ELECTRONICS AND TELEVISION

& SHORT-WAVE WORLD

APRIL, 1940

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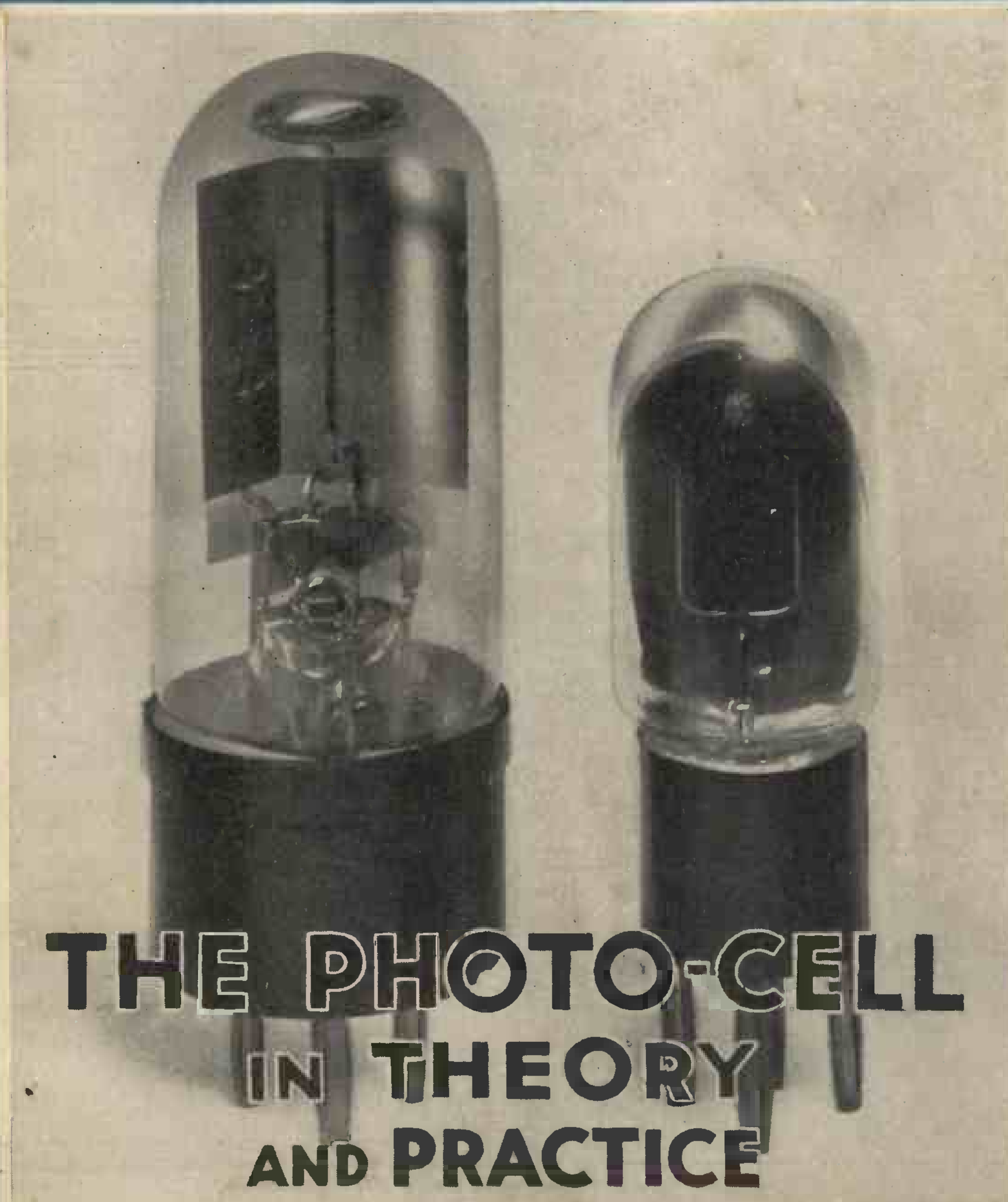

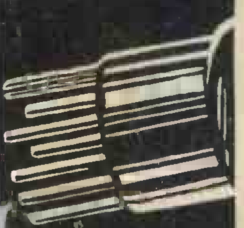

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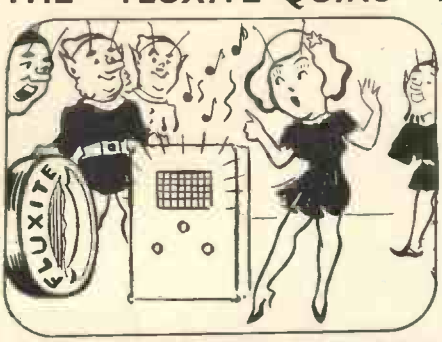

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News and Views

It is no secret, of course, that both the Allies and Germany have considered the possibilities of television in war and it was known that during the past two years many developments in Germany were purposely withheld from publication on account of their possible use in this respect. Naturally all information regarding the subject is taboo at the present time but it is interesting to note some recent tests in U.S.A., in which a television transmission was made from an aeroplane flying over New York and the picture was received near Schenectady, a distance of 129 miles. It is stated that the picture was so distinct that work being done on buildings in New York could be seen, and the observers were also able to distinguish waves in the harbour.

The transmitter in the plane was a new light R.C.A. model and its signal was picked up and retransmitted by the N.B.C. transmitter on the Empire State Building. The performance is regarded as one of great scientific importance and possibly forecasting a new era in warfare. The commander of the Schenectady Army Depot, termed the performance as " extremely significant " from a military viewpoint. " It is likely to revolutionise artillery fire," he said.

The Television Service

An interesting matter for reflection on the possibility of a limited television service being instituted during the war is contained in a statement regarding the personnel of the Hollywood television station operated by the Don Lee Broadcasting System.

This station is on the air approximately 10½ hours a week and has a permanent production staff of seven technical men and two production men on full time. There are also three part time assistant production men.

A camera is used to film outside broadcasts, and to date viewers have seen two fires, a hurricane, an aquaplane race, a Tournament of Roses parade, and many other items of local interest.

The above staff, of course, is exclusive of artistes but as a considerable amount of film is employed, we assume that expense in this connection is reasonably limited. Cost and the limited number of viewers has been one of the most important factors in the decision recently made not to reintroduce the London service at the present time and our contention is that a solution in this respect could be found with immense benefit to the industry.

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A Secondary-emission Amplifier Valve with Screen-grid Characteristics

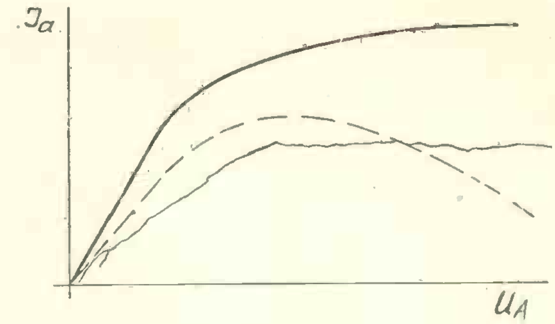


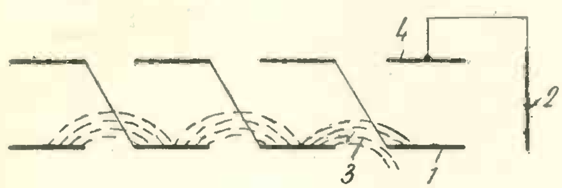
Fig. 1. Comparative anode voltage output characteristic curves.

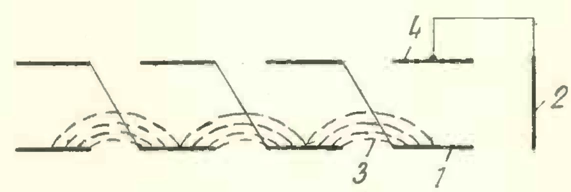
IN the case of ordinary thermionic valves it is recognised that the anode current should preferably be unaffected by changes in anode voltage, and the screen grid has been introduced to ensure that the anode current shall be practically independent of the anode voltage over the operating range, or, in other words, that the valve shall have a high A.C. resistance.

In the case of secondary-emission amplifiers, however, the use of screen grids would involve difficulties both in construction and operation: hence, in order to obtain the desired type of characteristic it is desirable to adopt some other expedient. In Fig. 1 the broken line curve shows the type of anode voltage output current characteristic which is frequently found in multipliers. It will be seen that the output current decreases when the anode voltage exceeds a particular value. This is undesirable and the full line curve shows the preferred type of characteristic, which, it will be observed, is generally of the screen-grid valve type.

