FIRST COMPLETE DETAILS MARCONI-E.M.I. SYSTEM

TELEVISION

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and SHORT-WAVE WORLD

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MORE ABOUT THE NEW STATION

Dr. ZWORYKIN on the ELECTRON MULTIPLIER

HOW THE CATHODE-RAY MAKES THE PICTURE

THREE SHORT-WAVE RECEIVERS

Constructional Details

Garland

No. 97 VOL. IX MARCH, 1936.

TELEVISION and SHORT-WAVE WORLD

Special Features

TELEVISION AND SHORT-WAVE WORLD

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COMMENT OF THE MONTH

Another Step Forward.

THE publication in this issue of the complete details of the Marconi-E.M.I. system marks another step towards the fulfilment of a service which has been awaited for the past twelve months. Progress may have seemed slow, but with the details of the B.B.C.'s elaborate plans and the very elaborate equipment of the Marconi-E.M.I. concern there can be no complaint that television is not being tackled in a thoroughly practical manner. As the photographs show the Marconi-E.M.I. gear is actually in being and complete in every detail and we believe the Baird Company is in the same position in regard to their apparatus. It is abundantly evident that all experimental work has been conducted and that the finished product is ready for installation at the Alexandra Palace.

The Public and Television.

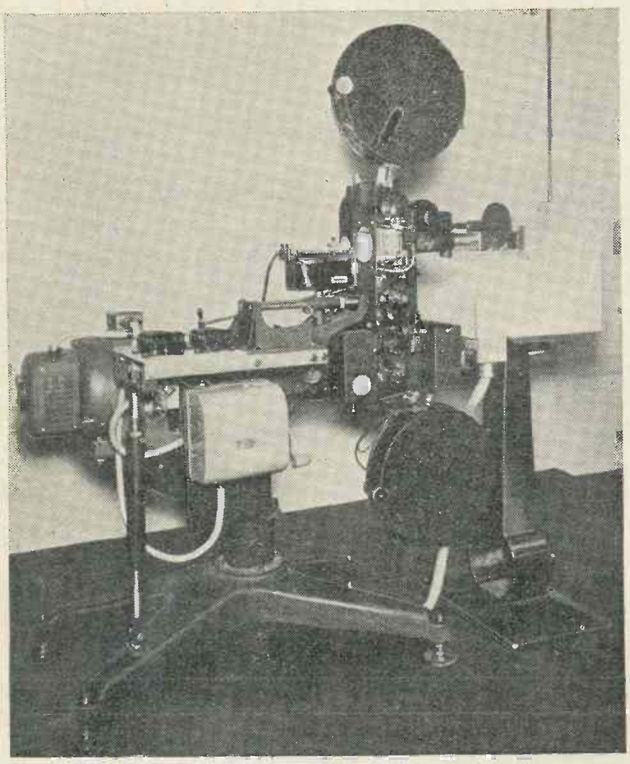
IT is very evident that the general public, as represented by "the man-in-the-street," is most lamentably ignorant concerning television. On the whole there is a good deal of scepticism regarding the subject, which is hardly to be wondered at considering the conflicting matter that has been published and the anti-television campaign that has been conducted within the past twelve months. In the daily press television is practically taboo, or else there is the other extreme of wild statements which have no foundation in fact. Hardly any attempt has been made to educate the public as to what is possible and just what state of development the art has reached. Obviously the impression that has been created will not help matters at the start and we suggest that our readers will be doing television a service if they enlighten their less technical acquaintances on the subject and provide them with information that seemingly it is not possible for the average person to obtain elsewhere. All sorts of absurd misconceptions exist ranging from the idea that it will destroy all privacy, to the risk of extremely high voltages and that it will only be the plaything of the highly technical person. Then there is the too optimistic person who is under the impression that some little addition to the ordinary wireless set will enable him to receive the programmes, or again, that he will be able to have pictures which will occupy a considerable portion of one of the walls of an average sized room. There is in fact no end to the amazing ideas that are current and the sooner they are removed the better.

THE FIRST COM
OF
MARCONI - E. M. I.

EMITRON SCANNING CAMERA : :
MODULATION : : THE RAD

"Television and Short-wave World" is privileged to pub
to be used at the Alexandra Palace for

It is common knowledge that for some years research in the principles of television has been conducted in the experimental laboratories of Marconi's Wireless Telegraph Co., Ltd., and of Electric & Musical Industries, Ltd. Both these organisations held the opinion from the commencement of their investigations that the many problems involved could only be solved by applying the scientific resources of well equipped research organisations, and also by treating the joint technique of the radio transmission and reception of television pictures as one fundamental and indivisible problem. Marconi's Wireless Telegraph Co., Ltd., in the radio communications field, and Electric & Musical Industries, Ltd., with their famous trade marks of His Master's Voice and Columbia, in the broadcast receiver field, enjoy world-wide repute.



The film projector and scanning camera for televising film pictures.

The Marconi Company's unique experience of radio research and communications dates from the very beginnings of wireless and extends to every corner of the world, while Electric & Musical Industries. Ltd., possess one of the greatest vacuum and electron physics research organisations in Europe, coupled with many years' experience of sound recording and of the manufacture and distribution of sound reproducers and radio instruments for the domestic market. A joint concern was formed—The Marconi-E.M.I. Television Co., Ltd.—and this company has now produced a practical system of flickerless picture transmission and reception, which is the outcome of a close and sympathetic collaboration between the world's most advanced designers and constructors of wireless transmitting equipment and physicists and engineers.

Television presented a far more critical problem than any the art of radio communication has known before. The production and transmission of programmes for aural reception is a matter of considerably less technical complexity than is the case in the transmission of programmes which will be appreciated both by the ear and eye.

Features of Marconi-E.M.I. Television

The Marconi-E.M.I. television system embodies a complete equipment for the radio transmission of scenes enacted either in a studio or in the open air, as well as projection by the usual film process. Before describing the equipment in detail attention may be drawn to some of the outstanding features of the Marconi-E.M.I. television equipment.

Pictures of 25 per second with a detail of 405, 240 or 180 lines or intermediate values as required by local conditions can be transmitted at will. Straight or interlaced scanning is available. With interlaced scanning flicker is entirely eliminated. The method employed is simple and involves no additional controls or equipment at the receiver.

The "Emitron" television cameras have no moving parts, are noiseless, instantaneous and continuous in action, and can be used in any position. The "Emitron" cameras can be used under normal conditions of daylight on exterior locations or in studios.

Cameras can be used at large distances from the camera control equipment, which in turn may be connected to the radio transmitter by high-frequency cable or through a short-wave radio link.

Synchronism, i.e., picture steadiness with consistence of picture texture and shape, is under all circum-

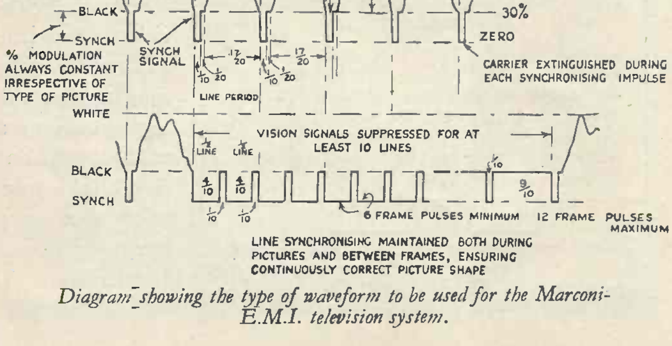
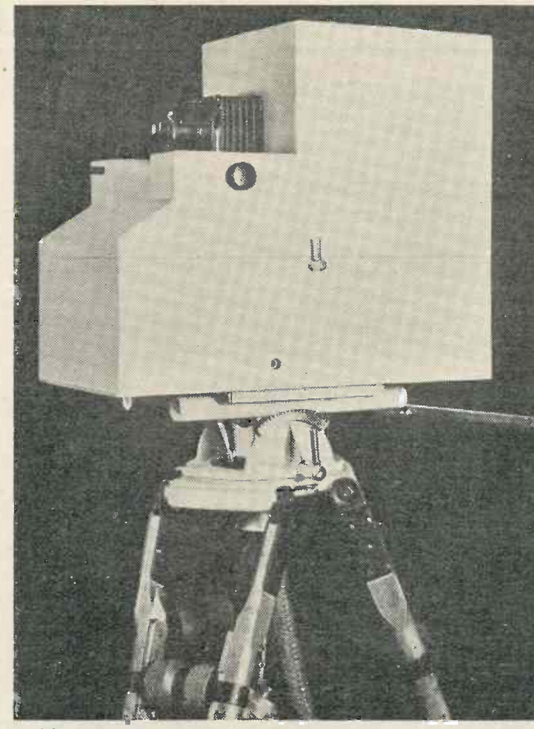


Diagram showing the type of waveform to be used for the Marconi-E.M.I. television system.

PLETE DETAILS THE TELEVISION SYSTEM

CONTROL AND SCANNING EQUIPMENT IO TRANSMITTER AND AERIAL

lish the first complete details of the Marconi-E.M.I. system the new high-definition transmissions.



The Emitron scanning camera mounted on a studio tripod.

stances " absolute " and is entirely independent of any variations of the main supplies. With the system employed the greatest economy and simplicity of receiver design and operation is secured.

The " D.C." system of modulation and synchronisation employed transmits changes in values of picture tone, e.g., from a sky scene to a dark interior instantaneously, irrespective of how long any one particular type of scene has been maintained, without the necessity of readjustment of the transmitter or receiver.

The circuits throughout provide a substantially flat response curve over a frequency band of approximately ± 2 megacycles.

While the use of a particular type of waveform is advised (see page 132), the system can be adjusted at will to transmit waveforms of other types if desired. The equipment is designed to operate on fixed wavelength selected within the ultra-short waveband of 3 to 8 metres (100,000-37,500 kcs.).

The high-frequency amplifying circuits of the transmitter are " driven " by a specially designed type of valve master oscillator which maintains the radiated frequency to within ±1 in 20,000 irrespective of normal variation of supply voltages and temperature.

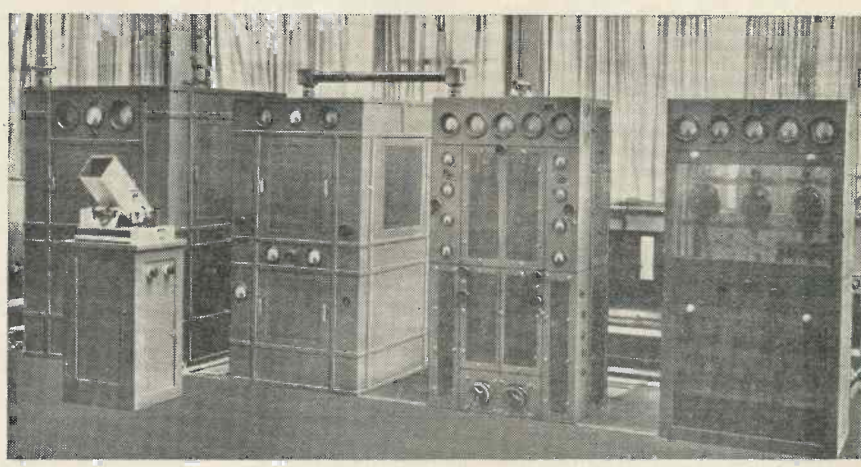
Pictures from a number of cameras can be arranged in any desired sequence or combination of studio, exterior or film scenes, ensuring that essential continuity of programme common to sound broadcasting, as distinct from film production methods. Monitoring arrangements are available for the vision director to look at any set or location which is due for subsequent presentation without disturbing the transmission in progress. Rehearsal and production conditions are catered for, in addition to the necessary picture and sound mixing devices, by the supply of adequate intercommunication speech channels centralising at the programme control desk.

The control of the transmitter is effected from a separate transmitting engineer's control desk, on which is mounted the necessary equipment for maintaining normal transmission conditions.

Description of the Equipment

The Marconi-E.M.I. television transmitting equipment may, for the purpose of this description, be divided as follows:—

(1) The Emitron television cameras.
(2) Camera control and scanning equipment.
(3) Modulation amplifiers.
(4) Constant-frequency master oscillator.
(5) Frequency doubler.
(6) Five stages of carrier-frequency amplification.
(7) Single stage modulated carrier-frequency amplifier.
(8) Aerial system.

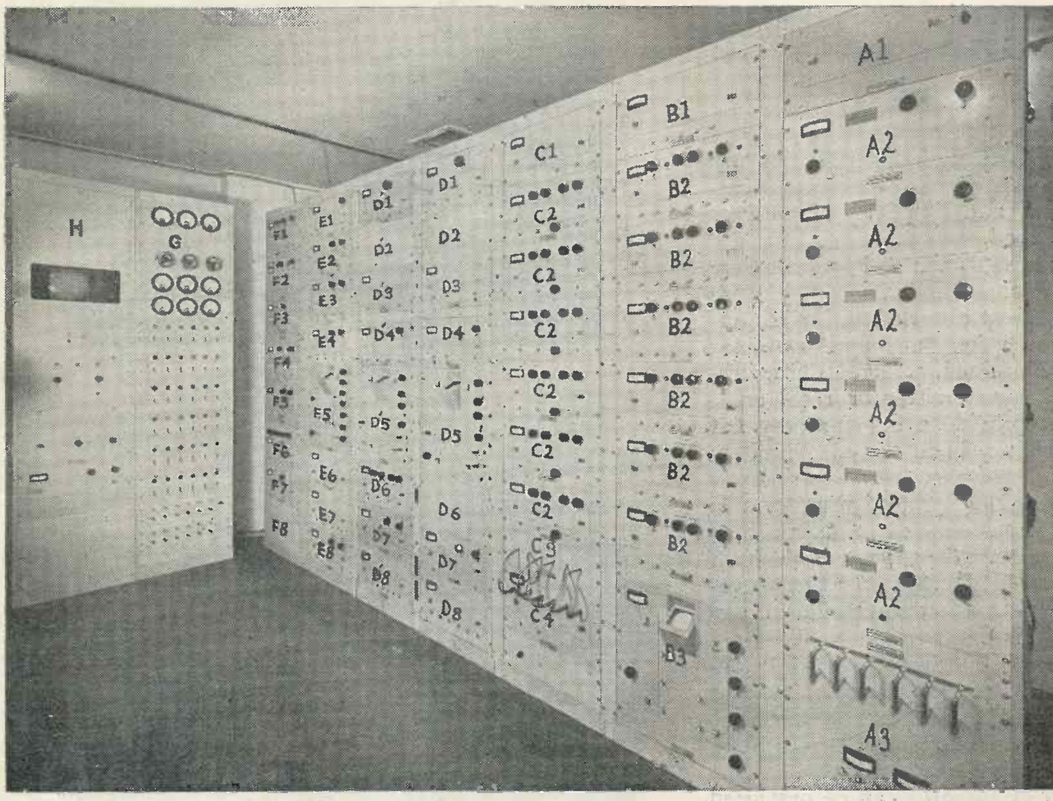


The Marconi-E.M.I. ultra-short wave radio transmitter gear.

THE MARCONI-E.M.I. CONTROL SYSTEM

Camera Equipment

The camera equipment includes four Emitron instantaneous scanning cameras and their associated apparatus for studios and outside broadcasting, and two Emitron film scanning cameras with associated film projectors and re-wind units for transmission of film pictures. The scenes to be transmitted are directly and continuously transformed by the cameras into electrical impulses. The cameras are fitted with 6.5 in. F/3 lenses normally focused at the camera itself.



This is the Marconi-E.M.I. camera control and scanning equipment of which full details are given in the text.

The cameras are connected to the camera control and scanning rack by a special design of multi-core cable fitted with male and female junction units.

Camera Control and Scanning Equipment

The camera control and scanning equipment consists of eight racks, each 24 ins. (61 cms.) wide by 7 ft. 5 ins. (2.3 metres) high, mounted together to form one complete bay. The equipment is complete with all the necessary signal and impulse observation tubes, calibration gear and remote controlled supply equipment. The camera control and scanning equipment is shown above.

The camera control equipment:—

1. Provides all operating electrical supplies and scanning pulses to the Emitron television cameras.
2. Amplifies and distributes the vision signals generated by the Emitron cameras.
3. Generates and applies the necessary synchronising pulses, in any form desired, to the picture signals for the modulation of the radio transmitter.
4. Provides means for visually inspecting and adjusting any camera picture or electrical impulse either as it passes to the transmitter or from individual cameras.
5. Superimposes or fades camera pictures from one to another whether from film, studio or outside locations.

The camera focus rack (A above), supplies to the six camera channels the necessary electrical focus potentials for controlling and biasing the scanning beam. These potentials are generated in the camera high-tension unit (A1) at the top of the rack. The necessary adjustment for each camera is provided in a series of six units (A2), below which is the junction unit (A3) for supplying the outgoing potentials to the cameras and collecting back the picture signals before passing them to subsequent racks of the camera control equipment.

The camera scanning rack (marked B) generates and distributes the saw-tooth potentials necessary for maintaining correct scanning conditions at the cameras. The actual saw-tooth potentials are generated at unit (B3) and distributed to the cameras *via* the units (B2) and the junction unit (A3) mounted in rack (A).

The rack, marked (C) is the "A" amplifier and fader which receives the incoming picture signals from the six camera channels and amplifies each camera output by means of units (C2) any of which can be connected into circuit by means of the plug board (C3). The pic-

THE MARCONI-E.M.I. METHOD OF MODULATION

ture signals from the amplifiers (C2) are then passed into a common amplifier (C4), in which arrangements are made for fading or superimposing any of the six camera outputs by direct controls mounted on the rack itself or by means of remote controls mounted on the vision director's desk.

Unit (C1) is for the purpose of reversing the picture from a " negative " to a " positive " for monitoring purposes.

The rack marked (D) is the "B" amplifier picture rack, and this enables further amplification of the selected vision programme to be effected by means of unit (D1), the picture detail being controlled by unit (D2) and further amplified by unit (D3) which also serves, together with unit (D4), to remove any spurious signal content which may be present. Picture contrast is adjusted by unit (D6), the finally adjusted and corrected picture signals being observed in the picture monitor tube mounted in unit (D5).

Unit (D7) injects the necessary picture synchronising impulses into the picture signals; the complete transmitter modulating signal, i.e., picture signal and synchronising impulses, passing through the amplifier unit (D8), from which emerge six separate channels, two of which (one spare) are taken to the transmitter modulators *via* a line frequency corrector and amplifier; the other four channels are available for monitor picture receivers located at required points. Such a monitor picture receiver is shown mounted on rack (H).

The monitor rack, which is marked (D1), is a replica of the picture bay and may be used as a stand-by equipment for that rack. The rack is equipped for the observation of the signals from any particular camera channel, the necessary contacts being made to the "monitor rack" by means of a plug unit (C3) of the "A" amplifier and fader rack.

The picture tube on the monitor rack allows observation of the picture signals on any of the six camera channels, and, in addition, supplies additional picture plus synchronising impulses for further picture monitoring apparatus which may be desired, in addition to those provided for by the channels available from the "B" amplifying picture rack.

The oscillator rack, marked (F), incorporates the master oscillators for maintaining the line and picture synchronising impulses at their correct frequencies.

Unit (F1) is an oscillator driven from the local supply mains. This oscillator drives a controlled oscillator unit. (F2), which, in turn, drives a master oscillator (unit F3) at a constant frequency.

Unit (F4) is a stand-by master oscillator similar to unit (F3) but independent of the mains supply.

Unit (F5) divides the frequency of the master oscillator (F3) by a suitable factor for controlling the line synchronising impulses actually generated and distributed by the impulse generator rack (E).

Unit (F6) divides the frequency of the master oscillator by a suitable factor for controlling the picture synchronising impulses actually generated and distributed by the impulse generator rack (E).

The rack marked (E) is the impulse generator rack, and it effects by means of units E1, E2 and E3 the actual generation and distribution of the impulses for line-frequency synchronising and picture-frequency synchronising. These impulses are of geometrically perfect waveform and are superimposed, as mentioned before, on the picture signals in unit (D7) of the "B" amplifier picture rack.

Unit (E5) incorporates a cathode-ray tube for observing the waveform of the outgoing oscillations; units (E6) and (E7) generate saw-tooth impulses at the line and frame frequencies respectively. These impulses are injected into the camera signals in the "A" amplifier rack for the purpose of adjusting the evenness of illumination of the televised image.

Unit (E8) supplies recurrent " black out " signals to the cameras *via* the focusing rack in order to prevent the return movement of the camera scanning beam at the end of each line scan and at the end of each picture scan being seen on the received picture.

Special junction unit for connecting multi-core cable between the cameras and the control equipment. The cable used is capable of passing a frequency band of ·3 megacycles without appreciable distortion.

The rack, marked (G), provides the necessary high- and low-tension potentials, both A.C. and D.C., for the operation of the camera control and scanning racks. Isolating switches and their associated meters are fitted for each section of the equipment, and the necessary rotary generators and motors which supply current to the racks are operated by remote push-button controls fitted to the supply rack (G).

Constructional Features

All the panel units are fitted with locking controls so that alterations to adjustments cannot be made without first unlocking the controls, and each unit assembly is in the form of a removable panel which can be withdrawn from the rack, if necessary. All valves are easily accessible by the removal of cover plates held in position on the fronts of the units by spring clips.

A milliammeter mounted on each unit, where necessary, enables the anode current of each valve to be measured, the instrument being connected to any desired circuit by means of push-button switches.

The combined picture signal and synchronising impulses from unit (D8) on the "B" amplifier rack are taken to a line corrector and amplifier before applying them to the modulating system. Irregularities of the frequency characteristic caused by the length of cable between the camera scanning squipment and the modulating system are here corrected.

D.C. System of Modulation

The method of modulation employed is that known as the Marconi-E.M.I. " D.C." system, whereby a

MARCONI-E.M.I. RADIO TRANSMITTER

direct current is introduced into the modulating circuits by a " black level " circuit. This method ensures that the relationship between the picture brightness and the carrier current is correct from instant to instant, without the need of adjustment of any kind at the receiver. In addition, zero carrier at each synchronising impulse ensures that the effect of interference on the synchronisation of a receiver is reduced to a minimum.

The percentages of carrier amplitude allocated to the picture and synchronising impulses are maintained at a constant predetermined value whatever type of scene is being transmitted, and irrespective of how much the scene changes in light values.

The modulator comprises six stages of amplification, namely:—

(1) A sub-modulator consisting of a single valve stage coupled to two valves connected in parallel;
(2) A sub-modulator stage consisting of a single valve stage coupled to two valves connected in parallel;
(3) A main modulator consisting of two stages each utilising cooled anode valves.

The modulating circuits are designed to have linear response from zero frequency (D.C.) to 3 megacycles.

The Transmitter

The radio transmitter consists essentially of a master oscillator, frequency doubler, five stages of carrier frequency amplification and a single stage modulated amplifier, with the addition of the necessary rectifiers for the main high-tension and grid-negative supplies.

The component parts of the high-frequency circuits are mounted in brass frameworks, and those of the rectifying circuits in iron frameworks. Tuning adjustments, circuit controls and indicating instruments are mounted on the fronts of the units and are within easy reach and view of the operator. The component parts subjected to high-frequency currents and high voltages are insulated by means of mycalex and porcelain, thus providing a high factor of electrical and mechanical safety.

The Master Oscillator.—A valve circuit of special design ensures constant frequency irrespective of any change in filament voltage, anode supply voltage or of temperature that are likely to occur. The current frequency is maintained to an accuracy of the order of ± 1 in 20,000 when the anode supply or filament voltage do not vary more than ± 5 per cent.

H.F. Amplifiers.—The master oscillator is followed by a frequency doubling stage, five stages of amplification at the carrier frequency and then by a single stage acting as an amplifier of modulated high frequency oscillations. Each amplifying stage consists of a valve or valves connected in a balanced bridge circuit, together with a closed oscillatory tuning circuit, each of which includes an inductance and variable air condenser controlled from the front of the transmitter. The first stage employs two glass envelope valves; the second stage two air-cooled valves; the third stage one air-cooled valve; the fourth stage two air-cooled valves. The fifth and sixth stages employ two water-cooled valves designed specially for operating on very short wavelengths.

The fifth and sixth stage amplifiers are mounted in separate units coupling between these two stages and also between the fourth and fifth stages being by means of adjustable inductance-capacity circuits connected through concentric tube feeders.

Low-loss Anode Cooling System.—The anode tuning inductance in each of the fifth and sixth stages forms an integral part of the valve cooling system, the cooling water circulating through the inductance, from which it is led out to rubber high-tension isolating spirals at the electrical centre of the circuit in order to avoid high-frequency dielectric loss in the water. The output circuit of the sixth stage is designed for coupling to a Marconi concentric tube feeder, having a characteristic impedance of 75 ohms. Provision is made in this stage for coupling to the outgoing feeder an external cathode-ray oscillograph mounted in the control desk. This enables a comparative visual check to be made between the incoming line signals and the output signals of the transmitter and any adjustments of the circuits can be carried out during transmission.

Rectifiers

The main power rectifier units, two in number, are arranged for full-wave rectification. They are similar in design and differ only in the size of valve used and the output. One of the units, incorporating six mercury-vapour rectifying valves, is used for providing high-tension direct current for the anode circuits of the sixth stage or final amplifier. The second unit, incorporating six mercury-vapour rectifying valves, is used for providing high-tension direct current for the anode circuits of the third, fourth and fifth stages of high frequency amplification. Provision is also made in each rectifier unit for " conditioning " two spare valves, so that they are ready for service when required.

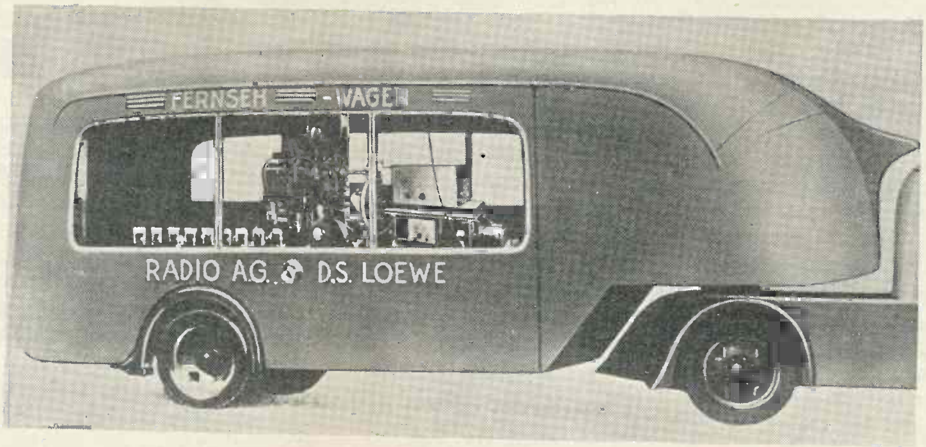
The rectifier filaments are heated from the main alternating current supply, and special starting rheostats are provided, in which motor-operated contactors bring the filaments to the working temperature in delayed steps. When the full filament voltage has been applied, auxiliary contacts on the rheostat allow of the application of the anode supply at a reduced voltage. The main power can then only be brought up to the full working voltage after a further controlled delayed period, when the proper vaporisation temperature of the mercury has been reached. The power input to each of the main rectifiers can be controlled from full power down to quarter power by means of separate motor-controlled induction regulators.

The auxiliary rectifier units, two in number, incorporate metal-oxide rectifiers, each of which is provided with its own smoothing system and supply transformer. Potentiometers or resistances connected in each rectifier output circuit allow the voltages to the various circuits to be adjusted to the required values. The first of these two rectifier units provides for the supply of anode current to the master oscillator, doubler and first amplifier, and to the second amplifier, and, in addition, filament current to the master oscillator, doubler and first amplifier, and grid negative bias to the master oscillator, doubler and first four stages of amplification.

(*Continued on page* 192.)

TELEVISION PROGRESS ABROAD

This article is a brief resumé of television activities on the continent and in America. Practically every country is now devoting serious attention to television and in many cases the governments are taking an active part in research work.



A German mobile television transmitter.

THE fact that with the possible exception of Germany all television activities are more or less experimental makes it exceedingly difficult to obtain any precise information regarding the progress being made. Even in our own country where a public television service is well on the way to fulfilment, the various concerns are not any too eager to disclose either their methods or the precise amount of progress made. Then again reports are constantly coming to hand of work of private individuals but without any definite proof of the claims that are made.

It is difficult even to make any comparison between the countries which are leading in the television race. Germany, for instance, has really got down to the practical side of the business and yet America is the pioneer of electronic scanning, and the work in this direction that has been done there gives that country a leading position although television has not yet entered into the practical stage.

The foreign countries which are known to be really active are America, Germany, France, and Russia, and to a lesser degree Italy, Sweden and Japan. There is also a certain amount of activity in the Colonies.

Television in America presents a difficult problem on account of the large areas that will have to be covered and it appears that the trouble is largely financial. Abortive attempts were made some four or five years ago to popularise low-definition television and several stations put out transmissions, but they only managed to interest a small number of experimenters, and when it was realised that there was no financial gain possible the transmissions were dropped.

This set back, if it can be termed such, did not deter the really serious workers from continuing their research and two outstanding names are now before the television-minded public of the whole world—Farnsworth and Zworykin. The latter is the sponsor of the Iconoscope and responsible for recent developments of the electron-multiplier; he occupies an official position with the Radio Corporation of America.

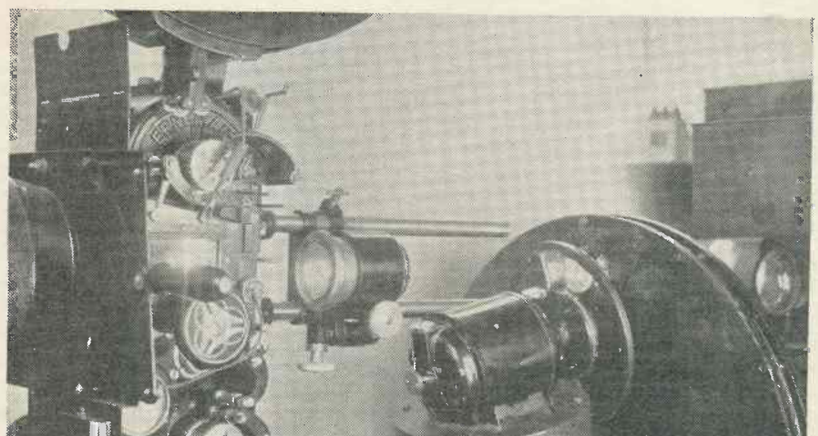
America

In May, 1935, the Radio Corporation of America decided that the time had come when television should be taken out of the laboratory, and announced its intention of spending £200,000 on development. The programme decided upon comes under three headings:

(i) The construction of the first modern television plant in the United States.

(ii) The manufacture of a limited number of television sets to be placed at strategic places.

(iii) The development of a programme service with the necessary



TeKaDe transmitter for interlaced scanning.

TELEVISION ON THE CONTINENT

studio technique to determine the most acceptable form of television programmes.

The experiments are expected to take at least 15 months, and the New York headquarters will probably be the 100th floor of the Empire State Building, where an experimental transmitter has already been in use for several years past. Visual programmes will at first only be available in thickly-populated cities, where a single transmitter erected on some high point can serve a comparatively large number of "lookers." Ultra-short waves will be used in the tests, with an expected range of 25 miles.

Fernseh cathode ray home receiver.

Another very active concern in the United States is the Farnsworth Television Corporation, and it is generally thought that this company will be transmitting a regular schedule of programmes before transmissions are commenced by the R.C.A. There are numerous reports of other television activities, but the fact that the Federal Communications Committtee has asked the Farnsworth Company and the Radio Corporation of America to settle such details as the line and picture frequencies, indicates that it is these two concerns that are really in the running. Philo. T. Farnsworth is responsible for the image camera which is to be used by the Baird Company in this country.

Germany

At the German Radio Exhibition in August, 1935, no less than twenty television receivers were exhibited operating from the Berlin 180-line twenty-five pictures per second transmissions, and it was proposed to carry on with a regular service of programmes. This scheme, however, was interrupted by a disastrous fire which broke out and destroyed the greater part of the apparatus.

The German Post-Office, which is taking a very active interest in television, decided, however, to take up high-power ultra-short-wave television broadcasting at the earliest possible moment again and gave orders to Telefunken to supply twin transmitters similar to those which were destroyed by the fire, with the least possible delay. As it would have taken some months before suitable transmitters for 240 lines and 25 frames per second could be ready the Post-Office and Telefunken decided to limit the new outfit to 180 lines and 25 frames. Work on these transmitters has been completed and they have been installed in a temporary transmitter building situated at the foot of the Witzeleben radio tower.

Programmes are supplied by the German Broadcasting Company and mostly consist of films or scenes taken by the help of the intermediate film reporters' van. Vision is broadcast on 6.722 metres and sound on 7.053 metres.

For the present the Witzeleben transmissions are regarded as educational and it is not proposed to make receivers available to the ordinary public for the time being in view of the possibility of technical improvements in the near future. It seems likely that the standard of definition will be raised very shortly for it is known that a good deal of work is being done with electronic scanning. Facilities are offered to the public to witness the programmes by the opening of eleven viewing rooms in different parts of Berlin. Broadcasts take place daily from 8 p.m. to 9 p.m. and are repeated from 9 p.m. to 10 p.m. To accustom Berlin listeners to ultra-short-wave broadcasting ordinary sound programmes relayed from the Deutschlandsender are broadcast daily from 5 p.m. to 7.30 p.m. and from 10 p.m. to midnight (Berlin local time).

France

France displayed very little interest in television until about April last year when a series of 60-line transmissions were inaugurated from PTT. It was announced at the time that these were only experimental and that it was proposed to gradually increase the definition. The picture frequency was 25 per second with a ratio of 3-4 on a wavelength of 175 metres. A decision, however, was quickly reached to increase the definition to 180 lines, and as a result the station was formally opened on November 17 working on 180 lines and 25 pictures per second. The studio is in the PTT building, rue de Grenelle, and the aerial is erected on the Eiffel Tower. Full details of this station were given in our January issue.

Russia

In Russia television is also making progress. The Radio Committee will have three special television transmitters erected during 1936; these will be situated respectively in Moscow, Kiev and Leningrad. A transportable transmitter is also being constructed for direct transmission. Apart from these stations, other television transmitters are also proposed for distant centres such as Khabarovsk, Nevosibirsk, Tachkent, etc.

Japan

The Japanese are taking a very keen interest in television though from reports received nothing more ambitious than sixty lines has been tackled. An experimental service is to be started this year with the object of determining the best system and studying the subject generally. This station is to be erected in Tokyo.

PROGRESS AT ALEXANDRA PALACE

Readers will remember that in our November, 1935 issue we published the first description of the Alexandra Palace as it will be when the necessary alterations are complete. The details then given were exclusive to TELEVISION and Short-Wave World. By courtesy of the Editor of the Hornsey Journal we are now able to give some further information which has been furnished by Mr. L. R. Charlwood, the Clerk of the Works, and was exclusively published in that paper.

SO far as constructional alterations of the Alexandra Palace are concerned, the work is now practically complete. No longer is there any connection between the portion to be used as London's first television station and the remainder of the Palace. Corridors and stairways that formerly led into the main building have been bricked up and a new entrance made under the south side of the tower.

Through imposing doors, probably of copper, the visitor will pass into a specious entrance hall of 33 feet by 20 feet. To his right front is an inquiry office. Straight ahead is the main staircase leading to the first floor, on which the studios are situated. The tower itself has been completely altered. Inside this steel girders have been erected to take the weight of the five floors inside the tower and of the 30-ton aerial mast.

Inside the tower the visitor will notice an alteration. Between the ground and first floors a mezzanine floor has been introduced, and this procedure has also been adopted between the first and second and third floors. Here there will be 26 offices. These will house the executive, and inside them the visitor's attention will be caught by the pleasant cantilever bay windows on the south and east elevations.

Artists' Rooms

From the second floor a long corridor branches off towards the south end of the building. To the left of the corridor are the two studios, which command a pleasant view over Hornsey and Wood Green, and to the right the offices and cloakrooms for the artists. First on the right comes the gentlemen's dressing-rooms and bathroom. Further down on the right are four ladies' dressing-rooms and the ladies' bathroom. The next door along the passage opens into an artistes' waiting-room, which gives into a 5 feet by 16 feet boudoir specially built for the lady announcer.

Beyond that, at the far end of the corridor, is the band rehearsal room, situated over the old Palace kitchens. To deaden the sound the walls of this room are being treated with special boarding and with slag wool.

At the end of the corridor is a staircase for staff use, leading back to the ground floor. Here a fireproof storing-place is being built to contain the films used for transmission.

The Studios

Now we will take the visitor along the corridor back to the tower. First on the right will be the Baird transmitting studio, a large room 67 feet by 29 feet, whose walls have been lined with asbestonite, a sound-deadening substance. Opening out of the studio are an observation-room and two transmission-rooms. Next door is the tele-cinematograph-room, from which films will be transmitted.

Next along the corridor is the control-room for the E.M.I. transmitting studio beyond. In this control-room a balcony has been built where an engineer will sit at the control panel looking through a large glass window in the wall on to the E.M.I. studio. This studio is slightly larger than the other, being 70 feet by 29 feet.

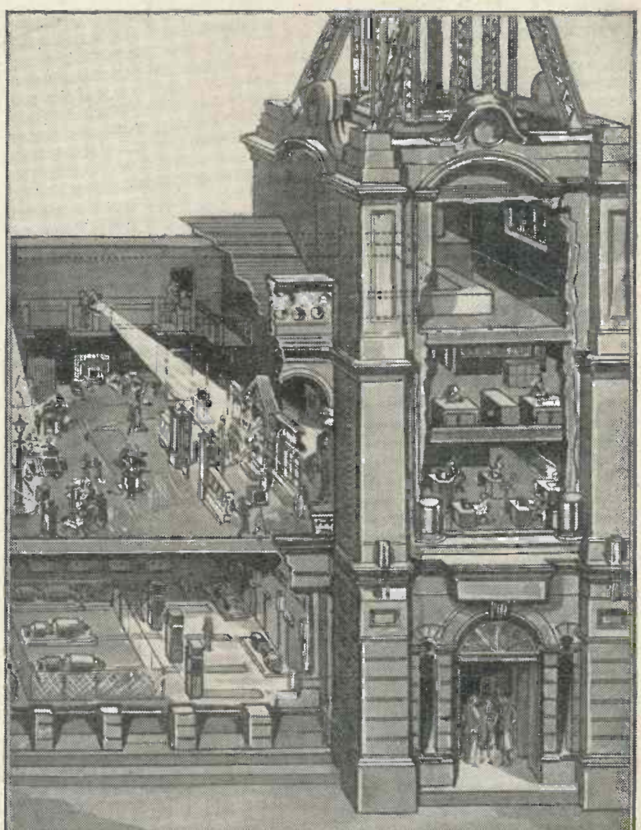
Except for staff cloakrooms situated at the end of the east wing there is nothing else on the first floor.

