps. at 15 volts. The dimensions of the other electrodes which are cylindrical in form are as follows :—

Electrode.	Diameter in cms.	Length. in cms.
Control grid	3.0	16
H.T. screen	4.5	18.5
Suppressor screen . .	6.0	14.0
Anode	8.0	12.0

The three grid structures are built of molybdenum wire, 0.15 mm. diameter, in a 1.5 mm. mesh construction. The anode is made of molybdenum strip wound basket fashion to a cylinder of the size given. During bombardment the control grid was joined to filament and a power of 4.8kW. was dissipated by the other electrodes which were all joined together and to the high tension supply.

This valve was not designed for the purpose outlined in these experiments, having, in fact, several disadvantages from that point of view, the two most important being :—

(*a*) The H.T. and suppressor screens have a closer mesh construction than is desirable. This will be seen by reference to the static characteristics of the valve which are shown in Figs. 3, 4 and 5. These reveal the fact that with equal potentials on anode and screen, the screen current is in general greater than the anode current. Thus, when this valve is used as an electron coupled oscillator, the driver portion absorbs an unnecessarily large proportion of the total input and so reduces the overall efficiency. These facts are all confirmed in the subsequent experimental work.

(*b*) In order to obtain the greatest amount of screening between driver and driven circuits, the anode seal should be brought out at one end, all the remaining seals being brought out at the other. In addition to allowing considerable improvements in screening, it would also be possible to obtain a better circuit lay-out of the driver circuit, a point which is of considerable importance when it is desired to work at short wavelengths.

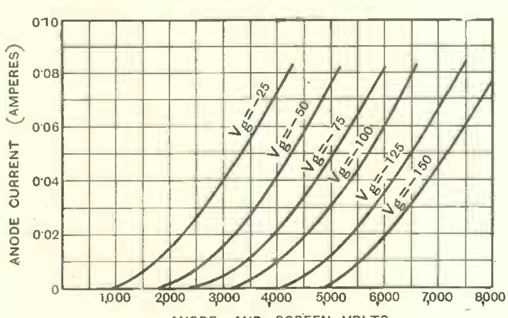


Fig. 4.—V_g = *control grid volts.*

Optimum Load

In order to obtain accurate figures for the efficiency of this valve, preliminary tests were carried out to ascertain the optimum load impedance for the output circuit. A

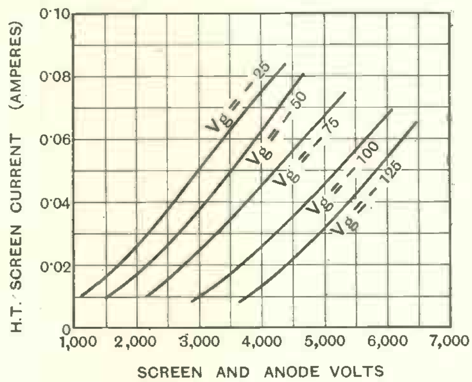


Fig. 5.—V_g = *control grid volts.*

Hartley circuit consisting of 15 turns of ⅜-inch copper tubing on a 5-inch former and 100 μμF. variable condenser set at maximum was connected between grid and H.T. screen, and this including valve capacities tuned to 80 metres. The output circuit consisted of 9 turns of ⅜-inch copper tubing on an 8-inch former and a 100 μμF. variable condenser. With the latter set at 77 μμF. this circuit also tuned to 80 metres. A series of readings of input and output power were taken, the variations being made by connecting various values of resistance in the tuned output circuit. These readings are shown plotted in Fig. 6 and indicate that for the circuit used the best output is obtained with a resistance of the order of 9–12 ohms in the output circuit. This corresponds to an output load impedance of from 15,000 to 20,000 ohms taking into account anode-screen capacity in parallel with the tuning capacity, but it will be seen that the value is not very critical. This estimate of optimum anode load impedance was made for three values of applied voltage, both anode and screen potentials being the same. Another estimate of optimum load impedance was made with the screen at a lower potential than the anode. With 3,000 volts on the anode and 2,300 on the screen, the optimum load impedance does not change very considerably, having a slightly higher value.

In this case, the lower screen potential was obtained by inserting a resistance in the H.T. lead from the common supply. It may be mentioned here that it was found necessary to insert a high frequency choke or a resistance of at least 1,000 ohms in this lead in order to eliminate coupling between driver and driven circuits *via* the common H.T. supply; if this was not done, the two circuits combined to form an inefficient oscillatory circuit of longer wavelength than that to which either was tuned.

In all of the subsequent tests on 80 metres (except those on frequency stability), the series high frequency resistance of the output tuned circuit was 9 ohms, a value which was checked in a separate experiment. This is equivalent to a load impedance of about 20,000 ohms and it will be seen that this represents a load fairly near the optimum for most conditions under which the valve was subsequently operated.

Optimum Conditions for the Driver Circuit

The next set of readings was taken in order to determine the best value of grid leak

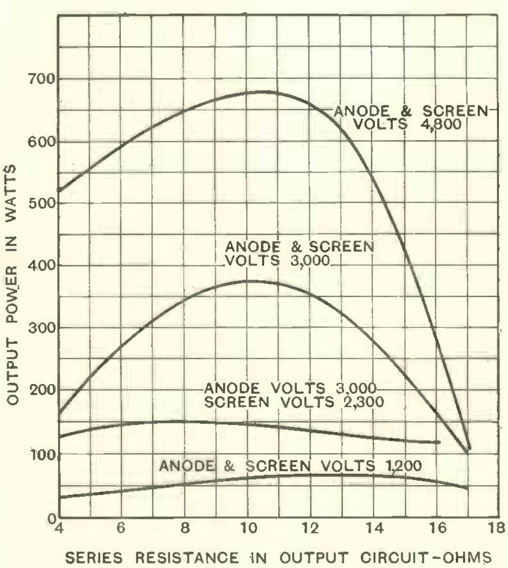


Fig. 6.—*Grid leak 2,500 ohms; driver circuit tapping 6½ turns from grid.*

resistance and tapping point on the coil of the driver circuit. The anode and screen volts were kept constant at 3,000. Curves plotted from the readings taken are shown in Fig. 7. In determining the best working conditions of the circuit, it is necessary to take into consideration the four factors: output watts, overall efficiency, efficiency of the output stage, and the ratio of input power to anode stage over total power input. This last factor is of some considerable importance in a circuit of this nature as it

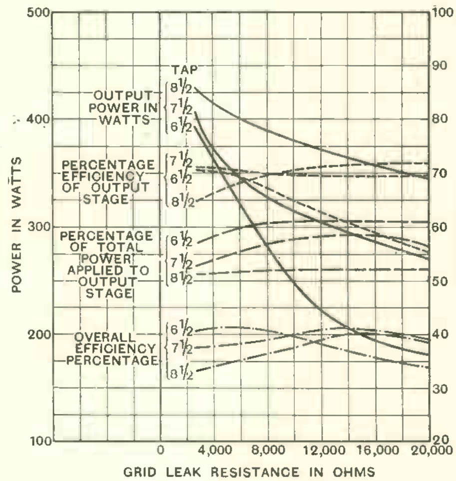


Fig. 7.—*Anode and screen volts = 3,000.*

gives some indication of the percentage power which is dissipated by the screen which forms the anode of the master circuit. It is quite obvious that as this is of mesh construction, the amount of power which is dissipated by it should be as low as possible and hence the ratio of input power to anode stage to total power input should be as high as possible. This applies more especially to the valve used in these experiments since the H.T. screen was not intended to dissipate a very large proportion of the input. A valve designed for an electron coupled transmitter should have a much more robust H.T. screen built up of thicker wire. On the other hand, the high values reached for the efficiency of the output stage indicate that, if necessary, the anode could be of a much lighter construction than that used, since it is not called upon to dissipate a very large proportion of the input power.

Taking all of the factors into consideration, it will be seen that the best conditions are obtained with a grid leak value of the order of 2,500 ohms and with a tapping on the driver circuit about 6½ turns from the grid end. With these conditions, the overall efficiency is just over 40 per cent. and the efficiency of the output stage just over 70 per cent. These efficiencies are comparable with those of a two-stage master oscillator transmitting on this frequency, that of the output circuit having reached almost the maximum efficiency of a class B amplifier stage. The percentage of the input power which is absorbed in the driver stage is of the order of 40 per cent. so that it may be assumed that the screen forming the anode of the driver stage is called upon to dissipate not more than 25 per cent. of the total input. The H.T. screen in this valve is just capable of dissipating this proportion of the total input at full load input of 4 kW. With a valve having H.T. and suppressor screens of more open mesh, the proportion of power dissipated by the screen could be reduced considerably and the overall efficiency increased.

It is interesting to note from the curves that as the tapping on the master circuit is moved away from the grid, that is, as the excitation is increased, the maximum value of overall efficiency is obtained with higher values of grid leak. This is what one would expect with a triode oscillating valve.

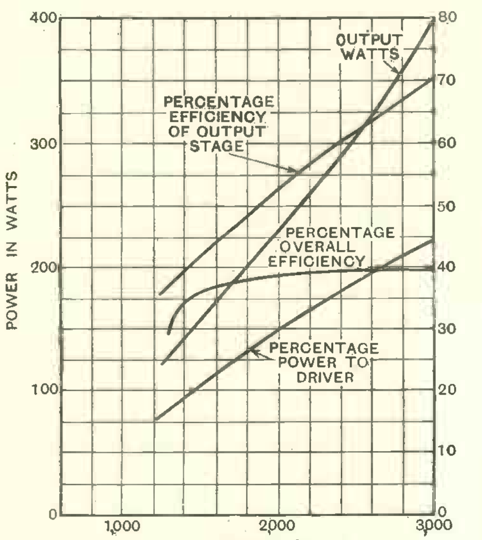


Fig. 8.—*Anode volts = 3,000 ; grid leak = 2,500 ohms.*

In order to determine the influence of screen voltage on power output and efficiencies, a set of readings was taken and are shown plotted in Fig. 8. It will be noticed that all of the curves have a rising characteristic although the overall efficiency curve flattens out after the screen volts exceed

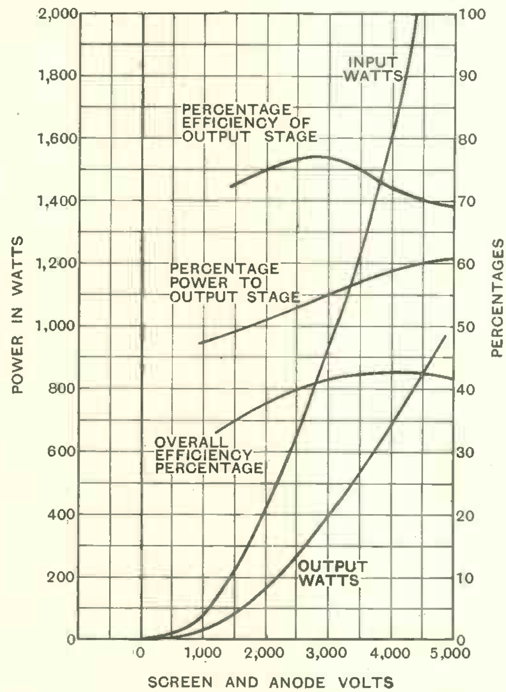


Fig. 9.—*Grid leak 2,500 ohms ; driver circuit tapping $6\frac{1}{2}$ turns from grid.*

50 per cent. of the anode volts. It is interesting to notice that the output watts rise as the anode volts are raised relatively to the screen volts, and at this point the overall efficiency is also at a maximum. Although the percentage of power absorbed in the driver rises with rise in screen volts, this is counterbalanced by the rise in efficiency of the output stage.