The latter type of characteristic may nevertheless be obtained by so arranging the various electrodes and operating conditions that an increase of anode voltage involves an increase of the multiplication factor at least at one of the secondary emitting or "target" electrodes, since this will have the effect of compensating for the reduction of output current which would otherwise take place beyond the maximum point on the broken line characteristic. The compensating action will follow electron-optical laws, the relations being so chosen that in the mean condition there is a certain derangement of the electron path; in other words, a certain amount of "detuning," which is corrected more and more as the anode voltage rises, resulting in an increase of anode current.

One way in which this electron optical compensation may be provided is by using the anode current to generate a magnetic field which helps to direct the electron stream through the amplifier. We may then arrange that for a given anode voltage the final target electrode is struck by only a part of the electron stream, the remainder shooting past in front of the target on account of its relatively insufficient potential. As the anode voltage rises, the anode current would reach a maximum and then fall off, were it not for the associated magnetic field; but since the latter can be arranged so that as the anode current tends to decrease the field tends to direct a greater fraction of the electron stream on to the final target electrode, the anode current is in fact prevented from falling, and the desired compensation is produced.





Figs. 2 and 3. Detuned and tuned conditions respectively in secondary-emission valve.

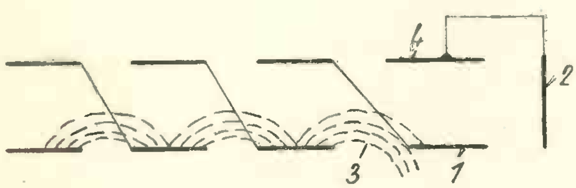


Fig. 4 (left). Example of partial detuning.

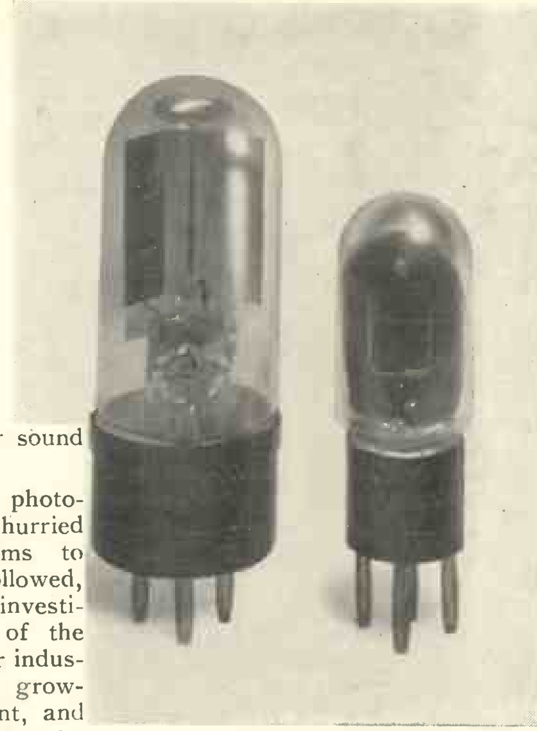
If the conditions are correctly satisfied it is possible to obtain an anode-current/anode-voltage characteristic of screen-grid type, as shown in Fig. 1.

Figs. 2 and 3 show respectively the "detuned" and "tuned" conditions in a secondary emission valve of the type where the emitting, or target, electrodes are all in one plane and have opposite them a number of field plates, which together with a magnetic field (not illustrated) direct the electron stream along the correct path. In these diagrams, 1 represents the final target electrode, 2 is the anode, 3 indicates the electron stream, and 4 the final field electrode. Alternatively, if the anode is arranged in a suitable space relation to the other electrodes, increase of anode voltage will alter the path of the electron stream, so as to increase the incidence on the final target and thus to maintain the current level.

In Fig. 4 is illustrated a further modification, in which the required partial "detuning" is obtained by placing the final target electrode at a distance from the preceding target greater than the separation between earlier stages. As the anode voltage rises the current can be maintained by the means already described.

Some THEORETICAL and PRACTICAL ASPECTS OF PHOTO-ELECTRIC CELLS

By the Technical Staff of Vacuum Science Products, Ltd.



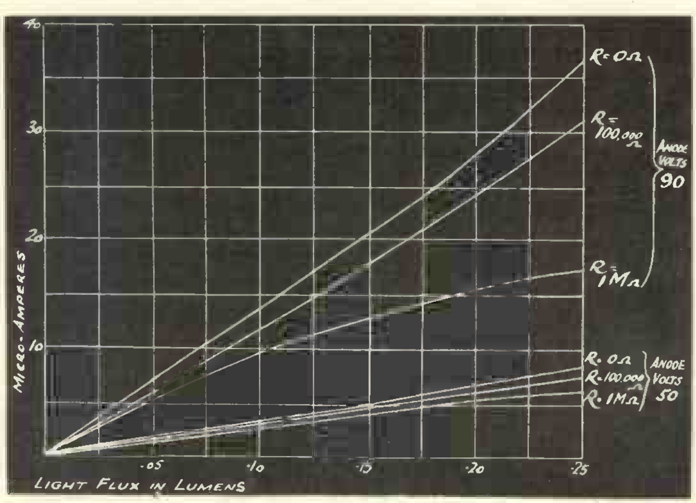
Typical Vacuum Science Products Photo-cells.

THE phenomena of Photo-Electricity have been known to scientists for very many years. In fact, as far back as the 80's of the last century, the emission of charged particles from metallic surfaces under the influence of ultra-violet light had been observed, but the full theoretical implications of these effects only became apparent when the general relationship between electricity and radiation were explained by means of the Quantum Theory. Prior to about 1925, the photo-electric cell was merely a delicate scientific instrument, used by investigators for complex physical measurements. It only possessed a limited sensitivity to blue or ultra-violet light, and was somewhat erratic and unreliable in its behaviour.

During the middle 20's, however, the advent of talking films accelerated photo-cell development, and by 1928, the modern caesium cell had been universally adopted. It was far more sensitive to normal light sources than the earlier potassium cells, while its construction and technique were so adapted as to make it capable of being produced in the large quantities necessary for sound film work.

After the initial rush on photo-cells, necessitated by the hurried changeover from silent films to talkies, a period of stability followed, which gave place later to the investigation of the possibilities of the photo-cell as an instrument for industrial control. This aspect is growing more and more prominent, and holds great possibilities for the future.

More recently, again, a limited but important field for photo-electric devices has accompanied the growth of television. Each of these new fields of activity made new demands upon the photo-cell. The early potassium cell needed merely some ultra-violet sensitivity. The sound film cell needed a good response to a metal filament lamp, whose light was modulated by a sound track at audio frequencies. The industrial control field demands reliability, mechanical rigidity and good response to normal light sources, while the television and picture transmission field involves high sensitivity and ability to respond to frequencies of several million cycles per second.



The effect of load resistance on the current-light curve at different anode voltages.

General Photo-electric Theory

The laws underlying electron emission under the influence of radiation are amply explained by the assumptions of the Quantum Theory. This assumes essentially an atomic structure for light, and the magnitude of the energy unit carried by any radiation proportional to the frequency of that particular radiation. The basic equation underlying photo-electric emission is as follows:—

$$E = hn = W + \frac{1}{2} mv^2$$

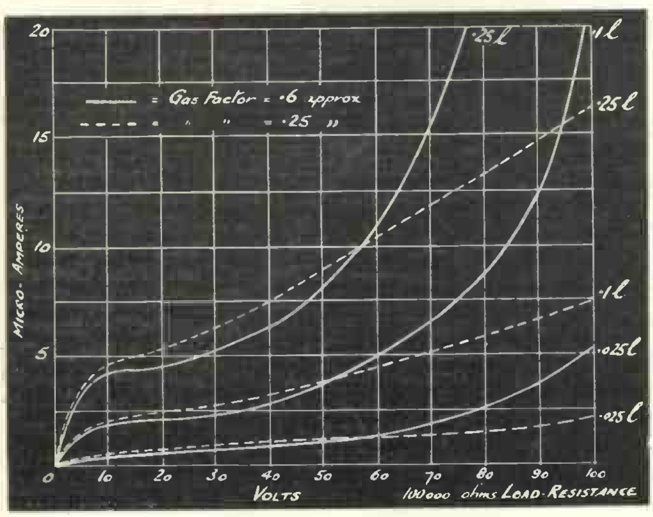
that is to say, the energy carried by the radiation in question will be used up in two ways, W being the amount necessary for the ejection of an electron (Work Function) while the excess will appear in the form of kinetic energy of the electron so liberated. The symbol H is termed Plancks Constant (6.55×10^{-27} ergs) and n is, of course, the frequency which is related to the wavelength by the equation—Frequency × Wavelength = Velocity of Light.