The Transmitters

The ground floor is taken up with the transmitters. Behind the entrance hall are two rooms containing the switchgear for the power supply. The current will be supplied by the North-Met. from large transformers, which will be erected on the site of the old boiler-house. In case of a breakdown stand-by generators will be installed.

Immediately under the E.M.I. studio on the floor above is the

(Continued on page 142)



Scannings and Reflections

By THE LOOKER

The Versatile Photo-cell

HARDLY a day passes without some new application for the photo-cell being discovered. When a static flash-over takes place from the radiating system of a high-power transmitter there is always the possibility of the current following *via* the ionised path of the spark. At WLW, Cincinatti, it was formerly the practice to detail an operator to watch for such flash-overs, who would then cut off the power. A photo-cell is now employed and when the flash appears at the spark gap the cell is caused to operate a relay which switches off the power and then switches it on again after the discharge has ceased.

Photo-cells are also being employed on the Brooklyn subway trains for the control of the train lighting. When the train enters a tunnel the lights are automatically switched on and they are put out again when the train once more emerges into the daylight.

Baird Television, Ltd.

An order of the High Court of Justice, Chancery Division, dated January 20, 1936, confirming the reduction of the capital of Baird Television, Ltd., from £875,000 to £825,000, was registered by the Registrar of Companies, January 27. A Baird Television issue of 2,100,000 20 per cent. non-cumulative preferred ordinary shares, each of 2s. 6d., has been over-subscribed.

Bush Radio to Market the Televisor.

Whilst " television " is a dictionary word, " Televisor " is the proprietory name of the Baird television receiver. It is now announced that Bush Radio, Ltd., which is linked financially with Baird Television Ltd., has in course of production a range of Televisors and will probably market them soon after the London television programme is inaugurated. Bush Radio agents, to be selected from those on the Bush Radio list, will distribute the Televisor; these agents are being sent in detachments to the Crystal Palace where they are receiving some training at the hands of the Baird engineers to assist them in selling and servicing the Televisor. Already Televisors produced by Bush Radio are being tested by the Baird people at the Crystal Palace in readiness for the public demand.

Is This Delay?

The Postmaster-General has stated in the House of Commons that it was not yet possible to give an approximate date for the opening of the television broadcasting service, but it was intended that the service should be operated dupring the coming summer. No explanation of the P.M.G.'s statement is available and as it stands it does not mean very much.

English Artists on the Paris Television.

Miss Nona Reed, the daughter of the London comedian, Mr. Herbert Mundin, has given great satisfaction in her singing and dancing numbers at the Paris television station, and we learn that another English dancer, Miss Iris Kirkwhite, of Nottingham, succeeds her.

Televising the Coronation.

Statements in the Press that the Coronation ceremony in Westminster Abbey in May or June of next year will be televised by the B.B.C. are, to say the least, a trifle premature. We are all in great hopes that the ceremony will be televised, but the difficulties in the way, both physical and political, are not to be despised. The lighting inside Westminster Abbey may be altogether too much subdued to allow of the television " eye " giving a reasonable response.

The B.B.C.'s Finance in 1935.

The B.B.C.'s financial report for 1935 shows an increase in the number of licence-holders of 622,540 to a total of 7,403,109. Licences have brought the B.B.C. £327,976 more than the previous year, the total being £2,038,262. " Other sources "—notably the B.B.C. publications—have produced £85,613 more, the total here being £434,310. Thus, the B.B.C. had a total income of £2,472,572, which is £413,589 more than in 1934. It has spent £195,547 more on programmes, of which amount £40,455 is accounted for by increases in the total of staff salaries, and altogether the sum spent on programmes in 1935, including artists, orchestras, rights and royalties, relay lines, and staff salaries and other expenses, is £1,110,572. Artists, orchestras, rights and royalties alone cost £141,841 more than in 1934, the total being £789,821, which is just over 41 per cent. of the B.B.C.'s net income of £1,918,154 after paying income tax. Salaries chargeable to programmes represent nearly 12 per cent. of the net income, and all *other* salaries, administration and wages and Governors' fees (£5,207) represents a further 22 per cent. (nearly) of that net income.

Engineering has cost £386,529, which is £51,571 more than 1934, and all other expenditure accounts the sum of £651,310, which is £43,478 more than in 1934. The grand total of expenditure is £2,148,411, a balance of £324,161 being carried forward to 1936. A large sum was expected to be spent on television in 1935, but for various reasons the expenditure has been delayed. While the B.B.C. has made a " profit " on its current account, there is a deficit on the capital account of £677,030. Capital expenditure is very heavy and further necessary capital schemes will involve high expenditure for some time to come. The B.B.C. in 1935 provided 68,795 hours and 38 minutes of transmission time.

The First Co-axial Cable.

Outside Broadcasting House a few days ago I saw a large drum containing a co-axial cable. It did not excite any interest in the ordinary passer-by although a few people, probably the more technically minded,

MORE SCANNINGS . . . .

stopped to examine it. This cable, as a matter of fact, will be the first of its kind to be laid in this country and it is the commencement of a line from Broadcasting House to the Alexandra Palace. The Post Office is responsible for it and it is being laid at the request of the B.B.C. to connect Broadcasting House with the Palace. This, it will be noted, is the result of a recent decision and is described as being for experimental purposes, presumably so that certain items at Broadcasting House can be relayed for re-transmission on the ultra-short waves from the Palace.

Television in the Provinces.

Speaking of co-axial cables it has generally been assumed that as the Post Office have in hand a project for laying a cable of this type to Birmingham this will be the first provincial centre for television. This, however, is perhaps a hasty conclusion which, when all things are taken into account, is probably incorrect. To be of use, a regular television service would have to be inaugurated in Birmingham and this would entail the use of the cable for several hours a day as a regular thing. On the face of it it does not seem likely that the Post Office would go to the huge expense of laying this cable and then relinquish its use for very considerable periods. Then, again, I am by no means certain that a cable of this length will answer the purpose of television, though obviously this installation will provide a basis of experiment.

Unofficially it has been stated that there will be no television in the provinces until twelve months' experience has been obtained with the London transmitter. It can be assumed that by that time very many more developments will have taken place and possibly new systems tested out. I think it is more likely, therefore, that when it is decided to extend activities the opportunity will be taken to try out any new systems that seem worth while.

A Mystery Transmission.

Very frequently of late what appears to be a thirty-line transmission has been heard on round about 41 metres, but nobody seems to know from where it emanates. It is quite a good signal and is usually on between nine and ten in the evening; it may be some amateur experimenting with television, but somehow I don't think so. Perhaps some reader can provide some information regarding these transmissions.

Implosion.

There is a good deal of speculation in technical circles regarding the possible danger of the cathode-ray tube collapsing. I have had personal experience of three tubes that "burst" and though no damage resulted to anybody the occurrences were rather alarming. Of course, a tube "bursts" inwardly, or implodes, but this fact does not lessen the potential danger for the particles by no means come to rest at the centre of the tube, and for all practical purposes the occurrence may be looked upon as an explosion. In one instance referred to the tube went off before it had even been unpacked; it was in fact merely standing in its carton undisturbed. There was no apparent cause for the second one bursting either and in this case broken pieces of glass marked the wall. The third was the result of careless handling.

When one considers the enormous pressures that are on these tubes it is surprising they stand up as they do. Their strength lies in their shape, and it is easily conceivable that any defect in this respect will tend to weaken the tube. So far as I am aware no precautions have as yet been taken in receivers to prevent the possibility of accidents and it would appear to be desirable to place a glass covering over the end of the tube as a precaution against flying glass.

On this score the indirect method of viewing as employed by the Baird Co. appears to offer certain advantages, for the actual tube is well outside visual range, and although an implosion might be alarming it is improbable that any damage would be done to anyone viewing the picture.

Mechanical Systems.

I am frequently asked how the mechanical systems are progressing under the somewhat severe demands of 240 lines. I can only say that sponsors of the various systems are quite optimistic regarding future results and, although they have been set a difficult problem, their faith has not wavered. Like many others, they are naturally experiencing some difficulty owing to no transmissions being available. Modulation, I am told, presents no difficulties at the high frequencies involved, but judging from casual remarks synchronism is likely to be the principal difficulty though to what extent it is difficult to say until the B.B.C. start transmitting. There is no doubt but that mechanical systems offer many advantages if they can be made practicable for the new standard and it is significant that some of the concerns which are developing cathode-ray television have not lost all their interest in mechanical systems.

Mains Supply for Unwired Homes.

The Birmingham Corporation Electricity Supply Department is to be congratulated for its offer to supply current for wireless purposes to premises that are not wired for electric light. There are still a very large number of houses that are not wired, and residents of these will no doubt be glad to take advantage of the offer. Under this scheme when the connection between the main and the house does not exceed sixty feet a fee of only ten shillings is charged and current is supplied at power rate subject to a minimum payment of five shillings a quarter. Many people will be glad to have the advantage of mains supply, but may not be prepared to go to the cost of wiring the house. It is a scheme that other electricity undertakings might follow with advantage.

Field Strengths of the B.B.C. Short-wave Transmitter.

For the past few weeks 7-metre transmissions have been put out from the roof of Broadcasting House and a van has been touring the country north of London plotting the field strengths in different areas. The results and purpose of these experiments are for the present hush-hush, but obviously they are in order to obtain data for the coming television transmissions. Of course, sound only has been transmitted, and for this either the National or Regional programme has been taken. By the kind co-operation of several friends in different parts I have been able to form some idea of the results, which vary from about 7 microvolts

. . . . . AND MORE REFLECTIONS

to 2 millivolts. No precise measurements have been possible, but it is clear from the reports that I have received that reception is decidedly patchy and that it varies very considerably within quite small distances.

Screening effects have been very noticeable and this seems to imply that in the majority of cases the television aerial will have to be erected as high as possible and clear of surrounding buildings if the best results are to be obtained. The aerial will, in fact, form quite an important feature of the installation. There should, however, be little difficulty regarding aerial height for the actual aerial will be of only quite small proportions. I remember that the Baird Company, for their demonstrations during the early part of last year, merely used a light bamboo rod about twelve feet long to which a couple of lengths of wire were attached. This was placed on the roof of their premises in Victoria Street, but later it was brought into the same room that the receiver was in and no appreciable difference was observed in the received picture.

30-line Transmissions from Holland

Readers who are in possession of thirty-line receivers will be interested to learn that transmissions which correspond to the old B.B.C. transmissions are now being put out from Holland and have been well received in this country. The picture ratio is 7 × 3 and 12½ per second, in fact they are the same in all respects as those to which we are accustomed, including vertical scanning. The wavelength is approximately 80 metres. The one snag is that the broadcasts are between 6.10 and 8.10 on Sunday mornings so they necessitate early rising. So far as I have been able to ascertain these broadcasts are likely to be continued for some considerable time, so it will be worth while digging out that old 30-line receiver.

W2XEM

Many readers have been sending me reports on the reception of W2XEM using a wavelength of 9.966 metres, 30.1 megacycles. B.R.S. 1784 has sent me some details of this station for the benefit of readers in doubt as to what they actually have been receiving.

W2XEM, QRA Newark, New Jersey, is used for calling police cars, although it is only intended to have a nominal range, it is heard in Europe up to R9. The transmitter, built by Western Electric, has an input of 500 watts and is capable of being modulated up to 100 per cent.

The line-up consists of two units. The first a 50-watt modulated amplifier feeding a 500-watt class-B amplifier. The frequency is maintained to within 25 cycles by using a conventional temperature controlled crystal. The third harmonic of the crystal is selected to give the transmitting frequency.

Messages are despatched from Police Headquarters, about half a mile from the transmitter, which is housed on the 34th floor of Newark's tallest building.

The aerial is a half-wave vertical with feeders 200 ft. long. Reports are appreciated from British listeners and should be addressed to W2XEM the Director of Public Safety, City Hall, Newark, New Jersey.

"The Transmission and Reception of Micro Waves" by C. G. Lemon.

The above preliminary article published in the February issue of TELEVISION was, we regret, inadvertently published without the permission of the author and of the Radio Society of Great Britain.

Silent Periods

Dr. J. H. Dellinge, Chief of the Radio Section of the American National Bureau of Standards, has just made an interesting discovery. He finds that a peculiar silent period occurs every 54 days. During that period all short-wave stations are wiped out on the illuminated side of the globe. The dark side of the globe is not affected. So far no theory as to the cause has been put forward.

Progress at the Alexandra Palace

(*Continued from page* 139).

E.M.I. transmitter-room, where massive concrete beds provide foundations for the power plant. One side of the room will be taken up by the controls which will be placed on a raised wooden floor, with the cables in ducts beneath. Beyond is the Baird transmitter-room, laid out on similar lines.

Cinema Projectors

Also opening off the corridor, which in this case will contain the power cables and has been made fireproof, is a fireproof projection-room where two cinema projectors will be installed. Next to this is a tiny cinema, where films that are to be televised will be inspected.

Further down the corridor is the kitchen—the old Palace kitchen, which has been completely converted. A large portion of it will be turned into a cafeteria for the staff and artists. The Palace Trustees-room has been converted into another staff-room.

Beyond the Baird transmitter-room is the carpenter's workshop, where all the scenery to be used in the two studios will be manufactured. Beneath the workshop, in the only part of the large basement to be used, will be the boiler-room, for the whole of the B.B.C.'s portion of the building will be heated by hot-water radiators.

No Theatre

Air-conditioning is not being employed, but fans are being installed.

More than ninety men have been employed on the work. The engineers found the task of reconstructing the interior of the Palace more difficult than was expected, but the work is practically up to the date scheduled.

Some Television Terms

Photon

A unit denoting the illumination of the retina of the eye with a pupil aperture of one square millimetre by an object having an intensity of one candle per square metre.

Lumen

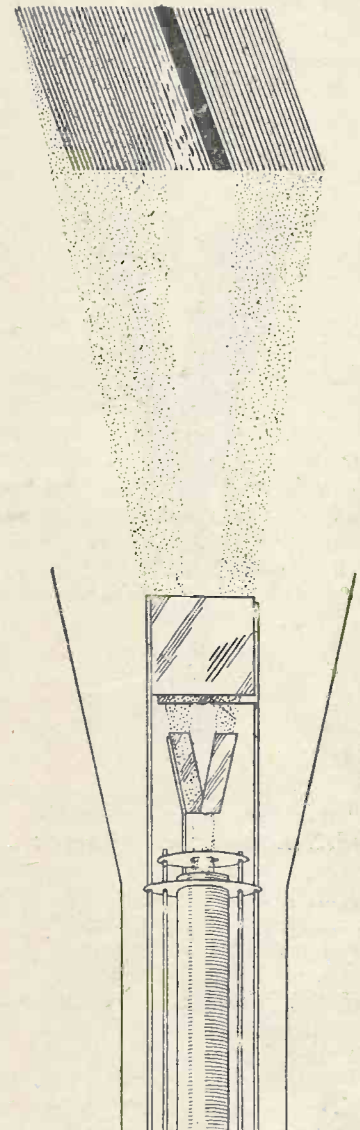
A unit representing a quantity of light: 4π lumens, spherically distributed, are emitted by a point source of one candle-power.

Phase Distortion

The effect produced by certain frequencies which go to make up the picture travelling at a different speed to others, with the result that they are out of place and produce distortion in the picture.

FOR THE BEGINNER

HOW THE CATHODE-RAY MAKES THE PICTURE



THE diagram shown here is a continuation of the series which we showed last month and illustrates the way in which the picture is formed on the fluorescent screen.

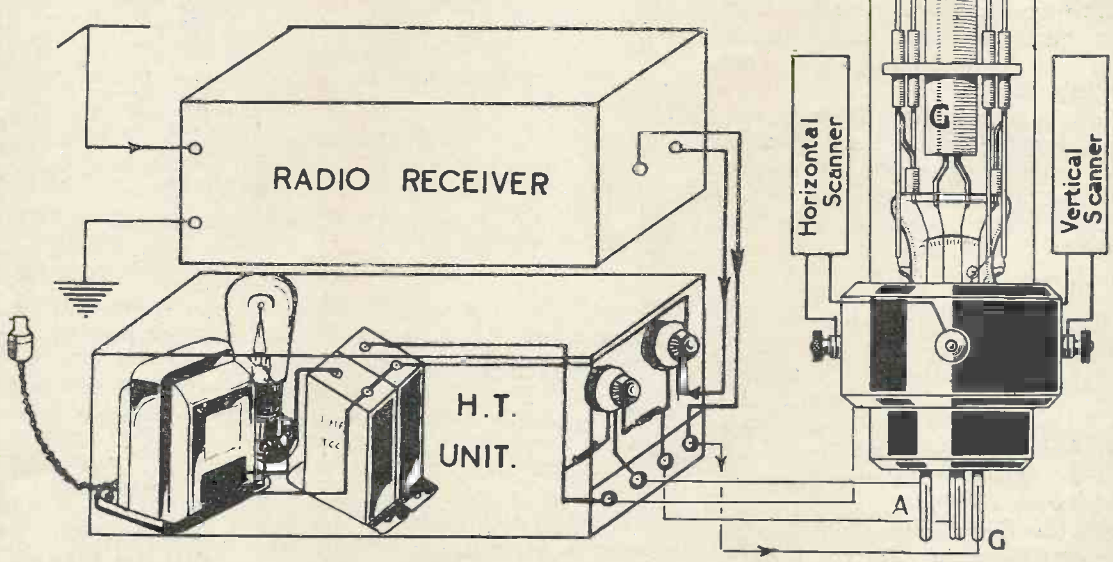
The electron stream is produced by the potentials applied to the electrodes of the tube from the H.T. unit marked. The transformer and valve produce 3,000 volts, which is smoothed by the condensers and applied to the tube anodes.

The "grid" G of the tube has a negative potential applied to it from the bias resistance shown, but the lead to the grid is taken to the output terminals of the receiver.

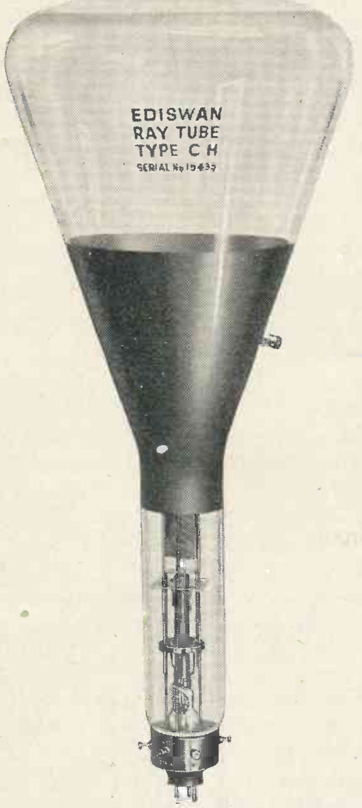
The action of the grid is similar to that of the grid of a valve—when a signal is applied the anode current (in this case the beam current) increases and decreases, giving light and dark patches on the fluorescent screen.

In the diagram a signal received from the aerial is applied to the bias potentiometer and has momentarily increased the grid bias, shutting off the beam and causing a blank to appear in the electron stream as it is swept to and fro across the screen. The fluorescence has disappeared from that part of the screen, leaving a dark patch.

We see that there are four components for the production of the picture: (1) The supply unit for the tube; (2) the vertical scanning circuit; (3) the horizontal scanning circuit; (4) the television receiver. In practice (2) and (3) are combined in one unit and fed from the A.C. mains together with the supply unit.



THE EDISWAN CATHODE-RAY TUBE FOR TELEVISION



The Ediswan Type CH cathode-ray tube with a 25-centimetre screen for television.

THE Edison Swan Electric Co., Ltd., have recently developed a cathode-ray tube of the high-vacuum type specially designed for television. This is the type CH and the material with which the screen is coated yields a high luminosity white fluorescence which makes possible the production of pictures of a very pleasing black and white. Special attention in the design has been paid to the focusing properties of the beam and the modulation characteristics with particular reference to picture reproduction.

As will be seen from the specification below the screen has a diameter of 25 centimetres and the tube length is 60 centimetres.

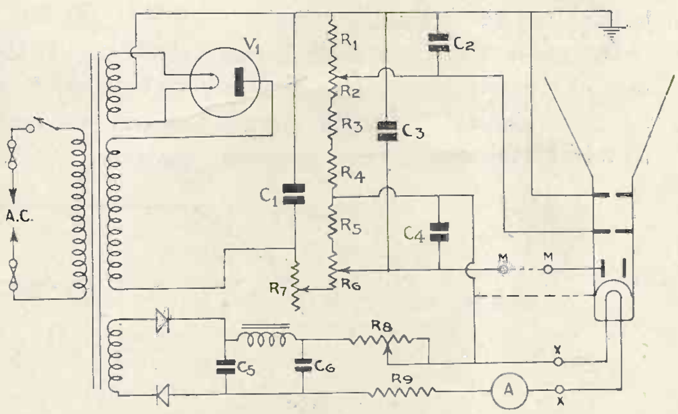
Cathode heater voltage (approx.) 2.0
Cathode heater current (amp. approx.) 1.3
1st anode potential (approx.) 1,200
2nd anode potential 3,500
Negative grid potential (approx.) 100/200
Sensitivity in mm./volt (where V is final anode voltage) $\frac{750}{V}$
Tube length (cms.) 60
Screen diameter (cms.) 25
Indirectly-heated cathode.

A photograph of the CH tube appears on this page and it will be seen that the construction follows generally accepted practice, the electrode assembly being mounted on a glass pinch with rigid support for the grid, anodes and deflector plates. The anode lead is shielded by a glass tube in order to avoid possibility of leakage at high voltages. The electrode structure is connected to the pins of a standard 4-pin base above which is an ebonite ring provided with four terminals for making connection to the deflector plates. It is probable, however, that a form of multi-contact base will eventually be fitted.

Full modulation can be obtained with this tube with from 10 to 20 volts on the shield and good results will be obtained if the signal is loud headphone strength. If desired, the beam can be deflected magnetically, coils being attached to the outside of the tube parallel to the deflector plates. The coils must be as nearly as possible identical, and should have a diameter approximately equal to the distance between them.

A suitable exciter circuit is shown by the diagram and the following notes are the maker's general operating instructions: When only one pair of plates is in use, the other pair should be short-circuited and earthed in order to prevent charges accumulating on them. A preliminary test should be made to ensure that the deflection obtained is within the effective diameter of the screen. The amplitude of the potential supplied to the deflector plates can be adjusted by the usual methods of potentiometer or transformer, care being taken that the circuit under observation is not appreciably modified by their insertion. The beam is easily influenced by external magnetic fields. It is advisable, therefore, to surround the tube with a magnetic shield, which should be earthed. Steel shields specially designed for the purpose can be supplied. Also the tube should be placed as far as possible from local sources of interference, such as generators or electro-magnets. Should the deflection of the beam not be symmetrical with reference to the screen after these precautions have been taken, it can be deflected by (1) a permanent magnet placed in the rear of the shield; (2) by means of a small biasing battery connected in series with one deflector plate, or (3) a battery-operated coil attached to the side of the tube. The spot should not be allowed to remain stationary on the screen for any appreciable time or the screen will be damaged.

The circuit of the exciter unit.



The price of the CH tube is £12, and the makers are The Edison Swan Electric Co., Ltd., 155 Charing Cross Road, London, W.C.2.

MECHANICAL FILM TRANSMISSION

A DISCUSSION OF ITS POSSIBILITIES WITH WELL-KNOWN SYSTEMS

By L. M. Myers.

This is the first article of a short series dealing with high-definition mechanical-optical film transmitters. The article below deals with the simple apertured disc transmitter and in the later articles other well-known mechanical systems will be considered and their efficiencies discussed.

NOW that it might appear that the death knell of mechanical-optical television systems is being sounded in every country adopting the more recent methods of electron-optical scanning, it may be well to pay tribute to the only present-day use to which the former systems can be applied with fair results. Even so, we must give some attention to the limitations which beset mechanical-optical systems having regard to efficiency for increasing definition.

We shall consider first the simple aperture disc, which has, perhaps, played the most important part of all in the early and later development of mechanical-optical systems for the transmitter and for the receiver.

It was first stated by Möller in "Fernsehen," for January, 1932, p. 36 (just over four years ago) that the efficiency of a mechanical-optical scanning system increased as the square of the speed factor for the aperture and lens-disc arrangement, and as the fourth power of this factor for the mirror-drum arrangement. By speed factor is meant the number of revolutions of the scanning system per one complete picture. In the early days, when the aperture disc received a spirally disposed system of apertures, the speed factor could not enter into consideration, because the spiral completed the one frame scan. The case is different for the film transmitter, owing to the fact that the film can be run continuously through the gate and the apertures in the scanning disc can be equidistant from the centre. Thus for a 240-line scan, the disc should bear 60 apertures at a speed of 6,000 r.p.m. The picture-frequency in this country is 25 per second, this corresponding to a disc speed of 1,500 r.p.m., if there is to be one complete revolution per picture. In the case considered, therefore, the speed factor will be 4.

By the efficiency of the scanning system is generally understood the amount of light flux in lumens reaching the photo-cell. We shall take first the case of the aperture disc scanning the continuously moving film.

Let B be the brightness of the light source in candles/cm^2.
- n be the number of lines in the scan.
- K be the picture ratio; i.e., K=Length/Width, the length being in the direction of scan.
- N be the number of picture elements. $N=Kn^2$.
- D be the effective diameter of the scanning disc. This will be the actual diameter of the apertures.
- a^1 be the area of the disc aperture.
- a be that area of the light source corresponding to the disc aperture (see Fig. 1).
- d be the diameter of condenser.
- r be aperture ratio of condenser.
- l be the distance between objective and light source.
- l^1 be the distance between objective and disc.

In order to effect the necessary scan the light source is first imaged on the line joining successive apertures of the disc. This light, after being scanned by the disc, then passes to a second image in the plane of the film and thereafter finally reaches the photo-cell. This is the simplest and, incidentally, the best of all the

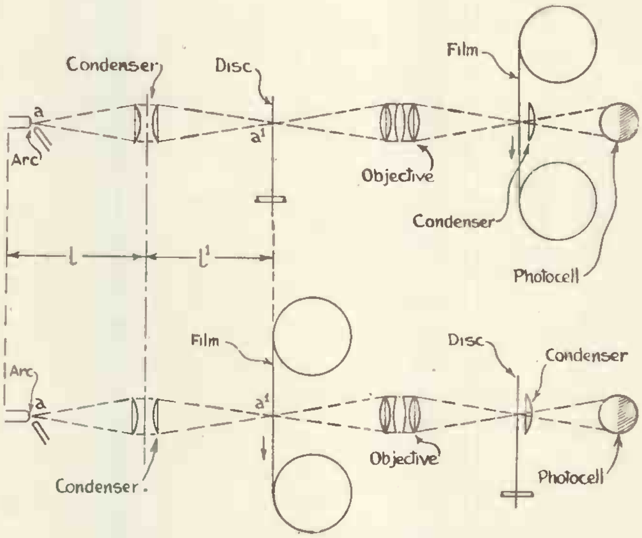


Fig. 1.—Simple optical layout of disc film transmitter.

optical layouts for the disc film transmitter. The imaging of the light source first on the film itself and then on the disc is found to possess certain inherent advantages and it appears to be the commoner practice. In both cases the efficiency expressions are identical.

The amount of light eventually reaching the photo-cell is equal to that passing into the first objective coming from that area in the light source corresponding to the aperture in the disc, after taking into account the losses encountered in its progress through the optical system.

The original amount of light is given by the well-known expression

$$F = Ba\omega$$

where ω is the solid angle subtended by the condenser at the area of the light source. In order to obtain the efficiency expression of almost any mechanical optical television system, the values a and ω have to be given

OPTICAL LOSSES WITH DISC TRANSMITTERS

in terms of the various dimensions and parameters of the system in question. In this case we can put for the solid angle ω

$$\omega = \frac{\pi d^2}{4 l^2}$$

From geometry we can write

$$\frac{a}{a^1} = \left(\frac{l}{l^1}\right)^2$$

which brings in the disc aperture area a^1.

Now this aperture area can be expressed in terms of the picture constants and the diameter of the disc for

$$a^1 = A/N$$

where A would be the area of the complete scan comprising n lines. If L is the length of one line in the scanning direction we can write

$$a^1 = A/N = L^2/KN.$$

Expressing L in terms of the disc diameter we have

$$a^1 = \frac{\pi^2 D^2}{KNn_d^2}$$

But the number of apertures n_d in the disc is equal to the number of lines divided by the speed factor. As $Kn^2 = N$, we find that

$$a^1 = \frac{\pi^2 D^2 p^2}{N^2}$$

so that the complete expression is

$$F = Ba\omega = B a^1 \left(\frac{l}{l^1}\right)^2 \omega$$

$$= \frac{\pi^3 B D^2 p^2}{4 N^2} \cdot \left(\frac{d^2}{l^{12}}\right)$$

In the case of the so-called daylight transmitter wherein the subject to be transmitted was some distance from the objective, the distance l^1 was equivalent to the focal length of this objective, so that the ratio in brackets is really the aperture ratio of the objective. However, in this case as the light source is much nearer the objective, the distance l^1 will be greater than the focal length. This fact decreases the efficiency of the system. Of course, the light source cannot be placed further away in an attempt to obviate this reason for reduced efficiency, because the solid angle would then be decreased, whereupon the efficiency of the system would be reduced still further. On the whole it is found advisable to position the disc and the light source in equal conjugate focal planes so that the objective is midway between the two. In this case the distance l^1 will be exactly twice the focal length, so that for our specialised case we can put

$$F = \frac{\pi^2 B D^2 p^2 t}{16 N^2 k^2} \text{ lumens}$$

where k now represents the aperture ratio of the objective. For a focal length of 10 cms. and an entrance pupil diameter of 5 cms. the aperture ratio would be k = 2.

Finally, we must consider the optical transmission losses of the system. It is found in practice that a transmission loss factor, t, of 0.1 arises in a well-designed system with objectives having three element lenses or less. This factor also accounts for loss on light transmission through the film when the density is at its minimum. We can now write for the final expression giving the light flux in lumens reaching the photo-cell.

$$F = \frac{\pi^2 B D^2 p^2}{160 N^2 k^2} \text{ lumens.}$$

If the film moves in vertical direction and there is a gate of one line width provided, then it is advisable to have radial slits in lieu of apertures in the disc. This overrides the difficulties of imperfect alignment and arcuate distortion.

A judicious use of a cylindrical lens will help to con-

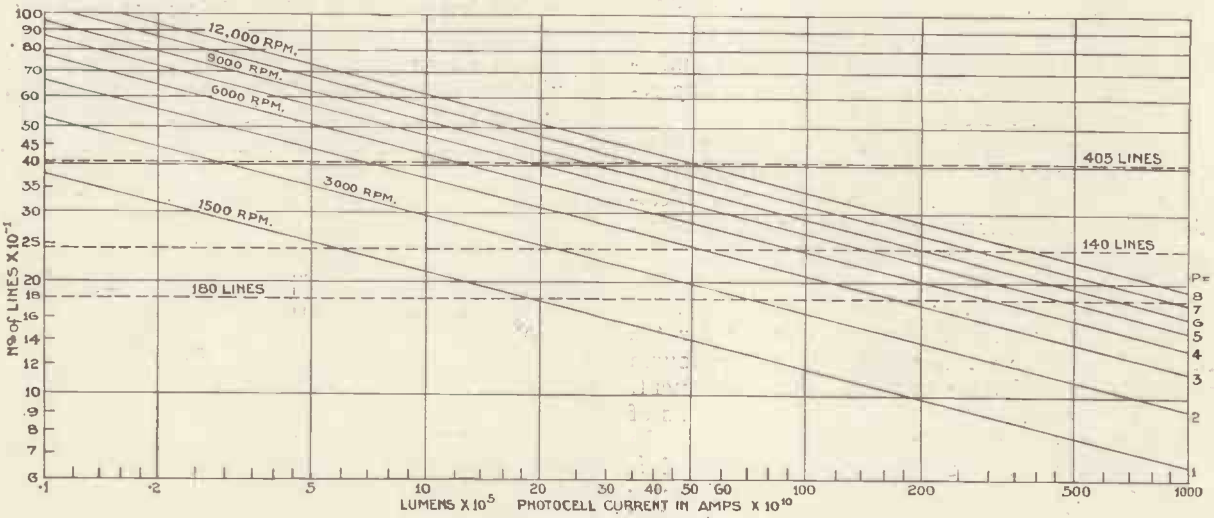


Fig. 2.—Graph showing the efficiency of the apertured disc film transmitter.

centrate the light somewhat, but this will not affect the efficiency expression as the latter is computed for the ideal case.

In German practice the speed factor was first turned to accounpt and discs revolving at 6,000 r.p.m. originated in that country. For discs of reasonably large diameter in the order of 40 cms., all rotating parts are disposed in a case which can be partially exhausted. Discs of 20 cms. or less diameter can easily be driven in normal conditions and speeds of 9,000 and even 12,000 r.p.m. are not beyond the possibilities of mechanical construction. These high-speed motors of fractional horse-power can be run from the 50-cycle mains through the intermediary of a frequency changer, or from a 3,000 r.p.m., 50-cycle motor through a Burn form of Watt silent gear.

In order to visualise the possibilities of the high-speed aperture disc we must choose particular values for the brightness of the light source, for the diameter of the disc and for the aperture ratio of the objective. We might consider the case for an arc lamp brightness of 20,000 candles/cm.^{2} and a disc diameter of 20 cms. and an objective aperture ratio of f/2.

The first objective may be a doublet corrected for chromatism and to a certain degree for spherical aberration, but the second objective which images the disc plans on the film must be a highly corrected anastigmatic lens of at least three elements. Some images have a picture ratio of 4/3, others of 5/4; we shall choose here the ratio 4/3. The ultimate difference in light efficiency is not very great, the proportion being 1.14 in favour of the 5/4 ratio.

Our expression now takes the form

$$F = \frac{2.1 \times 10^5 p^2}{n^4} \text{ lumens.}$$

With a picture definition of 240 lines, this reduces further to

$$F = 7.10^{-5} p^2 \text{ lumens.}$$

In Fig. 2 curves are drawn which give complete information as to the light reaching the photo-cell for a number of different speed factors. It is clear that the light flux value is indeed very poor, and without the employment of some form of electron multiplying device it seems hardly worth while considering the construction of an aperture disc film transmitter for definitions exceeding about 180 lines. Taking the case of 10^{-4} lumens with a vacuum cell rated at 10 microamps. per lumen, we shall receive a current of 10^{-9} amps., this being equivalent to 6.06×10^9 electrons per second. As the element period is 5.2×10^{-7}, i.e., roughly half a micro-second, the photo-electric emission will be only 3,000 electrons. This may just be amplified with a noise level lower than that of the signal, but great difficulty will be experienced with the amplifier.

The question of employing a lens disc in lieu of the aperture disc should not arise. In the first place the efficiencies of the two systems are identical and in the case of the lens disc, apart from the greatly increased cost, clear definition would be unobtainable. This is due to the fact that here the objective imaging the apertured light source on the film, or alternatively, imaging the film on to the apertured photo-cell, is the very lens within the disc. This lens, in view of the circumstances in which it has to operate, cannot be more than a doublet at best, whereas, for good definition it should be an anastigmat of at least three elements. The mounting of such anastigmats in the disc is, of course, out of the question. Aperture discs for high-speed operations are obtainable in Germany for about 200 R.M.

TELEVISION SOCIETY LECTURE

Thermionic Valves—An Account of Some Researches

ON February 12, the Television Society held its monthly meeting. A paper by Mr. T. Owen Harries was read entitled "Thermionic Valves—An Account of Some Researches."

In introducing the lecturer, the Chairman (Mr. G. Parr) reminded the members that Mr. Harries had delivered one of the first papers read before the Television Society at its original formation.

Mr. Harries, in opening his remarks, pointed out that the theory of the multi-electrode valve had not been fully investigated, and the design of such valves could not therefore be undertaken on the conventional formulæ governing the design of diodes and triodes.

Dealing particularly with the so-called dynatron characteristics, the lecturer showed how the bend in the curve could be completely eliminated by suitable proportion of the electrode distance, and that it was possible to obtain the optimum shape of curve by careful design.

The radiation of secondary electrons from the anode surface is at a lower velocity than that of the primary electrons, and the shape of the knee of the tetrode characteristic is governed by the number of low-velocity electrons produced in the screen grid-anode space.

The author concluded by describing experiments made with power valves, in which a special spacing was adopted between anode and control grid. The use of the suppressor grid was avoided by placing the anode at the "critical distance" to suppress the flow of secondary emission.

The characteristic of the multi-grid valve is substantially that of a triode for normal load, but the sensitivity is of the same order as that of a pentode.

The inter-electrode capacities are considerably reduced by the improved spacing adopted, the anode to earth capacity being 5 mmfds. as against the more useful figure of 14. If the grid is connected to the top cap and screened, the inter-electrode capacity can probably be reduced to .2.

Valves have been designed for short-wave work, which have anode control grid capacities too low to be measured on a set capable of measuring .001 mmfd. The capacity of an ordinary screen grid valve can be reduced by screening, but the use of the valve on high frequencies is thereby affected.

The author showed that by using his method of construction, the advantages of low self-capacity could be retained, and a very high impedance was possible.

Dealing with the question of harmonic distortion, in power output valves, Mr. Harries gave his opinion that the conventional method of measuring distortion by the use of sinusoidal wave forms was inadequate, as it did not give an indication of the behaviour of the valve under broadcasting conditions.