Efficiency when Working with Optimum Conditions

With the valve working with the complete set of optimum conditions as determined in the previous experiments, that is, driver tapping point $6\frac{1}{2}$ turns from the grid, grid leak resistance 2,500 ohms, output load impedance 20,000 ohms and equal voltages on screen and anode, a set of readings was taken to show the variation of efficiency and output with variation of anode and screen volts. These curves are shown in Fig. 9. The efficiency remains fairly constant at a value just above 40 per cent. when the voltage exceeds 3,000. The efficiency of the output stage reaches the very high value of 77 per cent. at about 3,000 volts potential, but falls off slightly beyond this value. These experiments were carried out in a laboratory fitted with a limited power supply which fixed the upper limit of supply voltage to the valve at about 5,000 volts. It is considered, however, that this voltage could be increased to 6,000 without exceeding the maximum load which the valve is capable of withstanding. The output power would then be about 1.6 kW.

Frequency Stability

Measurements of frequency stability were made at a wavelength of 80 metres. The ratio L/C of the output circuit was reduced considerably for this experiment in order that finer variations of tuning could be made. The constants used were C (including anode-screen capacity) 347 $\mu\mu$F., $L = 5.2$ μH.

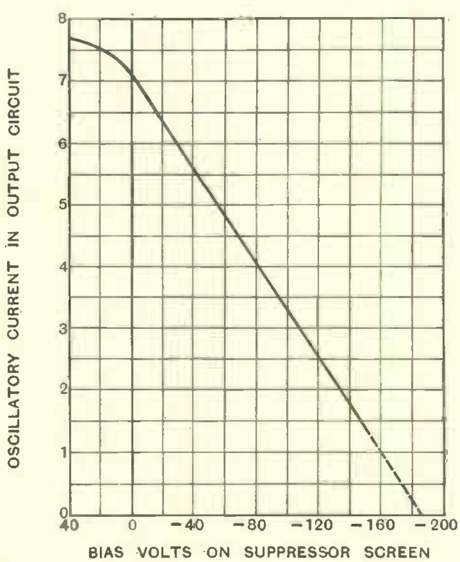


Fig. 10.—*Oscillatory current in output circuit. Anode and screen volts* 3,000 ; *grid leak* 2,500 *ohms.*

The high frequency resistance of this circuit was such that the anode load impedance was very near optimum value. The tuning capacity of the output circuit was decreased to 306 $\mu\mu$F. and a change in frequency of 1,000 cycles was observed. An increase in capacity from the tuning point to 388 $\mu\mu$F. gave the same change of frequency. Thus a variation of about 12 per cent. on either side of the tuning capacity caused a change of about 0.025 per cent. in the generated frequency. Even with the worst weather conditions, the change of aerial capacity in a ship, due to roll and wind, would never attain this high value.

A variation in H.T. from 1,200 to 4,800 caused a frequency change of not more than 1,000 cycles, the change being in the sense of an increase in frequency for an increase in voltage. This represents a frequency change of one part in 3,750 when the H.T. voltage is varied in the ratio of 1 to 4.

The filament volts were varied one volt on either side of the working voltage, the total change of frequency observed being about 1,500 cycles in the sense of an increase in frequency for a decrease in filament volts.

If the supplies for H.T. and filament were obtained from the same machine, the frequency changes due to variation of these voltages would, to some extent, cancel each other.

Modulation

During the preceding experiments, the suppressor screen was connected to the mid point of an equalising network of resistance and capacity connected across the filament of the valve. Using the original output circuit having an equivalent impedance of 20,000 ohms, a set of readings was taken to determine the relation between a bias voltage applied to this screen and the oscillatory current in the output circuit, the anode and screen potentials being maintained at 3,000 volts. The bias battery was shunted by a fixed condenser. Curves plotted from the readings taken are shown in Fig. 10. Between 0 and −185 volts bias, the oscillatory current bears a linear relation with bias volts. When the bias volts are increased in a positive direction, the curve begins to bend over. Thus, with 3,000 anode and screen volts and a fixed bias of about −90 volts, distortionless modulation for I.C.W. or speech transmission could be obtained with a 100 per cent. modulation, by applying an alternating voltage of 90 volts peak value to the suppressor screen. It will be observed that the required modulating voltage is a very small proportion of the anode potential and at this point of the investigation, it appeared that a very small valve of the receiving

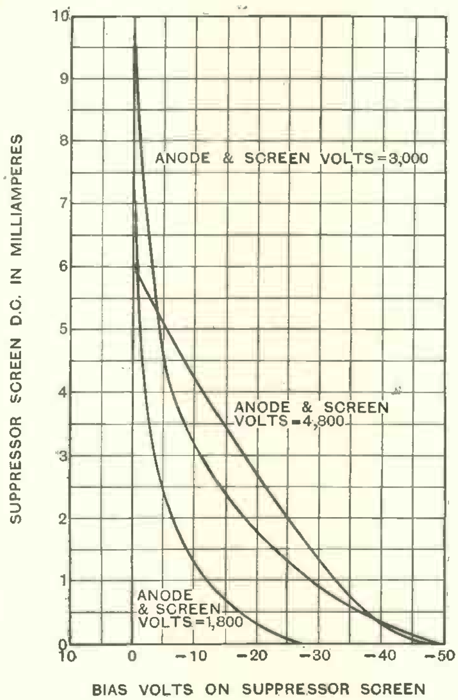


Fig. 11.—*Grid leak 2,500 ohms; driver circuit tapping 6½ turns from grid.*

general purpose type with its associated transformer would supply the voltage swing necessary to modulate completely this 4 kW. pentode. Before, however, coming to any hasty conclusions, it was considered advisable to ascertain whether any direct current flowed between suppressor screen and filament when the former was at a negative potential with respect to the latter. Readings were taken with three values of anode potential and the curves are shown plotted in Fig. 11. Here it will be seen that the greatest current at zero bias volts was 9.5 m.a. and this was obtained with an anode and screen potential of 3,000 volts. With the higher potential of 4,800 volts, the current at zero bias volts is less; it is also less with 1,800 volts. To check these readings a curve was plotted to show the relation between anode and screen volts and suppressor screen current with zero bias volts. This curve is shown in Fig. 12 and confirms the results shown in Fig. 11. These curves indicate that a certain amount of power will be absorbed by the suppressor screen when a modulation is applied to it though undistorted modulation of the transmitter still lies within the capabilities of a small receiving valve, possibly of the power type. The fact, however, that the screen did take current when at a negative potential, required some explanation. It was at first thought possible that an electron oscillation of the Barkhausen-Kurz type was being produced. To test for this, the suppressor screen was connected to the filament *via* a pair of Lecher leads bridged by a movable thermo ammeter. A reading was obtained in the ammeter which varied with the anode potential up to 3.5 amps. at 4,800 volts, but this reading did not vary with the position of the ammeter on the Lecher leads. The wavelength of the current in this circuit was measured and found to be 80 metres and is, of course, the capacity current fed from the driver and driven circuits *via* the inter-electrode capacities. It was decided that electron oscillations were not present,

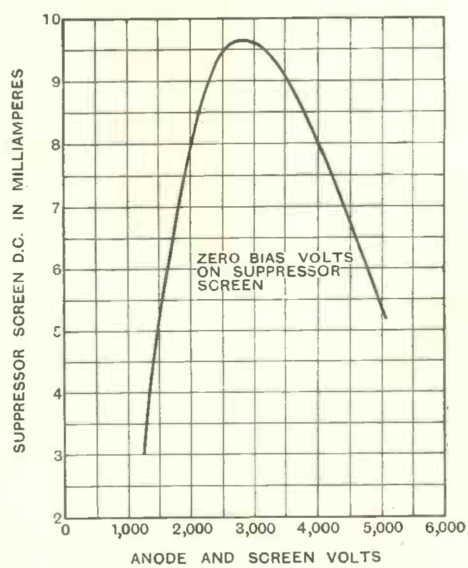


Fig. 12.—*Zero bias volts on suppressor screen; grid leak 2,500 ohms; driver circuit tapping 6½ turns from grid.*

the current taken by the suppressor grid being accounted for by the fact that the large capacity current from the main circuits will run this electrode positive during some part of the cycle if any impedance is present in the path from suppressor grid to filament. In the case of the silica valve this path is inevitably somewhat long owing to the length of seals.

The shape of the curve in Fig. 12 cannot be at present explained.

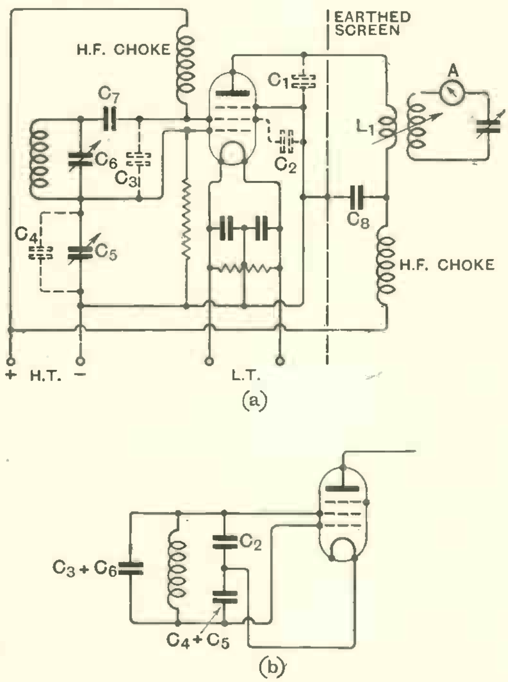


Fig. 13.—*Inter-electrode capacities shown at* C_1, C_2, C_3, C_4.

At the conclusion of these modulation tests, an observation of frequency stability was made for a change of bias volts on the suppressor grid. The bias voltage was varied from 0 to − 150 and no change of generated frequency was observed. Thus, amplitude modulation performed by this method would be entirely free from frequency modulation.

Lower Wavelength Limit

An attempt was made to determine the lower wavelength limit at which this circuit would operate satisfactorily. It soon became obvious that with a Hartley circuit as the driver circuit, the large interelectrode capacities rendered it impossible to obtain satisfactory operation below about 25 metres. It will be appreciated that the capacity between the suppressor screen and the H.T. screen forming the anode of the driver circuit, which is for this valve about 20 cms., unbalances the driver circuit when the tuning capacity is small. In order to avoid this difficulty, the circuit was changed to that shown in Fig. 13a. In this arrangement, the driver circuit is of the Colpitts type requiring no tap on the coil. The circuit can be redrawn as shown in Fig. 13b and it will be seen that the correct tapping is obtained by adjustment of C_5. The output circuit was also modified as shown in Fig. 13a, L_1 being a single turn coil of lower impedance than C_1. With this arrangement the transmitter worked satisfactorily down to 15 metres. Owing to the inevitably large interelectrode capacities in a pentode of this size, it would be impossible to obtain a sufficiently large ratio of $\frac{L}{C}$ for the driver circuit below this wavelength. Frequency doubling was tried but the overall efficiencies were so low, of the order of 5 per cent., that experiments were not pursued in this direction.

Conclusions

1. As a method of securing frequency stability, this pentode circuit compares favourably with a two-stage master controlled transmitter.

2. The ratio input to the driver circuit to total input is undoubtedly higher than in the case where two separate valves are used, reaching values of about 45 per cent. for conditions of optimum output. Owing, however, to the high efficiency of the output circuit, which in some cases reaches a value of 77 per cent., an overall efficiency of 40 per cent. or over can be easily obtained. It is probable that a valve designed without the disadvantages mentioned in the description, that is, with screens of more open mesh, the proportion of power absorbed in the driver could be reduced and the overall efficiency increased.

3. The highest values of efficiency are obtained with low values of grid leak, the driver circuit coil tapped near the centre, and the same voltage applied to both anode and screen.

4. Distortionless modulation up to 100

per cent. for I.C.W. or speech transmissions can be carried out with small expenditure of power and complete absence of frequency modulation.

5. For short wave working, the Colpitts circuit offers certain advantages over any other type of circuit, when used with the pentode as an electron coupled transmitter. Smaller valves having lower inter-electrode capacity would enable shorter wavelengths than 15 metres to be reached. In this connection, a small pentode of the 500-volt type now available on the market, might find considerable applications among amateur transmitters and others who desire to construct one-valve master controlled transmitters, if valve manufacturers could fetch the suppressor grid out to a separate terminal or pin. A valve of this type could most probably be completely modulated direct from a microphone transformer.