Considering the matter from another standpoint, it follows that for a particular surface possessing a definite Work Function, only radiation whose Quantum Energy is greater than that Work Function

Mechanism of Photo Emission

can eject electrons or, in other words, for any particular surface, there is a long-wave limit, and only light of frequencies greater than the threshold frequency can be effective in producing photo-electric emission. That is why the initial photo-cells only respond to ultra-violet light, and much development work was necessary before surfaces could be produced possessing Work Functions sufficiently low to permit of photo-electric emission, when acted upon by visible light or by near infra-red radiation.

The whole question of the spectral sensitivity of photo-cells and the peculiar characteristic of spectral selectivity, shown by various photo-electric surfaces, depends upon its Quantum relationship.



The effect of gas pressure upon the current-voltage curve at various light fluxes.

The modern caesium cell possesses a threshold frequency of about 12,000 or 13,000 Angström units. That is to say, in the near infra-red region there is a maximum response at about 7,000, then the curve drops away to a minimum, rising again towards the ultra-violet, and then drops again, owing to the filtering effect of the glass envelope, which cuts off more ultra-violet, as the wavelength becomes progressively shorter.

Turning to other matters, it will be remembered that the kinetic energy of ejected electrons depends upon the difference between the Quantum Energy and the Work Function. Hence, if highly sensitive surfaces are irradiated by ultra-violet light, the photo-electrons will possess high velocities. It should not be assumed, however, that the transference of radiation energy into electron emission energy is anything like complete in practice. Actually, the Quantum Efficiency is very low, since if ejection takes place at finite distances below the surface, there will be much scattering and absorption of light, and also, a proportion of electrons will fail to escape since they may be emitted in directions not pointing towards the exterior.

Another question that arises is the efficiency of a surface when irradiated by light incident at a particular angle to that surface. With polarised light and smooth surfaces, there is a definite optimum angle, and a vectorial selectivity curve results, but since in practice surfaces show irregular structures, this effect is not of practical importance. However, if the surface be too rough electrons emitted at the bottom of the microscopic craters will find it difficult to escape, and the cell will need a higher collecting voltage for complete saturation.

To turn to the mechanism of photo-emission, the actual sensitive surface may be considered as consisting of a very thin surface film of the order of 10-100 molecules thick of caesium absorbed upon a semi-conductor interlayer, in which are diffused certain amounts of finely divided reduced metallic silver. This interlayer may consist of caesium oxide or even of a saline deposit, such as calcium fluoride.

When a cell is exposed to light, the emission of photo-electrons from the surface is accompanied by the passage of current through the electrolyte, and this is facilitated by the presence of these conducting silver particles; but when comparatively heavy currents are involved there will, necessarily, be a polarising effect, resulting in the impoverishment of the semi-conducting interlayer. This will make itself apparent as a fatigue effect. Any treatment which facilitates the diffusion of metal particles through the interlayer, would render the cell less subject to such a fatigue. The conducting properties of the interlayer are improved by low temperature heat treatment, or by irradiation by infra-red light.

It will be seen that conservative operation as regards light and voltage is always to be recommended. This effect which accompanies external photo-electric emission may be described as an internal photo-electric effect in which the interlayer becomes ionised and the ions must be neutralised by conducting particles. Since the diffusion of such conducting particles becomes more rapid with increase of temperature, the fatigue effects due to this internal space-charge limit become very apparent indeed, if any attempt is made to operate photo-cells at low temperatures.

Quality and Quantity of Light

The light source normally employed in photo-electric work is a metal filament gasfilled lamp run at a temperature of 2,700° K. If we plot the Energy Distribution curve of such a lamp, it will be seen that its maximum energy radiation occurs at about 10,000 Angstrom units, in which region a caesium photo-cell possesses excellent response. With sound film work, it is usual to work with an exciter lamp, whose approximate colour temperature is 2,870° K., but since the light output of these lamps drops rapidly through life, it is necessary to employ for measurement purposes a stable sub-standard lamp run at a safe low temperature; 2,700° K. is normally employed.

In order to know the sensitivity of a cell, it is necessary to determine the intensity in lumination of the light falling upon the cathode. This depends upon horizontal candle power of the lamp, its distance, and upon the projected surface area of the cathode.

Gas-filled Photo Cells

$$\text{Lumens} = \frac{\text{Horizontal candle power} \times \text{Surface area}}{\text{Distance}^2}$$

If facilities are not available for photo-metric measurement it is possible to evaluate the approximate candle power, assuming it to be uniform in all directions, from a knowledge of its efficiency in lumens per watt.

Total Lumens = Efficiency × Wattage.

$$\text{Mean Spherical Candle Power} = \frac{\text{Total Lumens}}{4\pi}$$

If we have available a foot-candle meter to obtain the lumen value of the light falling on a photo-cathode, if the projected area be 1 sq. in., as in most standard sound film cells, then 1 ft. candle is equivalent to 1/114 lumen. It should be pointed out that it is not desirable to use more than about ¼ lumen light intensity on most photo-cells.

The mechanical demands of photo-cells will, of course, depend largely upon the uses to which they are to be put. At the present time the only standardisation yet attained is for those cells intended for sound film work. In this case, British Standard Specification No. 586 of 1935 describes several suitable mechanical dimensions, and also the electrical characteristics advisable for photo-electric cells in sound film equipment.

Vacuum Cells

The simplest kind of photo-electric cell to consider is, of course, the vacuum cell, in which the photo-electric effect predominates, and is not masked by subsidiary effects such as ionisation in gasfilled cells, and secondary emission in multiplier cells. Normally, in a practical photo-cell, the cathode is of concave shape, with the collector anode centrally disposed. This permits of the easy collection of electrons or, in other words, saturation at a low voltage.

If we plot a curve of photo-current against anode voltage with constant light input, it will be seen that after a small curved portion up to about 15 volts, the characteristic is approximately parallel to the voltage. Saturation is, however, not complete, since the surface is not uniform, and collection is sometimes difficult for electrons liberated in a recess or from the back of the cathode. Also, if the voltage increases, field emission effects may occur. In a well-designed vacuum photo-cell, the proportionality between light and current is very close indeed, provided the light intensity is not so great as to cause heating effects, and the voltage only high enough to ensure good saturation.

Caesium cells will possess a sensitivity of about 15-25 microamperes per lumen for light at 2,700° K., although isolated specimens giving as high as 40 microamperes per lumen will occasionally be met with. Provided sufficient care has been taken during the exhaust, vacuum cells are found to be remarkably stable.

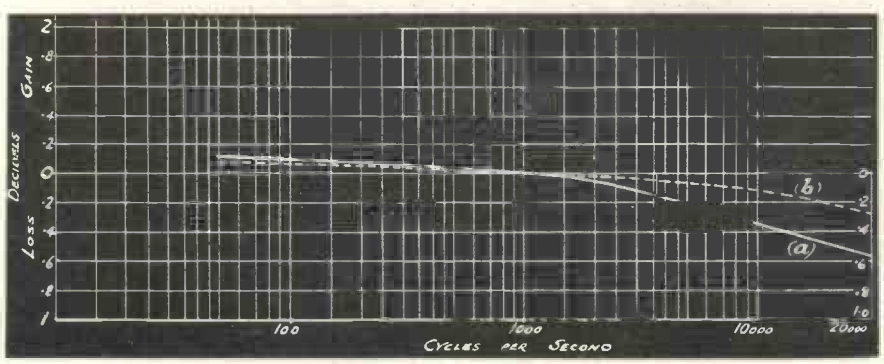
One of the important things to consider with vacuum cells is the dark current, that is to say, the total current which passes with normal voltage and no illumination. If we have 100 volts on the anode, the total dark current should be considerably less than .1 microampere. This, of course, means an insulating resistance of 1,000 megohms. Therefore, it is obvious that care must be taken to avoid leakage in the case or across the pinch of the cell itself.

In addition to these random avoidable leakages, dark current also includes thermionic emission from the cathode, since the Work Function of a caesium surface is very low and the large area of sensitive cathode may possess as much as 10^{-9} amperes of thermionic emission at normal temperatures. For special purposes, where very small light quantities are involved, it will be necessary to bring the collector out through the bulb and protect it, if necessary, by a guard ring device.

Gas-filled Cells

For most practical purposes, the type of photo-cell employed nowadays is filled to a low pressure with inert gas—usually Argon. This enables the small primary photo-electric current to be amplified several times, as a result of ionisation of the inert gas atoms, by collision with photo-electrons, during their passage from cathode to collector.

If we admit a small pressure of Argon—say, between .05 and .1 m/m. of mercury pressure, and plot a curve of photo-current against anode volts, we shall find that up to about 15 or 18 volts, the current will be slightly below that of the cell when measured under vacuum conditions. This is due to the impeding action of the inert gas atoms. Above this voltage, however, some of the small electrons will possess sufficient kinetic energy to eject electrons from the Argon atoms.



Frequency response curve of gas-filled photo electric cells. Cells measured with approximate gas factor of (a) .6 and (b) .25.