A New Type of Valve Coupling for the Transmitter

By S. E. Lewer, G6LJ

We feel sure that this short article showing how to increase drive of the P.A. stage will appeal to many transmitting readers. It is small points of this nature that enable low power stations to work real DX.

THE circuits shown in Figs. 1, 2 and 3 are applicable to any transmitter of the frequency-stabilised type where a low power oscillator is used to drive a larger power-amplifier stage. This new type of coupling may be successfully used either between oscillator and amplifier stages, or between successive amplifier stages. Its purpose is to overcome one of the chief troubles which occur in tuning up transmitters of this type, that is, lack of excitation.

It is an economy, of course, to use the smallest number of intermediate stages to drive the final power amplifier, but if this economy is pushed too far, the system will show a strong tendency toward instability; that is to say, the efficiency and general performance of the transmitter will be uncertain, and will depend critically upon such things as valve temperature and slight variations in tuning adjustments. This instability is a serious drawback to successful operation either from the experimental point of view or from the standpoint of straightforward communication.

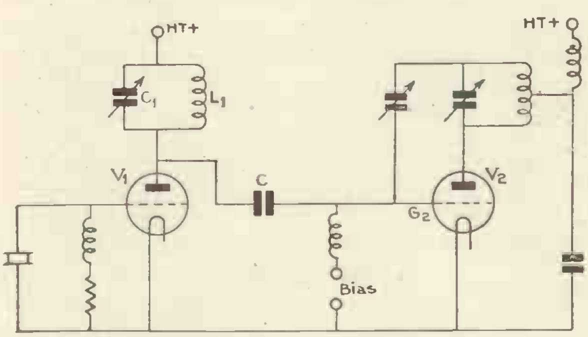


Fig. 1.

The circuit on the left is the usual system employed by low-power stations. The right-hand circuit will greatly improve excitation.

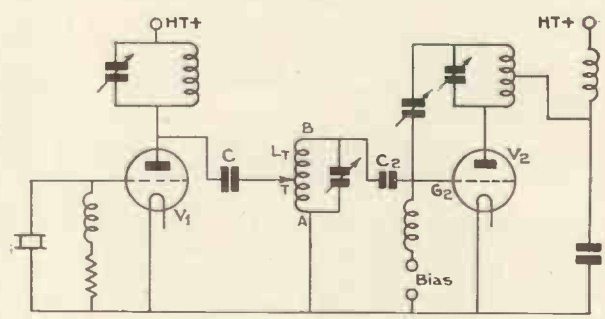


Fig. 2.

With some excitation in reserve, it is no longer necessary to keep each stage at the limit of its efficiency. What is required is a voltage swing which, when applied to the grid of the amplifier, will load that valve to the desired amount. With the usual coupling arrangement shown in Fig. 1 it is not always possible to provide sufficient voltage swing at the grid G_2 of the amplifier V_2 by means of the coupling capacity C. The actual voltage swing which is applied to the grid G_2 is dependent on such factors as the characteristics of the valve V_1, the values of L_1 and C_1 in its anode circuit, the value of C itself and the impedance of the input circuit of the valve V_2.

A voltage step-up transformer connected between C and the grid G_2 will enable a higher voltage swing to be applied to the valve V_2 without drawing appreciably more power from the valve V_1. A suitable circuit arrangement is shown in Fig. 2. Here the step-up transformer consists of the tuned circuit L_T C_T with the tapping point T as the input connection. The output is taken from the top end B of the coil L_T through a fixed condenser C_2 (of 0.0003 mfd. or more) to the grid of V_2. The voltage step-up is approximately equal to the number of turns between B and A divided by the number of turns between T and A. For instance, if the input is connected to a point T as the input connection. The up from the cathode end A, the voltage swing of the output at B will be about five times that of the input.

There is no extra difficulty in carrying out the sequence of operations in tuning and neutralising. After the anode circuit of V_1 has been brought into resonance, the transformer circuit L_T C_T is likewise tuned to resonance, followed by the anode circuit of V_2.

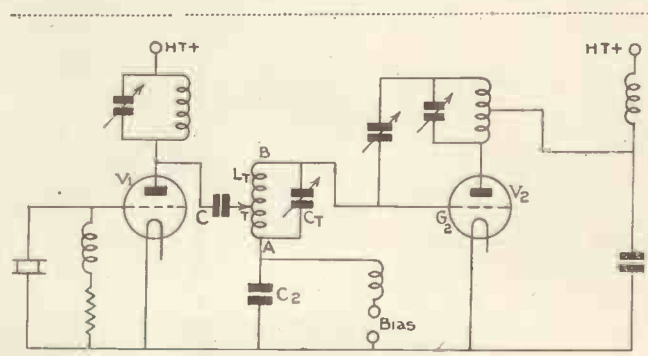


Fig 3.

A transformer effect of this type is particularly useful when coupled to the grid of a multi-electrode valve. Many operators have experienced lack of R.F. output when using pentodes. This circuit will be a great help.

Figure 3 shows an alternative arrangement of the connections given in Fig. 2. Here the bias for the grid of the valve V_2 is applied in series with the step-up transformer, whereas in Fig. 2, the bias is connected in parallel. The condenser C_2 acts as a by-pass condenser and may have any value greater than 0.0003 mfd. The choice between the two possible arrangements is best determined by the conditions existing in the transmitter itself.

A step-up transformer used in this way is quite easily capable of multiplying the power output by several times. There are some improvements that can only result in a fractional increase in efficiency, but this arrangement will probably do more than most hook-ups in improving the stability and increasing the power output.

A Portable Battery Transceiver

By L. C. Jones

This two-valve portable five-metre Transceiver has been tested up to 30 miles even though the input is only 1½-2 watts. The total cost being less that £3, it should appeal to those who intend taking part in the numerous contests and field days to be arranged during this summer.

IT is of little use thinking about five-metre equipment during summer months when every week-end brings forward more details of ultra-short-wave field days. Transceivers are all very well but they require a great deal more testing than is perhaps realised. Once, however, the design has been perfected they are capable of giving excellent results up to 30 miles or so.

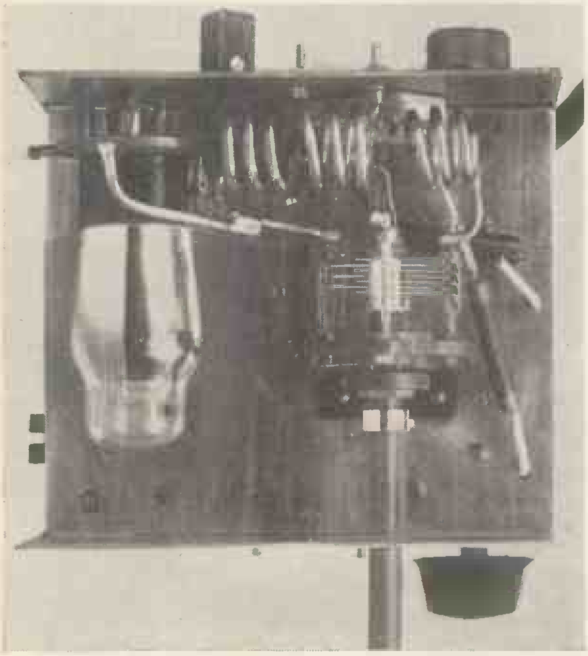


Fig. 1.—The way the coils are made and mounted can be seen from this plan photograph.

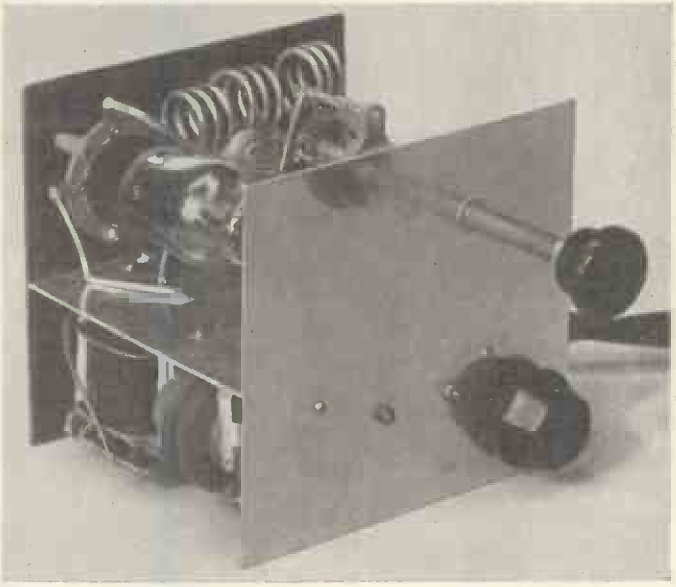


Fig. 2.—To make the unit more compact the master tuner can be made pre-set.

For those who intend spending more time on the five-metre band, here are details of a simple battery-operated and inexpensive transceiver, with which I have had exceedingly good results. Unlike midget units of this kind, all of the components are standard stock and can be obtained on demand.

First of all the circuit uses a Tungsram P215 triode and a Tungsram PP222 pentode. When the set is used as a transmitter the P215 operates as an oscillator and the pentode as a modulator. When switched over for reception the triode becomes a normal detector and the pentode a quench valve.

The change from send to receive is simply carried out by the rotary switch which when in a receiving position open-circuits the phone jack, grid leak and dropping resistance and the secondary of the quench circuit. By rotating the switch into the second position three sections are short-circuited, so removing the three-megohm grid-leak from the oscillator valve, short-circuiting the secondary of the quench coil, short-circuiting the phones and so making the circuit inoperative.

Three coils L1, L2 and L3 are required. These three coils consist of three turns of No. 14 gauge bare copper wire wound on a three-quarter inch former. Being of such heavy gauge wire the former can be removed after winding without the coils losing shape. For fixing they are soldered directly to their respective positions. The tuning condenser can be seen from the illustration and is fixed so that it is as close as possible to the tuning coils. The condenser used is an Eddystone type 900. The send-receive switch is of the Yaxley three-point change-over type which makes good contact without noise.

The transceiver is actually built on a chassis consisting of a front and back panel of press-pahn and aluminium respectively, whilst a sub-baseboard, of aluminium, is mounted between the two. The front and back panels are 6 by 5½ inches with a sub-baseboard 6 by 5 inches. It is an advantage, however, to make the sub-baseboard about an inch deeper so that the pentode valve can be removed more easily.

COMPONENTS FOR A PORTABLE BATTERY TRANSCEIVER.

CHASSIS.
1—Piece aluminium 5 in. by 6 in. 18-gauge (Scientific Supply Stores).
1—Piece Aluminium 5½ in. by 6 in. 18-gauge (Scientific Supply Stores).
1—Piece press pahn 5½ in. by 6 in. by 1/16th in. (Scientific Supply Stores).

CONDENSERS, FIXED.
1—.01-mfd. tubular (Sator).
3—.003-mfd. tubular (Sator).
1—.001-mfd. tubular (Sator).

CONDENSERS, VARIABLE.
1—.000025-m.mfd. type 900 (Eddystone).
1—70/140 m.mfd. capacitance (Cyldon).

COILS.
1—Quench coil unit type 958 (Eddystone).
3—Ultra short-wave coils to specification.

CHOKE, HIGH-FREQUENCY.
1—Type 1071 (Eddystone).

CHOKE, LOW-FREQUENCY.
1—Type 204A (Keston).

HOLDERS, VALVE.
2—Type 1015 4-pin (Eddystone).

PLUGS, TERMINALS, ETC.
1—Type J3 Jack (Bulgin).
1—Type P33 plug (Bulgin).

RESISTANCES, FIXED.
1—10,000-ohm. type ½-watt (Sator).
1—25,000-ohm. type ½-watt (Sator).
1—3-megohm type ½-watt (Sator).

RESISTANCES, VARIABLE.
1—10,000-ohm. potentiometer with switch (Erie).

SUNDRIES.
18—6 B.A. nuts and bolts (Scientific Supply Stores).
Connecting wire and sleeving.
2 insulated plugs and sockets (Clix).
1—4-way battery cord type BC2 (Bulgin).
1—Adjustable bracket type 1007 (Eddystone).
1—Extension handle type 1009 (Eddystone).
3—Knobs type 903 (Eddystone).

SWITCH.
1—3-point 3-way (Yaxley).

TRANSFORMER, MICROPHONE.
1—Type W44 (Keston).

VALVES.
1—P215 (Tungsram).
1—PP222 (Tungsram).

As can be seen from the photographs, the whole instrument is extremely compact, the tuning coils, tuning condenser and oscillator valve are mounted above the baseboard with the microphone transformer, low-frequency choke, switch, quench coil, volume control, and other small components beneath the baseboard.

ing knob and change-over switch, while on the back panel are two terminals for the aerial, sockets for the microphone, a phone jack and the volume-control-cum-on-off switch.

The actual operation of the transceiver should not present any difficulty. tion has been carried out over a distance of 30 miles.

This instrument only costs £3 including valves, which is a great point amongst the amateur fraternity. In addition to being suitable for field experiments and other portable work it

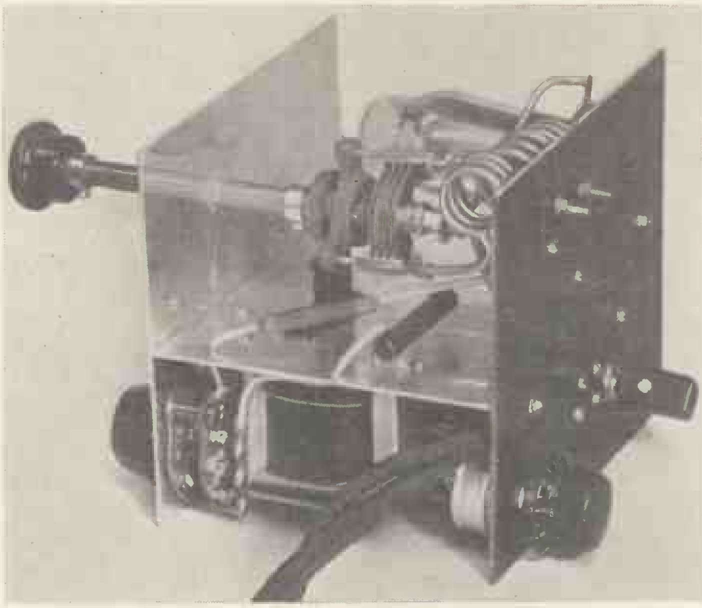


Fig. 3.—The two terminals at the top of the panel are for the aerial connections.

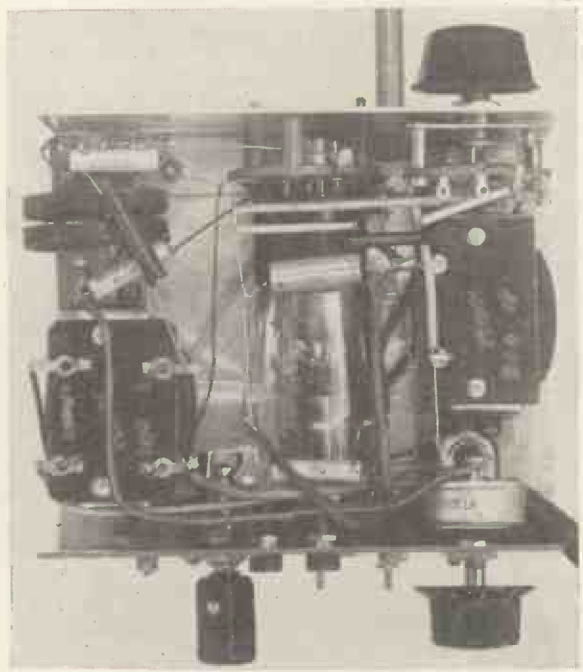


Fig. 4.—Some idea as to the layout can be seen from this view. The pentode modulator is in the centre of the chassis.

It is essential to use the specified type of microphone transformer and low-frequency choke. These are Keston products and have the following characteristics. The choke, a current-carrying capacity of 40-milliamps. at 25 henries and the microphone transformer a radio of 1-100. Both of these components are unusually compact and fit snugly into a limited space allowed.

On the front panel are the main tun-

When operated from a 120-volt supply, the power output is approximately 1½-2 watts. A half-wave aerial was found to be very satisfacory, although during the original experiments an Eddystone telescopic rod was used. While excessive range is not claimed for this transceiver, 20 miles is a good average, but the maximum distance covered will depend largely on locality and conditions. However two-way communica-

has been found satisfactory in a car.

Those who do not wish to build their own coils can obtain ready-wound 5- and 2½-metre silver-plated coils from Eddystone or Bulgin. These will require a different method of mounting but will make quite sure that the transceiver is being worked within the band. This is always a problem unless some means of calibration is available.

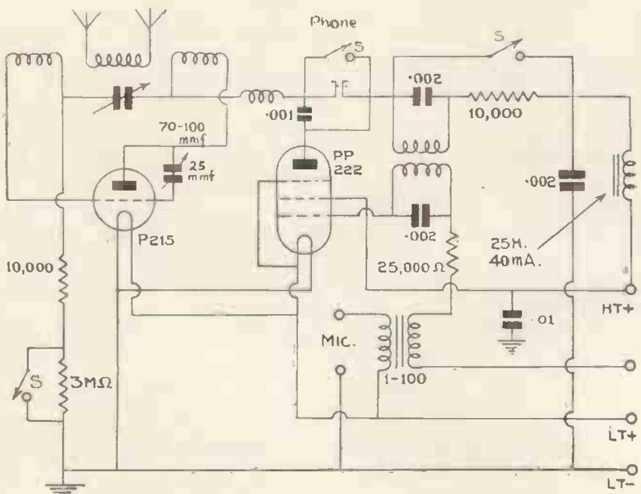


Fig. 5.—A microphone battery has to be connected up externally, but this can be part of the low-tension to save weight. For a microphone we suggest the use of a small carbon type which can be obtained very cheaply. This type of microphone also gives a high output.

African S.W. Transmitters.

Call.	
CNR	Director General des Postes, Rabat, Morocco.
CR6AA	Estacao Radio Difusora, Caixa Postal 103, Lobito, Angelo, Portuguese West Africa.
OPL-OPM	Radio Leopoldsville, Congo Belge, Africa.
SUV-SUX	Post Office Box 795, Cairo, Egypt.
VQ7LO	P.O. Box 777, Nairobi, Kenya Colony, Africa.
VSS	Overseas Communications, Kodak House, Shortmarket, Street, P.O. Box 962, Capetown, South Africa.
ZTJ	Radio ZTJ, P.O. Box 4559, Johannesburg, Transvaal, South Africa.

THE TELEVISION ENGINEER

THE DESIGN OF HIGH-DEFINITION AMPLIFIERS

By L. E. Q. Walke

The preceding articles of this series appeared in the January, 1936, November, September and August, 1935, issues. They deal with the complete theoretical considerations of the design of high-definition television amplifiers.

IF we refer back to (14) (January) we see that for relatively large values of b, $\frac{c}{a}$ may depart from unity to an appreciable extent without causing the final value of (14) to vary greatly. Providing, therefore, the product C_1L is kept at the right figure to give the requisite value of ω^2 and that the ratio ρ/R is also approximately correct, the degree of correction can be very nearly predicted and sensibly linear amplification achieved.

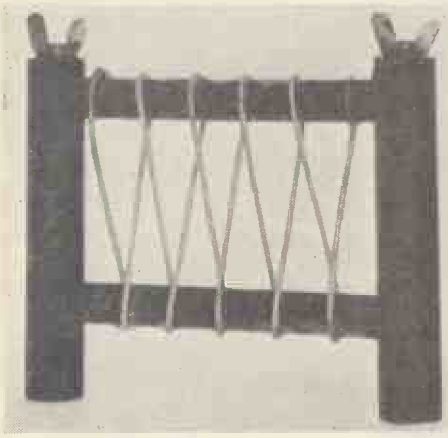


Fig. 32. A recommended type of grid and anode resistance wound non-inductively.

As in the case of low-frequency correction the correcting element may be included in the grid circuit instead of the anode circuit. This form of correction leads to similar results, but is not generally adopted, as, for many reasons, the anode feed circuit proves the more convenient.

So much for the theoretical analysis of the more orthodox types of correction applied to resistance capacity amplification. Let us now examine the matter briefly from a more practical standpoint.

Equation (9) provides the whole key to the problem. Obviously, if the imaginary term in the denominator of (9) is zero, the amplifier is perfect, for each stage produces an amplification which is entirely independent of frequency and which involves no phase angle between input and output voltages. Theoretically, then, we have an easy solution of our problem. Make C_1 zero and either C or R_g infinite, and the imaginary term disappears. Let us consider these two conditions independently.

C_1, it will be remembered, represented the distributed capacity of all the components employed in the stage, to earth. Specifying its value more exactly we must include

(a) The anode-filament capacity of the valve V_1 (Fig. 31).
(b) The capacity of the anode resistance to earth.
(c) The capacity of the condenser C *to earth* (not, of course, the actual capacity of C between its terminals).
(d) The capacity of the grid resistance to earth, and lastly,
(e) The capacity of the grid-filament circuit of the valve V_2 (Fig. 31).

The capacities enumerated above present no difficulty in assessing as far as (b), (c) and (d) are concerned. They are the actual capacities of these elements down to earth. The relevant capacities of the valves V_1 and V_2, however, are not so easy to estimate. So far as (a) is concerned, it is necessary to know the admittance of the valve V_1 looking back into it from the external anode circuit. This admittance is in the nature of a resistance in series with a capacity and involves not only the anode-filament capacity, but also the grid-filament and anode-grid capacities. It is of a complicated form and is given in full in many advanced works on valve theory.*

Similarly, the input admittance of V_2 (referred to above as (e) is of complicated form †. Here again the input impedance is of the form of a resistance and capacity in series. We may, in general, neglect the effect of the resistance, but the behaviour of the amplifier may be considerably modified by the presence of this input capacity of the valve V_2.

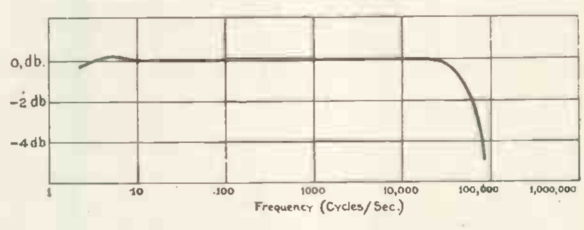


Fig. 34. Frequency response curve of Marconi television amplifier.

From the practical point of view, therefore, as we can do little to obviate the effects of these capacities (a) and (e) the most we can do is to chose valves, where possible, such that these capacities are small.‡ This represents the first practical limitation as regards high-frequency cut-off.

As regards (b) and (d) we can help matters considerably by keeping the capacities of these components to earth as small as possible. With regard to the grid

* Chaffee, Theory of Thermionic Vacuum Tubes, p. 274.
† Loc. cit. p. 274 and O. E. Keall, *Marconi Review*, No. 56, p. 10.
‡ Some modification may sometimes be effected in valve bases etc., to reduce capacities.

and anode resistance, the usual type of cartridge element is not so suitable as one which has been developed by the Marconi Company and which consists of a rectangular frame wound with Philips type resistance wire in a non-inductive fashion. A photograph of such a resistive element is shown in Fig. 32. This type of resistance possesses very little self-capacity and is almost completely non-inductive.

Lastly, with reference to (c) above, the coupling condenser between grid and anode circuits should also be carefully chosen. Cylindrical non-inductively wound paper condensers with some form of paper or composition case are found to be more satisfactory than the more usual metal-cased condenser and introduce but little additional self-capacity.

So much for eliminating, as far as possible, loss of amplification at high frequencies. To keep attenuation at low frequencies as small as possible the grid circuit must be considered. Either C or R_g must be made very large; in other words, the grid-circuit time constant CR_g must be large. In the majority of cases, however, we cannot increase this product indefinitely as we find that various practical considerations impose a limit beyond which it will not be permissible to go. Firstly, the valve itself presents a definite grid-cathode effective resistance to the circuit, and if we consider the grid resistance as being virtually in parallel with this we at once obtain a value beyond which we cannot increase the former. The grid-cathode resistance of typical valves has been found to be of the order of 5 megohms, and if we define the highest value of R_g to be not greater than one-tenth the value of this grid to cathode resistance, we see that it certainly is not desirable to increase R_g beyond .5 megohms. Actually .1 megohm has been found to be better from many points of view.*

Secondly, increasing C inevitably means increasing the bulk and hence the capacity to earth of the condenser. This will militate against good high-frequency performance and has to be avoided. Taking all these points into consideration, a value for $T_g = CR_g$ of 0.01 has been found to be representative for this class of amplifier.†

Lastly, the effect of the time constant itself on the reception of signals has to be considered. If the second valve of the stage has a very large signal suddenly applied to it, a phenomenon which is of constant occurrence in television work, the grid may be swung positive and grid current will flow. At the end of the signal the grid will be left with a high negative potential and this will decrease by the discharge of the coupling condenser through the grid resistance. Until such a time has elapsed as to bring the valve almost to its normal working potential, the valve will be paralysed.

Now the condenser discharges through the resistance in accordance with the well-known condenser time-constant law. That is to say, the charge, and hence the potential of the condenser, will decrease exponentially and the time taken to arrive at a normal condition will vary as CR_g. From this point of view, therefore, CR_g must be made small but from the amplification point of view CR_g must be made large.

A compromise must therefore be arrived at. We may say, for instance, that the charge on the condenser should have leaked away to one-tenth of its original value during the time of one scan line (for a 240-line 25-picture per second system 0.00016 sec.). This gives for CR_g a value of 0.000068; a value which is very much too small when compared with the figure of 0.01 given above. Using this latter figure we have for the time for the charge to leak away to 0.1 of its original value, an approximate value of 0.02 seconds, or the time taken by half a complete picture scan. Obviously the need for compromise is marked. In the majority of cases, the consideration of blocking takes second place and the value of CR_g is fixed by amplification consideration.

It may be of interest to conclude this section with a brief account of a typical amplifier designed to give substantially uniform amplification over a frequency-band of from 10 cycles to 100 kilocycles and to deliver an output of 12 volts into a 600-ohm line. This amplifier was designed and constructed by the Marconi Co. for television purposes and gave remarkably good results.

Correction was applied at each individual stage and the practical results obtained were checked against the calculated predictions. As the output to line was required to be of low impedance and as it was desired to eliminate transformers completely, the output valve was chosen to act as an impedance transformer.

Screen-grid valves of high-amplification factor were chosen and the anode load resistances were kept low in value for two reasons. Firstly, the frequencies at which internal valve capacities became important could be kept high and secondly, stage gain could still be kept relatively large.

The correcting components in each stage were included in the decoupling portion of the circuit and not in the anode or grid circuits themselves. Low-frequency correction was obtained by proportioning the values of interstage coupling condensers and decoupling condensers in such a way that the drop in output at low frequencies due to the former was balanced by the increasing impedance of the latter. Linearity at low frequencies was thus obtained down to 5 cycles/sec.

High-frequency correction was obtained by including a small air core inductance in series with the decoupling condenser.

The schematic diagram of a single stage is shown in Fig. 33. A and B represent decoupling resistances to screen grid and anode circuits, and F and E are the corresponding decoupling condensers. D is the inductance for H.F. correction, C the anode resistance, and G the inter-stage coupling condenser. H is the grid leak. Condenser E provides low-frequency correction.

The amplifier proper consisted of four screen-grid stages, preceded by the photo-cell and its own amplifier, and followed by the output impedance transforming valve. The measured gain of each screen-grid stage was of the order of 17 dB. The amplifier was contained in a brass box subdivided into compartments, each being well screened from its neighbour. The valves

(Continued on page 171.)

* O. E. Keall. Correction Circuits for Amplifiers, *Marconi Review*, No. 54, p. 19.

† O. E. Keall. *Marconi Review*. Nos. 54 and 56.

Dr. ZWORYKIN on THE ELECTRON MULTIPLIER

"Television and Short-wave World's" Exclusive Report of the Lecture given by Dr. Zworykin at the Institution of Electrical Engineers on February 5th.

DR. VLADIMIR ZWORYKIN, the inventor of the Iconoscope, was invited to lecture at the meeting of the Wireless Section of the Institution of Electrical Engineers on Wednesday, February 5. To a crowded audience he described his new invention in electron multipliers and electron lenses, and the following is a condensed account of his paper:

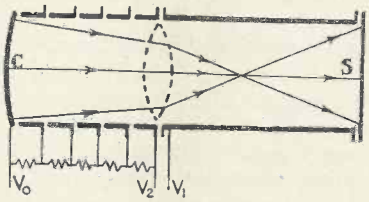


Fig. 1.—A simple electron lens system. Electrons from the cathode C are focused by the potentials applied to the cylinders and form an image on the screen S.

The beginning of electron optics can be said to be older than the discovery of the electron itself. It was known that a cathode-ray beam would cast a sharp shadow on a fluorescent screen from an object placed in its path, and in respect of this it was known that the cathode-rays resembled light rays.

It was not long after the discovery of the electron itself that work on the calculation of electron paths formed the groundwork of the science of electron optics. Since that time these particular theories have been studied in increasing detail as the importance of electron optics has become more and more recognised. Of particular interest is the calculation of the paths of electrons in a symmetrical field. These types of field-electrostatic and magnetic—both tend to cause the electron path to bend in a manner similar to that in which light is bent.

Two of the most important applications of electron optics, and ones that have been most fully exploited, are the electron gun and the electron microscope. The first is characterised by the fact that a very small electron source has to be forced into a very small image or spot. In the electron gun, both the spot and source producing it are close to the axis of symmetry of the lens, and relative distortion between the spot and source is not of great importance. (As an example of the fineness of spot obtainable, a 340-line television picture was shown.) The theory of this brand of electron optics is fully dealt with by Bruche and Scherzer in a monograph.

The Electron Microscope

A newer application is in the development of the electron microscope and electron telescope. In these instruments the image is focused on a semi-transparent photo-electric cathode, the electrons from which are focused by means of electrostatic lenses on to a screen placed at the opposite end of a tube (Fig. 1).

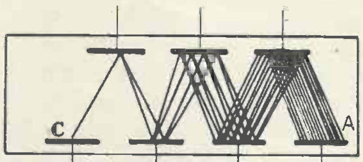
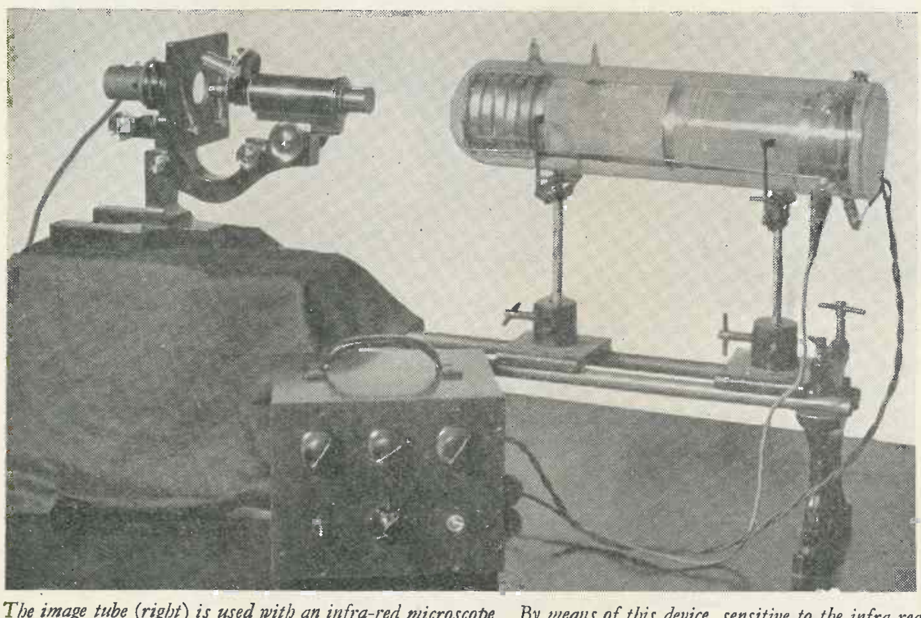


Fig. 2.—Showing the principle of the electron multiplier. The cathode C is the primary source of electrons, which are reflected to the anode A.

The requirements of such a microscope are that the image be free from distortion, the circle of confusion must be small, and as large an area as possible of object and image must be available. The degree of magnification of such systems varies between one-half to three times.

In order that the electron lens system of Fig. 1 should operate successfully the image must be able to be focused by changing the relative position of the lenses in the system.

Changing the position of the cylinders which form the lens system is very difficult though not impossible when the tube has once been evacuated and sealed off. To build a "fixed-focus" tube, giving perfect focus over the whole screen is practically impossible. The solution to the difficulty lay in devising a means of changing the focus electrically, by changing the potential applied to the electrodes. In changing the curvature of the equi-potential surfaces it



The image tube (right) is used with an infra-red microscope. By means of this device, sensitive to the infra-red rays, it is foreseen that the development of hitherto baffling minute organisms may be brought within the range of human vision. Such cells, in the past, have been studied by means of intense light or stains that often kill them.

ADVANTAGES OF THE ELECTRON MULTIPLIER

is important that the field next to the cathode is not changed at the same time. This is avoided by providing a number of separate cylinders (up to six) for the first part of the lens, as shown in Fig. 1, and applying a graded difference of potential to each cylinder. This potential gradient is obtained from a series of resistances shown, some of which can be conveniently incorporated in the tube.

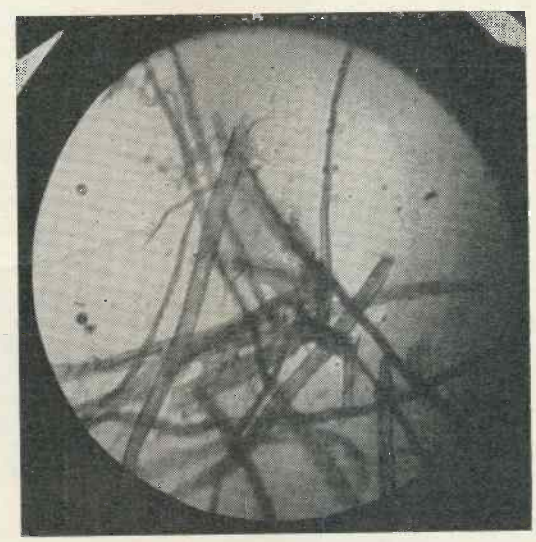
(The lecturer showed slides of the pictures obtained by focusing the cathode on external scenes.)

An important property of the electron telescope is that the object can be illuminated by infra-red rays and still be made to yield a visible image on the screen. This property is of great importance in the application of the telescope to fog signalling devices, etc.

If the tube is mounted as a camera in front of a microscope, the slide can be illuminated by infra-red light, and by this means it is possible to examine live and moving specimens, bacteria, etc., which would normally be killed by ordinary light, or by the various staining processes usually adopted.

If the lens is used in conjunction with an aperture inserted in the tube, the magnification depends on the position of the aperture with respect to the two sides of the lens system, and a wide alteration of magnification is possible by altering the effective position of the aperture.

A scene projected in infra-red or "black light" on the fluorescent screen of the image tube.



A visible image of a micro specimen on the screen of a tube.

The cathode used in the tube is a semi-transparent layer of caesium-oxide-silver, and the process of depositing this film is very similar to

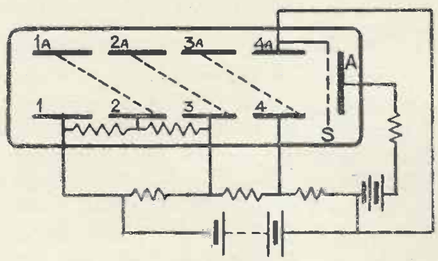


Fig. 3.—The circuit used for supplying potential to the electron multiplier. The initial stage resistances can be inserted in the bulb.

that used in making caesium photocells.

There is another field in which the application of electron optics is extremely important, and that is in the design of secondary emission multipliers. It has been known for many years that secondary electrons are emitted from a sensitised surface when primary electrons of sufficient velocity are allowed to strike it. In the ordinary thermionic valve this secondary emission is usually a handicap, as it increases the space charge and decreases the control of the grid.

The first practical use to which secondary emission was put was by Dr. Hull in the "dynatron," and since that time the idea of amplifying a small electron current by means of the secondary electrons produced has been investigated by various workers, including Farnsworth.

The problem of making a suitable electron multiplier to give a high gain is not so simple as may seem at first glance. The principle is shown in Fig. 2, in which a photo-electric cathode, C, can be illuminated by an external source, and the electrons produced are guided to a plate on the opposite side of the tube, where they give rise to an increased number of secondary electrons. These electrons are then attracted to a second plate diagonally opposite the first, and so on, until by successive reflection arrive at the collecting electrode A.

Such a multiplier in the form shown in the figure would be almost completely inoperative, for the reason that practically all the electrons in the track would not go to the first collecting electrode, but would traverse the length of the tube, owing to the potential applied to the collector.

In order to construct a satisfactory multiplier it is not only necessary to have a high ratio of secondary to primary emission, but a lens system must be provided to focus the electrons on each succeeding target.

To obtain a good emissive surface, i.e., one having a high ratio secondary to primary electrons, experiments were made on a large number of sub-

(*Continued on page 191*)

THE PRINCIPLES AND PRACTICE OF ELECTRON OPTICS

By N. Levin, Ph.D., A.R.C.S., D.I.C.

This is the Third of a series of articles describing in an easily understood manner the principles and practice of electron optics, a new branch of electronics which is becoming of great importance.

IT was shown in last month's article that an electron in a non-uniform field travels in a curved path and that where a sharp demarcation exists between two uniform fields the path is sharply deviated. Fig. 1 of that article showed a typical curvature of the field between a plate and a hollow cylinder. The equipotentials in that case are curved. In Fig. 3 the equipotentials are practically straight and parallel to the grids. In the first case the optical analogue is that of a series of curved layers of different kinds of glass, the refractive index and the curvatures gradually changing from one glass to the next. In the second the optical equivalent is that of a flat glass surface in contact with air, the refractive indices being sharply different.