The experimental work on which this article is based has been carried out at H.M. Signal School, Portsmouth, and the article is published with the permission of H.M. Board of Admiralty.

Book Review

Elements of Engineering Acoustics.

By Dr. L. E. C. Hughes. Pp. 159. Ernest Benn, Ltd., 154, Fleet Street, E.C.4. 1933. Price 8s. 6d.

Gramophones, broadcasting, and talking pictures mark the culmination of various stages of development in methods of simultaneously addressing large numbers of people, and in all these stages enormous popular interest has been aroused both on the part of the inventor and the listener. As an almost inevitable result the earnest student has been inadequately catered for and, in default of serious treatment of the subject at the Universities, he has suffered from piecemeal presentations of the more spectacular items in popular journals.

This defect has now been remedied to some extent by the institution of a Course in Electrical Communication at the City and Guilds Engineering College. The neglected child of Physics and Engineering has thus attained to adult dignity worthy of being recognised by the University of London. In the volume under review the elements of the subject of Engineering Acoustics are given by Dr. Hughes, who is Lecturer in the Course referred to, and it is refreshing to find an account of the fundamental principles stripped of the complexities which accrue in the actual design of a system containing a microphone, an amplifier, and a reproducer.

Considerable space is devoted to methods of measuring the gains and losses in the various links of the chain and attention is frequently drawn to the necessity of adhering to a logical system in such measurements. Thus the power level at any stage in an amplifier must be measured when the amplifier is properly terminated with an impedance equal to the impedance of the output load. Also the sound output of a telephone receiver is only of interest when the receiver is held against an artificial ear; results obtained when the receiver is held in open air are valueless.

In quantitative measurements the condenser transmitter is a most useful sub-standard for the calibration of microphones and reproducers. Calibration over a range of frequency at a low power level is not sufficient since amplitude and frequency distortions may arise at higher levels. Thus the amplitude distortion of an average telephone transmitter, as shown by the curve on p. 83, rises so rapidly with speech level that it is easy to see why little is gained in intelligibility by speaking loudly.

A novel conception appears in p. 11 in the use of the term *acoustic-ratio* to express the gain in decibels of the direct intensity of a sound over the reverberant intensity due to echoes from the walls and contents of a room. When this ratio is high the sound is *hard*, when low it is *mellow*. In the studio the acoustic-ratio is affected by room reverberation and by the directional variation in pick-up of the microphone, while in the auditorium the factors are reverberation and the concentration of high frequencies along the axis of the loud-speaker. The combination of these factors may give the same result as if the listener were placed very close to the source of sound so that the sound is extremely hard for high frequencies but not for lower frequencies—a subtle departure from fidelity which the author calls *acoustic-distortion*. The effect is so serious in talking pictures that the beam effect must be eliminated by pointing the horns towards a wall.

Another useful conception is that of *surface-loudness*, akin to surface-brightness in optics. It is the emission per unit area of the source and is large in speech but small in orchestral music. Hence when an orchestra is reproduced by a small loud-speaker the surface-brightness is excessive and the listener suffers from *sound-dazzle*.

The fundamental ideas, with which the author says he is primarily concerned rather than with formulæ, are clearly expressed and the anatomy of the subject is boldly shown without too much fleshy padding. Nevertheless, the condensation seems excessive and one would welcome larger type, more headlines, an appendix devoted to definitions with numerical examples, and a general expansion in treatment. In the second edition which will undoubtedly soon be called for, this book, which is probably destined to be the standard treatise on Engineering Acoustics, might well incorporate such features to the advantage of its readers. R. T. B.

"The Tilt of Radio Waves and Their Penetration into the Earth," editorial, *The Wireless Engineer*, November, 1933. In the last line of the left-hand column on page 591 "last line but one" should read "last line but two."

Circle Diagrams of Valve Input Admittance and Amplification Factor*

By F. M. Colebrook, B.Sc., D.I.C., A.C.G.I.

1. Object and Scope of the Paper

IN a previous paper[1] the writer has given a generalised analysis of valve input-admittance and voltage-amplification. A recent re-examination of the matter has shown that in certain cases of particular practical interest the variation of both these quantities can be shown very simply on circle diagrams, which have the advantage of clear physical interpretation and which enable the most important features of the variation to be formulated without elaborate calculation.[2] The particular cases concerned include all those in which the variation of the anode-circuit impedance, with tuning or with frequency, can be represented as that of a constant resistance in parallel with a variable reactance. Examples are tuned anode circuit or tuned-transformer amplifying stages, and audio-frequency intervalve coupling transformers. The object of the present paper is to call attention to the circle diagrams for amplification and input admittance for such cases both for audio and radio frequencies, and to demonstrate by this means the more important practical conclusions.

The discussion applies principally to triode valves, but is equally applicable to screen-grid valves in so far as conditions of operation are such as to give approximate validity to an assumption of constant mutual conductance and internal resistance.

2. The Triode Valve Equivalent Network

The network considered is illustrated in Fig. 1. Though twelve years have elapsed since this equivalent circuit was originally published and discussed by Miller in his classical paper in the *Bull. of the Bureau of Standards* (Vol. 15, p. 367), no reason has been found to modify it in any essential respect. Hartshorn has shown[3] that the interelectrode capacities have appreciable power-factors and also[4] that they will vary somewhat with the space-charge conditions of the valve. Both of these factors can be allowed for if desired, but the gain in quantitative accuracy is hardly worth the additional complication of the analysis. The equivalence of the network is admittedly approximate, since some of the quantities assumed to be constant are not quite constant in fact, but the network is nevertheless very valuable as a practical simplification of an otherwise very complicated system and is justified by the results obtained.

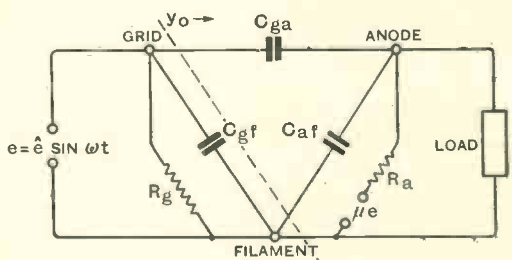


Fig. 1.

The total input admittance will contain terms due to the actual grid-filament capacity C_{gf}, and actual grid-filament resistance R_g, due to grid-filament convection current, if any, or perhaps to an actual grid-leak. There will be in addition an effective admittance due to the so-called "Miller effect," arising from the action of the grid-anode capacity. The paper is concerned with the last only of these components. As a further simplification, the anode-filament capacity C_{af} will be considered as associated with the anode circuit load, and will not be explicitly referred to as a separate component.

* MS. received by the Editor, December, 1932.

[1] "A Generalised Analysis of the Triode Valve Equivalent Network," *J.I.E.E.*, 1929, Vol. 67, p. 157.

[2] Since the present article was written the author has come across a similar development of input admittance in terms of circle diagrams, by Y. Watanabe (selected papers from the *J.I.E.E., Japan*, No. 21, Dec., 1928). Watanabe has confirmed the theory by measurement at 100 kc/s.

[3] *Proc. Phys. Soc., London*, 1926–7, Vol. 39, p. 108.

[4] *Wireless Engineer*, 1931, Vol. 8, p. 413.

The network is thus reduced to the somewhat simpler diagram of Fig. 2. It will be sufficient to remember that the actual input admittance of C_{gf} and R_g must be added to the effective input admittance of the system to the right of the line $\dot{y}_0$ as shown in Fig. 2, and that the admittance of the anode-filament capacity

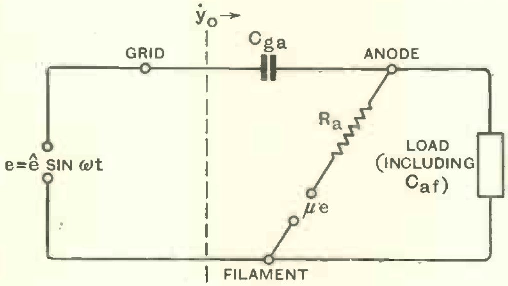


Fig. 2.

must be added to that of the actual anode circuit load. With this understanding the input admittance $\dot{y}_0$ will be written in the form

$$\dot{y}_0 = G_0 + jS_0$$

and the anode circuit load admittance as

$$\dot{y} = G + jS.$$

The valve a.c. conductance will be written as $G_a = 1/R_a$, the amplification factor as μ, and the mutual conductance μG_a will be written as g. The input e.m.f. is considered to be a maintained e.m.f. $e = \hat{e}\sin\omega t$, represented by the vector e, and the voltage amplification v/e is represented by the operator $\dot{m}$.

3. Operational Expressions for Amplification and Input Admittance

The circuit analysis is quite straightforward and is given in the earlier paper. The results are

$$\dot{y}_0 = \left(\frac{g + G_a + \dot{y}}{G_a + j\omega C_{ga} + \dot{y}}\right) j\omega C_{ga} \quad \ldots \quad (1)$$

$$\dot{m} = \frac{j\omega C_{ga} - g}{G_a + j\omega C_{ga} + \dot{y}} \quad \ldots \quad \ldots \quad (2)$$

Separation of $\dot{y}_0$ gives

$$G_0 = \frac{\omega C_{ga}(G_a + G + g) + gS}{(G_a + G)^2 + (S + \omega C_{ga})^2}\,\omega C_{ga} \quad \ldots \quad (3)$$

$$S_0 = \frac{(G_a + G)(G_a + G + g) + S(S + \omega C_{ga})}{(G_a + G)^2 + (S + \omega C_{ga})^2}\,\omega C_{ga} \quad \ldots \quad \ldots \quad (4)$$

The magnitude of $\dot{m}$ is

$$m = \left\{\frac{(\omega C_{ga})^2 + g^2}{(G_a + G)^2 + (S + \omega C_{ga})^2}\right\}^{\frac{1}{2}} \quad \ldots \quad (5)$$

$$\approx \frac{g(1 + \omega C_{ga}/2g)}{\{(G_a + G)^2 + (S + \omega C_{ga})^2\}^{\frac{1}{2}}} \quad \ldots \quad (6)$$

assuming $\omega C_{ga} << g$.

4. The Anode Circuit Load

As an example of a load circuit which fulfils very approximately the conditions already specified in section 1, we may assume a coil of inductance L and resistance R, tuned by a parallel connected condenser of capacity C. The admittance of such a circuit is given by

$$\dot{y} = \frac{R}{R^2 + \omega^2 L^2} + j\left(\omega C - \frac{\omega L}{R^2 + \omega^2 L^2}\right) \quad \ldots \quad (7)$$

i.e., very approximately

$$\dot{y} = \frac{R}{\omega^2 L^2} + j\left(\omega C - \frac{1}{\omega L}\right) \quad \ldots \quad \ldots \quad (8)$$

if $R^2 << \omega^2 L^2$. This will be abbreviated to

$$\dot{y} = G + jS \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

For variation of C, the admittance is that of a constant resistance (the so-called "dynamic" resistance of the tuned circuit) in parallel with a variable reactance. The same is very approximately true of variation with respect to frequency, since G will change comparatively little over the narrow range of frequency covered by the resonance curve.

The similar description of the tuned radio-frequency transformer and the audio-frequency transformer is quite familiar and need not be detailed.

In the following, therefore, it will be assumed, unless otherwise stated, that G is constant and S variable, either with frequency or circuit tuning.

5. The Circle Diagrams for Input Admittance and Voltage amplification

The complex quantity $\dot{r}$ defined by

$$\dot{r} = (\dot{a} + \dot{b}\epsilon^{-j\theta})$$

where $\dot{a}$ and $\dot{b}$ are constant complex numbers (or vectors) and θ is a variable angle, describes a circle of radius b (the magnitude of $\dot{b}$) having its centre at $\dot{a}$. The maximum and minimum values of $\dot{r}$ are clearly $(a \pm b)\epsilon^{j\alpha}$, α being the inclination of $\dot{a}$, and occur where $\dot{b}\epsilon^{j\theta}$ is parallel to and in opposition to $\dot{a}$ respectively.