This effect of ionisation by collision becomes more and more frequent with increasing anode voltage, until complete ionisation occurs and the gas glows like a neon lamp. Above this potential, known as the glow voltage, the cell passes a large current limited only by what resistance there may be in the circuit, current, of course, being independent of light.

The glow voltage is affected somewhat by the intensity of illumination and it is, therefore, dangerous to attempt to run a cell too close to this point, but between the commencement of ionisation and the glow voltage, there is a large useful range, in which ionisation can be employed to

(*Continued in 2nd col. of next page.*)

A New 80-watt Fluorescent

Discharge Tube

A NEW fluorescent discharge lamp of the tubular mercury-vapour type capable of producing illumination of daylight quality at a low temperature has been developed by the Ediswan Company.

The commercial applications of a lamp of this description are numerous, particularly at the present time when in many instances artificial illumination is necessary even during daylight hours, and in many cases where correct colour rendering is of importance, as in the printing, dyeing and textile industries, artificial illumination of this type is essential.

A photograph of the lamp is shown above and it will be seen that it consists of a glass tube approximately 1½ in. in diameter, fitted at each end with a standard B.C. cap, the overall length being 5 feet.

The interior surface of the tube is coated with a film of fluorescent medium, the function of which is to convert the short-wave (invisible) U.V. radiation produced by the discharge tube into a visible radiation of longer wavelength. The nature of this film of fluorescent material is such that the composition of the light emitted very closely approaches that of cold daylight.

Enclosed within each end of the tube are the electrodes between which the electric discharge takes place: the tube has a low pressure filling of inert gas for the purpose of initiating the discharge and also a small quantity of mercury.

An accessory unit comprising a choke, thermal switch and suppressor condenser is required for the operation of each lamp; in addition, a condenser of suitable size must be employed for each lamp or group of lamps if power factor correction is desired. The thermal switch and suppressor condenser are combined in the choke unit. The thermal switch is contained in a small bulb and it is, therefore, easily replaceable should it become damaged.

The lamp is connected to the supply mains in series with the tapped choke B, as shown in the diagram. This choke is necessary for current stabilisation. Upon switching on, current flows via the choke, through the electrode coils D and D, the circuit being temporarily completed through a thermal switch A (which is initially closed) for about three seconds, during which time the temperature of the electrodes is raised sufficiently to provide the necessary electronic emission to initiate the discharge between them.

After a period of about three seconds, the thermal switch automatically opens, causing a momentary rise of potential across DD, and the immediate establishment of a discharge between the electrode. C is the condenser for power factor correction if this is desired.

The lamp is for use on A.C. mains 200-250 volts, and the consumption is 80 watts with a light output of 2,800 lumens, with an efficiency of 35 lumens per watt. The surface brightness of the tube is 3 c.p. per sq. in. and the average life 2,000 hours.

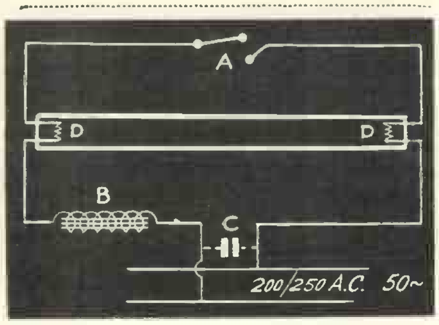


Diagram showing method of connecting discharge to the mains

A trough reflector is available for this lamp with the control gear housed in a sheet metal box. The reflector is fixed to this box by means of angle brackets, which also provide the angular adjustment of the fitting.

"Theoretical and Practical Aspects of Photo-cells"

(Continued from preceding page.)

amplify the initial photo-current a number of times. However, there are certain subsidiary effects which cause complications. In particular, the frequency response of a gasfilled cell; the modulated light is not so good as that of a vacuum cell, and its stability is definitely more variable.

If cells are to be used for sound film work, in which the light is modulated at audio frequency, it will be found that we cannot obtain a gain by ionisation of more than about five or six times, without an appreciable drop in sensitivity at 10,000 cycles per second. The relation between the output current at the working voltage—usually 90 volts—and the pure photo-current, measured at about 20 volts is known as the gas factor and an upper limit of gas factor is usually fixed. The exact reason for the drop in frequency characteristic is rather obscure. It was at first thought to be due to the fact that the passage of heavy positive ions from the point where they were produced back to the cathode was very slow because of their mass; but this delay by no means accounts for all of the falling frequency response.

Another effect is possibly the release of electrons, either thermionic or secondary as a result of bombardment of the cathode by positive ions. There is no doubt that an appreciable quantity of Argon gets trapped in the cathode surface during running, thereby lowering the effective gas pressure, and causing a drop in output sensitivity. On standing in the dark, however, some of this gas comes out again and the cell, when re-illuminated, will be practically as good as before. This may be accelerated by gentle baking of cells at about 130° C. to facilitate the release of the trapped Argon.

It is possible to construct gas-filled cells with improved frequency response by introducing an electrode at cathode potential close to the anode, which serves to shorten the path of the positive ions, and to prevent undesirable cathode bombardment. Improved frequency response may also be obtained by filling with other rare inert gases, such as Krypton or Xenon.

Measurement of Transmitting Valve Characteristics Above the Dissipation Limit

By G. Stolzer, D.E.E., Tungsram Transmitting Valve Laboratories, and J. A. Sargrove, N.C.M.E., F.T.S.; M.Brit.I.R.E., Chief Engineer British Tungsram Radio Works Ltd.

TO meet the demand for transmitters and power amplifiers of high efficiency, in which valves are used at instantaneous anode dissipations well in excess of the rated continuous dissipation, it is essential that the designer makes an intimate study of this part of the valve characteristic.

The type of operation, in which the valve operates for less than half a cycle is generally referred to as Class-C condition, and enables an anode circuit efficiency of more than 75 per cent. to be obtained. Where a low distortion percentage is essential, such as in audio-frequency amplifiers, this condition of operation is impossible, and Class-B condition is used, in which each output valve must function for at least a half cycle; hence the efficiencies obtainable are of a somewhat lower order, being in the neighbourhood of 50 to 65 per cent. as a rule.

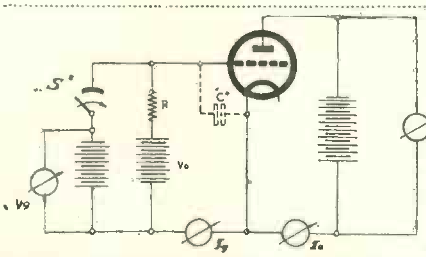


Fig. 1. Schematic diagram of measuring circuit. S is the rotary switch shown in Fig. 2. C is included to stop transient oscillations.

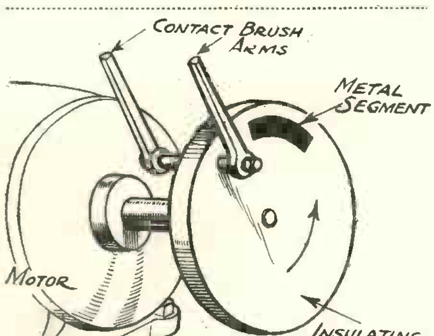


Fig. 2. Motor-driven rotary switch (shown as S in Fig. 1) for rapidly changing the grid bias.

In both Class-C and Class-B operation the valve has to function for a fraction of a half-cycle above the normal anode dissipation limit, which causes an instantaneous increase in the heat content of the anode, which, during the idle half-cycle has ample time to cool out by radiation. Provided the mean anode temperature is no greater than the anode temperature at the permissible continuous anode dissipation, this method of operation is quite satisfactory, and the higher efficiencies obtainable as against the 30 per cent. efficiency of the Class-A condition have made the latter quite obsolete.

It is obvious that to be able to produce a satisfactory design the characteristic curve of valves will have to be plotted from actual measurement. The usual static method of obtaining the anode-volts-anode current characteristic, as a function of the grid voltage, will not be possible above the permissible anode dissipation line without damaging the valve.

Damage to the valve is caused, not only by the excess anode temperature tending to liberate occluded gases which would spoil the vacuum (this is the popular conception although, in actual practice, it hardly ever happens as modern transmitting valves are evacuated and their parts degassed to a very high degree), but also by the excess filament temperature attained during test by inward radiation of the anode, a possible cause of premature filament failure.

Nor can we adopt a dynamic method of measurement with sinusoidal input, as, due to the inevitable distortion introduced by the valve, it would be nearly impossible to obtain the true characteristic.

New Method of Measurement

Though numerous methods of correction have been suggested, there being quite an appreciable amount of literature on the subject, these are uneconomical, complicated, and, in many cases, quite laborious. Hence a novel method has been devised whereby normal D.C. instruments and methods can be used, irrespective of whether the working point measured is inside or outside the dissipation limit.