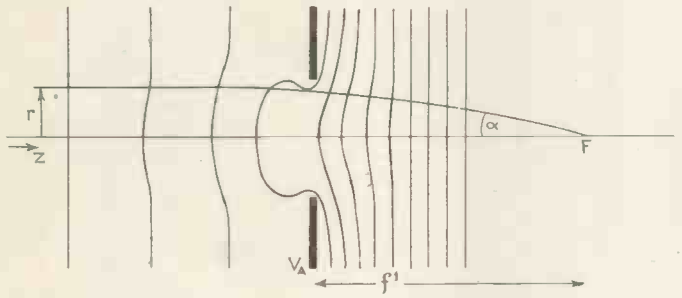


Fig. 1. Electron lens formed by a single aperture in a plate.

Another example is the boundary surface between air and water. It is incorrect to speak of a flat glass or air surface acting as a lens and the same can be said of a field with straight and parallel equipotentials. This is equivalent to a rectangular block of glass plates clamped together with each plate having a slightly different refractive index from those on either side.

The electrostatic electron lens generally found in practice consists of a uniform field on one side, say, the left, gradually changing to a uniform field at a higher potential on the extreme right, the condition producing the higher potential being in the simplest case an aperture in a conducting plate. For example, if we have a cathode at zero potential emitting electrons, these electrons must be made to travel to the right. Hence they must have an electrode or plate at a positive or accelerating potential. If they are to go beyond the plate, this must have a small hole in it. The equipotentials will be curved in the neighbourhood of this hole, but at some distance beyond the plate the equipotentials become equally spaced. Fig. 1 shows this state of affairs. The well-separated equipotentials indicate the weak field on the left and the closely packed lines on the right indicate the stronger field. An electron travelling from the left-hand side parallel to the axis will on passing through the aperture be deflected towards the axis.

The action is exactly analogous to a parallel beam of light being brought to a focus by a lens. The focal length of the lens is approximately the distance between the point of intersection of the path of the light or the electron and the centre of the lens. In the electrostatic case the centre of the lens can be taken as the centre of the aperture. This, however, is an approximation and only holds when the field strengths on either side of the aperture are not greatly different. Again, this finds its correspondence in the case of a glass lens. We can employ the centre of the lens as a reference point only if the lens is thin. If it is thick more general conceptions have to be introduced, of which the thin lens is a particular example. For instance, in an ordinary lens it is sufficiently accurate to measure the focal length from the back glass surface. In the extreme case of a telephoto lens combination this figure may be wrong by as much as 50 per cent. When it is remembered that all the preliminary design of a lens system is based upon a knowledge of the focal lengths this discrepancy becomes a serious matter.

Other examples of electrostatic lenses are two coaxial cylinders at different potentials (this has already been illustrated in the first article of this series) an apertured plate plus a cylinder and two apertured plates. Figs. 2 and 3 illustrate the equipotential lines existing in examples of the second and third classes. An electron optical system for cathode-ray tubes for television purposes generally consists of a combination of apertured plates and cylinders which may total as much as seven.

Calculating Focal Length

To calculate the focal length of an electron lens we shall consider firstly the simplest case of all, namely, that illustrated in Fig. 1. It is simple mainly because it can be considered by itself as a thin lens. It has been the first to be determined and lends itself fairly simply to experimental verification. One point must be thor-

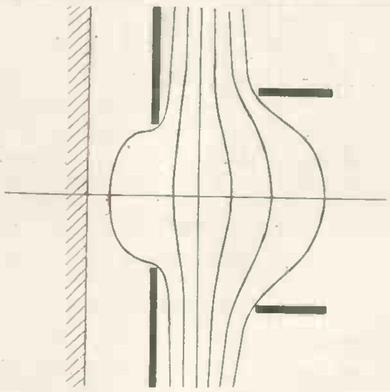


Fig. 2. Electron lens consisting of aperture and cylinder.

FOCAL LENGTH IN ELECTRONIC LENSES

oughly understood before we proceed to this calculation. Only those electrons which are travelling close to the axis will be assumed to be taking part in the formation of the image or focus. These are usually called the paraxial rays as distinct from those further away from the axis, which are called the marginal rays.

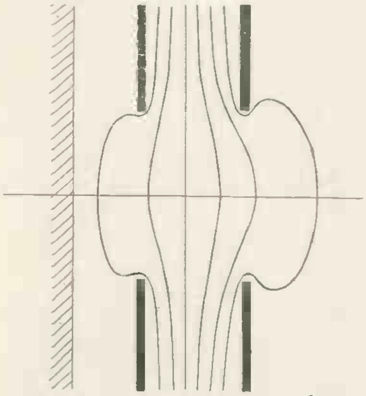


Fig. 3. Electron lens consisting of two apertures.

The paraxial region can be roughly taken as that in which the sine of the angle, the path under discussion, makes with the axis, can be assumed equal to the angle expressed in radians within the limits of experimental error. Under these conditions, the angle in radians is equal to the sine and to the tangent of the angle and the cosine is equal to unity. The marginal rays will generally, unless specially corrected, come to a different focus.

Since the method of correction for such distortions is not yet fully known in electron optical systems, it is the general practice to make the apertures small and to introduce stops in the cylindrical electrodes to cut down the marginal region until the image on the screen is sufficiently well defined for whatever purpose it is intended. Correction is particularly difficult in these systems, because opening out an aperture not only introduces marginal distortion but shifts the position of the equipotentials. That is to say, the lens now becomes much thicker and entirely alters the characteristics of the system as a whole. This can be very easily observed experimentally.

It will be appreciated how great a change can be made by making the aperture one millimetre diameter instead of half a millimetre, when we remember the high power an electron lens can have for any given diameter of hole.

Fig. 1 represents an aperture in a plate at a potential V_a. On the extreme left is the weak uniform field of intensity E and on the right the stronger uniform field of intensity E^1. The axial component of the field strength at any point z is E_z and the radial component at that point E_r. As already stated an electron travelling in the direction of increasing field strength will be deflected towards the axis on passing through the aperture and cross it at the point F. The distance between the aperture and F is the focal length of the lens and denoted by f^1.

Let v be the velocity of the electron. Then we have that $\frac{1}{2}mv^2 = eV$,
V being the potential at any point.

Let r be the distance of the electron from the axis. Then the radial force on the electron is $-eE_r$ and the radial acceleration is in the rotation of the calculus $\frac{d^2r}{dt^2}$. From Newton's Law of Motion we have for the radial motion

$$\frac{d^2r}{dt^2} = \frac{-e}{m}E_r$$

where the mass of the electron is denoted by m and is assumed to be constant.

$$\text{Now } v = \frac{dz}{dt}$$

Therefore

$$\frac{d^2r}{dt^2} = \frac{d}{dt}\left(\frac{dr}{dt}\right) = \frac{v\,d}{dz}\left(\frac{v\,dr}{dz}\right)$$

$$\text{Hence } \frac{v\,d}{dz}\left(\frac{v\,dr}{dz}\right) = \frac{-e}{m}E_r$$

We need now to determine the relation between E_r and E_z, in order to enable us to state the above equation in terms of known or measurable quantities. To do this we make use of Gauss' Theorem which states that the total normal outward flux from the surface of any enclosed space is equal to 4π times the total change in the space.

Consider a cylinder of length l and with a cross-section of radius r, shown in Fig. 4. Then the axial inward flux is $\pi r^2 E_z$ and the outward axial flux is $\pi r^2 \left(E_z + l\frac{\delta E_z}{dz}\right)$

Hence the net axial outward flux is $\pi r^2 l \frac{\delta E_z}{dz}$. The radial flow is all outward and is equal to $2\pi r l E_r$. Also the total charge inside can be approximately taken as zero. Therefore, we have that

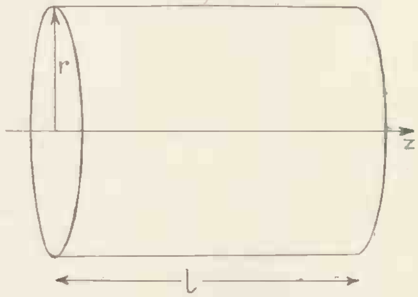


Fig. 4. The derivation of Laplace's equation for a cylindrically symmetrical system.

$$\pi r^2 l \frac{\delta E_z}{\delta z} + 2\pi r l E_r = 0$$

$$\text{or } E_r = \frac{-r}{2}\frac{\delta E_z}{dz}$$

Substituting in our equation above we have

$$\frac{v\,d}{dz}\left(\frac{v\,dr}{dz}\right) = \frac{-er}{2m}\frac{\delta E_z}{dz}$$

From $\frac{1}{2}mv^2 = eV$, we get finally

$$\sqrt{V}\frac{d}{dz}\left(\sqrt{V}\frac{dr}{dz}\right) = \frac{-r}{4}\frac{dE_z}{dz}$$

Integrating this once and supposing that V remains constant throughout and equal to the potential of the phase V_a, we get

$$\frac{dr}{dz} = \frac{-r}{4V_a}\left[E^1_z - E_z\right]$$

Where E^1_z is the axial strength of the field on the right and E_z is the axial strength of the field on the left. Now

$$\frac{dr}{dz} = \div \tan\alpha = \frac{-r}{f^1}.$$

$$\text{Therefore } \frac{1}{f^1} = \frac{E^1_z - E_z}{4V_a}.$$

We can finally make the assumption that E^1 and E_z are not greatly different from E^1 and E the field strengths that can be measured or calculated.

$$\text{Hence } f^1 = \frac{4V_a}{E^1 - E}.$$

The implications of this formula will be discussed in the next article.

A Battery Short-wave Superhet

This battery receiver has been designed by NORMAN BRANDON, 2BZN, for general short-wave listening from 12-200 metres. It is inexpensive to construct and can be run from small capacity high-tension batteries.

THERE are many points in favour of a battery-operated single-dial superhet. The fact that no power pack is required and that the valves are comparatively inexpensive is perhaps one of the most important features. Also, most amateurs find battery sets simple to get going. Problems such as eliminating hum, preventing arc-over, and obtaining the correct voltages by means of resistance networks do not arise.

Now that highly efficient battery-operated valves are available for superhet circuits there is no reason for the battery set not having a degree of efficiency comparable with that of a mains set.

Although the gain per stage is generally down, owing to the low noise level, and the fact that valves can be made to operate at maximum efficiency, the overall gain is usually of a very high order. Constructors find by varying the supply voltage the output can very often be increased without making any other alterations to the receiver. When it comes to altering the supply of a mains-driven set the fact that resistance networks have to be altered deters many from adjusting each stage for maximum gain.

Providing that the detector oscillator circuit is efficient on all wavebands there is no reason for a battery superhet not giving a good account of itself. This latest super was originally designed for portable use, the idea being that a two-stage cabinet could be used, the top section housing the receiver and the bottom section batteries and loudspeaker.

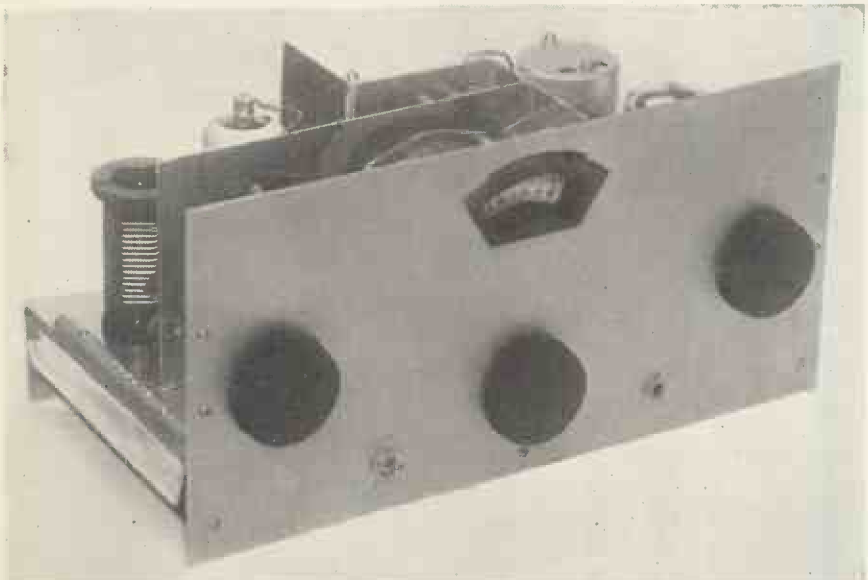
Triode Pentode

The receiver turned out to be more efficient than anything else in use at the time, and it is now being used continually for both amateur and broadcast reception. As can be seen from the diagram, the circuit consists of a triode-pentode detector oscillator. The pentode section has its suppressor grid internally coupled to the grid of the triode. In this way the conversion conductance of the valve is kept at a high order over a wide band of frequencies. It overcomes the use of external coupling coils which vary in efficiency from band to band. A separate high-tension tapping has been provided for the screen of the TP22 which requires between 40 and 70 volts. The voltage giving maximum gain has to be determined by experiment.

The triode-pentode valve can be seen on the right-hand side next to the aerial coil.

Naturally, with battery valves every component must be of the highest efficiency, so to that end the I.F. transformers have been wound with Litz wire. They are also provided with internal trimmers so that the frequency can be varied between 450 and 465 kc.

H.T. to the triode section of the TP22 is fed through a 40,000-ohm resistance. This value is not critical, but if there is any trace of squeggering this value should be increased to approximately 60,000 ohms.



Three large knobs certainly improve the appearance of the receiver in addition to making tuning more simple.

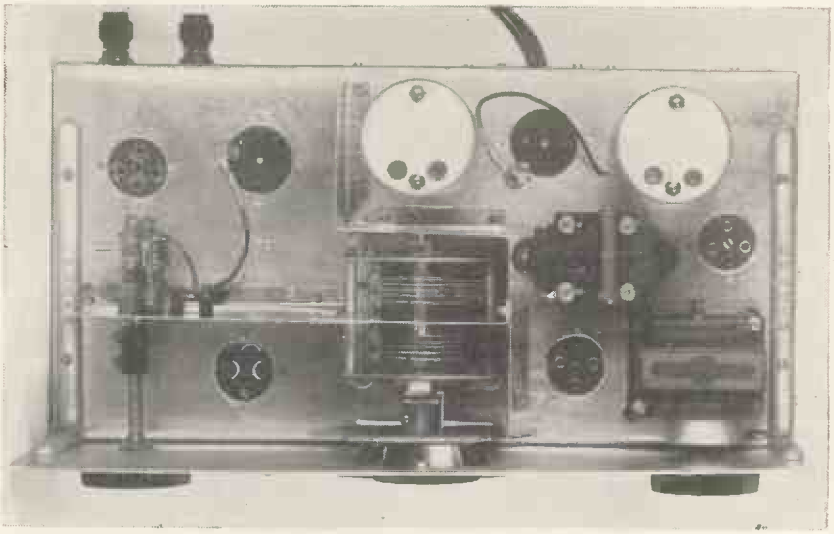
I.F. Reaction

The first intermediate frequency stage is conventional. It consists of an SP215 pentode feeding into the primary of a C51 I.F. transformer. This transformer, by the way, is fitted with a third winding, not shown, which can be used for regeneration if required. The correct means of doing this will be given in a subsequent issue. To obtain the correct screening voltage on the SP215 the full voltage has been applied through two resistances in series, one of 30,000 ohms and one of 10,000 ohms. As the screen current is particularly

The Triode Pentode

low, the voltage is reduced more accurately by connecting the anode circuit of the second detector to the low-potential side of the 30,000-ohm resistance.

It is essential that a screened anode



Notice how the aerial trimmer is fixed to the second screen.

lead be used in the SP215 circuit, otherwise slight traces of instability will be experienced. An efficient filter circuit is also necessary in the second detector. A screened high-frequency choke is by-passed by a .0002-mfd. condenser on the anode side and a .002-mfd. condenser on the high-potential side. In addition, a 70,000-ohm. resistance is connected in parallel with the primary of the inter-valve transformer.

From these details it will be realised that it is absolutely essential to use the specified I.F. and second detector valves, otherwise it will entail a change in resistance values. A ½-megohm potentiometer is connected across the secondary of the inter-valve transformer and governs the input applied to the pentode. This means that the receiver is always operating at maximum efficiency with volume varied in the output stage.

The Y220 will operate satisfactorily with a common voltage on both anode and screen, but it was noticed during tests that the screened voltage could be reduced very considerably without decreasing gain. As the current consumption went down by several milliamps, a resistance of 5,000 ohms was connected in series with the screen, so automatically reducing voltage.

No D.C. current reaches the loudspeaker or headphones owing to the use of a choke filter stage. In this way, although D.C. voltage is applied to the anode of the output valve, only speech currents reach the output circuit.

Although the makers recommend the use of a series resistance in the grid of the oscillator, this was not found necessary as the valve is only used on short waves. The manufacturers recommendation only applies on medium waves.

For those who have not had experience with a nine-pin base, the following are the connections for the TP22.

1—G2	6—Blank
2—A1	7—A, osc.
3—G3	8—G, osc.
4 and 5—Fil.	9—Met.

Top cap—G1

Coil Construction

Two coil forms are required, each carrying two coils. If the recommended B.T.S. slotted forms are used this will prevent any possibility of the coils being incorrectly wound as they are grooved so that the constructor always obtains the correct number of turns per inch. The constructional data for the four coils is given on the next page. In certain circumstances, where extreme selectivity is required, the number of turns on L1 should be reduced. Also where a very long aerial is used to prevent possible damping the number of turns on L1 should be reduced by approximately one-third.

The grid leak of 100,000 ohms in the oscillator circuit should be connected across the .00025-mfd. grid condenser. If, however, oscillation prove to be uneven, this leak should be connected between grid and L.T. negative.

Mica Condenser

It is essential that mica by-pass condensers be used in the R.F. section, otherwise trouble will be experienced on the higher frequencies. Second-channel reception will be noticed unless the trimmer in the grid circuit of the PT22 is accurately adjusted.

Lining up the I.F. circuit will make a marked difference to overall gain. Although an oscillator is a distinct help in lining up, another system works quite well with this super. Short-circuit the 40,000-ohm resistance in the oscillator-anode circuit which will cause the valve to squegger very badly. C50 and C51 should then be adjusted to give maximum output, after which the

BATTERY SHORT-WAVE SUPERHET.

CHASSIS AND SCREEN.
1—Aluminium to specification, 14 in. by 7 in. by 2 in. (Scientific Supply Stores).
1—Aluminium, 14 in. by 7 in. by 16-gauge (Scientific Supply Stores).
1—Screen, 8½ in. by 5 in. (Scientific Supply Stores).
1—Screen, 10 in. by 5 in. (Scientific Supply Stores).

CONDENSERS, FIXED.
1—.0001-mfd. type M (T.C.C.).
2—.0002-mfd. type M (T.C.C.).
1—.00025-mfd. type M (T.C.C.).
1—.0003-mfd. type M (T.C.C.).
1—.001-mfd. type M (T.C.C.).
1—.002-mfd. type M (T.C.C.).
1—.01-mfd. type M (T.C.C.).
3—.1-mfd. type 4513 (Dubilier).
3—1-mfd. type BB (Dubilier).

CONDENSERS, VARIABLE.
1—.00016-mfd. two-gang type VC2 (Raymart).
1—.000035-mfd. type 900 (Eddystone).

COIL FORMS.
6—4-pin slotted type (B.T.S.).

CHOKE, HIGH-FREQUENCY.
1—Type H.F.10 (Bulgin).

CHOKE, LOW-FREQUENCY.
1—20-henry 50-m/a type B8 (Ferranti).

DIAL, SLOW-MOTION.
1—Type 933 (Eddystone).

HOLDERS, VALVE.
1—9-pin chassis-mounting less terminals type V2 (Clix).
1—7-pin chassis-mounting less terminals type V2 (Clix).
1—5-pin chassis-mounting less terminals type V1 (Clix).
3—4-pin chassis-mounting less terminals type V1 (Clix).

PLUGS, TERMINALS, ETC.
2—Type B, marked Aerial, Earth (Belling-Lee).
1—Plug, type P38 (Bulgin).
1—Jack type J2 (Bulgin).
2—Spade terminals marked L.T. pos., L.T. neg. (Clix).
3—Wander plugs marked H.T. neg., H.T. pos., Screen (Clix).

RESISTANCES, FIXED.
1—500-ohm. type 1-watt (Erie).
2—5,000-ohm. type 1-watt (Erie).
1—10,000-ohm. type 1-watt (Erie).
1—30,000-ohm. type 1-watt (Erie).
1—40,000-ohm. type 1-watt (Erie).
1—70,000-ohm. type 1-watt (Erie).
1—100,000-ohm. type 1-watt (Erie).
1—1-megohm type 1-watt (Erie).
1—2-megohm type 1-watt (Erie).

RESISTANCES, VARIABLE.
1—500,000-ohm. potentiometer (Reliance).

SUNDRIES.
Connecting wire and sleeving (Scientific Supply Stores).
6—6 B.A. nuts and bolts (Scientific Supply Stores).
2—Plug top connectors (Belling-Lee).
2—Panel brackets type PB3 (Bulgin).
1—Flexible coupler (J.B.).
3-ins. ¼-in. dia. brass rod.
2 type 902 knobs (Eddystone).
5 yards single flex (Scientific Supply Stores).

SWITCH.
1—Type S80 (Bulgin).

TRANSFORMERS, I.F.
1—Type C50 465 Kc. (Bulgin).
1—Type C51 465 Kc (Bulgin).

TRANSFORMERS, LOW-FREQUENCY.
1—Type AF10 (Ferranti).

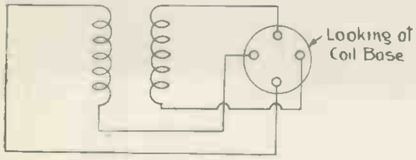
ACCESSORIES.

ACCUMULATOR.
1—Type DFG (Exide).

BATTERY, HIGH-TENSION.
1—120-volt type double-capacity (Ever-Ready).

VALVES.
1—TP22 met. (Mazda).
1—SP215 met. (Mazda).
1—L2 (362).
1—Y220 (Hivac).

Coil Construction



Grid Coil

λ			Space between Turns
20	3	5	1/8
40	6	16	1/8
80	10	28	1/16
160	15	45	—

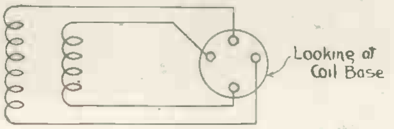
Four grid coils are needed to cover all bands. The windings are as shown.

shorting link across the 40,000-ohm resistance must be removed.

Construction does not call for any comment, but take particular care that the drive of the two-gang condenser is absolutely at right angles to the panel, otherwise it will distort when moved and the plates of the condenser may touch. Unusually long panel brackets have been employed, the idea being to prevent any possibility of panel movement.

Anode Current

The total anode consumption is only 9 milliamps, which is increased to 12 milliamps with a 150-volt battery. Grid bias for the Y220 is obtained automatically by means of a 500-ohm resistance between H.T. negative and L.T. negative.



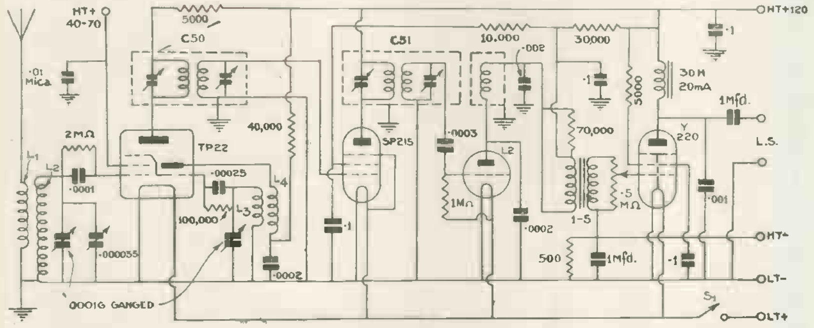
Osc. Coil

λ			Space
20	5	2½ (Bunch wound)	1/8
40	16	5	1/8
80	26	9	1/16
160	40	12	—

The oscillator coil is a very simple affair. Remember there are not any spaces between windings on the 160-metre coil.

A jack has been provided for loudspeaker connections, and as one side of this is at earth potential there is no need for any insulating bushes. The L.T. switch is in the positive lead, and as this has an insulating spindle it can be bolted directly to the front panel.

Three large control knobs have been used as these simplify tuning to a very great extent. For those who wish to use this superhet for amateur bands, band spreading could be arranged by connecting two type-900 15 micro-micro-farad condensers in parallel with the main two-gang condenser, though for general use this is not necessary.



A C51 I.F. coil is shown but without the third winding. The use of the winding will be described in the next issue.

The Power Stage

By W. J. Purvis, G6XT

In the design and construction of home-built amplifiers too little attention is paid to the low-frequency stages and particularly to valves preceding the power output stage. It is an easy matter to select a valve and give an output of, say, 10 watts, but correctly to load such a valve is a question that generally receives insufficient consideration. The stage preceding the final amplifier is of great importance as, unless it is capable of giving the necessary grid voltage to the power valve the overall amplification will be low. In such circumstances other means have to be used to increase gain with a consequent reduction in general efficiency and frequency response.

It is essential to know the grid voltage required fully to load the power valve for optimum output, otherwise there is little point in having a large power stage. If one is only feeding the output stage to half its signal handling capacity then a valve of a smaller type will work equally as well, so reducing cost and probably improving quality.

Consider as an example an ordinary radio receiver using a valve of the PX4 type in the output stage. It has been agreed that a station is not of programme value when it is dissipating less than 50/60 milliwatts in the impedance of a moving coil loudspeaker of average efficiency. This figure can, therefore, be used as the base of future calculations.

Ignoring the reactive properties assume that a resistance equal in value to the optimum load of the valve is connected in the plate circuit. From this can be obtained the voltage required across that resistance to dissipate 50 milliwatts. Firstly the current is found from: $C^2 = \frac{\text{watts}}{R}$, therefore,

$C^2 = \frac{50 \times 1{,}000}{2{,}400}$, where 2,400 is the optimum load of PX4. This gives $C^2 = 20.8$ and $C = 4.56$ m/a. The voltage can then be obtained by Ohms Law and is $E = \frac{4.56 \times 2{,}400}{1{,}000}$ giving 10.94volts.

We can then find the required grid voltage from the 10.94 volts divided by the gain of the PX4. This then becomes:

$$\text{Gain} = m \times 10^{-3} \times \frac{Z \times Ra}{Z + Ra}$$

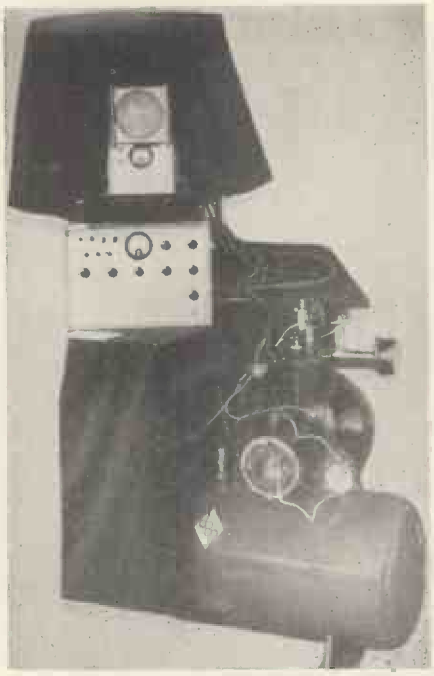
where m equals mutual conductance, Z equals valve impedance, Ra equals external anode impedance. This gives the following equasion:

$$\text{Gain} = 6 \times 10^{-3} \times \frac{830 \times 2{,}400}{830 + 2{,}400} = 3.9 \text{ volts,}$$

therefore, 10.94 divided by 3.9 equals 2.54 volts which is the minimum grid input required by the PX4 to give reasonable loading. It must be noted that this figure only applies when the impedance in the anode circuit is 2,400 ohms as other impedances will naturally effect the load figure.

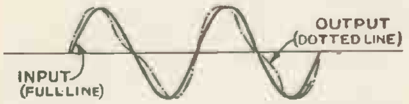
THE USES of The CATHODE-RAY TUBE

A brief summary of the more general applications of the cathode-ray tube.



A typical example of the cathode-ray tube being used as an engine indicator.

THE cathode-ray tube owes its development more to its uses for measuring purposes than television, and in the former field it has now a very large number of applications, both of measurement and observation. Among these are high-speed transients such as lighting surges, etc., checking of distortion in wireless receivers, the study of wave-form, size tolerances, impedance of loudspeakers, the study of the action of the heart, valve characteristics,



This diagram shows how distortion in an amplifier is revealed on the screen of the tube.

power absorption in circuits, phase differences between two potentials, compression and fuel detonation characteristics in internal combustion engines, air velocity fluctuations, speed measurements, watch and clock comparison, etc. Both the Ediswan and Cossor companies have developed special units embodying the cathode-ray tube for most of the purposes outlined above.

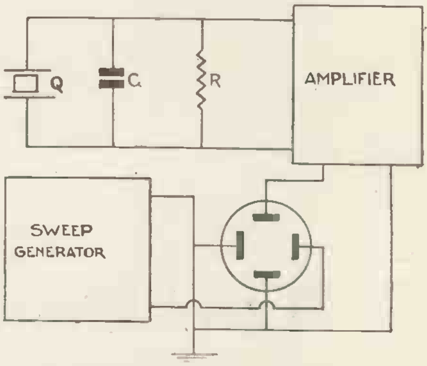
The Cossor Company manufacture two types of oscillograph, a linear portable mains apparatus employing a gas-focused cathode-ray tube of which some of the most general uses are examination of voltage wave forms of alternators, transformers, and other power apparatus, including D.C. generators and rectifiers; observation of starting load conditions; tracing of distortion in radio receivers; detection of unwanted frequencies (e.g., I.F. in L.F. circuits); examination of modulated wave forms, and oscillator wave forms; examination of smoothing circuits and residual hum in loudspeakers; ganging of R.F. and I.F. circuits in radio receivers; monitoring of level and wave form; examination of percentage modulation; detection of parasitic oscillations, etc.

This type comprises a gas focused cathode-ray tube of special design, with two pairs of deflector plates so arranged as to avoid origin distortion. The tube is housed in a metal shield which provides screening against magnetic fields. A linear time base sweep is employed which provides a sweep of approximately one screen diameter, the velocity being variable over a range of 4,000 to 1; the highest sweep frequency is approximately 10 kilocycles per second.

The high-vacuum oscillograph has a very extended frequency range and allows examination of individual cycles of from 5 cycles to 6 megacycles. The upper limit may be increased to something of the order of 100 megacycles by means of a radio-frequency oscillator used as a time base. Some of the more general uses of this instrument are wave form measurement and observation, measurements on radio transmitters and receivers, detection of parasitic oscillations, frequency calibration of oscillators, etc. This equipment consists of a high-vacuum (electron lens) cathode-ray oscillograph tube, together with all necessary power supplies. A balanced time base is also provided with an amplifier valve which may be used for amplying low voltages to increase the sensitivity.

The Cossor-Robertson cardiograph, another special application of the cathode-ray tube, is capable of providing permanent (photographic) records, also *direct visual observation* of the action of the heart.

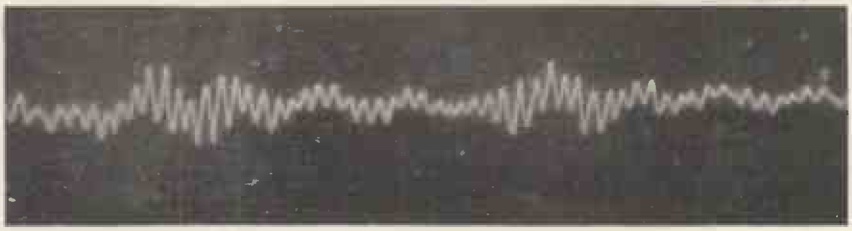
The amplified patient voltage shows up as a vertical movement of the recording spot of a cathode-ray



A simple circuit for using the tube as an engine indicator.

oscillograph. The unit also includes a time base circuit, which applies to the recording spot a horizontal traverse from left to right across the oscillograph screen, followed by an almost invisible flyback of the spot at the end of each sweep. By combining these horizontal and vertical movements, the spot traces out the wave-form of the electro-cardiogram. This is made visible by employing a screen with a long afterglow. This afterglow is actually of some seconds

(*Continued on page* 162)



Permanent photographic records can be produced as shown by this picture.

A NEW METHOD OF INTERLACED SCANNING

By L. S. Kaysie

Details of a new method of interlacing which dispenses with the odd half-line.

THE use of interlaced scanning is justified on the ground that it gets rid of the "flicker" effect which occurs in ordinary "straight" scanning, even when the picture repetition rate is as high as 25 a second. This may, perhaps, be described as an attempt to "paint the lily"; but on the other hand, high-definition television is setting a standard of its own in these matters, and if 25 frames a second still leaves evidence of flicker then the imperfection must be removed by hook or by crook.

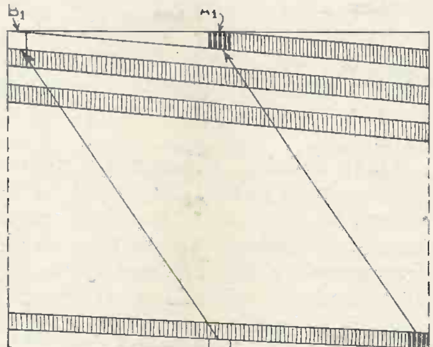


Fig. 1.—Illustrating method of interlacing.

In the kinema theatre, where the normal film-repetition rate is 24 a second, the modern practice is to eliminate flicker by throwing each of the 24 frames twice on to the screen, instead of once, so that the eye actually receives 48 separate impressions per second.

Of course, in theory, it would be possible to retain the "straight" system of scanning in television, and to get rid of flicker by doubling the rate of picture repetition, but this solution is not satisfactory in cold practice. For one thing it involves doubling the frequencies required for transmission, which, in turn, means doubling the side-band width occupied in the ether. Moreover any addition to the frequency-range adds considerably to the difficulty of handling and amplifying the signals, both at the transmitting and receiving ends.

Interlaced scanning offers a reasonable compromise which, particularly in high-definition work, gets rid of flicker with the minimum of inconvenience. It amounts to this: instead of keeping the same line frequency and doubling the number of pictures transmitted per second, the line frequency is halved and the picture frequency is doubled. That is to say the number of pictures transmitted per second becomes, say, 50 instead of 25, whilst the number of scanning lines contained in each picture is reduced from, say, 405 to $202\frac{1}{2}$. The odd "half-line" is significant and will be referred to again.

The Odd Half-line

Each individual picture, taken by itself, is complete, but naturally less perfect in definition than if it had been scanned by the whole 405 lines. But when projected in pairs, and properly interlaced on the screen, the resulting combination gives a complete and perfect representation. Naturally the two pictures which go to form the perfect pair must be thrown on to the screen in slightly staggered or "de-phased" relation, so that they fit between or "interleave" with each other, instead of occupying exactly the same position.

This is where the odd "half-line" comes in. Incidentally it involves a slight modification of the ordinary time-base circuit used for "straight" scanning because the line frequency is no longer a "whole-number" multiple of the picture frequency.

In Fig. 1, the manner of interlacing is illustrated by the alternate clear and shaded lines, which are, of course, shown greatly enlarged. It will be seen that the shaded spot A at the end of one picture must be returned to the centre point A1 of the first line of the next "repeat." It cannot start nearer the left-hand end of that line, because there is no room for it without overlapping and so "blurring" the corresponding line of its companion picture. For the same reason the last "stroke" of the unshaded line finishes at B, half-way along the bottom traverse, the fly-back movement taking it back to the point B1, ready to begin the next "repeat."

The presence of the odd half-line in each frame prevents the use of a single frequency-doubler, to link the "line" and "frame" saw-toothed oscillators in the time-base circuit, unless at the same time one uses some de-phasing adjustment, to pre-

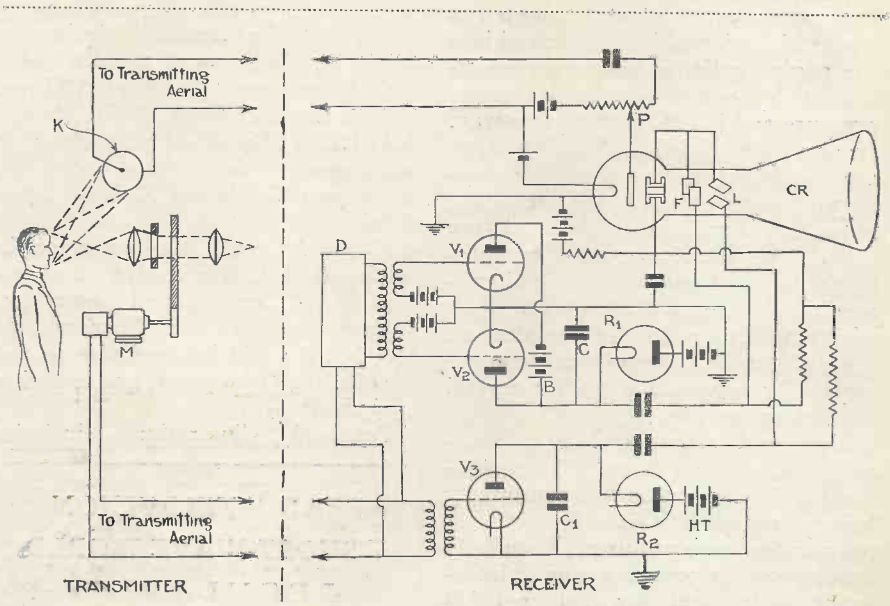


Fig. 2.—Time-base circuit for new method of interlaced scanning.

vent overlap. A further complication arises from the fact that the new high-definition television programmes are going to be shared equally between the Baird Company, which uses "straight" scanning, and the Marconi-E.M.I. Company which prefers the interlaced system. It is, therefore, necessary to find a receiver which can readily be adapted to handle both types of transmission with equal facility.

Fig. 2 shows a time-base circuit recently developed by the Electrical Research Products Inc. of America for "interleaving" in a new way.

In the first place, the odd half-line disappears, both frames being scanned by exactly the same number of complete lines. In the second place, the necessary "shift" or displacement of one frame relative to its "opposite number" is secured by applying a slight but definite biasing-voltage to the deflecting-electrodes of the cathode-ray tube during the scanning of one frame. During the scanning of the next frame, this biasing voltage is removed.