By simple manipulations, which are detailed in an appendix, the expressions (1) and (2) for $\dot{y}$ and $\dot{m}$ can be put in the above form, thus

$$\dot{y}_0 = \frac{\omega C_{ga}}{2(G_a + G)}\Big[\{\omega C_{ga} + j(g + 2G_a + G)\} + (\omega C_{ga} + jg)\epsilon^{-2j\phi}\Big] \quad .. \ (10)$$

$$\dot{m} = \frac{j\omega C_{ga} - g}{2(G_a + G)}(1 + \epsilon^{-2j\phi}) \quad ... \ (11)$$

where

$$\tan\phi = \frac{S + \omega C_{ga}}{G_a + G} \quad .. \quad .. \ (12)$$

These expressions look somewhat cumbersome, but the corresponding diagrams are quite simple in form. They are shown in Figs. 3 and 4. (The quantity ωC_{ga} is here considered as a constant. The circular form will be very approximately valid even when ω is the variable, provided, as is usually the case, the variation of ϕ (*i.e.*, of S) with frequency is very much more rapid than that of ω.)

It will be seen at once that the input admittance has a positive component (corresponding to a capacity) and a conductance component which may be negative over a considerable range of load variation.

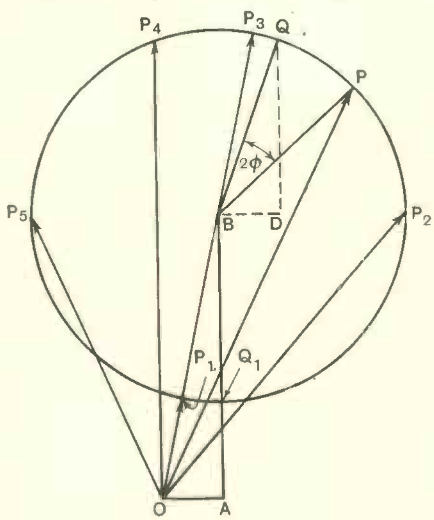


Fig. 3.—$OA = BD = k \cdot \omega C_{ga}$; $AB = jk(g + 2G_a + G)$; $DQ = jk \cdot g$; where $k = \frac{\omega C_{ga}}{2(G_a + G)}$; $OB = k \cdot \{\omega C_{ga} + j(g + 2G_a + 2G)\}$; $BQ = k\{\omega C_{ga} + jg\}$; $OP = \dot{y}_0$.

The relative magnitudes involved in the above diagrams will, of course, depend on particular cases. For illustration, the following valve quantities will be assumed.

$$G_a = \frac{1}{R_a} = \frac{1}{50{,}000} \text{ ohms} = 20 \times 10^{-6} \text{ ohms}^{-1}$$

$$g = 1 \text{ m.a. per volt} = 1{,}000 \times 10^{-6} \text{ ohms}^{-1}$$

i.e., $\mu = 50$

$C_{ga} = 4\mu\mu$F.

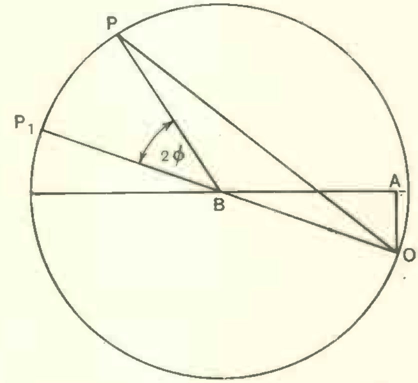


Fig. 4.—$OA = j\omega C_{ga}$; $AB = -g$; $OB = BP_1 = j\omega C_{ga} - g$; $BP = (j\omega C_{ga} - g)\epsilon^{-2j\phi}$; $OP = \dot{m}$.

The constant value of G (the conductance component of the anode circuit admittance) will be taken as

$$G = \frac{1}{200{,}000} \text{ ohms} = 5 \times 10^{-6} \text{ ohms}^{-1}$$

The forms taken by the diagrams for audio- and radio-frequencies will be considered separately.

6. The Circle Diagrams for Audio-Frequencies

At audio-frequencies ωC_{ga} will be negligible compared with g. Thus at 10 kc/s. ωC_{ga} will be only about 0.25×10^{-6} ohms^{-1}. The diagrams are then as shown in Figs. 5 and 6. The following particular points may be noted.

(*a*) G_0 is negative for all negative values of ϕ, *i.e.*, for all inductive loads. The maximum negative value of G_0 occurs when $2\phi = -\pi/2$, *i.e.*, $G = -S$, and is given by

$$G_0(\text{neg. max.}) = \frac{g}{2(G_a + G)}\omega C_{ga} \text{ ohms}^{-1} \ .. \ (13)$$

This is 5×10^{-6} ohms^{-1} (*i.e.*, a shunt resistance of 200,000) for the typical case quoted.

(*b*) The maximum positive value of G_0 is as in (*a*).

(*c*) The maximum value of y_0 is capacitive and occurs when $\phi = 0$ (*i.e.*, $S = 0$, the load being tuned or purely resistive). It is given by

$$y_0(\text{max.}) = S_0(\text{max.}) = \frac{(g + G_a + G)}{G_a + G}\,\omega C_{ga} \quad (14)$$

This is equivalent to $164\mu\mu$F. for the numerical case.

(*d*) The maximum value of m occurs when $S = 0$ (*i.e.*, when the circuit is tuned) and is given by

$$m = \frac{g}{G_a + G} \quad \ldots \quad \ldots \quad (15)$$

In an article on "Oscillation in Tuned Radio-frequency Amplifiers" (*P.I.R.E.*, Vol. 19, pp. 421–437) B. J. Thompson gives a limiting stability formula for a tuned r.f. stage using a screen-grid valve, derived from considerations of energy. His formula is immediately derivable from eq. 13 of sect. 6. Thompson gives very satisfactory experimental confirmation of the formula.

7. A Screen-grid Valve at Radio-Frequencies

As already pointed out in section 1, the quantities μ and G_a are far from constant

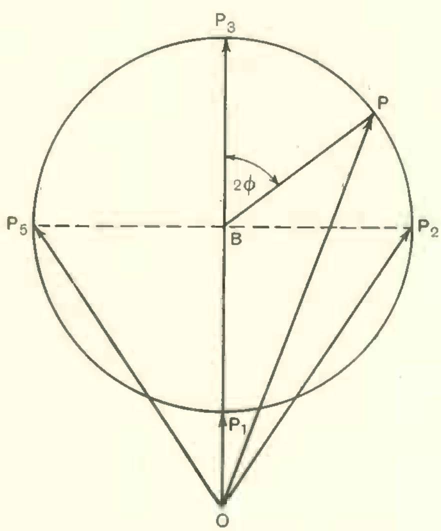


Fig. 5.—$OB = jk(g + 2\,G_a + 2G)$; $BP_3 = jkg$; where $k = \dfrac{\omega C_{ga}}{2(G_a + G)}$; $OP = y_0$.

in a screen-grid valve, and will vary appreciably with conditions of operation. Within these limitations, however, the smallness of C_{ga} in the screen-grid valve, and the consequent smallness of ωC_{ga} even at radio-frequencies, makes this case comparable with that of the ordinary triode at audio-

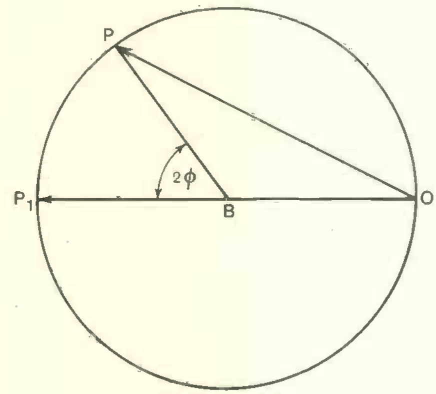


Fig. 6.—$OB = -g$; $BP = -g^{-2j\phi}$; $OP = m$.

frequencies. The conclusions of section 6 can, therefore, be taken as, at least, an indication of the nature of the variation of the input admittance and amplification of the screen-grid valve.

8. Triode Valve at Radio-Frequencies

At a frequency of 10^6 cycles per second, ωC_{ga} for the example given in section 5 will be 25×10^{-6}. This is comparable with G_a. The circle diagrams will therefore be as in Figs. 3 and 4, except that in these diagrams OA and AQ_1 are somewhat exaggerated relative to AB for the sake of clearness. The following particular points may be noted for comparison with corresponding conclusions of section 6.

(*a*) G_0 is not negative for all values of inductive anode load, but only for those for which P lies to the left of O. The maximum positive and negative values of G_0 are given by

$$G_0\,(\text{max.}) = \frac{\omega C_{ga}}{2(G_a + G)}\left\{\sqrt{\omega^2 C_{ga}^{\,2} + g^2} \pm \omega C_{ga}\right\} \quad \ldots \quad \ldots \quad (16)$$

For the numerical example

$G_0\,(\text{max.}) = +\,525 \times 10^{-6}$; $-\,475 \times 10^{-6}$.

Thus the negative input shunt resistance reaches in this case the very low figure of about 2,000 ohms. It is, of course, this low negative input resistance which accounts for the instability of un-neutrodyned tuned-circuit triode-valve amplifying stages.

(*b*) The maximum value of m is

$$m\ (\text{max.}) = \frac{\sqrt{g^2 + \omega C_{ga}{}^2}}{G_a + G} \quad \ldots \quad (17)$$

and occurs when $\phi = O$, *i.e.*,

$$S + \omega C_{ga} = O \quad \ldots \quad \ldots \quad \ldots \quad (18)$$

(*i.e.*, the circuit is tuned by its own capacity plus the grid-anode and anode-filament capacities). For the numerical example

$$m\ (\text{max.}) = 40.$$

(*c*) The input admittance at maximum amplification is given by

$$y_0 = \frac{(\omega C_{ga})^2}{G_a + G} + j\frac{g + G_a + G}{G_a + G}\,\omega C_{ga} \quad \ldots \quad (19)$$

$$= 25 \times 10^{-6} + j\,1025 \times 10^{-6}$$

i.e., a resistance of 40,000 ohms in parallel with a capacity of 164 $\mu\mu$F.

(*d*) The maximum value of y_0 is not that associated with maximum amplification, but the difference is very little in practice (*c.f.*, OP_3 and OQ in Fig. 4).

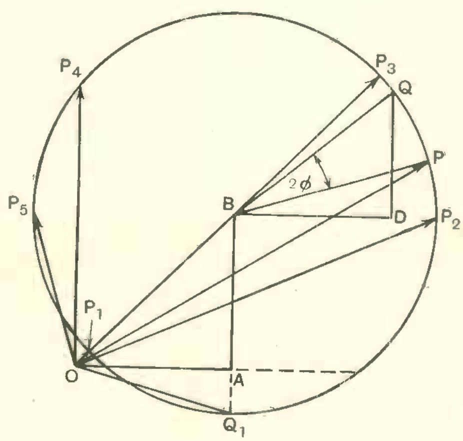


Fig. 7.—$OA = BD = k \cdot \omega C_{ga}$; $AB = j \cdot k(g + 2G_a + 2G)$; $DQ = j \cdot k \cdot g$; where $k = \dfrac{\omega C_{ga}}{2(G_a + G)}$; $OB = k\{\omega C_{ga} + j(g + 2G_a + 2G)\}$; $BQ = k\{\omega C_{ga} + jg\}$; $OP = y_0$.

Of the above, the most important points are the low value of negative input resistance for an inductive load, and the fact that at the maximum amplification setting the input conductance is positive and not very large, the input admittance being practically capacitive.