Fig. 1 shows the schematic diagram in which the switch S is intermittently closed, in this case by a copper segment mounted on a rotating disc of insulating material driven by a motor, the copper segment making the circuit between the two contact arms mounted on either side of the disc. (See Fig. 2). It has been found convenient to make the "on" period 1/6.3 of a revolution, the latter taking 1/25th of a second, at 1,500 rev. per min.

The various voltages are obtained from separate power packs in order to eliminate interaction, and the constancy of the anode voltage even at very high voltages is assured by the provision of an 8-μF. condenser across the valve. By this means, during the active period, the anode can reach a dissipation greatly in excess of any normally encountered in operation, and the continuous anode temperature will be maintained within the permissible range by the comparatively long idle period.

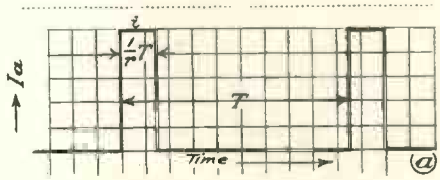


Fig. 3a. Ideal anode current waveform.

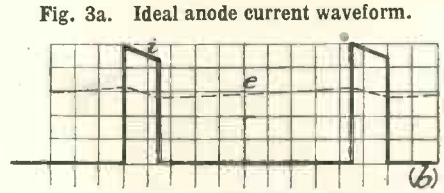


Fig. 3b. Approximate actual anode current (i) and voltage waveform (e).

In order to obtain correct anode current for the working point, the readings of the D.C. current meters have to be multiplied by 6.3 in our case, which is the computation factor corresponding to the ratio of the angle of the conductive segment to the total of the rotating switch S.

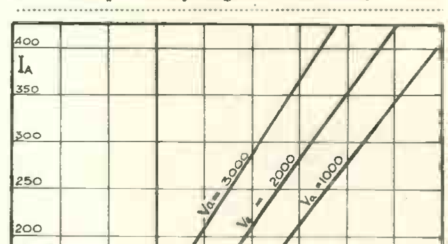


Fig. 4. Grid-volts-anode-current curve of the Tungsram 0-300/3,000 U.S.W. transmitting triode extending above the dissipation limit.

To stabilise the grid-voltage supply (also derived from a power pack) the

Experimental Procedure

latter is shunted by a 50-μF. condenser. It was found most convenient to use accumulators across voltage Vo, as during the short active period a current

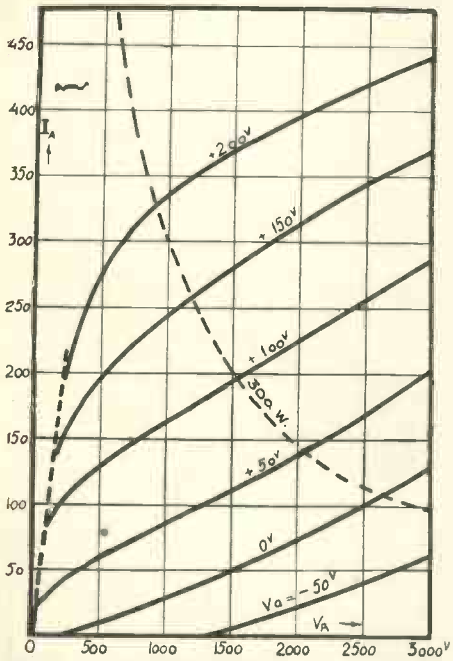


Fig. 5. Anode-volts-anode-current curves of the Tungsram 0-300/3,000.

as high as 5 mA. is drawn through the resistance R, which in this instance, has a value of 100,000 ohms.

The accuracy of the reading by means

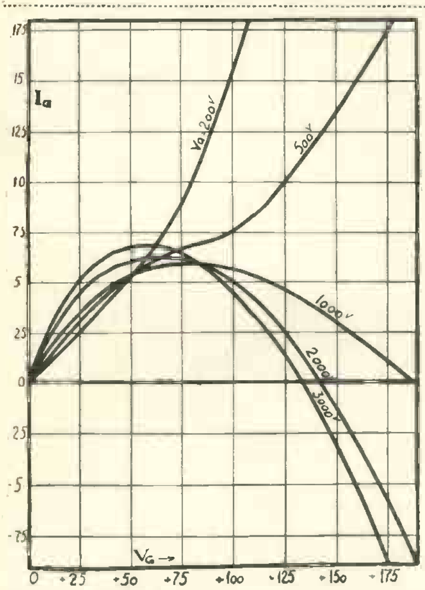


Fig. 6. Grid-volts-grid-current curves of the Tungsram 0-300/3,000 showing the effect of secondary emission from the grid.

of the rotating switch can easily be checked at anode currents within the dissipation limit against readings taken by normal static means. Also, an approximate check can be obtained at higher readings by conecting a square-law instrument in series with the D.C. instrument. Assuming the ideal square-topped waveform, as shown in Fig. 3a, the square-law instrument would show an anode current whose value would be higher than that shown on the D.C. instrument by the square-root of the computation factor (r); that is, the square-law instrument would show a current of :

$$\frac{Ia}{\sqrt{r}}$$

whilst the D.C. instrument would show :

$$\frac{Ia}{r}$$

where Ia is the anode current.

However, the true current waveform is more of the form shown in Fig. 3b, due to the fact that the anode voltage smoothing condenser is not infinitely large. Owing to this we only obtain an approximate anode current value with a finite condenser, but this approximation is very good. As will be seen from the appendix the error is negligible as it is smaller than 0.1 per cent., even at high current values.

At this juncture we must mention two further difficulties which had to be overcome. As we used an asynchronous motor for driving the switch, we found that, unless the smoothing of the rectifiers was improved, we obtained a slow periodic hunting in the current indicating instruments corresponding to the beat frequency between the mains frequency and the switch speed, which was slower than the mains frequency by the slip of the motor. We eliminated this by improving the smoothing of the anode supply and adopting D.C. heating for the filament of the valve under test, obtained from a large current low-voltage rectifier.

A further trouble was experienced due to transient oscillations occurring at the beginning of the active period, which was eliminated by connecting a condenser from grid to cathode of the valve under test. We used a condenser of 0.002 μF., and the small distor-

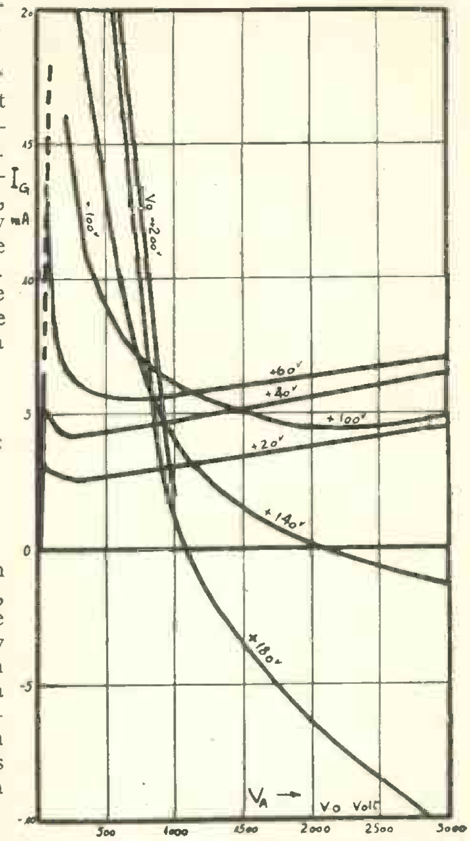


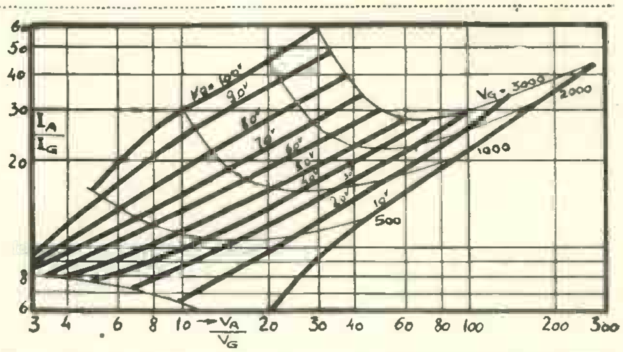
Fig. 7. Anode-volts-grid-current curves of the Tungsram 0-300/3,000.

tion of the current waveform caused by this is dealt with under appendix 2, from which it will be seen that the error introduced by it is negligible.

New Method Applied.—To elucidate this method of measurement, we shall describe it in detail as applied to a 300-watt transmitter valve (Tungsram O-300/3,000). The characteristics taken are shown in Fig. 4 Ia/Vg, Fig. 5 Ia/Va, Fig. 6 Ig/Vg, Fig. 7 Ig/Va curves.