The resulting "shift" in the position of one set of lines due to the presence of the biasing voltage is sufficient to interlace them accurately with the succeeding set of lines on the fluorescent viewing-screen.

Starting at the transmitting end, the object is scanned in the ordinary way and picture-signals are derived from the photo-electric cell K. Simultaneously line-scanning impulses are produced by the motor M, and the two sets of signals are then combined for transmission.

At the receiving end, the picture signals are fed at P directly to the control electrode of the cathode-ray tube CR. Simultaneously the synchronising impulses are applied to trigger a gas-filled valve V3, and so discharge a condenser C1 which applies saw-toothed oscillations to the line-deflecting electrodes L of the cathode-ray tube. The condenser C1 is charged from the H.T. source through a constant-current valve R2.

The framing-control for the interleaved pictures is shown in the centre of the diagram. The condenser C, which frames both pairs of interleaved pictures, is charged up through a constant-current valve R1 from a source of high-tension. It is discharged by two separate valves V1, V2 acting in push-pull. The gas-filled valve V1 first applies one set of framing oscillations to the electrodes F of the cathode-ray tube, and the gas-filled valve V2 then supplies a second set, which must interleave with the first.

The gas-filled valve V2 completely discharges the condenser C2, though when the valve V1 is in action the discharge is not complete. The reason is that the battery B, which is in the plate circuit of V1, makes its presence felt across the condenser C during the second discharge. This applies a biasing voltage across the deflecting electrodes F sufficient to shift the lines of the second picture by the amount required to interlace them with the lines of the first picture.

One definite advantage of the arrangement is that the impulses required to control the framing operations are derived, through a single frequency-divider D, from the same synchronising signals that control the line-scanning condenser C1. At the same time if the biasing battery B is switched out of action, the time-base circuit can be used to receive pictures sent by ordinary "straight" scanning.

"The Uses of the Cathode-ray Tube"

(*Continued from page* 160)

duration, and several cardiac cycles therefore remain visible simultaneously on the screen.

Compression and fuel detonation characteristics of internal combustion engines are obtained either by the use of a piezo-electric crystal mounted in a special holder which is screwed into the engine cylinder head or a resistance which responds to variations of pressure and is used in the same way. In the case of the crystal, voltages are developed according to the pressure of the gas and the resulting potential is applied to the cathode-ray tube. The resistance type operates by the application of an external voltage in a local circuit and the voltage varies according to the pressure on the resistance. The circuit arrangements for use with a quartz crystal are shown by Fig. 1.

New applications of the cathode-ray tube in the spheres of measurement and observation are continually being made and it is clear that its possibilities have not as yet been fully developed. It provides a most interesting instrument for further fields of research.

A Plymouth Lecture

THE usefulness of the cathode-ray tube projector was explained by Mr. G. Parr, of the Edison Swan Electric Company, in a lecture on new principles of television, given at the Plymouth Athenaeum on Tuesday, February 11, in conjunction with the west country district of the National Society of Radio Engineers and the Plymouth and Devonport Technical College. Mr. S. Gordon Monk, M.Sc., B.Sc., A.M.I.E.E., head of the electrical engineering department of the Devonport Technical College, presided.

Not only could the projector be employed for the testing and recording of speech and radio frequency currents, Mr. Parr pointed out, but it could be used also to test the efficiency of wireless and electrical equipment.

Practical illustrations included traffic vibrations from the street outside represented on the screen of the cathode-ray tube, and by similar means impressions of variations in the sound of a human voice were also shown.

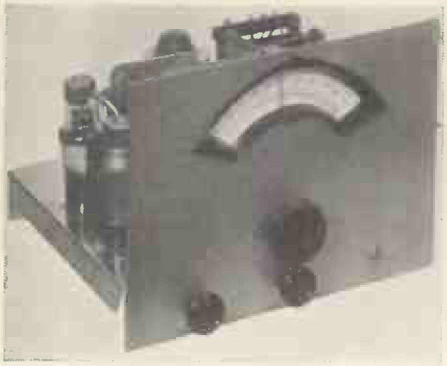
A vote of thanks was accorded to Mr. Parr on the proposition of Mr. A. S. Barnes, engineer in charge of the Plymouth B.B.C. Station, seconded by Mr. W. L. Cornish.

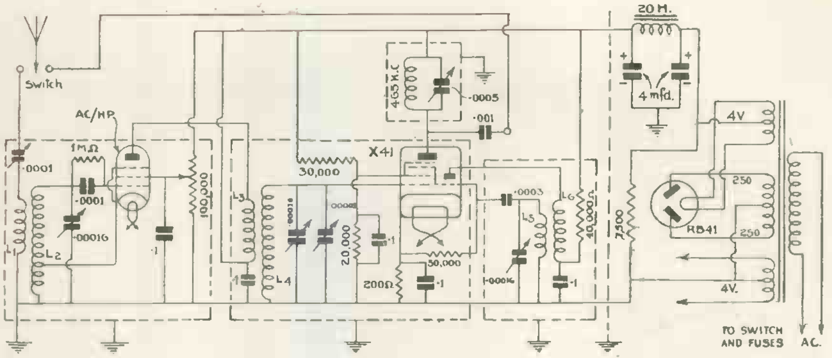
Blackpool and Fylde Short-Wave Radio Society

Readers in Blackpool should remember that the new Blackpool and Fylde Short-wave Radio Society is now busy arranging future programmes and field days. All the information required can be obtained from the Hon. Secretary, BRS 2078, H. Fenton, 25 Abbey Road, Blackpool, S.S.

Tunbridge Wells and District A.T.S.

This Society is particularly active arranging future programmes and short-wave enthusiasts should get in touch with the Secretary, W. H. Allen, G2UJ, 32 Earls Road, Tunbridge Wells. Numerous transmitting amateurs are numbered amongst its members, while BRS and A.A. amateurs will be assured of a welcome.





Pre-selector Converter Unit

We consider this superhet converter with an R.F. stage to be one of the most efficient of its type ever published. It has been designed by Kenneth Jowers for use with such receivers as the Communication Receiver described in the January and February issues.

IT is generally agreed amongst serious short-wave experimenters that one receiver can never really give optimum results on all wavebands and in all circumstances. A receiver of the 2 H.F. type does, as a general rule, prove most efficient when noise level is bad. On the other hand, a super-het of the multi-valve type will generally bring in broadcast and powerful amateur stations very much better than a straight set when conditions are good.

For duplex working a superhet is essential in order to obtain the required degree of selectivity, but the amateur who only having a superhet at his disposal would very soon find many days during which stations were lost owing to noise.

This converter was designed for several reasons. First of all a large number of broadcast listeners have asked how they can hear short-wave stations with their ordinary receiver, and hear them well.

For such readers this unit will be invaluable. It can be connected in front of any superhet or tuned H.F. receiver and left permanently in circuit. By reference to the theoretical circuit it will be seen that the aerial can be switched either through the converter or directly to the broadcast receiver. This means that the superhet converter can be switched in or out of circuit by means of one rotary switch at the back of the chassis.

Amateurs using simple receivers which probably bring in long-distance stations on headphones if reaction is pushed to the limit can also use this type of converter for general use when selectivity is of primary importance.

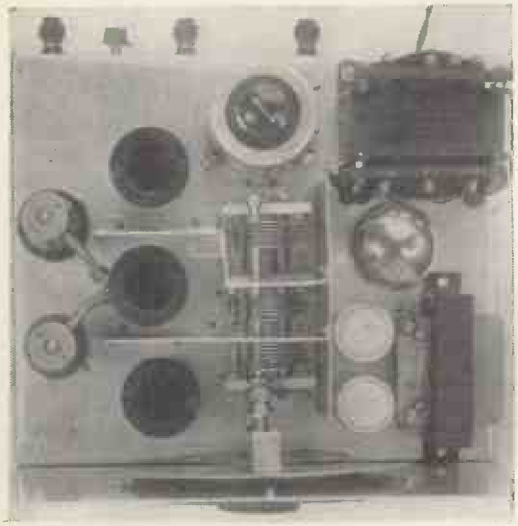
Those already using multi-valve receivers and even superhets will find it an advantage to consider the use of a converter. An ordinary superhet without H.F. invariably has a reasonably high noise level, but with a stage of speech frequency amplification plus regeneration and a really efficient detector oscillator the results will be improved enormously. Looking at it from all angles a converter of this type has a multitude of uses.

Points in Design

So as to obtain absolute optimum gain several interesting features have been embodied. First, the aerial is coupled to the grid of a fixed grid base pentode by a conventional grid coil, but with a loosely-coupled primary. This pentode valve is connected as an electron-coupled oscillator which is the only efficient means of obtaining regeneration. By means of this regeneration, signal strength can be increased very appreciably while selectivity is also slightly improved. Regeneration is controlled by means of a variable potentiometer supplying voltage to the screen of the pentode, so obviating the use of a reaction condenser.

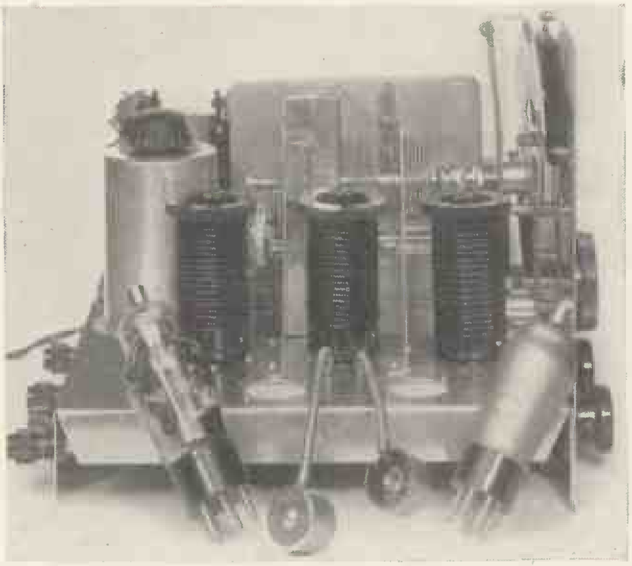
Triode-hexode

The pentode is then coupled by means of a transformer to the grid of



The plan view on the left gives a very clear idea as to the way the components are laid out.

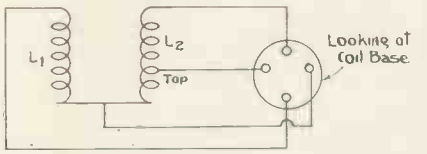
In the centre of the illustration on the right can be seen the matching circuit of approx. 500 k.c.



A Triode-hexode Unit.

The three coils are carefully screened from one another. On the right is the aerial coil, in the centre the grid and to the left the oscillator.

an X41 triode-hexode used as a detector-oscillator. This valve permits of level oscillation down to well under ten metres with a very high conversion conductance. The triode sec-



λ	L_1	L_2	Top	Space between Turns
20	3 Turns 28 DSC.	6 Turns 22 En.	2 Turns	1/8
40	8 " "	16 " "	4 "	1/8
80	12 " "	30 " "	6 "	1/16
160	17 " "	50 " "	9 "	Close

These are the aerial coil windings for four wavebands.

tion of the X41 has its grid circuit tuned and anode circuit untuned.

So as to make coil construction simple, and at the same time eliminate any ganging difficulties, which would be intolerable on the ten-metre band, a padding condenser is in parallel with the tuning condenser in the grid of the triode-hexode. In this way the grid coil can be matched up to the sharply-tuned oscillator, while the aerial coil which is, when compared with the oscillator, reasonably flat has to be wound as accurately as possible.

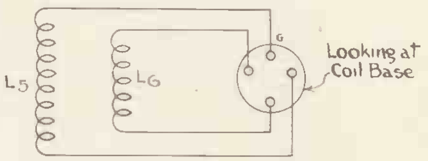
Many superhet converters fall down very badly when it comes to matching up with the input circuit of the following receiver. To overcome this difficulty the anode of the X41 feeds into a broadly-tuned circuit. This circuit is tuned by means of a .0005-mica dielectric condenser to a wavelength of about 600/700 metres. This is not important, but it should match up with the wavelength of the broadcast set to which it is coupled. If, for example, the broadcast set is tuned to 600 metres, then the output circuit of the converter should be similarly arranged.

Most amateurs will probably omit the power pack, for with home-built receivers it is a comparatively simple matter to tap off the anode and filament voltage. However, with commercial receivers that are totally encased it is essential that any addition be self-powered. So for that reason a conventional 250-volt power pack has been included making the converter a self-contained unit. Owing to the fact that the X41 and HP take less than 15 milliamps, a 7,500-ohm bleeder resistance has been connected across the high-tension supply to dissipate the excess current. This resistance is of the high-wattage type and is most essential, otherwise the voltage will rise to a figure in excess of 300.

Screening

Owing to the high efficiency of both stages, screening has to be very complete. The plan view of the receiver shows just how this is carried out. The whole unit is built on an aluminium chassis with a screen made up of three sections which isolate the three sections of the tuning condenser and the three tuning coils. The 465 kc. output circuit is also mounted within a metal can having the tuning condenser mounted in the top. The centre screen also isolates the bulk of the power pack so that all four stages are screened from one another. The centre screen is $5\frac{1}{2}$ ins. long and 5 ins. high, while the right-angle screens are $5\frac{1}{4}$ ins. $\times$ $5\frac{1}{2}$ ins. Notice how the second screen is bent at $2\frac{1}{4}$ ins. for a length of 1 in. and then bent again for a further 3 ins. This bending is necessary to allow the tuning condenser to travel its whole 180 degrees without the tips of the rotor plates coming into contact with the aluminium screen.

The three coils all have four-pin connections and are wound with the primary in between the secondary winding. The actual number of turns and the spacing can be obtained from the



λ	L_5	L_6	Space Between Turns
20	6 Turns 22 En.	4 Turns 28 DSC.	1/8
40	17 " "	8 " "	1/8
80	35 " "	14 " "	1/16
160	58 " "	20 " "	Close Wound

L5 & L6 Interwound on 20, 40 & 80 Coils

The triode-hexode grid coil is wound in this way.

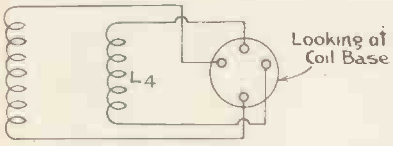
tables. The 10-metre band can be received without any difficulty, but owing to variation in components it is not advisable to give the exact coil windings. Those interested, however, can gauge quite simply by comparison with

On the left of the photograph can be seen the 7,500 ohm. bleeder resistance which is across the main supply.

Electron-coupled R.F. Stage

the 20-metre coils just how many turns to use.

The .0001-mfd. grid condenser in the pentode circuit is most important, and a distinct improvement was noticed by the use of an air-spaced condenser. This condenser can be seen from the sub-baseboard view behind the .0001-mfd. aerial balancing condenser.



λ	L3	L4	Space between Turns
20	4 Turns 28 DSC	6 Turns 22 En.	1/8
40	12 " "	16 " "	1/8
80	20 " "	30 " "	1/16
160	40 " "	50 " "	Close wound

L3 & L4 Interwound on 20, 40, & 80 Coils

Only the 160-metre oscillator coil is close wound. The remainder of the coils are spaced as indicated.

Simple Smoothing

Owing to the fact that there is no low-frequency amplifying circuit the smoothing required is less than usual. One 20-henry choke and two 4-mfd. electrolytic condensers are more than adequate, no trace of hum being noticeable. However, when the unit is connected to a broadcast receiver of the untuned type, care must be taken that hum is not picked up between the receiver and the mains transformer in the converter.

Both panel and chassis are constructed of aluminium which is very soft so that drilling will not entail any difficulty. All of the components can be bolted or riveted as preferred, and providing the specified components are adhered to there will be no need to bush panel components.

The efficiency of the unit is reasonably level from 15 metres upwards, so that those interested in any particular band, such as the 1.7 or 3.5 Mc., can rest assured that the efficiency will be of a high order.

Broadcast Programmes.

Readers interested more in the reception of programmes will find the commercial stations on the recognised bands such as the 16, 19, 25, 31 and 48 will be received with good regularity. It must be appreciated that if a broadcast superhet of the five-valve type were used the addition of the converter will make it into a seven-valve short-wave superhet which would normally cost from £20 to £30. At the same time, when used in front of a four-valve straight set, owing to the regeneration on the high-frequency and in the second detector stage, efficiency is extremely good.

There has been some query as to the advisability of using a single valve as detector oscillator. On wavelengths down to ten metres it is an absolute waste of space and money to bother with a separate oscillator.

Operation

Listeners with broadcast receivers should connect up this converter in the following way. Connect to the mains and remove both aerial and earth from the radio receiver and re-connect to the appropriate terminals on the converter. A wire should then be taken from the output terminal on the converter to the aerial terminal on the receiver. The aerial switch on the converter should then be arranged so that the aerial is switched directly to the broadcast set.

The set should then be tuned to the top of the medium-wave band where there is a silent point, and with volume or reaction controls set at maximum. The aerial is then switched to the converter and the converter tuned in the usual way. Of course, the renegeration control on the H.F. stage should be at zero until the unit has been correctly lined up. Make sure to adjust the aerial series condenser to give maximum signal strength or to balance the aerial coil. The .00003-mfd. padding condenser across L4 should be adjusted to eliminate double tuning.

Finally, adjust the .0005-mfd. condenser in the screened can so that the converter matches up correctly with the receiver. Remember that there is no need to disconnect the converter at any time. When medium-wave stations are required, the aerial can be switched to the broadcast set and for short-wave stations the aerial is switched to the converter.

PRE-SELECTOR CONVERTER UNIT.

CHASSIS, PANEL AND SCREENS.
1—Panel aluminium 12 in. by 8 in. by 18-gauge (Peto-Scott).
1—Chassis aluminium 12 in. by 10 in. by 3 in. (Peto-Scott).
4—Special screens to specification (Peto-Scott).
COIL FORMERS.
3—Coil formers for each wave-band, 4-pin type (B.T.S.).
CONDENSERS, FIXED.
2—4-mfd. electrolytic type 0281 (Dubilier).
1—.0001-mfd. type air-spaced (B.T.S.).
4—.1-mfd. type tubular (T.C.C.).
1—.001-mfd. type M (T.C.C.).
1—.0003-mfd. type M (T.C.C.).
CONDENSERS, VARIABLE.
1—.00016-mfd. three-gauge (Utility).
1—.0001-mfd. type 900 (Eddystone).
1—.00003-m.mfd. padder (B.T.S.).
1—.0005-mfd. mica dielectric type 2093 (Jackson).
CHOKE, LOW-FREQUENCY.
1—Type 30 m/a (B.T.S.).
DIAL, SLOW-MOTION.
1—Type 970 (Eddystone).
HOLDERS, FUSE.
1—Type F16 with two 1A fuses (Bulgin).
HOLDERS, VALVE.
2—7-pin type Ceramic chassis (Clix).
4—4-pin type chassis (Clix).
PLUGS, TERMINALS, ETC.
3—Type B marked Aerial, Earth, and Output (Belling-Lee).
RECTIFIER.
1—Full-wave valve type RB41 (362).
RESISTANCES, FIXED.
1—7500-ohm. type 20-watt (Bulgin).
1—1-megohm type 1-watt (Erie).
1—50,000-ohm. type 1-watt (Erie).
1—40,000-ohm. type 1-watt (Erie).
1—30,000-ohm. type 1-watt (Erie).
1—20,000-ohm. type 1-watt (Erie).
1—200-ohm. type 1-watt (Erie).
RESISTANCES, VARIABLE.
1—100,000-ohm. potentiometer (Erie).
SUNDRIES.
2—Screened plug-top connectors (Belling-Lee).
Connecting wire and sleeving (Peto-Scott).
12—6 B.A. nuts and bolts (Peto-Scott).
2 ozs. No. 34 SWG D.S.C. wire.
1—1 by 1½ in. paxolin former (Wearite).
1—Screening can type No. R9/321 (Goltone).
TRANSFORMER MAINS.
1—To specification (Bryan Savage).
SWITCHES.
1—Type S88 (Bulgin).
1—Type S86 (Bulgin).
VALVES.
1—Type AC/HP met. (Hivac).
1—Type X41 (Osram).

Our Policy
"The Development of Television."

Southend and District Radio and Scientific Society.

At a meeting held at the Society's Headquarters, Cotgrove's Restaurant, 16 High Street, Southend, on January 31, Mr. W. D. Davies, of Ekco Works, gave an interesting lecture entitled "The Moulding of Synthetic Resins." The lecturer described the chemical constituents of various moulding materials, such as Bakelite, and gave details of the process of manufacture from the preparation of moulding powders to the pressing of the finished articles. He also described the tests carried out on moulded insulating materials.

A series of lectures on television has been arranged, and the Hon. Secretary, Mr. F. S. Adams, of "Chippenham," Eastern Avenue, Southend-on-Sea, will be pleased to hear from prospective members. The Society is fully licenced for experimental transmission and is now affiliated to the Radio Society of Great Britain.

Receiver Data

U.S.A. Developments

Our Readers' Views

Eiffel Tower Transmissions

5-metre Transmission

Correspondence is invited. The Editor does not necessarily agree with views expressed by readers which are published on this page.

Television Receiver Data.

SIR,

The recently published specifications of the Marconi-E.M.I. and Baird television systems shortly to be broadcast from the Alexandra Palace station did not include sufficient information for the designers of receivers and amplifiers to work on. For example, although it is stated that for optimum definition the low-frequency response should be level to 2 megacycles there is no mention of any permissible tolerances in respect of either amplitude or phase conditions at that frequency. Likewise at lower frequencies (it is stated that 2 megacycles is not essential) one needs similar details.

I am sure many struggling designers would welcome official information of this kind.

J. BEARDSALL (London, N.).

Developments in U.S.A.

SIR,

What interests me is the fact that the by-products of television, as it were, are appearing in America before electronic television itself.

The Farnsworth Multipactor tube was a by-product of television research, and now the R.C.A. image tube comes forward, which is also a by-product of television research.

The R.C.A. image tube is, in short, an electronic pick-up, and receiver, all in one tube. The electron beams are ingeniously focused, or "magnified," electrostatically.

I may mention that electronic television will be out in this country within a few months. This city is fortunate, since all of the worthwhile research centres here, Farnsworth is on the outskirts of the city, and R.C.A., of course, is in Camden, which is just across a river.

Recently, in the Farnsworth laboratories, I saw the preliminaries of the small projection tube for electronic television. This will, I feel, be sensational.

The Federal Communications Commission has, it seems, asked Farnsworth and R.C.A. to settle between themselves the "lines and frames." It seems that it will be 343 lines at 60 pictures per second, interlaced. American power lines work on 60 cycles, and thus, 60 cycles for vertical scanning will eliminate much interference.

From my own observations I think Farnsworth's Philadelphia station will be transmitting before the R.C.A. station from the Empire State Building, in New York City.

Farnsworth is about to lay some ten miles of special co-axial cable, made to his specifications by the General Cable Co., from his laboratory on the outskirts of the city, to the Franklin Institute, in the heart of the city. This will be the first co-axial cable ever laid in America for exclusive use in television experiments.

GEORGE H. ECKHARDT (Philadelphia, Pa., U.S.A.).

The Eiffel Tower Transmission

SIR,

A few days ago, listening to some people highly placed in French television, I heard that the new transmitter of 10 kilowatts was not to be erected in the Eiffel Tower, as is supposed, but at Yssy des Moulineaux at the Porte de Versailles Paris, south-west.

Transmissions are to be tried at 25 or 24 pictures per second, twice twelve or twelve-and-a-half, with interlaced scanning, and 180 lines per frame.

So many things are supposed to be done that I cannot assure you that this is perfectly true, but it might be of some interest to you to know what is to be heard unofficially.

I will have further indications later. Hoping this will be useful to you.

AMATEUR (Paris).

SIR,

On Friday, February 7, I wrote to you to say that I heard from one of the television engineers that the new station of Paris will be at Yssy les Moulineux.

Yesterday I was introduced to the company which is making the experiments for our national television.

There I heard that the new transmitter would be under the Eiffel Tower, 180 lines 25 frames, and that they will try interlaced scanning at twice 25 pictures per second.

I saw the reception of the Eiffel Tower at something like seven kilometres, aerial a vertical doublet, the receiver a superhet. The picture was rather blurred and not very stable because of static. There was, however, plenty of detail most of the time; it was all direct pick-up, scenes, singing and dancing on the stage, etc.

I also saw in the laboratories the transmission and reception of cinema films and reception on the biggest Cossor tube, transmission by disc scanning. They showed me moving drawings, ice skating, the usual cinema scenes, and a man speaking at the mike.

The results were amazing, absolute stability (stability better than Pathé Baby) very clear and good contrasts. The picture size was about 8 ins. by 10 ins. With moving drawings the vertical lines were blurred but not more than about 1/30 of an inch. At one and a half yards distance the blurring was not noticeable.

I must tell you that I am very enthusiastic about your periodical. I see others, but they are not to be compared with yours, because you give very good and interesting technical articles and good patent analysis.

"AMATEUR" (Paris).

5-metre Transmission

SIR,

Mr. Parsons' letter in the February issue calls for some comment.

The report of the five-metre contact between G6PU and G2PB is inaccurate because Mr. Parsons was unscientific enough to proclaim the matter to the public before he had a written confirmation from G2PB. If 2PB was smart enough to hoax a large number of 40-metre amateur telephony stations into thinking he was genuine, he may have carried the hoax further.

On Saturday, December 14, I heard G2PB working G6AU, of London, and as soon as their contact was over, I called G2PB. Guessing he was a pirate by his queer objections to giving his address, I asked him certain questions, which although I tried to make as natural as possible, probably put the pirate on his guard

(Continued on page 168.)

AUTOMATIC GRID BIAS IN TELEVISION AMPLIFIERS

By R. Congreve.

MOST television constructors drive their amplifiers from the electric supply mains, and take advantage not only of an inexpensive source of power but of the several good features of indirectly-heated valves. One of these is the separate cathode which enables automatic grid-bias to be simply introduced; it is a common practice nowadays to dispense with batteries and insert the necessary resistance in the cathode lead to provide the requisite grid voltage. It is not always realised, however, how easily this arrangement can be the cause of serious distortion to the lower frequencies unless adequate precautions are taken.

The simplest possible automatic bias circuit is depicted in Fig. 1, where R_1 is the anode load resistance and R_2 provides the bias, through the grid leak R, due to the voltage drop caused by the anode current. Unfortunately, such a simple circuit is not good enough in practice, because it seriously impairs the amplification of the stage. It will be understood that the anode current consists of two components—the direct current, and the alternating current which is caused by the alternating signal voltage on the grid. Although the direct current gives us the required voltage drop across R_2 and biases the grid accordingly, unfortunately the alternating component also causes a voltage drop which is fed back to the grid *in opposition* to the applied signal volts. This results in an effective diminution of grid signal volts, and the amplification is reduced accordingly. Another way of looking at the question is to regard the grid volts as unaltered, but the valve impedance *increased,* which would obviously reduce the amplification. It can be shown mathematically that the exact effect is as if the valve impedance is increased by $(\mu + 1)R_2$, where μ is the amplification factor of the valve. To demonstrate the practical effects of this circuit, let us assume a triode valve having the following constants: $\mu = 30$, Rv (valve impedance) = 10,000. Suppose the anode resistance is 20,000 ohms, and the anode current 5 ma. We want, say, 2.5 volts grid bias so the resistance R_2 must be

$$\frac{2.5 \times 1{,}000}{5} = 500 \text{ ohms.}$$

Thus, the valve impedance of 10,000 ohms is effectively increased by 31 × 500 = 15,500 ohms so that the total effective impedance is 10,000 + 15,500 = 25,500 ohms. The ordinary formula for stage-gain is

$$\frac{\mu R_1}{R_1 + R_v}$$

and substituting figures therein we find the amplification to be 13.2. Compare this with the amplification we should have obtained without R_2, i.e., substitute in the formula R_v = 10,000 ohms, instead of 25,000 ohms. The answer is 20; so we have sacrificed a good deal by inserting R_2, instead of employing a battery for bias.

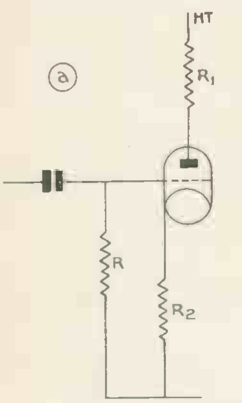


Fig. 1.—Automatic grid bias is derived from the voltage drop across R_2, but amplification is impaired.

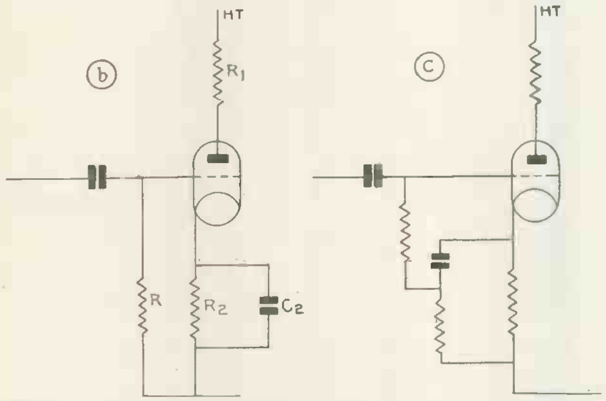


Fig. 2.—Two methods of decoupling the bias resistance, both of which, with proper choice of condensers, avoid any loss of amplification.

There are two well known methods of dealing with this difficulty. Suppose (Fig. 2a), we place a capacity C_2 in parallel with R_2. This will not in any way affect the function of R_2 in providing bias, but it will offer an alternative path to the alternating component of the anode current. This is called de-coupling. If the capacity is large enough this parallel path can have a much lower resistance, or more strictly reactance, which means that the *alternating voltage drop* across R_2 will be considerably lessened, and hence there will be less opposing volts fed back to the applied volts on the grid, and more amplification. It will be remembered that the lower the frequency the higher the reactance of a condenser, so C_2 must be big enough to have a sufficiently low reactance to give a negligible alternating voltage drop at the lowest frequency we are concerned with. In the case of modern television this would be 25 cycles per second. Consequently the condenser needs to be very large and would be expensive, but for the re-

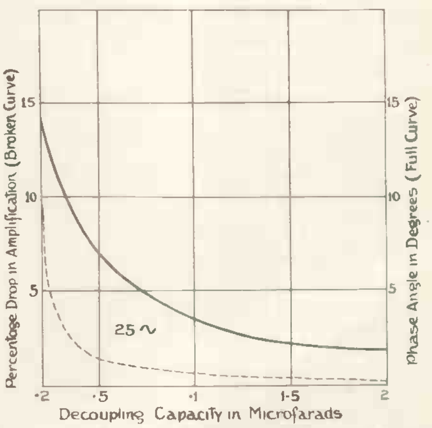


Fig. 3.—Showing effect on amplification and phase angle of different values of decoupling capacity for typical circuit with following constants: R_v = 10,000, R_1 = 20,000, R_2 = 1,000, μ = 30.

AUTOMATIC BIAS IN TELEVISION AMPLIFIERS (Contd.)

cent introduction of suitable electrolytic condensers at a comparatively low price. Obviously the working voltage need not exceed the D.C. bias voltage across R_2, so that the 12 v. type of condenser will be suitable for most stages of an amplifier.

To indicate the sort of capacities required with average conditions, Figs. 3 and 4 show phase displacement and amplification, at 25 cycles per second, plotted against capacity for two commonly used valves, with typical load and bias resistances. for example, if we are using the triode valve and anode resistance of

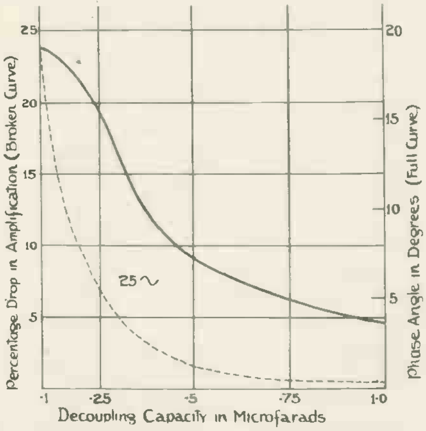


Fig. 4.—Showing effect of using screen grid valve. $Rv = 500{,}000$, $R_1 = 20{,}000$, $R_2 = 500$, $\mu = 1{,}000$.

Fig. 3 and we require the phase angle to be not greater than 5 degrees at 25 cycles, a capacity of approximately 70 mfds. is needed. Such a capacity is quite easily obtainable, but generally one finds a smaller size in use. The amplitude drop with this capacity is 1 per cent., which is not very much.

Perhaps more commonly employed is the de-coupling method indicated in Fig. 2(b). Here we have, in parallel with the resistance R_2, a capacity and resistance in series, labelled C_3 and R_3 respectively, and the grid leak R is now taken to the junction of these two components. Generally R_3 has a very much higher resistance than R_2 so there is still developed across R_2 the alternating signal voltages the influence of which on the grid we have shown to be undesirable. But the grid leak now being connected to the point shown, only a *portion* of the opposition voltage is fed back to the grid. There is, in fact, a potentiometer across R_2 and the proportion of the total feed-back voltage which is allowed on the grid depends on the ratio $\frac{1}{\omega C_3}/R_3$, $\frac{1}{\omega C_3}$ being the reactance of the condenser R_3 at a frequency $\frac{\omega}{2\pi}$. Obviously the larger C_3 at any given frequency, the less the reactance and the less the feed-back voltage between grid and cathode.

As in the case of the previous method the de-coupling will be less effective at the lower frequencies and C_3 has to be big enough for the lowest frequency involved.

Figs. 5 and 6 are curves for the same two valves as in Figs. 3 and 4, but having R_3 fixed at 100,000 ohms; phase angle and amplification are plotted against capacity C_3 for a frequency of 25 cycles per second. With this latter method the capacity required to give the equivalent effect is obviously very much less. As an example, from the curve of Fig. 5, we observe that for a 5° phase angle at 25 cycles the capacity must be approximately .7 mfd. Under these conditions we find the amplitude dropped by 1 per cent. as before. It is not advisable to use an electrolytic condenser (in any case they are only made in much larger capacities) for, owing to its comparatively low D.C. resistance, this would upset the steady grid bias, which should only reach the grid through R_3.

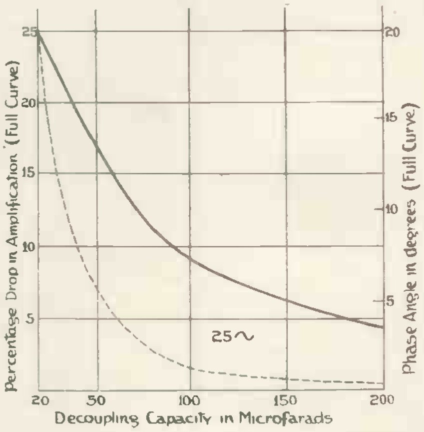


Fig. 6.—Second method, using screen grid valve (same as in Fig. 4): $Rv = 500{,}000$, $R_1 = 20{,}000$, $R_3 = 100{,}000$, $R_2 = 500$, $\mu = 1{,}000$.

Although we have only been concerned with the effect of the de-coupling condensers at the extreme low frequency, the assumption being that at high frequencies their reactance would be quite negligible, the fact should not be overlooked that some —indeed most—types of condensers have inductance. The latter is always small, but may become appreciable at frequencies in excess of 1 megacycle. Since modern television has frequencies as high as 2 megacycles, it is as well to recognise the possibility of inductive reactance, and a good method of avoiding any trouble is to connect in parallel with the de-coupling condenser one of the well-known types of small, flat mica condensers, which have quite a negligible inductance. Suitable values would be .01 mfd. for the first method, or .0001 mfd. for the second.

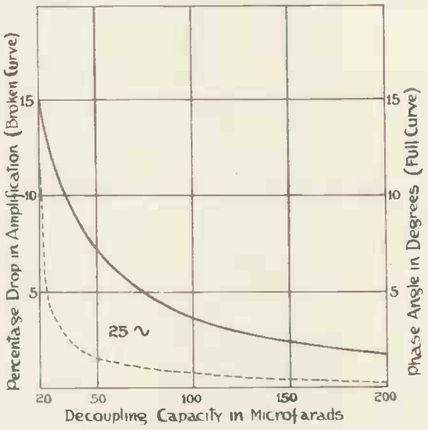


Fig. 5.—Showing effect with second method of decoupling for same valve as in Fig. 3. $Rv = 10{,}000$, $R_1 = 20{,}000$, $R_3 = 100{,}000$, $\mu = 30$, $R_2 = 1{,}000$.

"Readers Views."

(*Continued from page* 166.)

and caused the disappearance of G2PB from the 40-metre band.

The location of G2PB is therefore unknown, and might even have been Portsmouth!

The letters B.R.S. are not, unfortunately, a scientific qualification, and the report of T9 for a signal received on a super-regenerative receiver is meaningless and shows that the writer of the report is not too familiar with amateur codes. G6PU is apparently basing his claim on the B.R.S. report. During the last few months I have received several reports from B.R.S. referring to transmissions I have not made.

E. J. WILLIAMS, B.Sc. (G2XC)
(Hon. Sec. South Hants R.T.S.).

RECENT ULTRA-SHORT WAVE DEVELOPMENTS—II.

By "*Microwave*"

WITH SIMPLIFIED EXPLANATIONS

The first part of this article appeared in last month's issue. The diagrams provide some simple analogies of the Barkhausen-Kurz mode of operation and the action of the magnetron.

IN the research for generators to produce frequencies above 300 megacycles another mode of operating valves was discovered. Let us try a simile.

A Simple Experiment

Take a semi-circular trough (Fig. 2) about two feet wide, say, and with a slot at the bottom just wide enough to allow a marble to drop through. Release a handful of marbles high up near one edge of the trough. They will run down the side of the trough, and all except perhaps one or two will be carried by their impetus over the slot and some distance up the further side of the trough. Thence they will return, being carried by their impetus up the near side. This action continues, with decreasing amplitude of motion, losing one or two marbles down the " drain " at each traverse, until all are gone. This is the principle upon which the positive-grid valve works (the so-called Barkhausen-Kurz mode of operation). Electrons take the place of the marbles in our homely illustration, and the positive grid of the B.K. triode takes the dual role of gravity and the " drain." A negative potential is usually impressed on the anode to assist the return of the electrons which have passed once through the grid. (This corresponds with a device to prevent the marbles from running over the further edge of the trough and so getting lost before they have done all possible work by running backwards and forwards until they are lost down the slot.)