9. Input Admittance and Amplification at Very High Radio-Frequencies

At very high frequencies (*e.g.*, 10^7 c/s.) ωC_{ga} becomes correspondingly large (250×10^{-6} for the case considered in (6)). The input admittance diagram will then become as in Fig. 7. The conclusions of section 8 are not thereby modified, but it is interesting to note that there is a possibility of a range of negative (*i.e.*, inductive) values for the input admittance for large values of 2ϕ (*i.e.*, for large values of the susceptance components of the anode circuit admittance). The point is, however, mainly of theoretical interest. Of more practical interest are the very low values reached by G_0 at the maximum positive and negative conditions. For the typical numerical example these values correspond to input shunt resistances of about + 150 and − 250 ohms respectively.

10. Summary

In a triode valve amplifying stage of which the external anode circuit admittance, including the anode-filament capacity, can be represented as a constant conductance G in parallel with a variable susceptance S, the variation of the principal part of the input admittance, *i.e.*, that part which is due to coupling through the grid-anode capacity, can be represented by means of a simple circle diagram. The voltage amplification given by the stage can be similarly represented.

The principal formulæ derived are restated here for convenience of reference and comparison.

Load admittance $= G + jS$.

Valve conductance, G_a; mutual conductance g; grid-anode capacity C_{ga}.

Input admittance $= G_0 + jS_0$.

(*a*) The maximum positive and negative values of G_0 occur when $G = \pm S$ approximately, and are given by

$$G_0 = \frac{\omega C_{ga}}{2(G_a + G)}\left\{\sqrt{\omega^2 C_{ga}{}^2 + g^2} \pm \omega C_{ga}\right\}$$

In most practical cases, this is very approximately

$$G_0 = \frac{g}{G_a + G}\,\frac{\omega C_{ga}}{2}.$$

(*b*) The maximum amplification occurs when $S = -\omega C_{ga}$.

Putting M for this maximum value,

$$M = \frac{\sqrt{g^2 + \omega^2 C_{ga}{}^2}}{G_a + G}$$

$$= \frac{g}{G_a + G} \text{ very approximately.}$$

(*c*) At maximum amplification

$$G_0 = \frac{(\omega C_{ga})^2}{G_a + G} = \frac{M}{g} (\omega C_{ga})^2$$

$$S_0 = \frac{(g + G_a + G)}{(G_a + G)} \omega C_{ga} = (M + 1)\, \omega C_{ga}.$$

(*d*) For any values G and S (anode circuit conductance and susceptance)

$$G_0 = \frac{\omega C_{ga}(G_a + G + g) + gS}{(G_a + G)^2 + (S + \omega C_{ga})^2} \omega C_{ga}$$

$$S_0 = \frac{(G_a + G)(G_a + G + g) + S(S + \omega C_{ga})}{(G_a + G)^2 + (S + \omega C_{ga})^2} \omega C_{ga}$$

and

$$m = \left\{ \frac{(\omega C_{ga})^2 + g^2}{(G_a + G)^2 + (S + \omega C_{ga})^2} \right\}^{\frac{1}{2}}$$

APPENDIX

Derivation of circle diagrams for $\dot{y}_0$ and $\dot{m}$.

$$\dot{y}_0 = j\omega C_{ga} \frac{(g + G_a + G) + jS}{(G_a + G) + j(S + \omega C_{ga})}$$

$$= j\omega C_{ga} \left\{ 1 + \frac{g - j\omega C_{ga}}{(G_a + G) + j(S + \omega C_{ga})} \right\}$$

$$= j\omega C_{ga} \left[1 + \frac{g - j\omega C_{ga}}{2(G_a + G)} \left\{ 1 + \frac{(G_a + G) - j(S + \omega C_{ga})}{(G_a + G) + j(S + \omega C_{ga})} \right\} \right]$$

$$= j\omega C_{ga} \left[1 + \frac{g - j\omega C_{ga}}{2(G_a + G)} (1 + \epsilon^{-2j\phi}) \right]$$

where $\tan \phi = \dfrac{S + \omega C_{ga}}{G_a + G}$

$$= \frac{\omega C_{ga}}{2(G_a + G)} [\{\omega C_{ga} + j(g + 2G_a + 2G)\} + (\omega C_{ga} + jg)\epsilon^{-2j\phi}]$$

The derivation for $\dot{m}$ is similar.

Naval Wireless

I.E.E. Wireless Section, Chairman's Address

THE opening meeting of the I.E.E. Wireless Section was held on 1st November, when Mr. G. Shearing, O.B.E., B.Sc., M.I.E.E., delivered his inaugural address as Chairman of the Section.

In introducing his subject, the speaker referred to the ramifications of modern wireless and to the connections with physics and engineering practice in modern wireless work.

He then proceeded to give a broad account of naval wireless practice, beginning with a map of naval wireless stations throughout the world. The traffic concerned was long-distance point-to-point work from these stations to England, as well as traffic between ship and shore, and traffic between ships of a squadron, etc. The long-distance point-to-point work was done mostly on short waves, but the medium wave region was still of considerable importance in ship working.

The lecturer then described the equipment of ships, giving general information as to the type of transmitters and receivers used. Communication was practically entirely by telegraphy, radio-telephony being only very slightly used. Reception was entirely by earphone so that no great attention had to be paid to a power output-stage at the receiver. This also had the merit of keeping down the number of stages and giving a low noise-level. The standard types of naval receiver cover the range of 15 kc/s to 23 Mc/s. W/t offices on ship are usually below deck and at some distance from the aerials, and the lecturer discussed the cabling arrangements feeding the aerials into the apparatus. A slide was also displayed illustrating the number of aerials and the difficulties of wireless installations on H.M. ships.

The speaker also discussed shadow and screening effects due to ship structure and superstructures, giving a theoretical reasoning which was well confirmed in the case of the particular ship for which it was calculated. Interference between transmitters and receivers on the same ship was also discussed ; this was usually helped by the frequency separations involved, but precautions had to be taken against spurious radio-frequency noises generated in machine-leads. Voltage supplies to transmitters were now mostly by high-tension alternators at 500 c/s, and receivers were increasingly using indirectly heated cathode valves deriving l.t. and h.t. from alternators.

The lecturer next discussed direction finding practice, which had, in the Navy, several important applications in addition to that of navigation. Various types of ship d.f. installations were described, with a discussion of the field-distortions giving rise to quadrantal error. Methods (due to Mr. C. Horton, of H.M. Signal School) were also described for correcting these errors. An automatic direction-finder was also described and demonstrated in operation cn a local signal.

Dealing with recent advances in wireless generally, the speaker referred particularly to various new types and tendencies in valves. He then discussed some of the recent progress in working on wavelengths below 10 metres, describing several new methods of generating greater power at these ultra short waves. A new magnetron for about 1 metre working was demonstrated in operation. Finally, the lecturer dealt briefly with the changes of frequency-allocation arising out of the Madrid Conference and Lucerne plan.

Correspondence

Letters of technical interest are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.

Beat Frequency Oscillator

To the Editor, The Wireless Engineer.

SIR,—In your issue for September is an article by M. F. Cooper and L. G. Page, which describes an audio-oscillator, and contains an oscillogram of the ripple in the high tension supply.

Present with others is a component having a frequency of 3.3 to 3.4 kc. This, we are told, " is a record of the valve hiss." No possibility exists that it may be anything else ; in spite of the fact that valve hiss, like the surface noise picked up from a gramophone record, is an aperiodic phenomenon, and the recorded wave shows a very definite form even on the half-tone illustration, those responsible for the statement jump thoughtlessly out of the frying pan of improbability into the all-consuming fire of assertion.

Even in the improbable event of the recording oscillograph resonating at so low a frequency, or of some suitably placed *LC* product being maintained in oscillation at its natural frequency by the valve hiss, the statement to which objection has been taken still cannot be justified, since the oscillogram would be in no wise a record of the valve hiss, but merely of its presence.

It would therefore clear matters up if the authors would put forward their grounds for making the statement. ARCHIBALD W. STEWART.

Whitefield, Manchester.

Applications of the Dynatron

To the Editor, The Wireless Engineer

SIR,—In his very interesting article on " Applications of the Dynatron," published in your issue dated October, 1933, Mr. Scroggie describes an application of the technique of automatic gain control to the dynatron circuit. He refers to a paper by Arguimbau (*P.I.R.E.*, Jan., 1933) as being, to his knowledge, the only paper describing a similar idea. It may therefore be of interest to him and to your readers to know that Dr. J. Groszkowski has already published a description of a dynatron oscillator with automatic grid-bias control, the circuit being essentially the same as that arrived at independently by Mr. Scroggie. Groszkowski's paper also contains experimental data illustrating the great improvement in frequency-stability with respect to operating conditions which is obtainable in this way. The paper is, unfortunately, in Polish (*Przeglad Radjotechniczny*, May 15th, 1933), but it is hoped to arrange for the publication of an English version in the near future.

I may say that after the publication of Arguimbau's paper, I carried the amplitude-control idea described in it a stage further, and constructed a self-maintained triode oscillator circuit in which very full control of the amplitude was obtained by means of an associated automatic-volume-control type of amplifier, having a controllable maximum output-voltage. With this arrangement it was possible to maintain oscillation over almost any desired range of the so-called " straight " part of the oscillator characteristic, however small. It is hoped to publish a brief description of this work at a later date.

In the course of his article, Mr. Scroggie referred to certain papers of my own on the characteristics and advantages of the dynatron circuit. While I am prepared to endorse practically everything Mr. Scroggie has said about the merits and practical usefulness of this very attractive circuit, I must confess that my earlier enthusiasm has been tempered somewhat by subsequent experience, at least as far as frequency stability is concerned. It is true that the frequency can be made very satisfactorily independent of small changes in the supply voltages, but in some cases I have encountered a small but persistent frequency drift which appeared to be due to a corresponding small but steady change in secondary emission (the agency responsible for the negative-resistance characteristic). The variability of the secondary-emission effects as between different valves of the same type, a point mentioned by Mr. Scroggie, suggests that secondary emission is critically dependent on the nature of the surface of the emitting electrode which surface may itself be affected by the intensity and duration of the secondary emission. It would be interesting to know if Mr. Scroggie has any data on the long-period constancy of secondary emission in small receiving tetrodes. It is true that the direct effect on the frequency of any consequent variation of the negative slope of the characteristic may be expected to be very small, but there is a larger indirect effect on frequency arising from the dependence of interelectrode capacitance on the space-charge. (See Baker, *J.I.E.E.*, August, 1933).

F. M. COLEBROOK.

Teddington, Middlesex.

To the Editor, The Wireless Engineer

SIR,—I am obliged to Mr. Colebrook for drawing my attention to Groszkowski's paper on oscillation amplitude control. Unfortunately, the Polish language has been outside my education, and in any case the paper appeared some months after my own was submitted. Quite a number of valuable contributions, more especially on the frequency maintenance question, have appeared since ; and some of these were included in my bibliography.

As the great bulk of the literature on the subject is either purely theoretical, or refers to extremely precise and specialised practice I felt that there was room for information of a more workaday character. My references to frequency stability must therefore be interpreted on this understanding, and I would not presume to give an original opinion as to the possible degree of constancy. I understand, however, that Mr. Griffiths's recent paper on this subject is founded on extensive experience of the work in which Mr. Colebrook expresses interest.

My own less systematic work does nevertheless support Mr. Colebrook's statement that the secondary emission is critically dependent on the nature of the surface of the emitting electrode; which may be considerably changed, or even ruined, by over-running the valve: hence my advice to limit the screen current.

I am interested to learn that Mr. Colebrook has carried into effect the idea of amplified amplitude control. My attempts to obtain extreme constancy in this way failed, because the time constant of the bias control circuit, which had to be sufficiently great to prevent amplified oscillations from being fed back to the oscillator, led to intermittency of oscillation. In fact, stable control appeared to be possible only if the control rectifier damped the oscillatory circuit to a certain minimum extent; which was one of the things the system was designed to avoid, with the object of minimising harmonics.

These tests were confined entirely to dynatron oscillators; which appeared the most hopeful by reason, among other things, of the high degree of control exercised by the grid bias voltage. I very much hope that Mr. Colebrook's work on triode oscillators will be published.