Occurrence of Secondary Emission.—The downward bend in the grid-volts-grid-current curve is caused by secondary emission from the grid. The

Fig. 8. Voltage - ratio to current-ratio curves of the Tungsram 0-300/3,000.



secondary emission factor is a function of the grid-voltage. It is obvious from Fig. 8 that the Ia/Ig as a function of Va/Vg curves, with Vg as parameter,

Formulae

approximately follow the law:

$$Ia/Ig = C \left(\frac{Va}{Vg}\right)^{\alpha}$$

In a double logarithmic scale we should obtain straight lines where α approximately equals 1/2, and C increases with the grid voltage.

A good survey of the maximum efficiency and driver requirements can be obtained from the measurements taken along the load-line corresponding to the smallest permissible load resistance. The smallest permissible load resist-

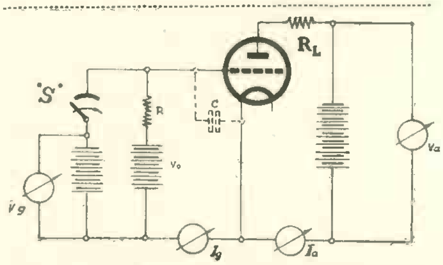


Fig. 9. **Circuit including smallest permissible anode load.**

ance from anode to anode in a class-B circuit is $0.4 \dfrac{Va^2 \text{ max.}}{Wo}$. With smaller values the maximum permissible anode dissipation is exceeded.

This value of anode to anode resistance referred to one valve, i.e., from anode to anode H.T.+, corresponding to load line of which value is:

$$R_L = 0.1 \frac{Va^2 \text{ max.}}{Wo}.$$

In order to plot the points along this line we introduce a resistance having this value into the anode circuit of the valve under test, as shown in Fig. 9. Two examples of the curves taken on two dissimilar valves but at the same anode load and at the same effective anode voltage, are shown in Figs. 10 and 11, whilst in Fig. 12 a direct comparison is shown of several valves of the 25 to 37 watts category of small power and transmitting valves.

From these their performance in class-B push-pull circuit can be computed, giving the following results:—

Maximum output in watts (for 2 valves)

Tungsram Type.	up to Va-Vg	up to Ig-60 mA.
P25/450	86	85
P25/500	110	108
P30/500	119	110
OP37/600	121	113

By adding a cathode-ray oscillograph to the points as shown in Fig. 13 a visual demonstration of the characteristic curve can be obtained. However, this, quite obviously, has rather a qualitative than a quantitative value. The alternating grid input voltage is connected, for the sake of convenience, to the horizontal X axis, it being applied throughout the investigation. We chose for our purpose the output from a low-frequency oscillator, having a frequency of 2,000 c.p.s.

The Y plates could be connected either to the volt-drop across the anode load resistance, or across a small resistance situated in the grid circuit, as clearly shown in Fig. 13.

Appendix I.

Method of ascertaining the error due to voltage drop of the H.T. supply owing to the finite size of the smoothing condenser:—

The voltage drop is:—

$$\Delta Va = \frac{Ia \times t}{C}$$

/Change in Ia neglected/.

The difference between maximum and minimum current is:—

$$\Delta Ia = \frac{Gm}{\mu} \Delta Va = \frac{Gm}{\mu} \cdot \frac{Ia\ t}{C}.$$

In our arrangement:—

$$t = \frac{1}{25 \times 6.3} = 6.35 \times 10^{-3} \text{ sec.}$$

$$C = 8 \times 10^{-6} \text{ F.}$$

$$\Delta Ia = \frac{Gm}{\mu \times 1.26 \text{ mA./V.}} \times Ia$$

for instance, assuming an amplification

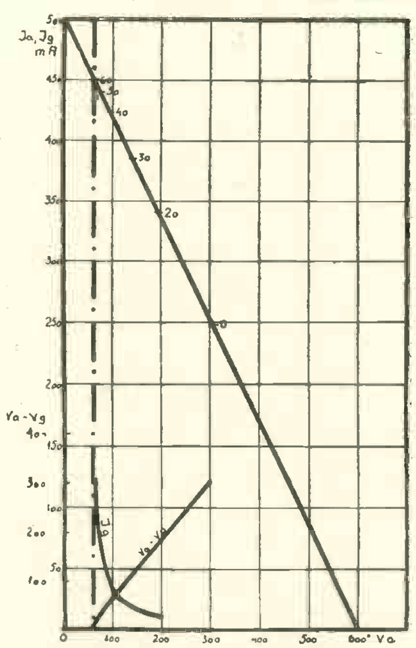


Fig. 10. **Anode-voltage-grid and anode-current curve limits showing smallest permissible anode-load line of Tungsram type OP-37/600.**

factor of 10, and a mutual conductance of 1.26 mA./V.

$$\Delta Ia = \frac{1}{10} Ia.$$

If we assume that Ia and Va vary linearly between their maximum and minimum values there would be no difference between the measured and the

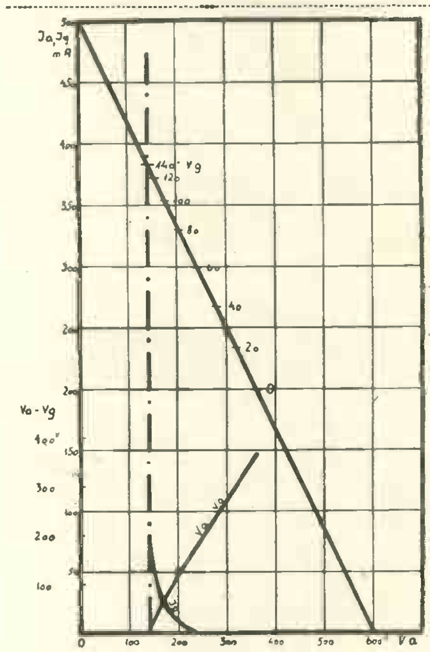


Fig. 11. **Anode-voltage-grid and anode-current curve limits showing smallest permissible anode-load line of Tungsram type P-25/450.**

calculated mean values. On actually checking this we found that the practical error due to our above assumption is negligible.

$$Ia = K \times V^{3/2}$$

$$(V = \text{the grid potential} = Vg + \frac{Va}{\mu}).$$

The mean current value (measured with linear instrument) is:—

$$I_a = k \int_{t_1} \frac{V^{3/2} \times dt}{\Delta t} = k \int_{V_{min}}^{V_{max}} \frac{V^{3/2} \times dV}{\Delta V}$$

$$= \frac{k}{\Delta V} \cdot \frac{2}{5} \left(V_{max}^{5/2} - V_{min}^{5/2}\right) V_{max}^{5/2}$$

$$\text{and } I_k = k\left(V_{min} + \frac{\Delta V}{2}\right)^{3/2}$$

Extending these equations and neglecting the higher terms containing ΔV we get

$$I_a - I_k \approx \frac{1}{32} \left(\frac{\Delta V}{V}\right)^2 \times I_a$$

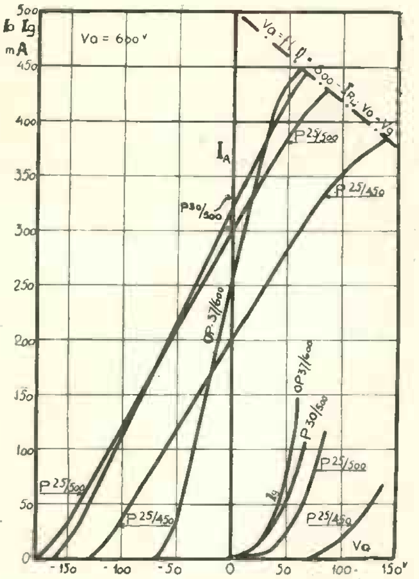


Fig. 12. Grid-volts-anode and grid current curves of several Tungsram types of the 25-37 watts category, taken with the smallest permissible anode load. R_L = 1,200 ohms.

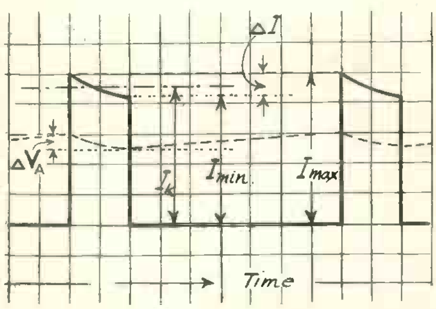


Fig. 14. Anode current waveform as a function of time.

Hence in our example, where $\Delta V/V = 1/10$ we get

$$\frac{I_a - I_k}{I_a} < \frac{1}{3200}$$

This is an absolutely negligible error. It should not be forgotten, however, that the error is even further diminished by the fact that the power pack feeds the condenser even during the time that it is being discharged.