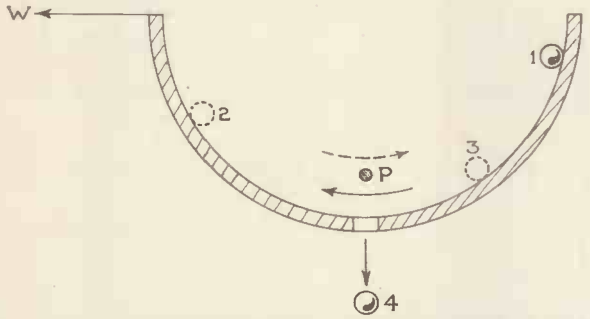


Fig 2.—A mechanical anology of the Barkhausen-Kurz mode of operation.

Furthermore, if the trough in our illustration was carefully pivoted and balanced so as to rock about its longitudinal axis, normal to the direction of traverse of the marbles (mechanical) power would be transferred from the marbles to the trough at each traverse, and if the period of swing (rocking) of the trough corresponded with the time period of traverse of the marbles, the two actions would tend to mutually assist one another. Again, the rocking of the trough might be made to operate a simple mechanical device to release fresh relays of marbles at the correct moment in each swing, so that the action would continue indefinitely so long as a constant supply of marbles was available, the energy to continue the action being derived from the potential energy stored in the mass of the marbles.

An Analogy of the B.K. Cycle

This is an almost exact analogue of the B.K. cycle. We can carry the analogy still further. Increase the force of gravity (i.e., increase the positive potential on the grid, in the case of the B.K. valve) or make the width of the trough smaller (decrease the spacing of the electrodes) and the time period of the cycle becomes shorter (valve generates higher frequency). The adjustment of the period of rocking of the trough corresponds with the tuning of the output circuit in the case of the valve. It is not essential in order for the action to take place, but it greatly increases the efficiency of operation and amount of available power output.

Thus we see that the operation of the positive-grid valve is dependent upon an effect of " statistical averages," that is, how many "swings" we can get before the average marble goes " down the drain." Thus the geometry of the valve is of paramount importance, and it is found that the generated frequency, operating potentials and valve electrode dimensions are all closely interrelated, the controlling factor here again being the " transit time."

Since the transit time is the controlling factor, the limitations upon the valve in regard to output and frequency are the same as in the case of the " straight " negative-grid triode. The efficiency of the B.K. valve is, however, much lower than that of the negative-grid triode, typical comparative figures at a frequency of 500 megacycles (=60 cms.) being 6 per cent. and 19 per cent. respectively. Up to frequencies of about 700 megacycles it compares badly with a properly designed negative-grid triode, but it can be designed to generate frequencies up to 2,000 megacycles (λ = 15 cms.), which is beyond the present capabilities of the latter. In spite of its lower efficiency, the B.K. valve can be made to give larger outputs than the triode at frequencies above 600 megacycles, on account of the fact that the interelectrode capacities and their loading effect upon the output circuit are not so important when the valve is operated in this manner, so that the valve can be made physically larger for a given frequency than the corresponding negative-grid valve.

MAGNETRON CHARACTERISTICS

The Magnetron

But for any frequency above 100 megacycles there is a formidable rival to the triode—the " split-anode " magnetron. Let us build an analogy to its mode of operation. We require marbles and a trough again. This time (Fig. 3), it is a double trough, forming a hollow cylinder. Having released some marbles inside the cylinder, we periodically reverse the force acting upon the marbles so that they roll round the inner circumference of the cylinder (in a manner that will be familiar to anyone who has played the child's game with a marble inside a cylindrical tin or mug). At each circuit the marbles will communicate power to the trough, and if the trough is suitably sprung so as to be able to vibrate in a direction normal to its longitudinal axis, the two actions will be mutually assistive.

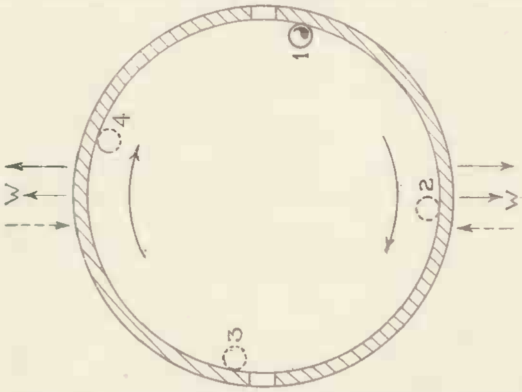


Fig 3.—An anology of the method of operation of the split-anode magnetron.

A Magnetron Analogy

As in the case of the B.K. device, the vibration of the trough could be made to operate a mechanical device to release fresh supplies of marbles at suitable moments in the cycle, and to release those which had done several circuits of the cylinder and expended nearly all their useful energy. In the case of the magnetron (Fig. 4a) the role of the marbles is again taken by the electrons emitted by the cathode, which is situated exactly along the axis of the cylindrical anode, which takes the role of the trough. The vibratory motion of the trough is simulated by the tuned circuit connected between the two halves of the anode. The electrons are given a rotary motion by means of a powerful magnetic field impressed along the axis of the electrodes.

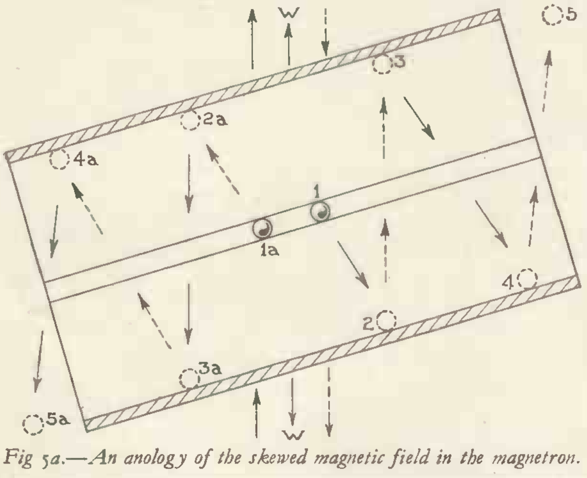


Fig 5a.—An anology of the skewed magnetic field in the magnetron.

It will be obvious even from a consideration of the crude mechanical analogies given here that the magnetron is much more efficient than the B.K. mode of operation. This is on account of the fact that there is no positively-charged grid to trap the electrons as they traverse anode-mathode space, so that in the magnetron each electron can be made to do much more work before it is finally rejected " down the drain." When the magnetron is used to generate very high frequencies (above 600 megacycles) it is found to be necessary to either " skew " the magnetic field at an angle of a few degrees to the axis of the electrodes, or else provide auxiliary plane electrodes at each end of the anode cylinder, these latter electrodes being held at a positive potential in order to remove those electrons which have performed their work in order to make room for others emitted from the cathode (Fig. 4b). The analogy with the case of the trough and marbles will be obvious. In a mechanical working model to illustrate the magnetron action, the trough-cylinder could be slightly tilted in the plane of vibration (Fig. 5a) in order to throw the used marbles clear, whilst the new marbles were fed in at the centre of the slots (analogy with tilted magnetic field) or a blast of air or suction device be directed along the axis of the cylinder (analogy with " end-plates ") (Fig. 5b).

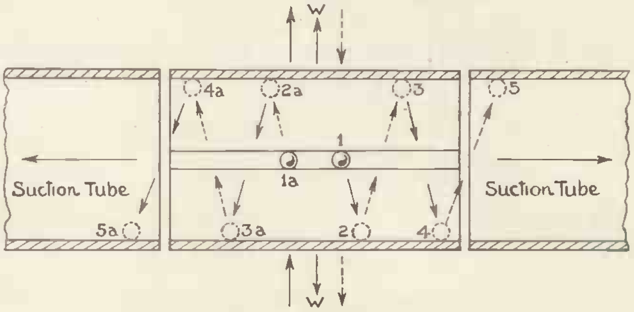


Fig. 5b.—Another anology to illustrate magnetron action.

Magnetron Output

The magnetron is capable of a greater output than either type of triode at frequencies greater than about 300 megacycles (λ = 1 metre) but is unpopular on account of the necessity of providing a strong magnetic field, rendering the device rather bulky and heavy. Where very high frequencies (above 300 megacycles) are required for medical or laboratory purposes, the magnetron is likely to be the device par excellence. It has been used with great success for communication work at very high frequencies.

Being like the B.K. valve an electron-oscillation device, the geometry of the magnetron is important, but the frequency latitude with a given valve is much wider than in the case of the B.K. valve. Whereas a B.K. valve designed to work at an optimum frequency of 600 megacycles could only work with reasonable efficiency between limits of 550 and 650 megacycles, a magnetron designed to work at this frequency would work at any lower frequency without appreciable loss of efficiency, and would work with reasonable efficiency up to a limit of about 1,500 megacycles. The advantage of the magnetron, so far as frequency range is concerned, is that the "transit time" problem is modified. Nevertheless increasing frequency requires decreasing dimensions, as in the case of the other valves, and this in turn involves power-dissipation problems, which on account of the inherently greater efficiency of the magnetron at the very highest frequencies are rendered somewhat easier as compared with its rivals. There is, however, one "snag" from the communication point of view. It is difficult to make the magnetron work efficiently as a modulated oscillator for telephony. Having regard to the small amounts of power necessary for communication at ultra-high frequencies this latter difficulty, and also the very low efficiencies of positive-grid triodes, may not prove to be of any great importance.

Fig. 4.—The Philips Magnetron valve.

To sum up, there promises to be an era of very rapid and successful development in the use of ultra-high frequencies for both laboratory and communication purposes. Suitable valves have been developed and even better ones are in the process of development. With those at present available there is not the slightest difficulty in designing and constructing efficient communication equipment to operate at frequencies up to at least 3,000 megacycles. Equipment to operate well up to 500 megacycles can now be constructed by any competent amateur, the key to the latter situation being the miniature valves recently developed.

"The Design of High-definition Amplifiers"

(*Continued from page 152*)

were mounted horizontally through holes in the compartment walls. Bus-bars were run underneath a platform extending the whole length of the box and screened leads were run to the various terminals through the platform. Considerable care was exercised in layout to keep wiring and circuit capacities at a minimum.

Condensers were of non-inductive type in bakelite cases and resistances were of the form described above and illustrated in Fig. 31.

A frequency response curve is shown in Fig. 34. It will be seen that the response is virtually linear from 5 cycles/sec. upwards, and that at 500 kilocycles/sec. the curve is 1 dB down.

Top Band Frequency Register

MANY new stations have been added to this list during February while one or two stations have altered their frequencies. There are, however, still a number of stations whose frequencies are not listed, and we shall be glad to receive these in time for publication in the next issue

Frequency.	
1726	G6GO
1730	6OK
1730	6WQ
1735	5ZJ
1740	5HO
1742	5WL
1750	2WK
1752	2KL
1753	6KV
1754	6ZR
1754	6GO
1755	6PY
1756	2AO
1757	6YU
1759.5	5JW
1759.5	2KT
1760	5AR

Frequency.	
1780	6QI
1780	6BO
1780	6HD
1781.5	5VS
1782	5RT
1784	5IJ
1785.5	5ZT
1785.5	6IF
1787.5	2XP
1788.5	2GG
1790	5MP
1790	5UM
1790	2SN
1791	5AK
1792.6	2QM
1794	5IU
1795	2UY

1760	5BM
1762	2UJ
1762.5	2ZN
1764	5NW
1765	5ZQ
1766	6OO
1766	2WO
1766	5JO
1768	6PL
1769	5GC
1769.5	5FI
1770	5PR
1773.1	5BC
1774	6SO
1774.5	6NU

1800	6TL
1801	5ZJ
1802.5	5LL
1802.5	2IZ
1806	5MM
1810	6BQ
1810	2LD
1810	5PP
1815	2DQ
1818.5	2OG
1824.5	2WG
1824.5	6UJ
1830	5KG
1830	6QB
1836.5	6RQ

1776.4	5YW
1775	5KT
1775	6ZQ
1776.4	5YW
1777	2JG
1778	6SY
1780	6BO
1780	5RI
1780	5BK
1850	6VD
1852	2KV
1857	6TQ
1857	2CF
1860	6QM
1861	2KL
1862	6WY
1869	2PS
1869	5PB
1870	2PL
1870	2LC
1870	5RI
1870.5	2WT
1874.5	2XP
1875	6WF
1881	6FV
1884	5KJ
1888	2XC
1890	2MI
1893	5RD
1899	5XF
1900	2PK

1840	2JU
1844	6VD
1849	5CJ
1850	2CD
1850	5OC
1850	2HF
1850	2SR
1850	6UD
1910	2NO
1910.5	2GG
1913.5	2UJ
1916	5VT
1921.7	2OV
1925	6CT
1925	6UU
1930	5OD
1936.6	5IL
1940	6PA
1950	6KD
1950	5GL
1950	5SZ
1954	2GG
1960	5UK
1961	5OQ
1961	2UJ
1965.5	5LL
1970	6UT
1975	6OM
1980	6KV
1988	5WW
1990	6AU

BINDING CASES AND INDEXES FOR 1935.

Binding cases and indexes for the 1935 volume of "Television and Short-Wave World" are now available. The cases are full brown cloth with stiff boards lettered in gold. The price, including the index, is **2/9** post free. Indexes may be obtained separately and the price is **6d.** post free. Orders should be addressed—

BERNARD JONES PUBLICATIONS, LTD., CHANSITOR HOUSE, 37/38 CHANCERY LANE, LONDON, W.C.2 and should be accompanied by the remittance.

All-wave Coil Design

DESIGNING coil assemblies to cover a wave range of 14-2,000 metres (25 mc.-150 kc.), presents a number of problems of great interest to the set designer and to the keen amateur.

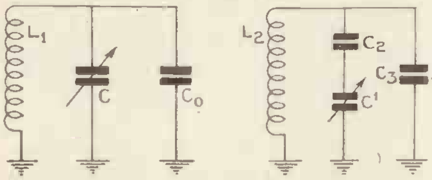


Fig. 1.—A signal frequency circuit and a conventional oscillator circuit.

Choice of Wave Ranges

The first point is the number of ranges into which the 14-2,000-metre range is to be divided. The average condenser gives a range of maximum to minimum capacity (the latter including circuit strays) of about 7:1. Since frequency is inversely proportional to the square root of capacity, so that a frequency coverage of about 2.5:1 can be obtained.

Assuming that the usual gap between medium and long waves is left, but that the range 550-13.5 metres be covered, the following approximate wave ranges are obtained:

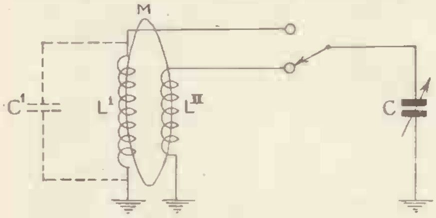


Fig. 2.—Absorption due to coupling by mutual inductance.

	Range.	Metres.
1.	Long wave	1935-775
2.	Medium wave	540-215
3.	Short wave (a)	215- 85
4.	Short wave (b)	85- 34
5.	Short wave (c)	34-13.5

Calculation of Circuit Constants

The next point is the calculation of the circuit constants to give these results. This calculation has been carried out for the signal frequency and oscillator circuits of a super-het receiver arranged as in Fig. 1.

L_1 and L_2 are inductance values.

C_0 and C_3 are trimming capacities (these values include all the stray capacities).

C_2 is the oscillator padding capacity.

C indicates the tuning condenser sections (these are assumed identical) for signal and oscillator circuits.

Taking the approximate wave ranges shown in Table 1, and assuming:—

a. An intermediate frequency of 450 kc.

b. That condenser C has a maximum capacity of 500 mmfd. and a minimum of 20 mmfd.

c. A frequency ratio of 2.520:1 for a swing of a tuning dial,

the results appear as in Table 1.

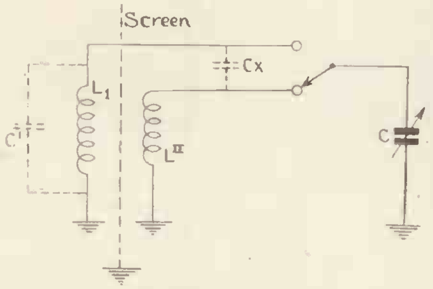


Fig. 3.—Absorption due to coupling by stray capacity.

The values of L_1 and L_2 are in microhenries and those of C_0, C_2 and C_3 are in micro-microfarads. The value of the padding condenser C_2 has been chosen to give correct ganging at three points in the range in each case. C_2 for the fifth range may be omitted if desired since it is large compared with the maximum value of the condenser.

Coil Design

The actual size and shape of coil adopted will depend on mechanical

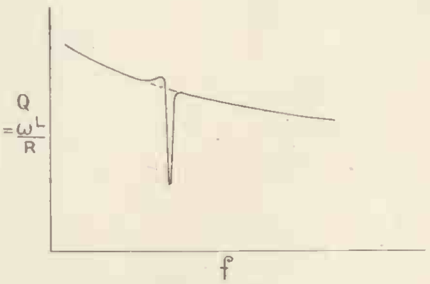


Fig. 4.—Sudden variation in Q of coil due to coupling with nearby coil.

considerations and the type of wave switching or coil changing adopted. However, once the space available for the coils has been decided on, the necessary number of turns, spacing, etc., can be decided on by calculation from

$$L = \frac{0.41\ a^2\ N^2}{9a + 10b}\ \text{microhenries.}$$

where 2a is the diameter of the coil in centimetres,

b is the width of the single layer coil in centimetres.

N is the number of turns.

The formula is accurate to 5 per cent. for b greater than 8/10.a.

It should be borne in mind that the proximity of other coils and screens will change the inductance value somewhat; a convenient check is to note the frequency to which the coil tunes (or oscillates) under working

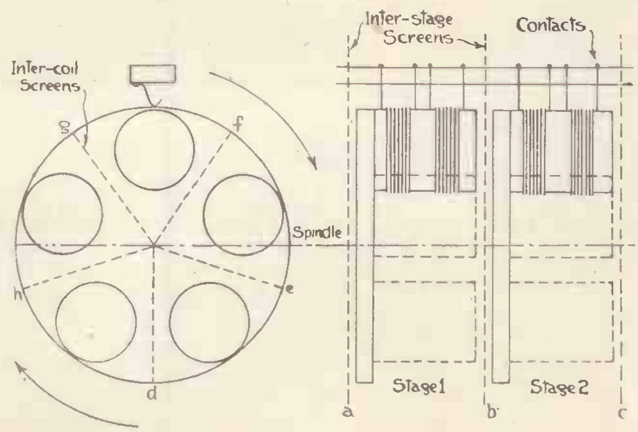


Fig. 5. — Turret principle of coil changing.

conditions with a condenser of maximum capacity 500 mmfd. connected across it. Turns or spacing should then be adjusted until the lowest frequencies shown in Table I are obtained. Also, it may be convenient to use honeycomb weave coils for the higher inductance values.

Absorption Effects

One of the difficulties in the use of multi-coil assemblies is the absorption effect due to the resonance of a neighbouring coil, together with associated self-capacity C[1], with the coil in use (L[11]). It is due to coupling which may either be a mutual inductance M between the coils (Fig. 2), or the presence of a coupling capacity C_x between the high frequency ends of the coils (Fig. 3).

The symptoms of absorption in the oscillator unit are that it oscillates only feebly or not at all for a particular point in the tuning range. In the case of a signal frequency coil it is shown by a loss of magnification or step-up. See Fig. 4. The latter is not so easily detected.

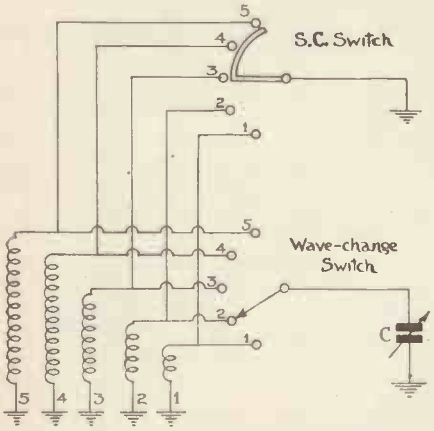


Fig. 6.—Coils of higher inductance than the one in use are short-circuited by an additional switch.

Mutual inductance coupling may be avoided by the use of an earthed screen between coils as in Fig. 2. This leaves the coupling by the stray capacity between switch contacts and the coil leads (Fig. 3). Alone, it is therefore not sufficient. The best method of avoiding the effect is to short-circuit the coils not in use, at any rate those of higher inductance.

If this is done, screening between coils is not necessary and a cheaper assembly results.

Alternatively, the coils may be separated to reduce the mutual inductance coupling and the switch contact capacities avoided by the use of a "turret" assembly.

Mechanical Considerations—Wave Range Changing

Two methods are in common use:
(a) Coil changing.
(b) Coil switching.

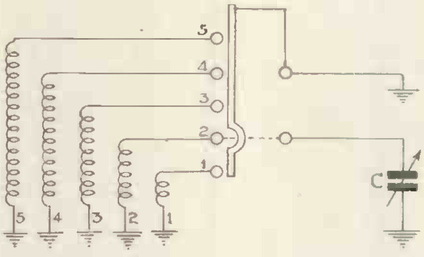


Fig. 7.—All unused coils short-circuited by single switch.

Coil Changing

The coil changing or "turret assembly" is illustrated in principle in Fig. 5. The coils are mounted on the periphery of a disc and are provided with contacts so that they can be rotated to a single set of spring contacts. Screening will be necessary between stages at a, b, and c and perhaps between coils at d, e, f, g. The system can be made very efficient but has the disadvantages of lack of compactness and heavy moving parts. It is used in several American superhet designs. This system is also applicable to low and medium power transmitter stages where quick coil changing is required.

Oscillator and one or more signal frequency stages may be ganged on a common spindle. An advantage lies in the fact that coils may be simply and individually trimmed for inductance, the trimming and padding capacities would then be located with each coil.

Coil Switching

It has already been suggested that the best method of avoiding "dead spots" due to absorption, is to short circuit coils of higher inductance than the one in use. Fig. 6 shows how the coils of higher inductance can be short circuited by means of an additional switch fitted with a wiper arm. Fig. 7 shows a type of switch arranged so that all unused coils are short circuited, "a" is a short circuiting plate, normllay earthed "b" is a ring which makes contact with the tag connecting to the coil in use. In this design one switch is made to cover the function of two.

Arrangement of Coils

In the interests of compactness the coils could be wound on a common former (say, 1 or 1½ ins. in diameter) and spaced about ½ in. This arrangement (3) is shown in Fig. 9 where the coil former is mounted vertically above the chassis and the switches ganged by means of a common spindle. The trimming and padding condensers are mounted so as to be opposite the corresponding coil, and reaction and aerial coupling windings can be accommodated either on the same former or on one of smaller diameter concentric with it.

Fig. 8. — Yaxley switch showing how all coils not in use are short-circuited.

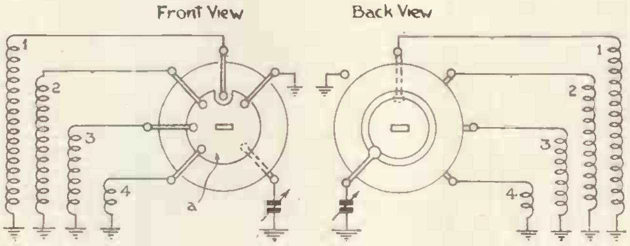
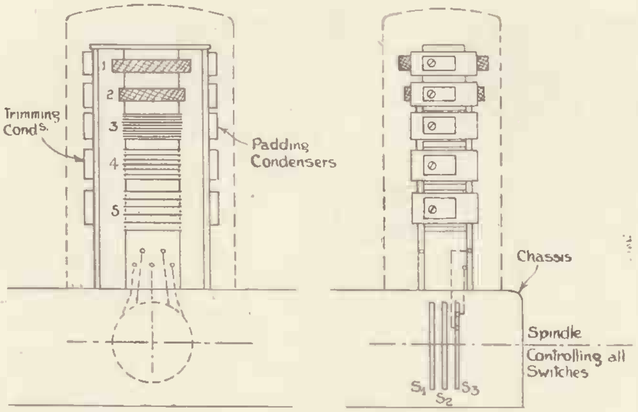
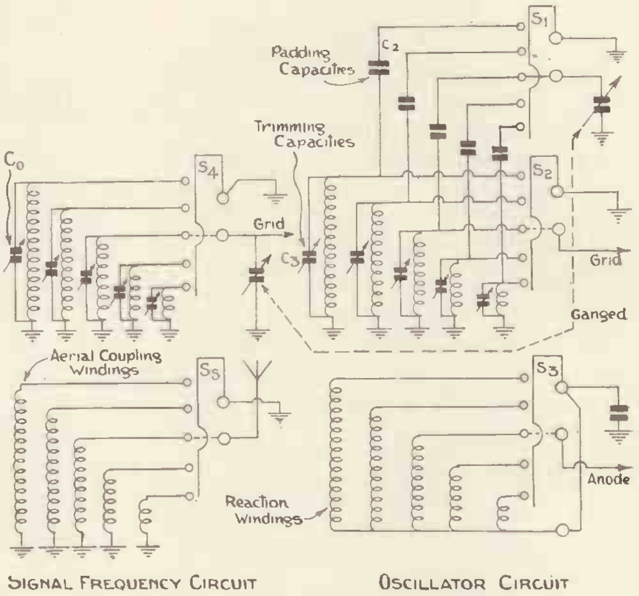


TABLE I.	Wave Range. mc.	Signal Frequency. L_1	L_2	C_0	C_2	C_3
1. Long	.155- .391	1845	192	66	314	168
2. Medium	.552- 1.39	146	60	66	861	105
3. Short (a)	1.39 - 3.51	22.9	15.3	66	2100	86
4. Short (b)	3.51 - 8.83	3.62	2.94	66	7230	80
5. Short (c)	8.83 -22.3	.57	.51	66	23500	67





(Above) *Fig. 9.—Arrangement of padding and trimming condenser for switched coil assembly.* *(Right)* *Fig. 10.—Complete circuit diagram for all-wave receiver with signal frequency and oscillator circuits.*

The final circuit diagram for signal and oscillator units then becomes as Fig. 10. The reaction and aerial coupling windings may then be switched by similar switches to those shown in the diagram above (Fig. 10). The number of turns for these windings is best determined experimentally, but may be 1/5 for the aerial coupling and 1/2 for the oscillator reaction winding of the turns on the corresponding tuned coil.

Picking Up Transatlantic Relays

By Hon. Michael Norton

These are the aerials used for reception at the Waldorf Astoria Hotel in New York.

DRESS rehearsals of transatlantic relays now provide yet another source of entertainment for the short-wave listener. Quite regularly during the year broadcasting bodies on both sides of the Atlantic arrange an interchange of programmes for re-broadcasting on medium waves. These relays have been made possible by short waves for high power stations with directional aerials are used solely for this purpose.

Consequently it needs only the simplest of short-wave sets to pick up these programmes. Generally speaking, the American commercial short-wave broadcasters are greater in strength than the programme stations such as W2XAD. Rehearsals of programmes to take place later in the day are radiated at all odd times, and it is these rehearsals that give one an insight into how programmes originating up to 10,000 miles away are picked up and re-broadcast with so little trouble.

The first of these transmissions I picked up was the rehearsal of a commemorative broadcast from Newfoundland. After that I heard the arrival in New York of the French liner " Normandie."

It was then that I noticed how the special transmission directed towards France came in better than the standard transmission from America. The reason, of course, was the extra power and directional array. On December 20 an excellent transmission was heard on 70 metres. It was part of a variety entertainment from the Radio City Music Hall, and was relayed to listeners in Germany. One relay that can be relied upon comes over at about 7 p.m. every Sunday evening. It is called the " Magic Key," and is sponsored by the National Broadcasting Company. The programme is sent out through its normal short-wave transmitters but, in addition, is sent to Europe by a special high-power link.

The programme opens with the announcer saying " The Magic Key of R.C.A. turns and opens the doors of space, and we take you now to . . . ." and then follows some interesting relay.

Towards the end of December one of the items relayed was Segovia, the guitarist playing at a Music Hall in Madrid. During the preceding items, one could hear the R.C.A. engineers in charge of the relays interrupting with " Ten Minutes to Go, Madrid," and " Cut the announcement short." When Segovia started playing the programme could also be picked up from the Spanish station EAQ on 30 metres. During one of the " Magic Key " programmes I heard a complete relay from Germany via one of the short-wave stations at Zeesen, which was then retransmitted back again to Europe so that by the time I heard it, it had travelled over 7,000 miles.

The little principality of Leichtenstein sent a special proramme to America via the short-wave station at Geneva. During the rehearsal engineers appeared to say " Something's overloading Geneva." The actual programme was ultimately transmitted on medium waves via the N.B.C. station WBZ in Boston. The connecting link with Europe being WQP, Rocky Point.

The B.B.C. send out quite a number of special programmes which are never heard in England. One of the most popular of these was Jack Hylton who, although he was playing in the London studio, was only heard on short-waves, as the programme was for the benefit of the American and colonial listeners.

Transmission Line Loss Calculation

In the February issue we published an article by the Collins Co. on their new low-loss aerial. This created such interest amongst British amateurs that we are now publishing a second article by the Collins Co. giving technical data about this wonderful new aerial.

IT has been the purpose of this project to study the various types of radio frequency transmission lines that might be used as connecting links between a radio transmitter and the radiating system proper. In this connection it is desirable to study the losses occurring in the line when terminated in its characteristic impedance—and in some cases when terminated in a different value.

This latter is the condition of operation of a section of line used as a transformer matching section between two impedances or, as a resonant feeder. It is also necessary to check the calculated characteristic impedance by experimental means and to determine experimentally the velocity of propagation of the electro-magnetic waves along the line. The velocity of propagation is necessary accurately to determine the phase shift in sections of line used in directional radiation systems.

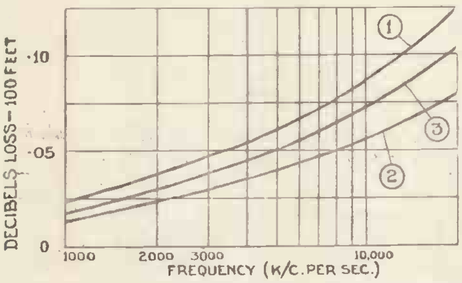


Fig. 1.—This curve shows Loss versus Frequency. (1) for 12-gauge copper wire at 600 ohms. (2) for ¼-in. copper tube at 300 ohms. and (3) ½-in. aluminium tube at 300 ohms.

There are essentially three types of lines which are used extensively in the transmission of radio frequency power. They are, namely, two wire balanced line, coaxial transmission line and twisted pair.

The two wire line may be essentially of two types. It may be constructed of solid wire with nominal spacing and having a characteristic impedance in the region of 600 ohms. This type of line is normally used as a properly terminated transmission line. The two wire line may, however, be made of copper or aluminium tubing of ¼ or ½ in. diameter and relatively close spacing. The characteristic impedance of this type of line is in the region of 150 to 300 ohms. This type of line is very suitable for use as matching sections in which it is desired to get high efficiency in the presence of standing waves.

The coaxial or concentric transmission line has a characteristic impedance in the region of 70 to 125 ohms, and is inherently an unbalanced transmission line of quite low loss. It is usually used to transmit power from the transmitter to an unbalanced load—such as feeding an antenna against ground.

It is very popular with broadcasters due to its high efficiency and to the fact that it may be run on or under the ground without further insulation or increased loss, thus giving neat appearance as well as a factor of safety where high power is involved.

A concentric line may also be used to transmit power to a half-wave doublet antenna. It is well adapted for this purpose since the impedance of a half-wave doublet in free space is 73 ohms, giving a good match with the concentric line. Twisted pair is sometimes used to feed a half-wave doublet. The characteristic impedance of twisted pair may be made in the order of 70 ohms by proper selection of the dielectric. The twisted pair is less expensive than some other types of lines but also has somewhat higher losses.

Considering first, the two wire line when terminated in its characteristic impedance: at high frequencies the resistance of a circular conductor is:

$$R = \frac{\sqrt{pf}}{a} \times 10^{-9} \text{ ohms/cm}$$

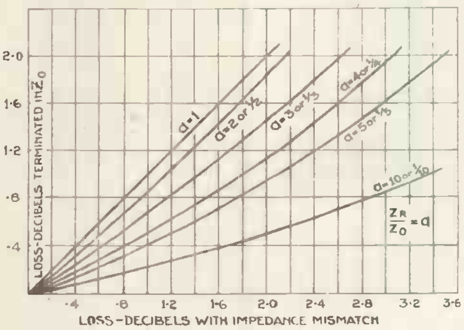


Fig. 2.—Chart for determining loss in given transmission line due to impedance mis-match.

Where p is the resistivity in electromagnetic units,
f is the frequency in cycles per second,
and a is the conductor radius in cm.

This resistance formula neglects the reaction on skin effect of the proximity of the conductors. The following correction may be applied:—

$$c = \frac{b}{\sqrt{b^2 - 4a^2}}$$

Where a is radius of conductors, and b is separation centre to centre.

This correction may be neglected except for the lines constructed of tubing having close spacing.

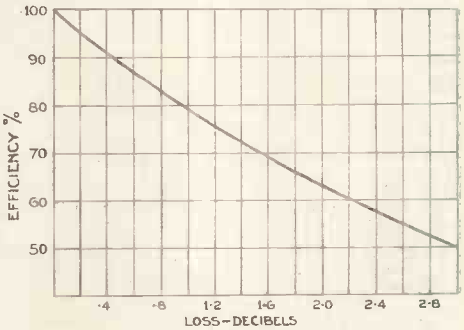


Fig. 3.—Efficiency versus Loss.

From transmission line theory the characteristic impedance and the propagation constant are given by:

$$Z_0 = \sqrt{\frac{Z}{Y}}$$

and $\gamma = \sqrt{ZY}$.

Where Z is the impedance per unit length,
and Y is the admittance per unit length.

For a given line:

$$Z = R\ j\omega l$$

and $Y = j\omega C$

neglecting leakage conductance.

Using the fact that for a low loss line $\omega L \gg R$ and the angle of Z is approximately $\pi/2$ gives

$$Z = \omega L / \pi/2 - R/\omega L,$$

since for small angles the angle in radians is approximately equal to the tan. of the angle.

Thus $Z_0 = \sqrt{L/C}\ /-R/\omega L$ and is almost a pure resistance.

Also

$$\gamma = \omega\sqrt{LC}\ \Big/ \pi/2 - \frac{R}{2\omega L}$$

$$= \omega\sqrt{LC}\left[\cos\left(\pi/2 - \frac{R}{2\omega L}\right)\right.$$

$$+ j \sin\left(\pi/2 - \frac{R}{2\omega L}\right)\Big]$$

$$= \frac{R}{2Z_0} + j\omega\sqrt{LC}$$

Thus the attenuation per unit length when terminated in Z_0 is $a = \frac{R}{2Z_0}$ nepers or $4.34R/Z_0$ decibels, and the phase shift per unit length is $\beta = \omega\sqrt{LC}$ radians, and the velocity of propagation is $V = \omega/\beta = \frac{1}{\sqrt{LC}}$.

Neglecting the effect of proximity and dielectric constant on capacitance:

$$Z_0 = \sqrt{\frac{L}{C}} = 276 \log_{10} \frac{b}{a} \text{ ohms}$$

where b is separation of conductors centre to centre and a is radius of conductor.

The effect of proximity on capacity does not appreciably change the characteristic impedance. The change is less than one-half of one per cent. in the case of ¼-in. tubing spaced 1-in. centre to centre. In air the dielectric constant may be taken as unity.

As an illustrative example of the loss occurring at radio frequencies on a transmission line terminated in its characteristic impedance, the computed loss in decibels per 100 feet has been calculated for three cases:

(1) No. 12 hard-drawn wire spaced 6 ins. with a characteristic impedance of 600 ohms.

(2) ¼-in. copper tubing spaced 1½ ins.

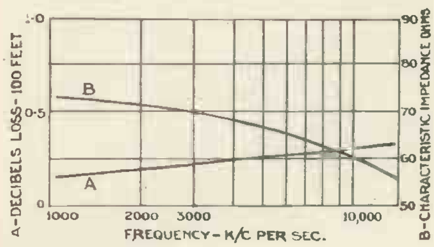


Fig. 5.—Concentric transmission line characteristics. Velocity is equal to 86.1 per cent. of free space between 2 and 10 M.C.

with a characteristic impedance of 300 ohms.

(3) ¼-in. aluminium tubing spaced 1½ ins.

It has been stated in previous articles on the subject that the measured loss at radio frequencies if 50 per cent. larger than computed values. This agrees quite well with tests made in our laboratories. The computed values increased by 50 per cent. have been plotted in Fig. 1 for the three cases mentioned. Actual tests on the ¼-in. tube line shows the velocity of propagation to be 5 per cent. less than that of free space.

If the two wire line is terminated in an impedance not equal to the characteristic impedance the loss is increased due to the presence of standing waves. The loss under these conditions can also be calculated from the well-known transmission line equations in terms of hyperbolic functions.

$$I_S = I_R \cosh yl + E_R/Z_0 \sinh yl$$
$$E_S = E_R \cosh yl + I_R Z_0 \sinh yl.$$

Where subscripts S and R denote sending and receiving currents and volt-

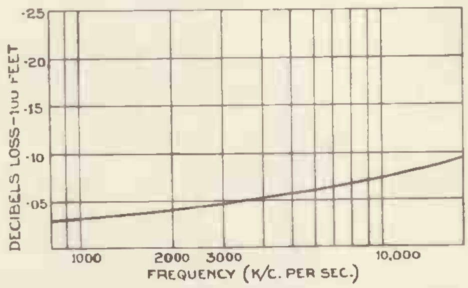


Fig. 4.—Loss versus Frequency with copper tube spaced 1. ins. Velocity of propagation is equal to 95 per cent. of free space measured loss.

ages respectively. Taking Z_0 as a pure resistance R_0 and terminating the line in a complex impedance $Z_R = E_R/I_R$.