I am also hopeful that those better qualified than myself may be able to explain satisfactorily the apparent discrepancy between theory and practice, noted towards the end of my paper; as it is of some practical importance.

M. G. Scroggie.

Upper Norwood, S.E.19.

To the Editor, The Wireless Engineer

Sir,—In your October issue M. G. Scroggie described the single circuit S.G. precision radio oscillator. Passing on to my double circuit oscillator (radio and audio) patent 310915, he says: "the precision is lower." If an audio circuit is put in series with the radio circuit there is a slight frequency change. But if the double circuit oscillator is calibrated as such, the precision is alike in the two cases.

It may be of interest to remark that crystal control is treated in 310915 (claim 6), and I have used it experimentally. Fig. 11 of Mr. Scroggie's article is a modification of Fig. 4 (claim 9) of 310915 of which he was obviously unaware.

Referring to the use of valves having low anode to grid capacity for precision oscillators, the first valve of this kind was made to my specification by the Osram Co. in 1929. It was used by Messrs. H. W. Sullivan in their oscillator at the Physical Society Exhibition in January, 1930.

London. N. W. McLachlan.

Philips's Receiver—Dynamic Resistance

To the Editor, The Wireless Engineer

Sir,—I beg to refer to a statement regarding Philips's 634 Superinductance Receiver, appearing in the October issue of The Wireless Engineer. The paragraph concerned reads as follows:—

"But in a number of receivers tuned circuits of high dynamic resistance are secured by operating the radio frequency amplifier with a controlled amount of regeneration. For example, Philips's 634A Superinductance Receiver, in addition to exceptionally good coils, has a potentiometer ganged to the tuning control which, by varying the bias of one of the H.F. valves, keeps the receiver just within the limits of stability throughout the waveband . . ."

Your statement gives the impression that reaction is an essential feature of the design of the Philips's 634 receiver and that the high dynamic resistance of the tuned circuits in this set is obtained by deliberate and controlled regeneration. This is not the case. The exceptional efficiency of these circuits is obtained by careful electrical and mechanical design and by highly specialised methods of production, whereby the electrical losses in all components associated with the tuned circuits are reduced to an extremely low value.

The actual purpose of the coupled potentiometer is to produce even sensitivity over the waveband by reducing the excessive gain which would otherwise occur on the lower wave lengths with a circuit arrangement of this nature.

London, W.C.2. A. B. Calkin, Philips Lamps, Ltd.

Double Channel Transmission

To the Editor, The Wireless Engineer

Sir,—I hope you may see your way in the near future to give space for discussion on an old subject which seems to be receiving more attention of late. There are several points obscure to me which if ever I venture to mention are usually "side tracked." Are engineers afraid to tackle them?

What *is* "stereoscopic" effect? Is it not in itself an illusion, if so would not any other successful illusion answer as well or better? The stock explanation is the "one eye—two eye" analogy. Am I abnormal when I claim to be able to see perfectly well with *one* eye and that the only difficulty is of focusing; one eye alone is capable of appreciating "depth." I suggest there are infinitely more than "double channel" lines of vision which enable us to appreciate perspective. Just the same with the ear for which member the focusing difficulty only is more apparent. Music seems no less real to me heard with only one ear. We do have reason to believe that each frequency is conveyed separately to the brain while is it not dangerous to assume, as is done, that we are so tolerant of phase displacement in reproduction?

I humbly suggest that radio engineers might aim higher than the "double channel" idea and concentrate on what constitutes perfect reproduction of sound not forgetting at the same time that certain illusion might be permissible as a means to an end.

Quite obviously the microphone has similar defects to a photographic plate but why assume that two microphones or two transmission lines to two ears are likely to be a good solution to the problem?

The need seems to be to contrive a "microphone" which is in itself a perfect "ear" and works on similar principles to the human organ, to "scan" if necessary the audio frequencies and render them separately as far as is possible at the producing end. Failing all this at least to *try* the effect of faithful phasing.

Ware. Gerald Sayers.

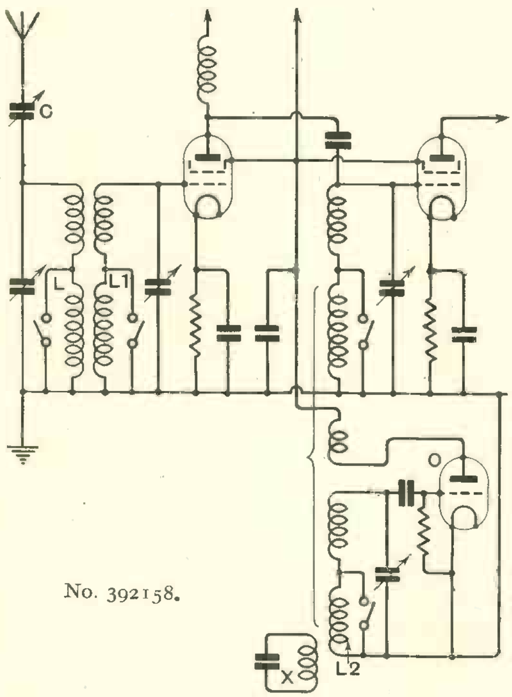
Some Recent Patents

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each.

SUPERHET RECEIVERS

Application date, 9th November, 1931. No. 392158

In order to preserve a constant ratio between the tuned input and local oscillator circuits in a superhet set, so as to permit single-knob tuning over both the medium and long wave-bands, a "compound" impedance (preferably a loop circuit of inductance and capacity) is coupled to the long-wave or loading inductance of one of the circuits. As shown, the aerial is connected through a condenser C to a band-pass input comprising switch-operated loading-coils L, $L1$, the auxiliary "compound" impedance X being coupled to the loading-coil $L2$ in the grid circuit of the local oscillator valve O.



No. 392158.

Patent issued to The Plessey Co., Ltd., and C. E. G. Bailey.

PREVENTING MAINS "HUM"

Convention date (Germany), 23rd November, 1931
No. 393495

In certain types of mains-driven valve, the filament and cathode are separated by a discharge space which carries a minor or auxiliary electron stream. Since the latter fluctuates with the potential and temperature of the filament, it tends to set up "hum." According to the invention this is prevented by tapping-off, from a resistance inserted between the anode and cathode, a biasing potential sufficient to saturate the discharge-space in question. A different tapping from the same resistance supplies the biasing-voltage for the control grid.

Patent issued to Telefunken Ges für drahtlose Telegraphie m.b.h.

H.F. AMPLIFIERS

Convention date (Germany), 29th February, 1932
No. 393553

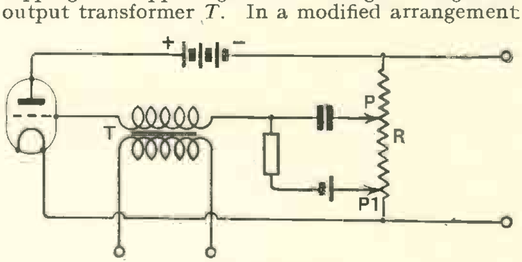
When using screen-grid valves for amplifying ultra high frequencies it is desirable, in order to avoid undesirable reaction effects, to maintain the screen-grid as nearly as possible at the same high-frequency potential, *i.e.*, for the working frequency. In order to achieve this result the screen grid is connected to the cathode through two condensers in series, and the anode is connected to the cathode through a third condenser. The inherent capacity between the screen-grid and anode inside then forms the fourth side of a balanced bridge, and the output impedance is connected across a diagonal.

Patent issued to Telefunken Ges fur drahtlose Telegraphie m.b.h.

AMPLIFIER CIRCUITS

Convention date (Germany), 29th December, 1931
No. 393520

Distortion due to curvature in the valve-characteristic, or to some undesired variation of the external circuit impedance, is compensated by feeding-back to the grid from a tapping P on the resistance R an AC component in phase-opposition with the AC component to be corrected. Another tapping $P1$ supplies grid-bias voltage through the output transformer T. In a modified arrangement the two tappings are taken from different parallel resistances, both shunting the anode-cathode circuit.



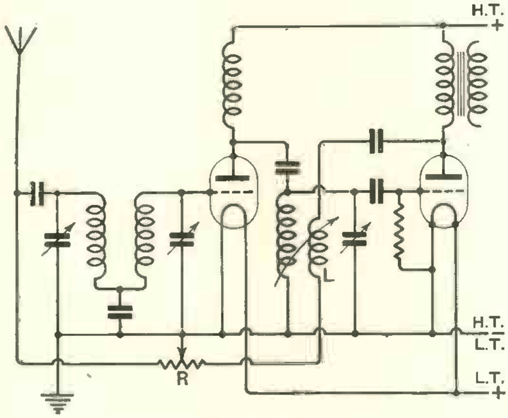
No. 393520.

Patent issued to Telefunken Ges für drahtlose Telegraphie.

VOLUME CONTROL

Application date, 23rd September, 1931. No. 391469

Part of the volume-control potentiometer *R* is arranged in shunt with the aerial circuit, whilst the remainder is in series with the reaction coil *L*. As the earthed tapping-point is moved to the left to reduce volume, the series resistance in the re-



No. 391469.

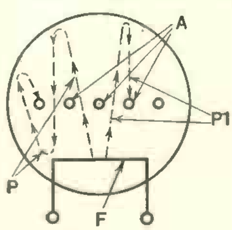
action is increased, thereby preventing overloading.

Patent issued to The Paragon Rubber Mftg. Co., Ltd.

SHORT-WAVE GENERATORS

Convention date (U.S.A.), 4th December, 1930. No. 392533

As shown in the Figure the electron emitter *F* co-operates with a second electrode *A*, which may be a perforated plate or any similar grid-like structure, provided the total area of the spaces or perforations is large compared with the projected area of the solid parts. The frequency and amplitude of the generated oscillations are determined by the potential applied across the "grid" *A* and filament *F*, and are due to the elongated path taken by the bulk of the electron stream, as indicated at *P* and P_1.



No. 392533.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

SHORT-WAVE SYSTEMS

Application dates 5th November and 18th November, 1931, and 4th March, 1932. No. 392210

Relates to a system of generating and receiving ultra-short waves by the Barkhausen-Kurz method. The valves are operated in push-pull and are coupled through tuned Lecher-wires to dipole aerials of various forms, some of which are designed to produce high-directive effects. Two or more pairs of valves may be coupled together by connecting the filament circuits through tuned Lecher-wires. Various methods of applying the necessary operating potentials are described, together with a special "optical image" arrangement of the valve electrodes to ensure symmetry. Modulating signals may be applied either to the plate or grid, and the receiving circuits may be designed to give super-regenerative amplification.

Patent issued to Marconi's Wireless Telegraph Co., Ltd., and G. A. Mathieu.

TELEVISION RECEIVERS

Convention date (U.S.A.), 15th January, 1932. No. 392869

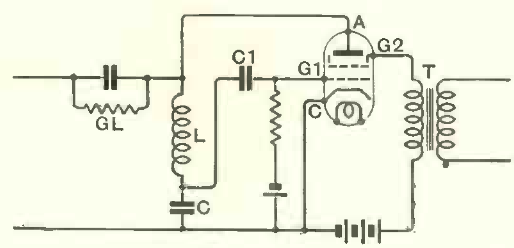
The characteristic greenish appearance of the picture reproduced on the fluorescent screen of a cathode-ray television receiver is converted into a more natural and pleasing colour by projecting on to the screen, simultaneously with the received picture, a beam of unmodulated monochromatic light, preferably complementary to the fluorescent colour. The compensating light is derived from one or more auxiliary lamps mounted in close proximity to the receiving surface, but screened from direct observation. A similar method may be used to offset the characteristic colour effect due to Neon and similar lamps used in other types of television receivers.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

DETECTOR-AMPLIFIERS

Application date, 13th May, 1932. No. 391979

A screen-grid valve of normal type is used as a combined diode rectifier and L.F. amplifier. The



No. 391979.

modulated signal energy is applied across the anode *A* and cathode *C* through a grid leak combination *GL*. Rectified currents are fed from the junction of a coil *L* and condenser *C* (forming a radio-frequency shunt) through a condenser C_1 to the control grid G_1, the usual screen-grid G_2 being coupled to the next stage through a low-frequency transformer *T*. If a pentode valve is connected up in a similar manner, the extra electrode can be used as a space-charge grid.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

1

INDEX

VOL. X. The Wireless Engineer & Experimental Wireless 1933

I. GENERAL INDEX

II. INDEX TO AUTHORS

III. ABSTRACTS AND REFERENCES

PROPAGATION OF WAVES

Propagation of Waves.