Appendix II

Method of ascertaining the error due to the grid cathode shunting condenser shown in Fig. 1 *assuming a grid-leak of* 100,000 *ohms.*

The initial discharge current of the condenser is :—

$$I_0 = \frac{\Delta V_g}{R_g} = 10^{-5}\,\Delta V_g \text{ Amps.}$$

ΔVg = difference between measuring grid-bias and the cut-off bias. Rg = 0.1 megohm.

If this current would flow continuously, the discharge time would be :—

$$T_0 = \frac{Q}{I} = \frac{2\times10^{-9}\times\Delta V_g}{10^{-5}\,\Delta V_g} = 2\times10^{-4} \text{ sec.}$$

(The tangential section shown in Fig. 15).

The surface area of the exponential voltage discharge curve is identical with the rectangular area over the baseline To and height Vg.

According to this the error due to the voltage area is equal to

$$\frac{\text{tangential discharge period}}{\text{active period}} = \frac{2\times10^{-4}}{6.35\times10^{-3}} = 3{\cdot}15\%.$$

This error can be considerably reduced by pushing the grid-bias for the inactive period well beyond the cut-off bias.

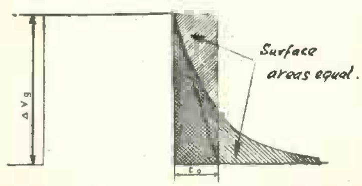


Fig. 15. Grid voltage waveform due to the action of the grid shunt condenser included in circuit Fig. 1 in order to eliminate transient oscillations.

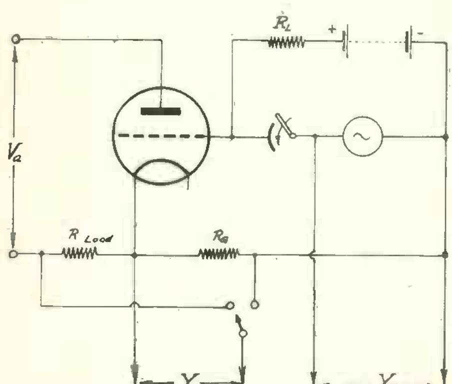


Fig. 13. Circuit for oscillographic observation of characteristics.

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The " Dispenser " Cathode

A New Type of Cathode for Gaseous Valves

By P. G. Day, B.Sc.

The type of cathodes at present in use in gaseous valves consist of a nickel or nickel-platinum surface coated with the oxides of barium or strontium. The coating process is carried out by spraying or dipping. This type of cathode is very strong mechanically and has a high initial electron emission although it possesses numerous disadvantages when used in valves handling a considerable amount of power. The coating tends to flake off, it gradually evaporates giving a decreasing electron emission, it electrolyses causing liberation of oxygen and it has to be activated before use.

A. W. Hull, in America, has recently devised a new type of cathode in which the coating substance is gradually dispensed from a heater to the cathode proper throughout the life of the valve. In this way the high initial electron emission of oxide coated cathodes is maintained all the time the valve is in service. The new cathode has been called the " Dispenser " cathode.

In Hull's cathodes the electron emitting members were radial vanes of clean molybdenum instead of oxide coated nickel, and in place of the usual tungsten wire filament there is a porous tubular heater (a cylindrical mesh of fine molybdenum wires) filled with activating material which dispenses the coating and also heats the actual emitting surfaces. The activating material consisted of barium oxide in the form of small granules of fused barya-alumina eutectic mixture and with this substance it was found that at the operating temperature of 1,150° C. the rate of diffusion of barium oxide to the emitting surfaces was sufficient to give a constant electron emission throughout the life of the cathode.

The life of valves equipped with dispenser cathodes appears to be very great and it is recorded that after nearly 24,000 hours operation, only 2.4 per cent. of the barium oxide has been lost from the cathode enclosure, and at the end of a three year's life test the cathodes showed undiminished electron emission.

Recent Developments in Electron Engineering

From the annual reports issued by leading manufacturers, 1939 saw many notable developments in radio and electron engineering. The General Electric Co. and The British Thomson-Houston Co. have described some of these developments of which the following will be of interest to readers.

The General Electric Co.

AMONG lamps designed for special purposes the extra high pressure mercury vapour compact source lamp has been developed by the G.E.C. in various sizes. Some of its applications were discussed before the Illuminating Engineering Society of London, in a recent paper* which gave the results achieved by the use of a 2½ kW Osira compact source lamp in a 14 in. diameter mirror. This lamp gave only 30 per cent. less screen illumination than a 55 ampere high intensity arc. The colour of the light from the mercury lamp was found very satisfactory for the projection of black and white films and lantern slides, although for dull red and near-red colours in colour films improvement could be gained by the use of a suitable filter.

Other applications to different forms of projection apparatus are also being thoroughly explored.

Cathode-ray Tubes

The rapid increase in output of cathode-ray tubes to meet the public demand for television brought with it many manufacturing problems requiring chemical and physical research. The solution of these problems has made possible a high speed of production with maximum economy.

The design of a range of magnetically focused and deflected tubes was completed and 9 in. and 7 in. tubes were put into production, with larger sizes following. These tubes, which are of the triode type requiring only the application of heater, modulator and accelerator volts, are designed for a modulation input of 30 volts and for acceleration voltages of 3,500 to 6,000 volts according to size. These tubes are very short, using wide angle deflection and allowing direct viewing of the picture in a cabinet of small back to front depth. The use of the very successful short 12-in. electrostatically controlled tube was continued and the relative merits of the electrostatic and magnetic methods of operation are still somewhat in the balance when the more distant future is considered. Both are capable of excellent performance.

* V. J. Francis and G. H. Wilson, Transactions of Illuminating Engineering Society of London, Vol. IV., No. 4, p. 59.

Radio Sets

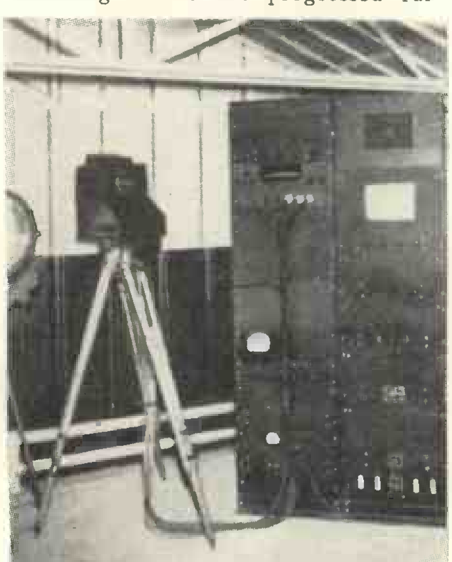
Development had been completed and production commenced of a range of main station and mobile transmitters and receivers operating on the ultra-high frequency bands. The sets are intended primarily for use in connection with police communication systems and the like. Equipments have already been supplied to several of the more important police forces.

Work is proceeding upon crystal controlled transmitters incorporating band switching between multiple frequencies, and a high-grade communication receiver embodying the most advanced technique with reception covering a range of 8.5 to 2,000 metres.

A device which will be found very useful to those who wish to run an A.C.receiver from a D.C. supply, is a D.C./A.C. conversion unit, which is a type of automatic polarity changing switch. When connected to a D.C. source it will operate to give a supply which will be suitable for the operation of a normal A.C. receiver. This unit is capable of supplying sufficient power to drive a 10-valve receiver.

G.E.C. Receiving Valves

The trend towards greater economy in the heater wattage consumption of receiving valves has progressed further by the introduction of the new Uniwatt range of mains valves, the basic types of which incorporate heater cathode systems of 1 watt rating. This achievement has been made possible by many detailed improvements in cathode coating efficiency, mechanical design and glass manipulative technique, resulting in valves not only of low consumption bnt of small physical dimensions.



B.T.H. Iconoscope scanning equipment in the Television Laboratory

The basic heater rating of the range has been so chosen that a wide range of applications can be met. Thus, with a nominal rating of 5.8 volts on the filament and 0.16 amp. filament current, satisfactory working from a 6-volt acumulator is assured and the low basic current rating offers a considerable advantage to the designer of series running A.C./D.C. receivers, where hitherto the dissipation of the power lost in the valve heater limiting resistance has proved a difficulty.

Another manifestation of the same trend towards greater cathode efficiency is found in the new range of 1.4-volt battery valves. A detailed study of the influence of core materials upon the emissive coatings of valve filaments has led to the introduction of battery valves of a nominal 1.4-volt, 0.05-amp. rating, which have such liberal emission reserve that satisfactory performance is maintained when the filament voltage is allowed to fall as low as 1.0-volt.