Where

$$Z_R/Z_0 = \frac{R_R}{R_0} + j\frac{X_R}{R_0} = a + jb.$$

CONSTRUCTING THE NEW COLLINS AERIAL

Readers constructing the new Collins aerial may experience difficulty in obtaining the feeder wire or tube. 12-gauge copper wire can be obtained from Lewcos, or P. Ormiston of Clerkenwell Road. The price for 5 pounds, equal to 150 feet, is 5/6d.

Copper tubing of 22 gauge costs 1/8d. per pound and can be obtained from J. Smith & Sons, St Johns Square, E.C. 140 feet weighs approximately 6 pounds.

Aluminium tube or wire can be obtained from the British Aluminum Co. Ltd.

From these equations the input power to the line may be calculated as

$$P_i = aR_oI_r^2 \left[\cosh 2al + \frac{a^2 + b^2 + 1}{2a} \sin 2al\right.$$

The output power into Z_R is

$$P_o = I_r^2 R_r = aI_r^2 R_o.$$

The line loss in decibels is then given as

$$L = 10 \log_{10} P_i/P_o = 10 \log_{10}.$$
$$\cosh 2al + \frac{a^2 + b^2 + 1}{2a} \sinh 2al.$$

If the termination is a pure resistance, then b = 0. Also if this termination is a resistance equal to Z_0 a = 1 and the loss is 8.68 al in decibels. Thus if the loss is known when the line is terminated in Z_0 the above relations may be used to determine the loss when the line is terminated in a value other than Z_0. In Fig. 2 there have been plotted the values of the loss in decibels for various degrees of mismatch versus the loss in decibels for the same length of line when terminated in Z_0.

In Fig. 3 there has been plotted for convenience the efficiency versus loss in decibels as calculated from the relations

$$\text{Loss (db)} = 10 \log_{10} \frac{P_i}{P_o}.$$

$$\text{Eff. (\%)} = 100 \frac{P_o}{P_i}.$$

This is useful in obtaining the efficiency of any length of line with any degree of mismatch. The loss of the given length of line when terminated in Z_0 can be determined from Figs. 1, 4, 5 and 6 by direct ratio. For the degree

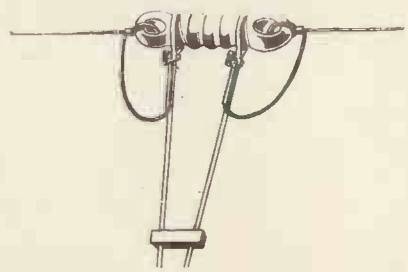


Fig. 7.—This is the way the feeders should be connected to the insulator in the centre.

of mismatch for which is desired the efficiency is read from Fig. 3. Thus, for example, 250 feet of ¼-in. copper tubing spaced 1½ ins. and terminated in 60 ohms resistance has an efficiency of 90 per cent. at 14 megacycles.

Figs. 4, 5 and 6 show the results of experimental measurement of losses on three types of lines. Fig. 4 is the ¼-in. copper tubing line computed previously. Fig. 5 is a small size coaxial transmission line made up of No. 12 wire inside of ⅜ in. copper tubing and centred by Isolantite beads spaced 1¼ ins.. Fig. 6

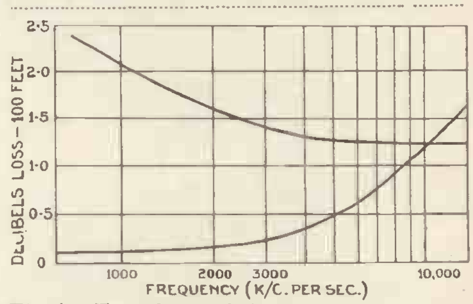


Fig. 6.—Twisted pair feeder characteristics. Velocity of propagation is 61.6 per cent. of free space at 1,210 k.c., 64.2 per cent. of free space at 3,300 k.c. and 68 per cent. of free space at 7,350 k.c.

is a type of twisted pair often used for radio frequency transmission. It consists of two No. 12 wires with a spacing approximately 5/32 in. Each wire is rubber covered, and the two wires are twisted together and covered with an impregnated braid. The loss for this type of line increases more rapidly with frequency than the theoretical

(*Continued on page* 192)

FOR THE BEGINNER

SIMPLE FACTS ABOUT TIME BASES

A PRACTICAL ARTICLE GIVING MUCH USEFUL INFORMATION

By J. H. Reyner, B.Sc., A.M.I.E.E.

The time base is really a high-speed automatic switch which can be made to perform at incredibily high speeds. The theory has been dealt with in preceding articles (see ABC of the Cathode-ray Tube, September and October, 1935 issues). This article deals in a simple manner with the practical working of time bases and the various factors which affect their operation.

THE theory of time bases has been discussed on various occasions in this Journal. The basic requirement is that a voltage shall increase slowly to a certain value and then fall rapidly to zero again, repeating this process indefinitely at a steady rate. Usually we charge a condenser through a high resistance and then discharge it through a low one which gives us the necessary saw-tooth waveform required.

The actual discharge may be effected by a gas discharge tube which is an ordinary triode with a small filling of neon, mercury vapour or helium. It is over-biased so that it normally carries no current, but when the anode voltage reaches a certain value, dependent upon the setting of the bias, anode current begins to flow. The electron stream in its travel from cathode to anode encounters atoms of gas which are ionised by collision, liberating free electrons. Both these, and the heavy positive ions left, encounter other atoms producing further ionisation, so that a cumulative increase of current takes place resulting in a very rapid discharge.

When this discharge has taken place the gas inside the tube must return to its normal condition again and this takes a little time so that there is a limit to the speed at which the process can repeat itself. Consequently, although a time base of this sort is quite satisfactory at low frequencies, we begin to encounter difficulties at frequencies of several thousand per second. Mercury vapour has a somewhat long de-ionisation time and this form of tube cannot be used satisfactorily above two or three thousand cycles per second (assuming 25 pictures per second) while the interlaced scanning system of E.M.I. requires still higher frequencies of 10,125 cycles per second.

Neon filled tubes are rather better in that their de-ionisation time is shorter and they will therefore operate successfully at frequencies of 10,000 cycles and upwards, while helium can be used successfully up to frequencies of this order.

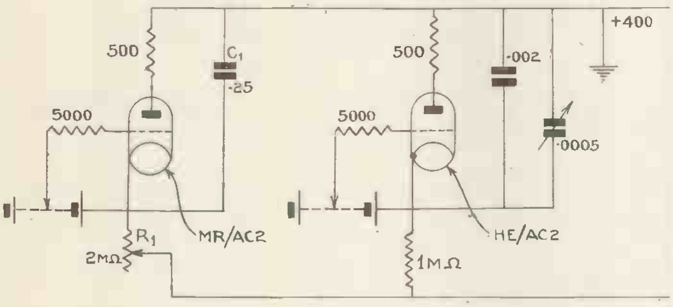


Fig. 1.—Time base circuit suitable for high-definition television employing gas discharge tubes.

Fig. 1 illustrates a time base suitable for high-definition television using gas discharge tubes. The frequency is controlled by alteration either to the condenser capacity or the charging resistance. At the low frequencies, of course, the former expedient is not practicable and the control is obtained by altering R_1. If the tube is to have long life C_1 must be kept small. On the high frequency base, however, the value of condenser required is small, and a convenient arrangement is to vary the condenser capacity, using a variable condenser in parallel with a suitable fixed capacity. Note the resistors in the anode leads to limit the discharge—another desirable precaution if long life is required from the tubes.

Importance of Steadiness

The most important feature of the time base, and particularly the high-frequency circuit, is that it shall be steady. Any sort of variation, either of the resistance or the capacity, will give unsteadiness in the working. Wire-wound resistances are not as a rule very satisfactory, for the moving contact is liable to take up an indeterminate position resting on the junction between two turns and is liable to slip from one to the other in operation.

Another point which requires attention is that of leaks across the valve holders of the "poppers." An excess of flux on a joint will cause a thin film of grease to spread between the various terminals, and this in time will pick up dust and dirt and form a conducting path. The leak may be of relatively high resistance but if, as is usually the case, it is variable, unsteady working is bound to ensue.

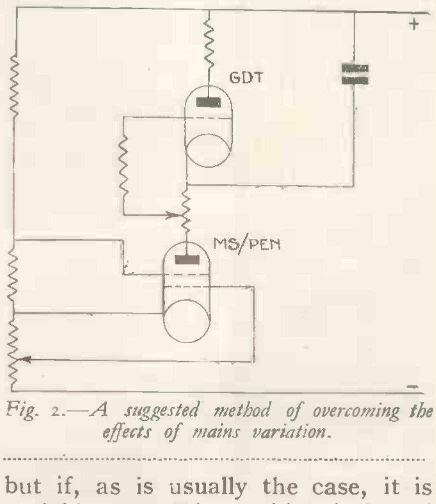


Fig. 2.—A suggested method of overcoming the effects of mains variation.

PRACTICAL POINTS ON TIME BASES FOR THE BEGINNER

Pre-set or bakelite di-electric condensers must not be used for the same reason for slight variations in pressure or temperature give rise to alterations in the capacity and unsteadiness again results.

Mains variations, of course, are also liable to cause trouble and the circuit of Fig. 2 is sometimes suggested as a means of obviating trouble from this cause. Here the charging resistance is replaced by a constant-current charging valve such as a pentode, the effective resistance being altered by varying the grid bias on the valve. Such an arrangement is very largely independent of the actual h.t. voltage applied across the circuit, provided that the valve is operating under present correct conditions. It is important,

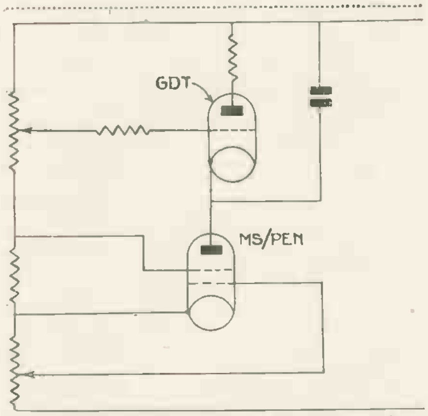


Fig. 3.—Another successful method of providing a continuous variation of sweep.

however, when using such a circuit to make sure that the valve is not sensitive to variations in screen voltage, because this voltage must be fed from a potentiometer across the h.t. supply. Avoidance of this difficulty is usually merely a matter of correct choice of screen volts.

Sweep Variations

Variation of sweep, i.e., the actual length of travel of the spot before it flies back, is controlled by the grid bias on the gas discharge tube. For the experimenter the best arrangement is undoubtedly a simple grid battery since the 1½-volt steps on such a battery are usually sufficient, and an 18-volt bias is sufficient to provide a sweep of 200 to 300 volts. More than this is not desirable as it shortens the life of the gas discharge tubes.

The sweep is dependent upon the control ratio of the tube which is a factor analogous to the amplification factor in an ordinary valve. Actually it is the figure by which the grid bias must be multiplied to arrive at the anode voltage at which the tube will "fire." Thus a tube with a control ratio of 20 and a grid bias of 18 will fire at 360 volts.

This control ratio is not an absolutely determinate factor. Gas discharge tubes draw grid current, so that if there is any series resistance in the grid circuit, the actual applied voltage will be somewhat less than the theoretical amount. It is customary to include a resistance in the grid circuit so that the grid itself shall be able to vary at an a.c. potential irrespective of the fixed polarising d.c. voltage. This is desirable for purposes of synchronism so that the actual firing point of the valve may be controlled by a suitably applied pulse; but in view of the possibility of grid current it is desirable that the total grid to cathode path should not be more than 10,000 to 20,000 ohms. This includes the resistance of any potentiometer used across the grid battery.

An alternative method of controlling the sweep is that shown in Fig. 2. Here the grid is biased off a potentiometer in the cathode lead. During the charging cycle, the current into the condenser is constant (or it should be so if the time base is structly linear), and therefore a constant voltage is developed across this potentiometer, and a suitable portion may be tapped off to bias the grid. Once the tube has fired nothing we do to the grid will make any difference until the condenser is completely discharged, reducing the voltage on the anode to zero. Hence, what happens to the grid voltage after the firing point does not trouble us.

Still another circuit is that shown in Fig. 3 where the grid is polarised by being connected to a potentiometer across the h.t. supply. This arranges that the grid is always at a certain fixed potential. The cathode of the valve starts by being at the same potential as the h.t. line (when the condenser is discharged) and is therefore several hundred volts positive relative to the grid potential point. As the condenser charges up the cathode of the gas discharge tube begins to run negative and therefore approaches the potential of the grid. In other words the effective grid bias gradually reduces itself until a point is reached at which the tube fires.

Both these methods are quite successful and give a continuous variation of sweep. They both have the disadvantage, however, that they do not fully utilise the control ratio of the tube and the maximum sweep obtainable will not be as great as with battery bias.

Heater Connections

To avoid hum it is customary to connect the centre tap of the heater winding for the valves and discharge

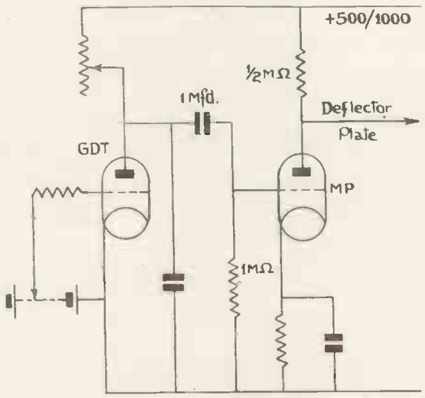


Fig. 4.—An amplified time base.

tubes to some point of fixed potential. Care must be taken to avoid high voltage between heater and cathode.

For example, in Figs. 1 to 3, the cathode of the gas discharge tubes is sometimes at full positive potential. Hence the heaters should *not* be connected to H.T. – but to H.T. +. Even so there is a danger of excess voltage and the best plan is to earth the heater winding through a leak of ½ to 1 megohm.

The ordinary gas discharge tube will give sweeps of 200-300 volts without difficulty provided the circuit is carefully laid out, but for any more than this, it is necessary to use an amplifying valve, and in fact it is often preferable to use an amplifying valve in any case and to limit the actual sweep of the gas discharge tube to a matter of 20-30 volts only. A circuit for doing this is shown in Fig. 4. A simple resistance coupled valve is used driven from the "pop-

(*Continued on page 181.*)

RECENT TELEVISION DEVELOPMENTS

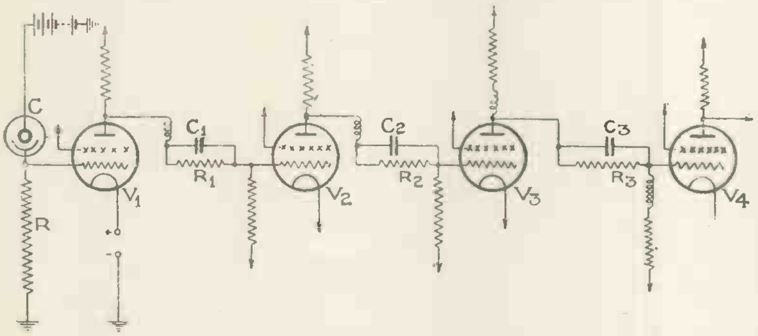
A RECORD OF PATENTS AND PROGRESS
Specially Compiled for this Journal

Patentees:—A. D. Blumlein and C. O. Browne :: D. W. Pugh and Baird Television Ltd. Communication Patents Inc. :: Radio Akt. D. S. Loewe :: The General Electric Co., Ltd. and L. C. Jesty :: J. C. Wilson and Baird Television Ltd.

P.E. Amplifiers

(Patent No. 436,734.)

In order to maintain an even balance over the very wide range of frequencies produced in television, the output from a photo-electric cell C is amplified by a series of valves V1, V2, V3, V4 which are progressively graded in their frequency response.



Circuit of photo-cell amplifier, Patent No. 436,734.

In the first place the resistance R in the P.E. cell circuit is of high value, so that there is a comparatively large leakage of the highest frequencies across its shunt capacity. Then the parts R1, R2, R3 of the resistance-couplings of the valve amplifiers are shunted by condensers C1-C3 which are made gradually smaller, so that each valve favours a progressively higher frequency-band.

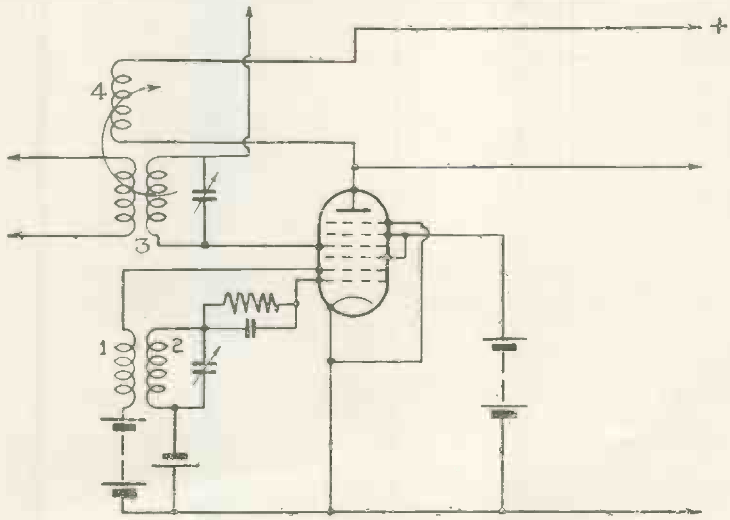
The very low signal frequencies pass through the first three valves practically unaltered in value, but are amplified in the last valve V4. Here, too, the original loss of the highest frequencies across R is made good by the intensifying effect of the inductances L, L1. The circuit is designed to keep the signal voltage well above the background of static and other disturbance.—(*A. D. Blumlein* and *C. O. Browne.*)

Super-regenerative Receivers

(Patent No. 437,460.)

A single multi-grid valve is used as a super-regenerative amplifier, the quenching-frequency being generated by the first two grids, which are separated by a virtual cathode from the signal input. The circuit is suitable for the reception of television signals.

As shown the first two grids are back-coupled by the coils 1, 2 so as to generate a comparatively low "quenching" frequency. The third and fifth grids are connected together. A virtual cathode is formed near the third grid, and supplies electrons to the upper part of the valve at the quenching frequency. Meanwhile, the signals are applied to the fourth grid through an input coil 3, which is back-coupled to the anode or output coil 4. The grid nearest the anode is connected to the cathode and acts as a suppressor.—(*D. W. Pugh* and *Baird Television, Ltd.*)



Super-regenerative receiver for television. Patent No. 437,460.

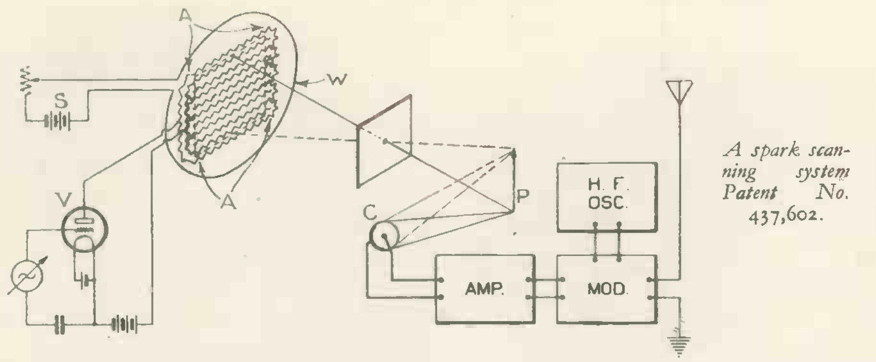
Television Systems

(Patent No. 437,602.)

The viewing-screen of a television receiver is made up of a series of spark-gaps forming a long line which is bent to and fro in zig-zag fashion so as to fill the rectangular area A. Each spark-gap consists of a pair of opposed points formed on each side of two parallel wires or line-electrodes, these being fed with sufficient D.C. voltage to put them on the verge of discharge.

Alternating current supplied from a valve V starts up the first discharge, which is then made to travel along the line, from beginning to end of the area A, by the magnetic field from a coil-winding W. The winding is energised from a source S.

When used for transmission the travelling spark-discharge scans the



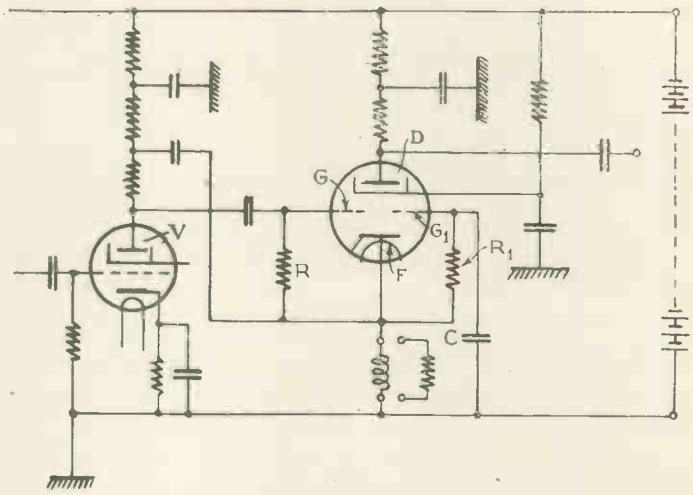
A spark scanning system Patent No. 437,602.

picture P, and the reflected light is received by a photo-electric cell C and is used to modulate the outgoing carrier-wave in the usual way. At the receiving end, the brilliancy of the spark-discharge on a similar viewing-screen is constantly varied by the incoming signal voltage, and so reproduces the light-and-shade effects of the original picture.—(*Communication Patents Inc.*)

Removing the Carrier Wave

(Patent No. 437,643.)

When transmitting television signals on a medium-wave band, say, of the order of 200 metres, the presence of the carrier-wave in the receiving circuits gives rise to whistling and to picture distortion. The received signals are therefore applied in phase-opposition to two divided control grids G, G1 in the detector valve D. This allows the carrier to be balanced out and eliminated from the output circuit of the detector without causing any loss of the highest signal-component, even when the latter is fairly close to the carrier frequency.



Removing the carrier wave. Patent No. 437,643.

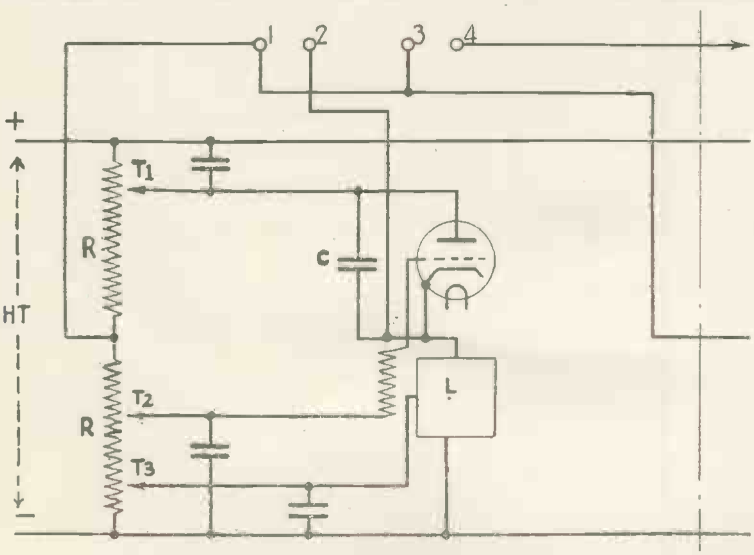
It will be seen that one grid G is coupled to the plate of the last intermediate-frequency valve V, whilst the other grid G1 is earthed, so far as A.C. components are concerned, through a condenser C. The cathode F. is connected to the mid-point of two equal resistances R, R1 in order to ensure the necessary out-of-phase relation between the two grids.—(*Radio Akt. D. S. Loewe.*)

Controlling the Scanning Spot

Patent No. 438,386.)

It is necessary to be able to determine the point at which the path of the electron beam begins and ends its sweep across the fluorescent screen of a cathode-ray tube. If every cathode-ray tube could be constructed with perfect accuracy, this would be entirely a matter of electrode design, but, as it is, it involves some method of adjusting the operating voltages applied to the deflecting electrodes.

The figure shows a time-base circuit for feeding scanning voltages to one pair 1, 2 of the deflecting-electrodes in a cathode-ray receiver. A similar circuit is, of course, necessary for supplying the second pair of electrodes marked 3, 4.



Controlling the scanning spot. Patent No. 438,386.

The condenser C is slowly charged up from a high-tension supply H.T. through a current limiter L, and is then rapidly discharged to produce saw-toothed oscillations, when the valve V is "triggered" by a synchronising signal. The H.T. supply is shunted by a resistance R from which tappings are taken at T1, T2, T3, to enable the required adjustments to be made. The tapping T1 controls the voltage range applied to the control electrodes 1, 2 and, therefore, the position of the electron beam, whilst T2 controls the points at which the condenser C starts to discharge. Finally, the current through the limiter L is regulated by the tapping T3.—(*The General Electric Co., Ltd.,* and *L. C. Jesty.*)

Television "Insets"

(Patent No. 438,533.)

It is sometimes desirable to be able to produce so-called "ghost" effects in television, such, for instance, as the figure of a person with an "inset" which represents his changing thoughts.

In a light-spot scanning system, this effect is secured by "masking" the part of the background which is to take the inset scene, separately scanning the latter in a different part of the studio, and then combining the two scannings in proper phase. Alternatively, when floodlight scanning is used, the light may be cut off or reduced on the "inset" area, and a separately-scanned picture introduced in its place.—(*J. C. Wilson* and *Baird Television, Ltd.*)

Summary of Other Television Patents

(Patent No. 437,021.)

Film television system utilising both "interlaced" and "straight" systems of scanning.—(*J. C. Wilson* and *Baird Television, Ltd.*)

(Patent No. 437,216.)

Cathode-ray tube provided with special cooling fins on the anode and other electrodes near the Wehnelt cylinder.—(*Fernseh Akt.*)

(Patent No. 437,340.)

Rotating - disc photo - electric "syren" for producing synchronising signals.—(*P. V. Reveley* and *Baird Television, Ltd.*)

(Patent No. 437,507.)

Symmetrical and demountable coupling for high-frequency feed-lines.—(*N. Cave* and *Baird Television, Ltd.*)

(Patent No. 437,594.)

Arranging and mounting the electrodes of a cathode-ray tube.—(*L. F. Broadway* and *W. F. Tedham.*)

(Patent No. 437,624.)

Method of aligning the electrodes in a cathode-ray tube.—(*General Electric Co., Ltd.*; *L. C. Jesty* and *G. W. Seager.*)

(Patent No. 437,656.)

Producing clear-cut apertures in a rotating disc used for scanning.—(*Electrical Research Products Inc.*)

(Patent No. 438,117.)

Method of mounting the electrodes of a cathode-ray tube so as to avoid spot "displacement" on the fluorescent screen.—(*E. Hudec.*)

(Patent No. 43,8424.)

Scanning system in which a rotating ring of lenses is used in combination with stationary prism.—(*Scophony, Ltd.*; *J. H. Jeffree* and *G. Wikkenhauser.*)

(Patent No. 438,716.)

Scanning system based on the production of an electron image in a cathode-ray tube.—(*L. Schiff.*)

(Patent No. 439,121.)

Fixed and rotating mirror system used for "interleaved" scanning.—(*C. O. Brown.*)

(Patent No. 439,146.)

Producing synchronising signals for transmission by means of a grid-controlled gas-filled valve.—(*Compagnie des "Compteurs.*)

(Patent No. 439,225.)

Interleaved scanning system in which the line frequency is a "whole-number" multiple of the frame frequency.—(*Electrical Research Products, Inc.*)

"Simple Facts about Time Bases."

(*Continued from page* 178).

per" which is left running at a fixed amplitude. Sweep control is varied by a potentiometer in the anode circuit of the amplifying valve.

Many people prefer to use hard valve time bases because the operation of the gas discharge tube is slightly variable. It depends essentially upon the ionisation of the gas in the tube and this is liable to be affected by variations in temperature. In any case it is always advisable to allow gas discharge tubes five or ten minutes to warm up before any serious work is done.

The difficulty with the ordinary hard valve is that the rise of the anode current is nothing like sharp enough to give a really rapid discharge. Secondly, there is no cumulative or relay action. If we imagine a condenser with a valve connected across it, biased to cut-off point in the same way as the gas discharge tube, then when the voltage on the condenser rises to a certain value the valve will begin to conduct current in the same way as we have already discussed. The discharge of the condenser, however, will cause the voltage on the condenser to drop and as soon as this happens the anode current of the valve drops again. Hence the condenser will only discharge a short way and then the discharge will cease. It is necessary, therefore, to incorporate some device which keeps the whole action going once it has started and these will be discussed in a later article.

20-Metre DX Reception

MANY amateurs have worked or heard all W districts except 6 and 7, but, try as they may, seem unable to obtain the coveted cards from these two districts. The difficulty appears to be not knowing just when the stations are to be heard.

Firstly, they are audible in London at twelve-hour intervals; in the morning via the Pacific Ocean and Asia, and in the evenings via America. So to obtain maximum signal strength try directional receiving work, remembering which way the stations come in.

Time is important. In general, they are heard from 05.00 to 07.30 G.M.T. at peak strength, and from 07.00 to 20.00 G.M.T. at varying strength. May and June are the best months for reception, but W6's and W7's can be heard nearly all the year round.

Once heard, they can always be recognised by the characteristic note "flutter." It is a very extraordinary effect and caused mainly by selective fading. Selective fading is the technical term used to describe the particular form of fading which causes different nearby frequencies to fade at different frequencies. Thus a 2-kc. difference may mean good reception or bad fading.

Do not imagine that these signals must be weak for very often they come in at phenomenal strength peaking up to R9. So listen to the strong signals as well as the weak ones.

For DX purposes the 14-mc. band is divided into three parts, viz., the low-frequency end from 14,000 to 14,150 kc. for phone, 14,150—14,250, and the high-frequency end 14,250—14,400.. W6 and W7 signals come through on one portion of the band, while the rest may be absolutely dead.

To raise DX it is always better to call in the same section of the band as the station wanted. Otherwise it is just a waste of time and power.

The next important point is the choice of frequency. A station calling in the low-frequency end of the band immediately starts listening for replies at 14,000 kc. tuning upwards in frequency. On the other hand, some choose a frequency of 14,400, listen on this frequency and then tune downwards. This has caused all the high power stations to congregate on the edges of the band, i.e., from 14,000—14,030 and from 14,370 to 14,400 kc. The idea of this is that stations looking for DX often come across those on the edges on the band first. Those using high power would be advised to go in for these frequencies, but with low power go to 14,300 or 14,100 where QRM will be much less.

The Short-wave Radio World

A Review of the Most Important Features of the World's Short-wave Literature

Reception with Short Aerials

THE University of Prague has evolved a new arrangement to increase the efficiency of short receiving aerials. Provision can be made either for adjusting the aerial circuit by means of a variable inductance L_1 in series with the coupling coil (partial resonance *P*) or for adjusting the secondary capacitance (partial resonance *S*). When the voltage produced at the grid of the first screen grid valve is represented by a vertical line of length E_2 for each pair of values ωL_1 and $1/\omega C_2$ (where ω = 6.28 times frequency and ωL and $1/\omega C_2$ are plotted in a horizontal system of co-ordinates), the points obtained form two mountain ridges, each one with a sharp bend at a nearly right angle near the highest points. The first ridge starts with a relatively low altitude near the point $1/\omega C_2$ = zero and $\omega L_1 = /\omega C_1$, and runs parallel to the $1/\omega C_2$ axis (or X-axis), but when it approaches the point *R* at which $1/\omega C_2 = \omega L_2$, it makes a sharp bend and runs for the rest of its course parallel to the ωL_1 (or Y-axis) towards larger and larger values of ωL_1. For larger values of $1/\omega C_2$, on the other hand, the second ridge runs also parallel to the ωL_1 axis, but from the opposite direction, near the point *R* for which $1/\omega C_2 = \omega L_2$ and $\omega L_1 = 1/\omega C_1$ (resonance) it turns and runs for the rest of its course parallel to the $1/\omega C_2$ axis toward large and larger values of $1/\omega C_2$. The two ridges are connected by a saddle in the centre of which lies the point *R* for which the antenna as well as the grid circuit are tuned to the incoming wave of angular velocity ω. In practice the aerial cir-

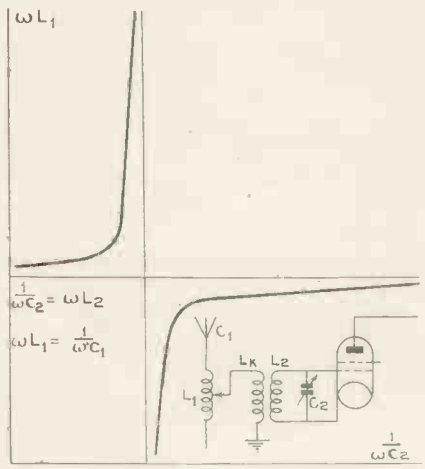


Fig. 1. Those interested in short-wave aerials will not experience difficulty with this novel arrangement.

cuit is left untuned, ωL_1 being much smaller than $1/\omega C_1$.

A perpendicular plane parallel to the $1/\omega C_2$ axis (and corresponding to partial resonance *S*) or parallel to the ωL_1 axis (partially resonance *P*) cuts one ridge at a time along a curve having the shape of an inverted *V*. The highest points of the ridges trace a hyperbola when projected upon the horizontal plane, the peaks lying not far from the point *R*.

While giving higher voltages at the grid of the first valve, this region has the disadvantage that tuning is not very sharp since a perpendicular plane parallel to $1/\omega C_2$ either cuts the saddle or runs nearly parallel to one of the ridges. Better tuning can be obtained as a rule for small values of ωL_1, that is without attempting to adjust the aerial circuit since perpendicular plane, which cuts the ridges along a curve representing the changes in $1/\omega C_2$ is then nearly at a right angle to the ridge. Tests with an antenna 12 m. long receiving a 470-m. wave ($\omega = 4 \times 10^6$) and a 249-m. wave ($\omega = 7.57 \times 10^6$) prove this point. (Capacitance of the antenna about 85 $\mu\mu$f.).

A different system of ridges is obtained for each incoming frequency. It may be shown that when using an aerial which can be tuned to the incoming wave, the larger values of ωL_1 and the correspondingly smaller values of the coupling factor $k^2 = M^2/L_1L_2$ increases the chances that two stations interfere in the receiver. The use of variable antenna circuits offers therefore practically no advantages.

Regeneration Control

A novel idea for regeneration is described in *Radiocraft*, its main advantage being that the screened-grid voltage remains constant. In a short-wave receiver using an electron-coupled detector, it is necessary under certain conditions to control regeneration at a point where the available voltage on the screen falls below that normally required for efficient detection. The idea illustrated is simple and worthy of the attention of the experimenter.

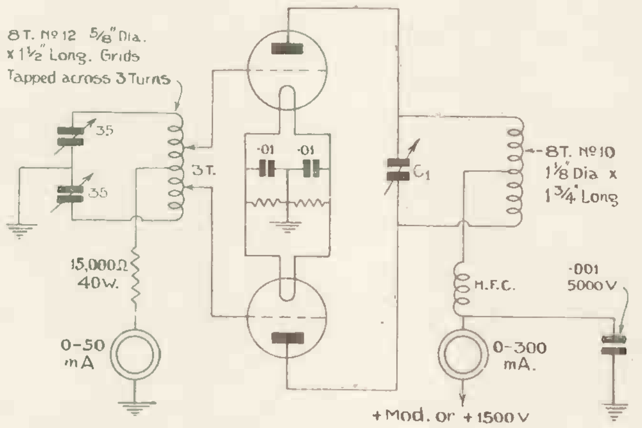


Fig. 3. A circuit of this type can be adapted to use any type of valve. Of course the anode voltage has to be re-adjusted, otherwise the circuit remains unchanged.

Between the cathode tap and earth is connected a potentiometer of between 2,000 and 5,000 ohms resistance, having the cathode connected to the variable point. In this way the screened-voltage can be set for optimum gain and regeneration controlled independently.

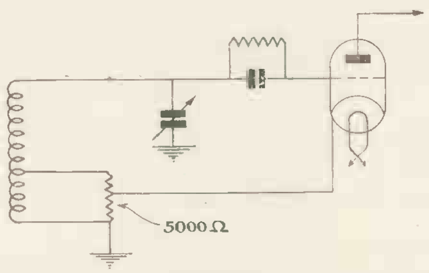


Fig. 2. Electron coupling is an arrangement that should be more widely used. This is a particularly good circuit.

A Stable U.H.F. Oscillator

Some interesting results have been obtained in using valves of the S.W. 501 type at relatively high power. These valves have the grid and anode leads coming out from the top of the bulb, resulting in construction ideal for high-frequency operation. Although rated at 65 watts a quarter kilowatt is obtainable with push-pull at ten metres. The circuit shows two of these valves used with the grids tapped only across part of the tuned grid circuit.

This allows the grid tuning circuit to become the frequency controlling circuit instead of just a grid excitation

A Ten-metre Transmitter

control. In such circumstances, the plate should be tuned to low "C" as in any neutralised amplifier. The grid circuit is fairly high "C" in order to gain stability. The grids are tapped across only enough turns to obtain oscillation, the results being sharp tuning of the grid and plate circuits.

The principal advantage of frequency control in the grid circuit of this push-pull oscillator is that aerial swinging effect does not directly act upon the frequency control circuit. Also power is lower in the grid circuit, so that double-spaced split stator condensers can be used without danger of flash-over up to 2,500 volts D.C. Frequency stability with wide change in anode voltage is very good when the grid leads are only across a small section of the grid coil. Stability is sufficient for direct modulation on ten metres. This is perhaps the best indication that can be given.

The circuit shown is suitable for use in diathermy oscillators for the grid excitation control prevent overheating of the grid leads and valve failure.