Propagation of Waves.

Propagation of Waves.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

Atmospherics and Atmospheric Electricity.

Atmospherics and Atmospheric Electricity.

Atmospherics and Atmospheric Electricity.

PROPERTIES OF CIRCUITS

Properties of Circuits.

Properties of Circuits.

TRANSMISSION

Transmission.

RECEPTION

Reception.

The Mode of Action of Diode **Detection**.—Urtel, p. 623.
An Analysis of Power [Grid] **Detection** [and the Use of a High-Impedance Choke in place of the Grid Leak and of a Tungsten Lamp as Plate Series Resistance].—de Cola, p. 566.
Detection : see also **Demodulation**.
Screen-Grid Voltage and **Detector** Sensitivity.—Flippin, p. 38.
The **Detector**.—Lewis, p. 38.
Improving the Grid-Leak **Detector** : a Simple Method of Obtaining Greater Linearity in a Superheterodyne Receiver [Addition of Second R.F. Choke between Anode and Junction of By-Pass Condenser and R.F. First Choke].—Smith, p. 100.
The H.F. Screen-Grid Valve as an Anode-Bend **Detector**.—Kammerloher, p. 623.
The Functions of the Leaky-Grid **Detector** with Reaction, divided between Two Valves, p. 157.
The **Diode** Quality Four [Four-Valve Battery-operated Receiver with Diode Rectifier].—Smith, p. 39.
Some Notes on the Use of a **Diode** as a Cumulative Grid Rectifier.—Biedermann, p. 326.
Diode Detection Analysis.—Kilgour and Glessner, p. 566.
Design of D.C. Sets : Problems Peculiar to **Direct Current** Supply.—Cocking, p. 39.
The Tuning Curves of Electrical **Distant Control** Devices for Radio Receivers.—Schadow, p. 39.
Why the **Double Hump** ? [In Band Pass Filters].—Howe, p. 623.
Voltage Amplification with High Selectivity by means of the **Dynatron** Circuit.—Colebrook, pp. 212 and 326.
Trends of Design at the Ninth Radio **Exhibition**, Paris, 1932.—Adam, p. 155.
The Radio **Exhibitions** [National and International] in Paris, 1932, p. 505.
Exhibitions : see also Berlin, Radio, Trend, and under "Miscellaneous."
The Introduction, into an Existing Receiver, of **Exponential Valves** in the place of ordinary Screen-Grid Valves, p. 446.
Anti-**Fading** Circuit using Variable-Mu Valve.—Chrétien, p. 100.
Anti-**Fading** Circuits.—Chrétien, p. 158.
Counteracting **Fading** by Periodic Detuning of Receiver.—Deutsche Tel:werke u. Kabelind. A.G., p. 214.
The Influence of **Fading Compensation** on Contrast in Music.—Sturm, p. 623.
The New Tuning Coils [" **Ferrocart** " Iron Cores].—Sowerby : Vogt, p. 39.
Ferrocart, a New Material [and a Two-Valve Receiver using Ferrocart Coils].—Olvenstedt, p. 100.
Iron Powder Compound Cores for Coils [**Ferrocart**, etc.].—G.W.O.H. p. 173.
The **Ferrocart III**.—Cocking, p. 273.
Class " B " **Ferrocart** Receiver.—Page, p. 326.
Iron-Content [**Ferrocart**] Cores for High-Frequency Coils.—Schneider, p. 403.
Ferrocart : see also under " Subsidiary Apparatus and Materials."
Fidelity Compensation by Regeneration [by Feeding-back Part of Output in Phase to Screen-Grid Circuit of Tetrode].—Matthews, p. 212.
Adjustment of Band Breadth in a Band-Pass **Filter** by Variable-Coupling Coils tending to Neutralise the Fixed Couplings.—Meissner, p. 566.
The Best **Filter** Chain for Mains-Driven Apparatus.—Piesch, p. 158.
Filter for the Intermediate-Frequency Amplifier [of a Superheterodyne Receiver].—Piesch, p. 211.
Square-Top **Filters** [especially for the I.F. Circuits of Superheterodyne Receivers].—Piesch, p. 504.
French Receiver Trends.—Picard, p. 155.
Retaining Higher Frequencies : Part II. **Frequency Correction**.—Bowen, p. 99. See also Tone Correction.
Glow-Discharge Tube between Grid and Anode of Reaction Audion to prevent Adjustment beyond Oscillation Threshold.—Hinrichsen, p. 272.
Grid Bias from Anode Current : Some Necessary Precautions.—van Reysschoot : Pound, p. 100.
An Obscure Cause of Poor Reception [Faulty Combination of Parallel-Feed Transformer and Automatic Grid **Bias** Resistor].—M. G. Scroggie, p. 213.
High-Selectivity Tone-Corrected Circuits.—Robinson : G.W.O.H., pp. 99 and 156.
Wireless in the Modern **Hotel** [Waldorf Astoria].—Dinsdale, p. 39.
Suppression of Mains **Hum** : the Use of an Auxiliary Valve in Opposition to Output Valve : of a Bridge Circuit : of Rectifiers in Opposition across Heating Circuit.—Siemens-Schukert, p. 448.
Bridge-Type Push-Pull Amplifiers [to avoid **Hum** induced in Coupling Transformer].—Tulauskas, p. 504.
Ingenious Circuits in New Radio Receivers, p. 100.
Study of the **Input Circuit** of a Radiotelephonic Receiver [and the Predominant Importance of the H.F. Losses].—Mezey, p. 448.
Various Methods of Detecting Faulty **Insulators** on H.T. Lines under Tension.—Robertson, p. 392.
The Law of the Broadcast Listener and the Elimination of Wireless **Interference**.—Adam, p. 157.
Concerning the Second Congress of Defence against Radioelectric **Interference** (Paris, 25th–27th November, 1932).—Adam, p. 325.
Fundamental Points in the Suppression of Radio **Interference** [Man-Made].—Alexander, p. 392.
Interference with Wireless Reception Arising from the Operation of Electrical Plant.—Angwin, p. 39.
The Radio-Noise Meter and Its Application to the Measurement of Radio **Interference**.—Barhydt, p. 392.
Eliminating Radio **Interference** from Pin Type Insulators.—Barrow, p. 325.
Avoidable **Interference**.—Bernaert, p. 505.
Antenna Transmission Line Systems for Radio Reception [Elimination of Man-Made **Interference** by Suitable Location of Aerial and the Use of a Shielded Lead-In].—Brigham, p. 449.
Cutting Out the Crackle : What the Listener Can Do to Minimise **Interference**.—Calkin, p. 40.
Whistle Suppressor [A Simple Tuned Filter for Eliminating Heterodyne **Interference**].—Cocking, p. 39.
Interference with Broadcast Reception due to Mercury-Vapour Rectifiers.—Dennhardt, p. 391.
The Construction of Choking Coils for Preventing Radio **Interference** [e.g. from Mercury Vapour Rectifiers].—Glas, p. 39.
Interference : Notes on Methods for Elimination of Interference caused by Non-Radio Devices.—Glas, p. 157.
Interference with Broadcast Reception.—G.W.O.H., p. 447.
Devices to prevent Man-Made **Interference** with Radio Reception, and Their Use.—Hémardinquer, p. 157.
The Effect of the Leads to an **Interference-Suppressing** Condenser.—Kotowski and Kühn, p. 325.
Radio Reception and **Interference** from Neighbours [from Electrical Apparatus, etc.].—Mestre, p. 325.
Problems of Electrical **Interference**.—Morris, p. 623.
Interference with Broadcast Reception.—Nat. Elec. Light Assoc., p. 447.
The Legal Position of Producers of Wireless **Interference** with respect to the Listeners.—Ottoz, p. 158.
[Hints on] Reducing Noise **Interference** [including the Limited Usefulness of the Shielded Lead-In].—Philco Company, p. 325.
Anti-**Interference** Filter for Electric Motors, etc., which does not raise Potential of Frame of Motor.—Philips' Company, p. 325.
An Apparatus for Measuring the [Radio-] Frequency Spectrum of Sources of **Interference** with Broadcast Reception.—Wild : Siemens and Halske, p. 272.
Some Causes of **Interference** with Radio Reception on Aeroplanes, and Methods of Overcoming Their Effects.—Zanini, p. 100.
Interference Filtering [Special Wave-Trap Circuit], p. 157.
Electrical **Interference** [Additional Causes, including Static Charge on Motor Frame due to Belt Slippage], p. 39.
Interference : see also Noise, Screened, Superhet, and under "Aerials."
Italian Broadcast Receivers : " Radiomarelli " 1932–33 Receivers, p. 623.
Broadcasting Progress in 1932, and European Broadcasting versus Economic Depression [U.I.R. Statistics of **Listeners**].—Burrows, p. 393.
An Improved Version of the **Loftin-White** Circuit [using only Indirectly-Heated Valves, including a **Pentode** in the Output Stage].—Prinzler, p. 100.
The H.F. **Currents** produced by H.T. **Magnetos**.—Jaffray, p. 271.
Superheterodyne Receiver with **Magnetostrictive Coupling** in I.F. Circuit to increase Selectivity.—USSR Electrot. Association, p. 273.
VDE Regulations for **Mains-Driven Broadcast Receivers**.—Verband Deutscher Elektrotechniker, p. 326.
The Influence of **Matching** [Circuits with Valves] on the Amplification and Selectivity of Tuned R.F. Amplifiers.—Baerwald, p. 503.
Matching : see also under " Properties of Circuits " and " Aerials."
An All-Wave [Two-Valve] **Midget** Receiver : a Semi-Portable covering from 12 to 4 500 Metres.—Parmenter, p. 100.
The **Midget** Universal Mains Set.—Keith Henney, p. 273.
The **Modern D.C. Three** [with Screen-Grid Detector].—Page, p. 157.
The Production of **Negative Conductances** by means of Retroactive Couplings [and the Calculation of Retroactive Receiver Circuits].—Kautter, p. 447.
Suppression of **Noise** in Radio Receivers : QAVC [Quiet Automatic Volume Control], NSC [Noise Suppression Control], or simply " Squelch."—Messing, p. 326.
An Inter-Carrier **Noise** Suppression System [using the Wunderlich Valve of a New Type, with Small Shielded Extra Anode].—Wunderlich, p. 447.
Noise Intensity in Radio Reception.—Byrne, p. 448.
Inter-Carrier **Noise Suppression** : a New System [using the Wunderlich B Valve and Automatic Volume Control].—Wunderlich, p. 213.
Maximum **Output**, Efficiency, and Optimum External Resistance of Output Valves [for Class A and Class B Amplification].—Urtel, pp. 274–275.
The **Pentagrid** Converter [Combined Oscillator-Detector for Superheterodyne Receivers].—Lyons, pp. 394 and 504.
Improvements to the **Pentode** Output Stage [Reduction of Capacity in Choke Filter Output Circuit].—Piesch : Sims, p. 157.
The " **People's Receiver**," pp. 505 and 567.

Reception.

Reception.

An Unusual 56Mc [**Ultra-Short**-Wave] Super-Regenerative Receiver: Details of a Portable Set with Self-Quenching Detector.—Haydock, **p. 567.**

Reception of **Ultra-Short** (3 Metre) Waves on a Tourmalin-Stabilised Receiver.—Heinrich-Hertz Institute, **p. 622.**

The Reception of Decimetre [**Ultra-Short**] Waves with the Retarding-Field Audion.—Hollmann, **p. 621**: see also Retarding-Field.