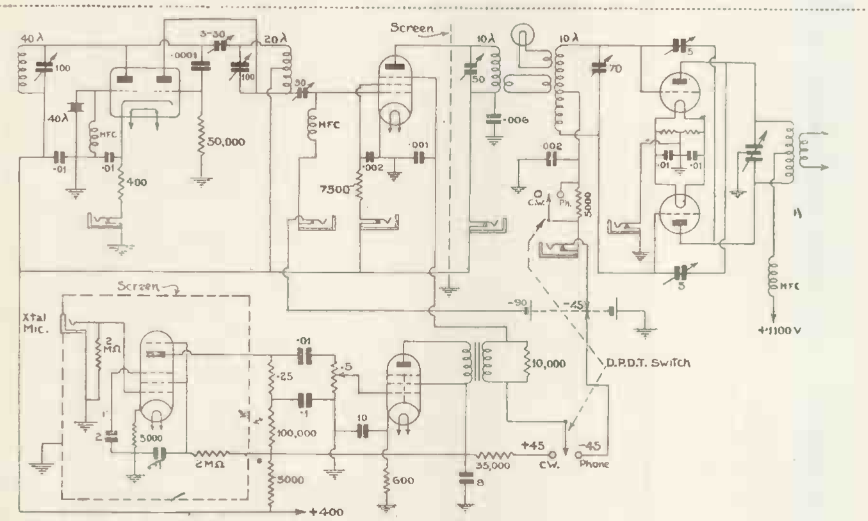


Fig. 4. The ten-metre band has proved its use this year. Here is a straightforward circuit that can be adapted for English valves.

Ten-metre Transmitter

This ten-metre transmitter, described in *Radio*, is suitable for 30-watts output on phone and 100 watts output on CW. The complete outfit, less power supply, was built on an 11 × 30 × ¾-in. baseboard. A 6A6 twin triode is used for crystal oscillator and doubler on 40 and 20 metres. Regeneration in the doubler section increases the available output while the control of excitation to the grid of the RK25 pentode is obtained by a 50-mmfd. midget condenser. Regeneration allows the operation of the 6A6 as a quadrupler to ten metres from a 40-metre crystal. No difference in the modulation can be noticed by monitor tests when operating the RK25 either as a straight buffer or as a doubler.

The modulator consists of a 6C6 pentode arranged to have a gain of about 100 times. If a crystal microphone is used the entire input circuit including plug and jack must be completely screened.

The 6C6 drives a type 41 modulator feeding into a 1-1 ratio output transformer. This provides sufficient gain if the input to the microphone is kept to a high level. On phone operation the carrier output is 30 watts with 1,000 volts on the RK18.

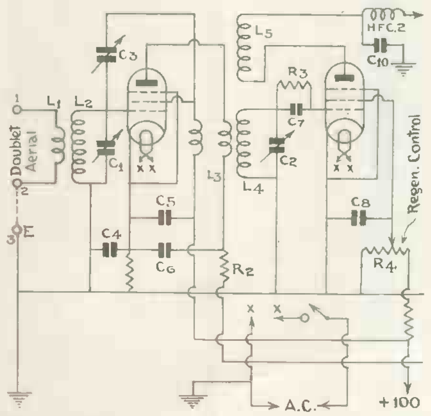


Fig. 5. This simple idea can be tried without going to any great expense. It is suitable for either battery or mains valves.

A New R.F. System

In *Short-wave Radio* there is a new receiver with a highly efficient tuned R.F. stage. It was reasoned that an inclusion of a capacitative reactance in a screened circuit would cause the same effect as one in the plate circuit, but would have the added advantage that its scope could be increased by deliberately providing a suitable screen-to-grid capacitance. This would obviate the necessity of employing critically-wound coils and enable a simple R.F. choke to be used as the capacitative load.

In practice the system was found to work satisfactorily. The choke RFC1 provides the capacitative load and has a value of 85 mh. The variable condenser C3 provides the desired amount of regenerative feed back to compensate for the regenerative effect produced by the resistive load in the anode circuit. Although this control is brought out to the front panel, it is not in the least critical and can generally be left at its maximum value of 50 mmfds., except on the ultra high-frequencies.

New Mervyn Lines

The Mervyn Sound & Vision Co., Ltd., have recently introduced several lines of interest to short-wave enthusiasts. One is a converter adaptor for the 13/55-metre wavebands as detailed in Mervyn's advertisement last month. A photograph of this appears in our advertisement pages. A full-scale open-vision dial with 100-1 slow motion tuning is provided. This instrument sells at the remarkably low figure of 42s.

Pre-selector Heptode Converter

This month's Mervyn release is a superhet converter with many technical features. It employs a triode heptode valve and its own L.T. transformer. For some months past this model has been efficiently receiving the 7.75-metre broadcast regularly, and amateurs should have no difficulty in receiving this transmission.

The triode heptode converter has been specially designed for receiving the broadcast type transmissions. Regular reception is obtained from America, Australia, Italy, etc., on the wavebands between 13 and 55 metres. With suitable coils, obtainable from the makers, reception can be extended to 100 metres allowing reception of the 30-line television broadcasts from Holland on 80 metres.

Our Dutch readers will be interested to know that Mervyn 30-line television apparatus is obtainable from radio dealers in Holland.

DIGESTS AND DATA

ABSTRACTS FROM AUTHORITATIVE CONTRIBUTIONS ON TELEVISION IN THE WORLD'S PRESS

SPECIALLY COMPILED FOR THIS JOURNAL

Graphical Harmonic Analysis. By J. A. Hutcheson. Electronics, Vol. 9, No. 1. Page 16.

A method is described of determining the harmonic output of amplifying systems. It is mentioned that in the past methods of graphical analysis have been used, which determined the second and third harmonics introduced by the amplifier tube, with good accuracy. It is now necessary for the engineer to know the amplitude of harmonics of a much higher order, and this method makes it possible to determine harmonics up to the eighth, using the data given in the paper, but it is also possible to extend the method to the determination of as many harmonics as necessary. Also this method is applicable to waves of the type where there are present sine components of odd harmonics and cosine components of even harmonics. This covers the field in which the dynamic operating characteristic of the device can be represented by a curved line.

A Critical Study of the Characteristics of Broadcast Antennas as Effected by Antenna Current Distribution. By G. H. Brown. Proc. Inst. Rad. Engineers, Vol. 24, No. 1, Page 48.

The action of broadcast antennas with various current distributions is examined in order to ascertain which are the most likely combinations to be useful. The vertical radiation characteristics, the radiation resistance, and the electric field intensity at the surface of the earth one mile from the antenna are determined in each case, and the relative merits with respect to fading suppression are considered. It is mentioned in the paper that for heights of the order of a half wavelength it is difficult to find anything more efficient than a straight vertical wire; some of the arrangements save a small amount in height, but do not improve on the straight wire in any other respect. An analysis of an antenna with decreased velocity and antennas spread in a horizontal plane show that both these types are definitely ruled out of the picture, and it is mentioned that the Franklin type antenna would be very useful if it were not for the great heights that are required.

1935 in Review. Electronics, Vol. 9, No. 1, Page 7.

This review actually deals with the advances in radio receivers, but one paragraph is devoted to the consideration of television progress. It is stated that an ambitious test of cathode-ray ultra high-frequency television will be carried out in New York during the coming year. For this purpose a new transmitter is being erected in the Empire State Building and receivers are being built and will be installed at different points in the metropolitan district. A statement is made in this paragraph to the effect that it will be extremely dangerous to say that electronic devices have completely eliminated mechanical systems of television.

Some Comments on Broadcast Antennas. By Ralph N. Harmon. Proc. Inst. Rad. Engineers, Vol. 24, No. 1. Page 36.

It is suggested in this paper that a constant phase and current antenna possesses more desirable characteristics than sinusoidal distribution.

It is shown that the maximum non-fading range is a function of the antenna height, frequency, and ground conductivity, and it is mentioned that it was recently shown that if the maximum non-fading range is desired, the height of the antenna should be nearly $0.54\ \lambda$. One aim of the paper is to show that: (a) The ground field strength of a self-radiating vertical radiator is proportional to the square root of the antenna height, if the amplitude and phase of the current is constant throughout the entire length.

(b) A constant amplitude current throughout the radiator is more effective than a sinusoidal distribution.

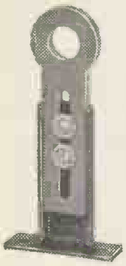
(c) The optimum antenna height for maximum non-fading range is greater than $\frac{5}{8}$ of a wavelength and is determined by (1) frequency, and (2) ground conductivity.

A system is suggested in which a high angle suppressor is combined with a vertical constant phase and current antenna. It is then shown that with this system the high angle lobe of radiation is cancelled and the non-fading range therefore increased.

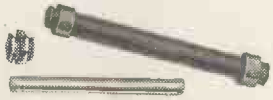
The Broadcast Antenna. By A. B. Chamberlain & W. B. Lodge. Proc. Inst. Rad. Engineers, Vol. 24, No. 1, Page 11.

In this paper actual field results that were obtained with tower radiators are given, data are included on efficiency, base voltage, base loss, design considerations, and cost. Conclusions are drawn showing that the conventional antenna supported by two towers is inferior to the single vertical radiator, or in special cases, a combination of vertical radiators in a directional array. The following conclusions are drawn and enumerated at the end of the paper. (a) Because of their physical configurations, and because tower radiators are built over an earth of finite conductivity, current distribution is not sinusoidal. Therefore these towers do not perform as would a single vertical wire over a perfect earth, but in some cases a very close approximation is obtained. (b) A vertical radiator employed in place of an older conventional type antenna will under average circumstances produce an increasing signal which will be equivalent to doubling the power of the transmitter. (c) A self-supporting radiator can be used effectively up to heights of at least $0.5\ \lambda$. (d) The vertical radiator is well adapted for use in directional antenna systems.

IT PAYS TO BUY THE BEST



ADJUSTABLE BRACKET.
A strong baseboard bracket for mounting components controlled by an extension rod. Has adjustable (2½" to 3½") slide of DL-9 H.F. insulation.
No. 1007. **Price 1/6.**



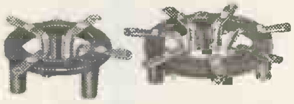
EXTENSION CONTROL OUTFIT.
Ample length adjustment is obtainable with the 4" non-warp precision-drawn insulating tube and 3" brass rod provided in this outfit. Complete with panel-bush and nut. No. 1008. **Price 1/3.**

BAR INSULATOR.
An ultra high frequency insulator for strain or spacer purposes, made from Frequentite. Slotted ends for feeders with 2" spacing.
No. 1017. **Price 4½d.** each.

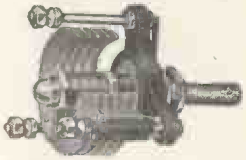
ULTRA SHORT-WAVE H.F. CHOKES.
These chokes are single layer space wound on DL-9 formers, and have an exceedingly low self-capacity. 2½-10 metres.
No. 1011. D.C. Resistance 1.3 ohms. **Price 1/3.**
No. 1021. D.C. Resistance 0.4 ohms. **Price 1/3.**

INSULATING PILLARS.
Invaluable for mounting components in ultra short-wave receivers. White DL-10 insulations 7/16" diameter. Long 6BA adjustable screw shank at top. N.P. Metal foot.
No. 1028. 2½" high **6d. each.**
No. 1029. 1½" high **4½d. each.**

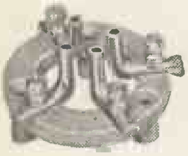
MIDGET INSULATOR.
Made from Frequentite for high frequency work, with N.P. metal parts. 1" overall height.
No. 1019. **Price 4½d.** each.



UNIVERSAL S.W. VALVEHOLDER.
A low loss holder for above or below baseboard use. The valve enters the contacts from either side. There is no measurable increase of self-capacity to that already in the valve base. DL.9. H.F. dielectric, one-piece noiseless contacts.
No. 1015. 4-pin, **1/3.** No. 1016. 5-pin, **1/5.**
No. 1024. 7-pin, **1/8.**

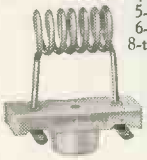


EDDYSTONE MICRODENSER
(No. 900).
For Ultra Short Waves from 5-10 metres D.L.9 insulation. Low series resistance at high frequencies. Noiseless operation.
15 m.mfd. **3/9.** 40 m.mfd. **4/3.** 100 m.mfd. **5/-.**

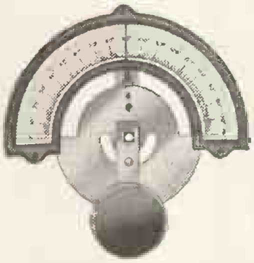


LOW LOSS VALVE HOLDER
Suitable for all high frequency requirements. Frequentite base, one piece metal sockets, lowest self capacity.
No. 949. 4 pin **1/5**
No. 950. 5 pin **1/8**

FLEXIBLE COUPLER
Free from back-lash but very flexible, this coupler banishes alignment troubles. DL-9 H.F. insulation. For ¼" spindles.
No. 1009. Price **1/6**



ULTRA SHORT-WAVE COILS.
The coils are wound with 14g. copper wire, heavily silver plated. The mean diameter is ½". A Frequentite base is used for mounting purposes. No. 1020. 3-turns, **1/6.**
4-turns, **1/6.**
5-turns, **1/7.**
6-turns, **1/8.**
8-turns, **1/10.**



WIDE VISION VERNIER DIAL.
A precision dial for all purposes where accuracy and smoothness of tuning are required. 22 : 1 ratio entirely free from back-lash. Black bakelite escutcheon. 0-180° dial with travelling pointer.
No. 973. **Price 10/6.**

EDDYSTONE SHORT WAVE COMPONENTS

STRATTON & CO., LTD. Bromsgrove Street, BIRMINGHAM. LONDON Service Depot : Webb's Radio Stores, 14 Soho Street, Oxford Street, W.1

SATOR

POTENTIOMETERS

fully variable **3/6** (switch 1/6 extra), semi-variable **2/-**

RESISTANCES

fixed - - - from **5d.**

CONDENSERS

fixed - - - from **6d.**

ARE MORE THAN JUST

WIRELESS COMPONENTS

THEY ARE SCIENTIFIC INSTRUMENTS

TOLERANCES ARE EXTREMELY NARROW AND VALUES REMAIN CONSTANT DURING LIFE

SATOR COMPONENTS WILL CURE ALL YOUR TROUBLES

SUPPLIES FROM—

ORION LAMPS LTD., 72, Oxford Street, W.1

MUSEUM 5053 HEAD FACTORY IN AUSTRIA

Heard on the Short Waves

BATTERY users will probably be amused at the efforts of an American manufacturer who has just introduced a multi-valve all-wave radio receiver, powered by means of wet cells which are in turn kept fully charged by means of a windmill charger. It has so been arranged that the windmill charger keeps the batteries in perfect condition with only a light breeze for about two hours a day. This is based on the assumption that the set will be used for about ten hours a day.

Several new short-wave stations are shortly to come on the air. Syria, and Lybia are shortly to have their own stations for keeping in touch with their Nationals in America. The site for the new station will probably be at Homs.

G5YW tells me that he is operating on 56-Mc. from 10.45 p.m. to 11 p.m. every day except Saturdays and Sundays. On Sundays the 56-Mc. tests will be from 3 p.m. to 4 p.m. Reports from any station or BRS listener will be appreciated.

The transmitter consists of a modulated oscillator in push-pull and a driven P.A. in push-pull. Power is about 10 watts on the P.A. and 50 watts on the M.O.

G5UK has now returned from abroad and has been on the air on 1.7 Mc. Other Southend amateurs are still very active and include G2LC, G2SO, G6IF, and G5VQ. All these stations and 6CT have entered for B.E.R.U.

W9DXX

I have arranged schedules with W9DXX in Chicago each Wednesday and Friday at 14.00 G.M.T. The frequencies used by this station will be 14,286 Kc. A second schedule has been arranged for Friday nights at 01.00 G.M.T., the frequency being 7160 kc. If any reader should hear these signals I should be glad of a report in case I do not make contact myself.

I have been rather deserting the 160-metre band just recently in favour of 80, for the Canadian phone stations are coming over at an extraordinary strength. It is surprising how few amateurs have coils for this band, which, after all, is much better for DX than 160, and does not suffer from QRM like 40. It really is worth a visit.

Those who complain about the restrictions of the Post Office and other small troubles should be glad that they do not live in Bulgaria. A friend of mine out there tells me that the Bulgarian Government, having taken over control of radio, have forbidden the use of amateur stations and, in addition, confiscated all the apparatus.

The 362 Valve Co. sent me one of their new RFP-15's. This is a small transmitting pentode requiring an anode voltage of 500 and a screened voltage of 400. From the preliminary tests it looks as though it is going to be a good valve. The R.F. output is quite high considering that the drive is only 6 or 7 milliamps through 10 volts. I understand the price will be about 30s., which is most attractive.

Those taking up transmission for the first time should make a note about this valve, for it can be used for suppressor grid modulation and is ideal for a small transmitter.

West London Radio Society.

Sixty-one members were present at the inaugural meeting of the West London Radio Society held in the Ealing Town Hall on Wednesday, January 15. The proceedings were opened by a demonstration of an all-wave superhet loaned by Messrs. Lissen, Ltd. This was followed by the election of Mr. Douglas Walters, G5CV, as President, and other officers.

The presidential address was made by G5CV over the air from Chiswick and was received at good strength. Those interested in short waves should communicate with the Honorary Secretary, H. A. Williamson, 22 Cambourne Avenue, West Ealing, W.13.

Bennett Short-wave Converter.

A NEW short-wave converter suitable for either battery or mains operation is now available from the Bennett Television Co., Ltd., Redhill, Surrey. This converter can be used with any standard broadcast receiver to receive short-wave stations, without making any alterations whatsoever to the existing receiver.

It is fitted with a slow-motion drive and tunes between 13 and 52 metres, so covering all commercial wavebands. The design of this unit is particularly good and is one of the first we have tried to be supplied complete in a metal case. No additional valves or components are required and the price of 30s. covers everything. For those who wish to gain experience in short-wave listening we can thoroughly recommend this inexpensive short-wave converter.

The British Institute of Radio Communication.

We have received the following information about the formation of a new radio society from Eric Adcock, G2DV. We feel sure that serious experimenters will appreciate the aims of this new society.

This new society is to further the aims of technically-minded amateur transmitters. It will not be open to any newcomer interested in short-wave radio, and to this end, once initial formalities have been completed, members will be required to submit a short thesis on the particular branch of research in which they are interested.

It has been arranged to hold the first meeting in Birmingham on Sunday, March 29, 1936, at 1.30 p.m. The formation of the Institute is supported by such well-known amateurs as G5BY, G5NI, G5BJ, G6XQ and G2DV. Those desirous of attending are requested to write to G2DV for the place of meeting, enclosing an addressed envelope. Limited transport is available from London and other areas.

This journal will be the official organ for the new society.

Salisbury Short-wave Club

Mr. C. A. Harley, proprietor of Southern Radio and Electrical Supplies, 85 Fisherton Street, Salisbury, has just inaugurated a local short-wave club, of which he is Secretary. The first meeting took place on January 27 at 1 Orchard Road, and was well attended.

It was decided that a subscription of 3s. 6d. per annum be made for junior members up to the age of 18 years, and 5s. per annum for full membership. Meetings will take place once a fortnight at a place to be announced later.

All interested will be most welcome, and are invited to get in touch with Mr. C. A. Harley at his trade address given above.

Surrey Radio Contact Club

The last meeting of the Surrey Radio Contact Club was held at the Railway Bell Hotel, West Croydon. Between 20 and 30 members listened to a particularly interesting lecture by 5GQ on high efficiency transmitters. Points raised included the design of crystal, amplifying and doubling circuits, impedance matching and general construction. The new Mullard 35-watt R.F. pentode was also shown in a 10-metre circuit, while a neat version of the Jones exciter unit created much interest. G5AN said a few words about the Society's Club Room and transmitter to be erected on Caterham Hill. G5ZJ was in the chair.

The next meeting is on March 10 which will be the annual general meeting, preceded by an informal supper. It is hoped that after the proceedings of the evening have been discussed time will be found for another interesting lecture. Readers in the West Croydon district are invited to attend.

Calls Heard

B.R.S. 1784, Martin G. Bourke, Jersey C.I. (*1.7-Mc. Phone.*)

G6GO, 5MM, 2OV, 5ZJ, 6KU, 5OC, 2AO, 5CJ, 5JO, 6KV, EI6F.

(*1.7-Mc. C.W.*)

G2UJ, 5JO, 5OD, 6UD, F8RJ, FA8BG, HB9T.

(*3.5-Mc. Phone.*)

W1BES, 1FO, W2JP, 2DGD, W3DQ, 3EOZ, 3EFS, 3CWG, W8BWH, VE1EI.

(*7-Mc. C.W.*)

FA8BG, U3AS, U4OG, LY1HB, VE1MP, 1IU, 1ET, 1EP, VK3KR, 2RF, 2PV, 3ZW, ZB1H.

(*14-Mc. C.W.*)

ZE1JE, VQ4CRO, YT7MT, VO1C, ZB1H, 1E, U1BL, 1CN, LU2DF, ZL3JA, 3GN, 3AB, 3BJ, 4BO.

(*28-Mc. Phone.*)

W2BCR, 3AUG, 3TC, 3ZX, 4EF, W9BHT.

B.R.S. 1847, J. A. Jaggers, Guildford, Surrey. (*28-Mc. Phone.*)

VE2EE, W1NW, 1ZE, 1DBE 1HQN, 1DQD, 2CBO, 2IXY, 2FWK, 2AIE, 2AOG, 2BZR, 3ZX, 3AUC, 5BDV, 5DUQ, 5EYZ, 6AC, 6PN, 8AGU, 9BAE, 9OWM.

28-*Mc. Phone.*)

44 W1, 22 W2, 21 W3 plus W4BDP, 4DCK, 4AH, 4MR, 4CA, 5DNE, 5AFX, 5AGP, 5AXY, 5BEE, W6PW, 6DIO, 6CRI, 6FQY, 6WB, 6JNR, 6FZQ, 6DLV, 6BAM, 6JJV, 6JN, 6GEQ, 7DFI, 26 W8's, 12 W9's, K4AOP, CP1AC, ZS2A, SX3A, CT3AB, CN8NJ, 8MQ, AO4B, VO1H, 1N, FA8IH, 8GB, CM2HC, 2FA, LU9AX, HJ3AJH, VS6AF, 6BD, SU1JT, OH5NG, 7NB, 7ND, SM6WL, U6PZ K6FJF, VE1DV, 1EA, 2FR, 3AQ, 3ER, 3KF, 3TD, 4IG, 4UY.

(*B.E.R.U. Calls.*)

VP7NB, ZB1E, VO1C, HO1H, VO4Y, VQ4SNB, 4CRO, VS6AH, VU2CQ, 2EP, 2EQ, ZE1JF, 1JJ, 1JO, ZS5V, ZT6Z, ZU6M, ZS1AL, 6T.

B.R.S. 2042, P. A. Tremaine, Witham, Essex. (*7-Mc. C.W.*)

W1IDW, 1EPH, 2BIN, 2CSE, 2BJ, 8HIU, YR5FA, EA5ESL.

(*14-Mc. C.W.*)

ZS1AH, 4J, 2BIH, 2UIT, 2UIB, W1BQS, W3AWN, VE1FW, 2HG, 2DC, 3IJ, 1GY, 1ET, 1AW, OH3OJ, VK2YM, 7KV, 7JB, 3RK, 2NO, UIAN

2AHW, J. H. Worrall, Barons Court, W.6. (*7-Mc. Phore.*)

VP3MR, 6YB, 6FO, 6MY, 2CD, HI5X, 7G.

(*7-Mc. C.W.*)

ZS1B, PK1MO, KA1ER, 1HR, VS6AZ, VU2CQ, 2DB, OA4AI, K5AM, 5AI, 5AN, 5AA, TF3Z, CM2AI, 2GR, ES3Q, SU5NK, 1SG, 1RO, 1TM, K4BRN, W5BUZ, 5NW, PY3AW, ZL4PK, 3KG, 3DL, 2GN, 3AB, VK2ZT, 2KS, 2AN, 2QP, 2CX, 3UH, 2PX, 2PE, 2OC, 3GP, 3ZW, 3ZB, 2PB, 3KY, 3WW, 3MN.

2BMC, J. E. Church, Linthwaite, Huddersfield. (*7-Mc. Phone.*)

ON4AP, 4BR, G2NO, 2YX, 2AO, 2KT, 5QN, 5IS, 5JW, 5KF, 5JO, 5XC, 5TP, 5KT, 5JM, 5GL, 5ZQ, 5KG, 6WU, 6TY, 6PY, 6UD, VP3MR.

(*14-Mc. Phone.*)

VK2NO, F8ZE, EA3ER, LA1G.

(*3.5-Mc. Phone.*)

G5KG, 5YA, HB9T.

W9DXX, Mrs. Alice R. Bourke, Chicago, Illinois. (*7-Mc. C.W.*)

CM7AB, D4CSA, HH5PA, K5AI, NY1AA, VE2JO, 3AER, 3AH, XE2DQ, 3AC.

(*14-Mc. C.W.*)

CM2AX, 2DO, 6DW, 8AB, K4BU, K5AF, LU4BTK, VE1GE, 1DQ, VE2AQ, 2FI, 2HS, 2IT, 2JK, 2JX, 2LL, 2LR, 3AGW, 3UF, VE4GW, 4HU, 4OX, 4QZ, 4TO, VP7NB, ZS2A.

(*14-Mc. Phone.*)

HI5X, HI7G, VP6YD, YN1OP.

VK3ERS, Edgar R. Sebrire, Victoria, Australia. (*14-Mc. C.W.*)

EA7EO, FB8AT, G2DK, 2YL, HB9AT, KA1AN, OK2AK, 2OP, 3VA, VS6AF, VU2AI, 2AU, 2CQ, W4IB, 6JJA, X1AM, ZE1JN, ZT6AV, 6X.

(*14-Mc. Phone.*)

ON4PA, SM5WK, ZE1JR.

B.R.S. 1289, Bradford, Yorkshire. (*3.5-Mc. Phone.*)

G5GO, PAOISD, PAOVD, PAODCM, PAOPM, PAOPE, PAOPN, PAOSD.

G2UJ, W. H. Allen, Tunbridge Wells, Kent. (*1.7-Mc. C.W.*)

W1BMV, 1BB, 2UK, 1GBD, 1BNW, 8UU, 7OR, 7GBD, 7OR.

West Wirral Radio Society

An amateur transmitting and short-wave society is to be formed in the Hoylake, West Kirby, Grange and Heswall districts. Members of the Radio Society of Great Britain will be admitted automatically, while certain qualifications will be required of other applicants. Those interested should write to the Hon. Secretary, B. O'Brien, Caldy, Irby Road, Heswall, Cheshire.

W. Andrew Bryce & Co. have removed their entire works previously at Woodfield Works, Bury, Lancs., also the London office at 3/4 Ashland Place, Baker Street, W.1, to premises at North Road, Burnt Oak, Edgware, Middlesex, and this is the only address to which correspondence and goods should be addressed.

Special departments have been planned for dealing independently with coil winding, mains transformers and chokes, and condensers.

50 Short-wave Stations for March

Supplied by 2 BZN.

M.		
13.39	W8XK	Pittsburgh, 12.00-14.00.
15.93	PLE	Bandoeng, Tues., Thurs., Sat., 15.00-15.30.
16.89	W2XE	Wayne, New Jersey, 16.00-18.00.
16.87	W3XAL	Boundbrook, N.J., 14.00-22.00.
19.56	W2XAD	Schenectady, N.Y., 10.00-20.00, Sat. to 22.00.
19.64	W2XE	Wayne, N.J., 16.00-23.00.
19.72	W8XK	Pittsburgh, 14.00-00.00.
20.55	JVH	Nasaki, Tues., Friday, 19.00-20.00.
24.52	TFJ	Reykjavik, Sun., 18.40-19.00.
25.27	W8XK	Pittsburgh, 00.00-05.00.
25.4	W2XE	Wayne, N.J., 23.00-01.00.
25.45	W1XAL	Boston, 23.00-00.00.
25.6	CJRX	Winnipeg, 00.00-05.00, Sat. to 06.00.
27.93	JVM	Tokio, Tues., Fri., 21.00-22.00.
29.24	PMN	Bandoeng, Sun., 12.00-15.00.
31.28	VK2ME	Sydney, Sun., 06.00-08.00, 10.00-16.00.
31.32	VK3LR	Lyndhurst, 08.15-12.30 Sun., 03.00-12.30.
31.32	W3XAU	Philadelphia, 17.00-01.00.
31.35	W1XK	Millis, Mass., 11.00-05.00.
31.36	VUB	Bombay, Sun., 17.30-18.30. Thurs. and Sat., 16.30-17.30.
31.48	W2XAF	Schenectady, N.Y., 21.00-05.00.
31.56	PRF5	Rio de Janeiro, 22.30-23.15.
31.8	COCH	Havana, 16.00-17.00, 21.00-23.00, 01.00-02.00.
42.37	VP3MR	Georgetown, irregular.
46.0	YV6RV	Valencia, Ven., 17.00-18.00, 23.00-03.00.
47.05	YV4RC	Caracas Ven., 21.30-03.00.
47.5	HIZ	Santo Domingo, 21.40-22.40.
48.78	CJRO	Winnipeg, 00.00-05.00, Sat. to 06.00.
48.86	W8XK	Pittsburgh, 02.00-06.00.
48.92	COCD	Havana, 23.00-05.00.
49.18	W9XF	Chicago, Sun., Tues., Thurs., 02.00-07.00. Mon-Wed., Sat., 06.00-07.00.
49.18	VE9HX	Halifax, N.S., 22.00-22.00-04.00.
49.18	W8XAL	Boundbrook, N.J., Mon., Wed., Sat., 23.00-06.00.
49.26	VE9GW	Bowmanville, 22.30-04.00.
49.37	VQ7LO	Nairobi, Sun., 16.00-19.00, Mon. to Fri., 10.45-11.15, 16.30-19.30., Tues. and Thurs., 13.30-14.30, Sat., 16.00-20.00.
49.33	W9XAA	Chicago, 16.00-02.00.
49.50	W3XAL	Philadelphia, 01.00-04.00.
49.50	W8XAL	Cincinnatti, 05.00-06.45, 11.50-04.50, Sun., 13.00-01.00, and 04.00-07.00.
49.67	PRA8	Penambuco, 22.00-00.30.
49.67	W1XAZ	Boston, Mass., 00.15-02.15.
49.75	VE9CA	Calgary, Thurs., 15.00-08.00, Sun., 18.00-06.00.
49.75	W4XB	Miami, 22.30-04.00.
49.75	HP5B	Panama City, 17.00-18.00, 01.00-03.00.
49.92	COCO	Havana, 21.00-23.00, 01.00-03.00.
49.95	HJ3ABH	Bogota, irregular.
50.00	XEBT	Mexico City, 00.00-09.00.
50.16	HIX	Santa Domingo, daily, from 12.00.
50.60	HJ4ABE	Medellin, 16.00-17.00, 23.00-03.00.
51.28	YV5RMO	Maracaibo, 22.00-02.00.
51.50	TIGPH	San-Jose, 00.00-04.00. 04.00.
51.80	YV2RC	Caracas, 15.30-17.30, 23.00-03.00.

These short-wave stations all radiate programmes of entertainment and can be received on almost any efficient receiver. Actually all of the stations listed have been heard during the first few days of this year by many of our readers.

Our Policy
"The Development of Television."

When to Listen for Short-wave Stations during MARCH

By C. J. Greenaway—G2LC.

This Listening Chart completes a year of monthly forecasts. As further lists would only be a repetition, no useful purpose would be served by continuing the series. Should, however any further information be required it will be given upon request.

G.M.T.	3.5 mc.	7 mc.	14 mc.
0100		EA8 ; CM ; CN ; W2, 3, 4	
0600	W1, 2, 3, 8, 9	K4 ; TI ; VK ; W2, 3, 4; ZL	
0700	W2, 8	CM ; CN ; W1, 3, 4 ; VK ; ZL	
0800		K5 ; VK ; W1, 3, 4, 5 ; ZL	
0900		VK ; W4 ; ZL	SU ; VK ; ZL
1200			W2, 8
1300			W2, 3, 8
1400			CT3 ; W3, 8, 9
1500			W3, 8, 9
1600			W2, 3, 8, 9
1700			W2, 3, 8, 9
1800			CT3 ; FA8 ; VO ; VQ4 ; W1, 2, 3, 8, 9 ; ZE1 ; ZT ; ZU
1900		CN ; W9	CN ; FA8 ; VQ4 ; PY ; W1, 2, 3, 8, 9
2000		W1	PY ; VE1, 2, 3, 4 ; VP6 ; W1, 2, 3, 4, 8, 9
2100		W1	K4, 5 ; LU ; PY ; VE1, 2, 3, 4 ; W1, 2, 3, 4, 8, 9
2200		CM ; KA ; W1, 2, 3, 4	CE ; CX ; K4 ; LU ; VE1, 2, 3, 4 ; VP6 ; W1, 2, 3, 4, 6, 8, 9
2300		CM ; FA8 ; FF8 ; K4 ; VE1, 2 ; W1, 2, 3, 4 ; YI	HC ; W1, 2, 3, 9
2400		CM ; VE1 ; W1, 2, 3, 4, 8	

"Dr. Zworykin on the Electron Multiplier."

(*Continued from page* 154.)

stances of low work function, and the most satisfactory material was found to be oxidised silver, beryllium or zirconium, with a caesium surface layer. For these surfaces a secondary emission of 8 to 10 secondaries per primary has been reached, at a velocity of 400 to 600 volts (The lecturer here showed curves of secondary emission from silver-oxide cathodes.)

As will be seen from the curves the secondary emission increases with the increase of voltage, until the peak is reached about 500-600 volts, after which it begins to decrease.

For removing the secondary electrons and focusing on to the next target, either electrostatic or magnetic fields can be used. (The electron multiplier demonstrated by the lecturer at the conclusion of the proceedings was one in which the stream was magnetically focused, and it was shown that by altering the position of the field the number of electrons arriving at the target could be controlled, and with it the degree of amplification of the signal.)

Multiplying tubes of this type can be made to produce very high gains, as the number of stages increase: for example, a magnetically focused multiplier can be made with twelve stages, at an overall gain of several million.

The principal advantage of the electron multiplier over the multiplication obtainable with ordinary valve stages is in the high signal-to-noise ratio. In the ordinary thermionic amplifier, the signal-to-noise ratio is governed by the thermal noise from the coupling impedance between the valves, and in the photo-cell. In the multiplier the absence of such couplings reduces the noise, which is then only due to the fluctuation of the electrons passing up the tube.

The results of experiments show that a gain in signal-to-noise ratio of 60 to 100 times is obtainable with the multiplier as compared with a thermionic amplifier.

Fig. 3 shows the connections of a multi-stage magnifier. The light is focused on to the electrode 1, and the electrons are successively reflected from the plates 1A, 2, 2A, etc. The field plates 1A, 2, are connected internally, and these potentials are obtained from internal resistances in a similar manner to those of Fig. 1.

A tube of this type, having an output of as much as several amperes per lumen, can be designed, and is not much larger than an ordinary receiving valve. The amplifiers are very stable, and are unaffected by external interference. The amplifying action of the multiplier can be used for generating of oscillations by feed-back of energy or by the use of the negative resistance characteristics of the device. In fact, the secondary emission multiplier will become a serious rival to the thermionic amplifier in many of the fields which the latter has occupied for so long.

At the conclusion of the lecture, Dr. Zworykin demonstrated the use of the electronic multiplier in amplifying a signal from a pick-up to full loudspeaker strength. The absence of background noise on removal of the signal was marked, no hum being audible from the loudspeaker.

Bideford and District Short-wave Society.

Readers interested in short-wave radio in the North Devon area are invited to get in touch with Mr. E. K. Jenson, Secretary of the Bideford and District Short-wave Society, 5 Furzebeam Terrace, East-the-Water, Bideford.

"Marconi-E.M.I. Television System."

(*Continued from page* 136.)

The second auxiliary rectifier unit provides negative grid bias to the fifth stage amplifier, and variable negative grid bias for testing the adjustment of the sixth stage amplifier.

Control Desk and Aerial System

On the control desk are mounted the various switches, regulators, indicating instruments, alarms and signal lamps for controlling the power supply generators, air compressors and water circulating pumps. All are interlocked so that starting the complete equipment is performed in the correct sequence.

The aerial system is designed to give a circular polar diagram of radiation with maximum radiation in a horizontal plane. The system consists essentially of a number of aerial units suspended round the periphery of an octagon. Each aerial unit consists of a number of half-wave aerials so disposed that the resulting radiating current is uniform along the whole length. Behind each aerial are arranged reflector units, the actual distance between the aerial and reflector depending upon the wavelength used. The reflector units screen the tower from the high frequency field and prevent loss of energy or distortion of the polar diagram of radiation from the circular form.

The aerial and reflector units are supported from the top of a tower some 200 to 300 feet (60-90 metres) in height. The aerial is connected to the transmitter by a concentric copper tube feeder, junction boxes being suitably disposed between the aerial and the feeder to ensure the correct phase relationship between the currents in each aerial unit.

The tower normally provided for supporting a television aerial is designed specially to form, with the aerial system, a structure symmetrical in the horizontal plane. For this reason the upper portion of the tower is a column with parallel sides, the number of sides corresponding to the number of earial units. On the same mast a similar aerial system for use in conjunction with a "sound" transmitter can be accommodated thereby saving the cost and maintenance of two towers.

"Transmission Line Loss Calculation"

(*Continued from page* 176).

treatment would indicate. This is due to the addition of the dielectric loss of the insulation to the copper loss and skin effect.

The characteristic impedance of a co-axial transmission line is 138 $\log_{10} r_1/r_2$ ohms.

Where r_1 is the inner radius of the outer conductor, and r_2 is the outer radius of the inner conductor.

For the co-axial line measured r_1 = .15 in., and r_2 =.0404 in., giving a theoretical value 78.7 ohms for the characteristic impedance. The measured value is slightly less. This can be explained by the fact that the inner conductor of No. 12 wire is slightly oversized, and the capacity is increased partly by the dielectric constant of the Isolantite beads. The velocity of propagation is 15 per cent. lower than for free space.

In the twisted pair transmission line the velocity is reduced by 35 to 40 per cent. from the value for free space due to the increased dielectric constant.

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