Receiver for **Ultra-Short** Waves, using Split-Anode Magnetron.—Int. Gen. Elec. Company, **p. 273.**

Oscillating Split-Anode Magnetron as Detector for **Ultra-Short** Waves.—Int. Gen. Elec. Company, **p. 326.**

Experiments on the Reception of **Ultra-Short** Waves.—Marconi, **p. 155.**

Ultra-Short: see also Ultra-High.

Visual Test Devices [giving R.F. Frequency Response Curve of Receiver or Components, for Production Testing: Rotating Sweep Condenser and Mirror, Mirror Galvanometer, etc.].—Schuck, **p. 39.**

Acoustically Compensated **Volume Control** for Radio and Phonograph Sets.—Wolff and Cornell, **p. 332.**

Manual **Volume Controls**.—Branch, **p. 326.**

The **Westector**.—Westinghouse Company, **p. 272.**

Wireless World Battery Baby Superhet.—Cocking, **p. 39.**

The **Wireless World** Modern Battery Four.—Cocking, **p. 623.**

The **Wireless World** Straight Three [Battery Operated].—Smith, **p. 100.**

AERIALS AND AERIAL SYSTEMS

Argument as to Reliability of Field Strength Measurements **taken in Aircraft**.—Gothe: Krüger, **p. 158.**

Airplane Radio Freed from Ignition Interference.—Jenkins, **p. 215.**

Angle of Elevation of Short-Wave Rays.—Walmsley, **p. 91.**

Experimental and Theoretical Study of the Polar Distribution of Energy in a **Beam** at Great Distance from the Sender [and Theory of the Transmission of Waves in an Ionised Gas in which there is a Horizontal as well as a Vertical Gradient].—Eckersley, **p. 624.**

The Improvement of **Broadcasting** Aerial Systems [Survey], **p. 158.**

Is the Problem of the **Communal Aerial** Solved?—Noack: Philips' Company, **p. 624.**

The **Concentrator** Antenna [giving Decreased Space Wave and Increased Efficiency at the Shorter Broadcast Wavelengths].—Westinghouse Company, **p. 449.**

Operation of the New ["**Concentrator**" Directive Broadcasting] Antenna at KYW., **p. 567.**

On the Numerical Calculation of the **Current** in an Antenna [and the Reduction of Related Double Integrals].—Murray, **p. 215.**

The Distribution of Radiated Power along a **Dipole** [Half-Wave] Aerial.—Bechmann, **p. 101.**

Asymptotic **Dipole** Expansions for Small Horizontal Angles.—Murray, **pp. 40 and 616.**

The Generalised Theory of the Electromagnetic Field of a **Dipole** and of Radiation from the Latter.—Rosing, **p. 40.**

Note on **Directed** Transmissions [from a Single, Greek-Pattern Array: the Production of Two Beams rotating in Opposite Directions by a Periodic Variation of Wavelength].—Longo, **p. 505.**

Theory and Practical Application of **Directed** Radiation [Comprehensive Survey of Beam Aerial Theory: Calculation of Radiation Diagram of Zeesen Short-Wave Broadcasting Aerial].—Ochmann and Rein, **p. 567.**

Directive Aerial consisting of a Conductor bent into a Zig-Zag in One Plane.—International Standard Electric Corporation, **p. 159.**

Phase Synchronisation in **Directive** Antenna Arrays, with Particular Application to the Radio Range Beacon [using the "Transmission Line" Antenna, Adcock Principle].—Kear, **p. 625.**

Extension of the Mesny "Meandering" [Zig-zag **Directive**] Aerial System.—Latour, **p. 159.**

Investigating the **Directive** Properties of an Amateur Antenna [Long L-Aerial for Short Waves].—Seaton, **p. 449.**

The New High-Power Broadcasting Station at Vienna, with Reflector Tower for **Directive** Working.—Telefunken, **p. 215.**

Directive Actions of Wave Resonators and Their Effects on the Plane of Polarisation of Electromagnetic Waves.—Uda and Nakamura, **p. 159.**

Horizontal **Directive** Short-Wave Antenna.—U.S.S.R. Elek. Ver., **p. 449.**

Improved **Directive** Reception on a Multiplicity of Aerials by using Repeated Frequency Multiplication before Combining.—von Plebanski, **p. 328.**

A New Type of **Directive** Aerial [with Radiating Elements of Progressively Increasing Length: Especially Suitable for Ship-Shore Working].—Walmsley, **p. 101.**

Short-Wave **Directive** Aerial Systems. Part I.—Whitehead, **p. 328.**

Directive Broadcasting at WFLA-WSUN [Two Insulated Towers tuned to a Quarter Wavelength and spaced a Quarter Wavelength].—Wilmotte, **p. 101.**

Directive Antennae for Broadcast Stations [particularly at WFLA, Florida].—Wilmotte, **p. 158.**

Earth Resistances [Potential Gradient in the Surrounding Soil depends only on Dimensions of the Earth Plate].—Tagg, **p. 101.**

The Resistance of **Earth** Electrodes [for Earthing Electrical Installations and Apparatus].—Morgan and Taylor, **p. 505.**

Effect of the **Earth's** Non-Homogeneity in Strata on the Electromagnetic Field of a Horizontal Transmitting Aerial [Theoretical Investigation and Experimental Confirmation on a 5.4 m Wave.]—Hara, **p. 159.**

Radiation from Antennae under the Influence of the **Earth's** Properties. E.—Radiation into the Earth.—M. J. O. Strutt, **p. 624.**

An Experimental and Analytical Investigation of **Earthed** Receiving Aerials: Corrections.—Colebrook, **p. 327.**

The Effective Combating of Short Range **Fading** in Broadcasting, by Special Transmitting Aerial Systems [for Space-Wave Suppression].—Harbich and Hahneman, **p. 40.**

Results of the Breslau "Anti-Space-Wave" [Anti-**Fading**] One-Wire Broadcasting Aerial.—Böhm, **p. 101.**

The **Fading**-Diminishing ["One-Wire"] Aerial of the Breslau Broadcasting Station.—Eppen and Gothe, **p. 394.**

The Polygon Broadcasting Aerial for Suppression of **Fading**.—Böhm; Böhm, Bechmann and Roosenstein: Telefunkem, **p. 158.**

The Effective Combating of Near **Fading** in Broadcasting by Transmitting Aerials of Particular Design [Elektrotechnischer Verein Discussion].—Hahnemann, Harbich, Runge, Gothe, Plendl, Krüger, **p. 158.**

Field Tests on Radio Communication over Long-Distance Aircraft Routes [including the Reduction of Short-Wave **Fading** by Alternate-Aerial Transmission or Reception].—von Handel, Krüger and Plendl, **p. 557.**

An Anti-**Fading** Aerial consisting of a Wire wound into a Spiral.—SFR, **p. 273.**

Fading eliminated by High Aerial supported by Balloon ["Blimp Antenna"], **p. 449.**

Anti-Fading: see also Concentrator.

Cable-Type H.F. **Feeders** [Buried, for Transmitting and Receiving Aerials].—Lambin, **p. 567.**

Twisted-Pair **Feeders** for the Transmitting Antenna.—Grammer, **p. 567.**

Feeders: see also Transmission Lines, Lecher Wires.

On the Calculation of the [Short-Wave] **Frame** Antenna with Uniformly Distributed Electromotive Force.—Iwakata, **p. 40.**

The **Gain** in Beam Antennas.—Kato and Takeuchi, **p. 505.**

Grounds [The Use of Ground Rods], **p. 40.**

The Electrical **Heating** of Overhead Lines against Hoar Frost.—Halbach, **p. 215.**

Mutual **Impedance** of Grounded Wires Lying On or Above the Surface of the Earth.—Foster, **p. 624.**

Mutual **Impedance** of Long Grounded Wires when the Conductivity of the Earth varies Exponentially with Depth.—Gray, **p. 327.**

General Formula for the Mutual Radiation **Impedance** of Any Straight Parts of the Wires with Standing Sinusoidal Current Distribution.—Hara, **p. 624.**

The Calculation of the **Impedance** of Aerials [with Mid-Point Feed: for Various Values of l/λ].—Labus, **p. 214.**

Mutual **Impedance** of Two Skew Antenna Wires.—Murray, **p. 214.**

Ellipse Diagram of a **Lecher Wire** System [and the Transition from Double to Single Hump of Current Distribution].—Hikosaburo: Mohammed and Kantebet: Takagishi, **p. 327.**

[Broadcast Receiving] Aerials and **Lightning**, **p. 505.**

Swedish Tests on Impregnating Processes for Wooden **Masts**, **p. 273.**

Lattice **Masts** of Tubular Construction, with Welded Joints.—Rixe, **p. 394.**

Buckling Loads in Lattice **Masts**, particularly in High Radio Towers, —Föppl, **p. 567.**

The Joining of Two Lines of Different Characteristic Impedance [and the Calculation of the Dissymmetric Quadripole for **Matching** a Two-Wire and a Concentric Line].—Pomey, **p. 449.**

Matching Feeders with Short- [and **Ultra-Short-**] Wave Transmitting Aerials.—Issakowitsch-Kosta, **p. 214.**

Radiation Characteristics of Beam Antennas [and the Dispersion of the Beam by the Heaviside Layer]: Errata.—Minohara, Tani and Ito, **p. 40.**

"The Calculation of the **Radiation Characteristics and Radiation Resistances** of Aerial Systems": Correction of a Formula.—Bechmann, **p. 567.**

Measurements on the **Radiation Induction** in Symmetrical [Short-Wave] Aerials [and the Influence of Height above Ground].—Schmidt, **p. 160.**

Calculation of the **Radiation Resistance** of a Two-Wire Feeder.—Loeb: Brillouin, **p. 160.**

Reply to Mr. Hallén's Remarks on my Paper "The Free Electrical Vibrations of **Rod-Shaped Conductors**."—Lindman, **p. 101.**

A Method of Measuring the Sag of Telephone Lines [Depending on the Velocity of Propagation of a Transverse Wave].—Thomas, **p. 160.**

Change of **Sag** due to Clearing of the **Sleet** on One of the Span Wires of a Suspended Overhead Transmission Line.—Nishiyama, **p. 160.**

"**Receptru**" **Screened** Lead-In Cable, **p. 624.**

The Installation of Aerials with **Screened** Down-Leads.—Wigand, **p. 449.**

Screened, Shielded Aerials, etc.: see also under "Reception."

Aerials and Aerial Systems.

VALVES AND THERMIONICS

Valves and Thermionics.

Valves and Thermionics

DIRECTIONAL WIRELESS

Directional Wireless.

ACOUSTICS AND AUDIO-FREQUENCIES

Acoustics and Audio-Frequencies.

Acoustics and Audio-Frequencies.

Acoustics and Audio-Frequencies.

PHOTOTELEGRAPHY AND TELEVISION

Phototelegraphy and Television.

Phototelegraphy and Television.

Phototelegraphy and Television.

MEASUREMENTS AND STANDARDS

Measurements and Standards.

Measurements and Standards.

SUBSIDIARY APPARATUS AND MATERIALS

Subsidiary Apparatus and Materials.

Subsidiary Apparatus and Materials.

Subsidiary Apparatus and Materials

Subsidiary Apparatus and Materials.

Subsidiary Apparatus and Materials.

Subsidiary Apparatus and Materials.

STATIONS, DESIGN AND OPERATION

Stations, Design and Operation.

Stations, Design and Operation.

GENERAL PHYSICAL ARTICLES

General Physical Articles.

MISCELLANEOUS

Miscellaneous.

Miscellaneous.

Miscellaneous.

Printed for the Publishers, Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1, by The Cornwall Press Ltd., 1-6, Paris Garden, Stamford Street, London, S.E.1.
Sole Agents for Australasia—Gordon & Gotch (Australasia), Ltd.
Sole Agents for South Africa—Central News Agency, Ltd.