The diminutive "Acorn" ultra-high-frequency triode and H.F. pentode types, referred to as HA1 and ZA1, have been supplemented by two newcomers, the HA2 and ZA2, of equivalent performance, but with heaters rated at 6.3 volts and pin spacing in conformity with American practice, as distinct from the 4-volt heaters and British Standard pin spacing of their forerunners.

A specialised type of small transmitting valve, the KT8, caters particularly for the lowest wavelength region. This type is a twin pentode incorporating a special form of ring seal mounting and connection scheme, which permits the minimum length of connections to be secured, a factor of supreme importance at the frequencies in the region of 200 mc./sec. where this valve is designed to serve.

Measuring Instruments

A new heterodyne reactance comparator takes the form of a portable mains

B.T.H. Television Research

operated test set and enables coils or condensers to be checked rapidly against standards. Two radio frequency oscillators, one of which is variable, are made to beat against each other. The resultant signal is rectified and heard, a loudspeaker contained within the instrument serving as an aural indicator. The variable oscillator is fitted with a knob and drum drive. An accuracy of ±0.1 per cent. is obtained.

A thermionic test set gives direct readings of A.C. and D.C. voltage and current. The A.C. current range is from .005 microamp. to 5 amperes, the A.C. voltage range from 50 millivolts to 500 volts on frequencies from 25 cycles to 20 megacycles, the D.C. current range from .0005 microamp. to 1 ampere, and the D.C. voltage range from 1 millivolt to 500 volts. A patented feedback circuit of the D.C. amplifier type using negative feedback is employed with a potentiometer input.

The instrument can be supplied either for battery or mains operation. The input impedance of the instrument on D.C. and on radio frequencies, when used as a voltmeter on any range, is 10 megohms so that it can be used for measuring voltages in high resistance circuits with great accuracy, current consumption from the circuit being negligible. The special circuit provides extremely high sensitivity and at the same time prevents the indicating movement from being damaged by heavy overloads.

Other instruments which have been introduced include: a new type of "Q" meter for measuring the "Q" of inductances, capacities, etc., at high frequencies; a miniature illumination meter with a range of 0 to 250 foot-candles; and also a slip-on ammeter. The range of valve voltmeters has been extended, and one of the new instruments employs an acorn triode H.F. valve.

British Thomson-Houston Co.

Steady progress in the development of B.T.H. electrical equipment is the result of continued study, calculation, investigation, and experimental work on the part of this firm's large staff of engineers, supplemented by the work of the Research Laboratory which is such an important part of the B.T.H. organisation.

Electrical and Development Section

The development section of the laboratory deals with researches and developments of an electrical, magnetic, or acoustical nature; with measurements of a special character; with cinema projection development, the production of instructional talking films, and illumination schemes and apparatus. It builds in its model room most of the experimental models of new apparatus and looks after the standardisation and calibration of laboratory instruments.

The B.T.H. cathode-ray tube with plane glass screen.

Television

The development of large screen television pictures was being actively pursued until recently. A new projector unit was built during the year, in which the cathode-ray tube with its screen at an angle to the beam co-operated with mirror projection. The experimental projector operates on 40 to 80 kV and the oblique projection is so arranged that the projector may be placed close to the viewing screen without interfering with the line of sight of the audience, and a wide aperture lens of small diameter may be used.

Experience with the original television projector showed the importance of flat screen television tubes for large screen projection, and resulted in the development of a special cathode-ray tube.

Improvements in the projector demanded further improvements in the transmission equipment. The test signal generator and the scanning circuits of the transmitter were reconstructed, and a transmission line was erected between the Television Laboratory and the Acoustical Laboratory where the necessary space is available for large picture projection. The reconstructed camera unit and circuit racks are shown in the photograph.

In parallel with the above work the development of television testing equipment has continued. The study of cinema television in 1938-39 necessitated the construction by the development section of special testing equipment in the form of a signal generator and auxiliary equipment whereby projection type cathode-ray tubes could be tested by means of a stationary pattern derived from the signal generator and applied to the tube under test by wire connection.

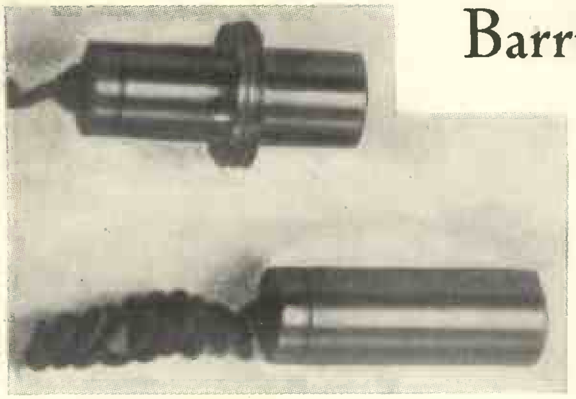
A carrier current link was also provided to test the receiving circuits associated with the projection tube and thereby to ensure that the highest possible fidelity was achieved in the absence of B.B.C. television signals.

Many items in this review can only be given the briefest mention, and among these are included photo-electric cells and many forms of radiation devices. Certain work on cathode-ray tubes also comes under this heading. Prior to September considerable research work had been done on high-voltage projection tubes suitable for large scale television, and work had reached an advanced stage showing that pictures could be projected with adequate brilliancy on to screens many square feet in area. To attain a uniform picture on a cathode-ray tube screen a technique has been evolved which enables a glass plane to be sealed to the cathode-ray tube envelope. This end can be of sufficient thickness to give the tube increased rigidity and can be ground optically flat if required. The advantages of a plane fluorescent surface are obvious, and a tube incorporating this feature is shown by the photograph.

A New Valve

Type 257 Gammatron

Heintz & Kaufman, Ltd., San Francisco, Calif., have recently introduced the Type 257 Gammatron, a beam pentode valve in which the elements are constructed entirely of tantalum and are mounted directly on a moulded base without the use of internal insulators of any kind. Thus, it is said to be possible to pump this valve under extreme temperature and to maintain a vacuum under operating conditions without the use of the usual "getter." The elimination of insulators and the unique construction employed reduces feedback capacity from plate-to-grid to approximately one-third of that found in similar multi-element transmitting valves. Thus, it will operate on higher frequencies without fear of self-oscillation. Another element of design which makes this type of operation practical is the employment of dual screen grid and suppressor grid leaks, which result in very low inductance drop over their short length, and make it comparatively easy to maintain these elements at earth potential.



This photograph shows the S5 and S5X barrier-layer photo-cells a little larger than actual size.

Barrier-layer Photo-cells for Sub-standard Talkies

EXPERIMENTERS who have been desirous of providing talking picture entertainment from sub-standard films, have mostly been compelled by reasons of expense to shelve the idea, as the use of the usual gasfilled caesium cells employed for large talkie work require very large sound heads together with elaborate low-noise level amplification.

However, a simple and inexpensive method is by the use of barrier-layer sound head cells, and the Tungsram types S5 and S5X have been produced for this and similar purposes. Two advantages are their small size (total length is only 32 mm. and diameter about 15 mm.), and the large electrical output which obviates the need for the special built-in one- or two-stage sound head amplifier, as required by the caesium type cell.

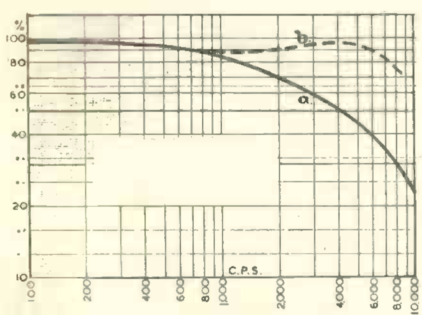


Fig. 1. Frequency response curves of type S5 cell in circuit. a—uncorrected. b—corrected.

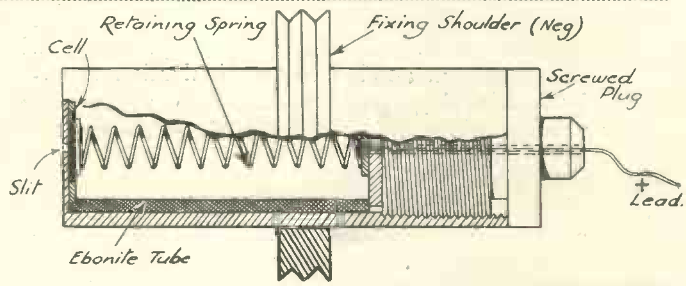


Fig. 3. Part section of type S5 photo-cell.

This barrier-layer selenium cell has a sensitive area of only 5 by 1 mm. arranged as a slit on the metal housing; it has a frequency response equivalent to the average wireless set, in other words, tolerable quality sufficiently good for the average listener.

This is shown in the uncorrected curve *a* (Fig. 1). In *b* the frequency response curve has been considerably improved by the inclusion of a small 2 hy. inductance in the load circuit.

In the past it was assumed that selenium barrier-layer cells could not be used for sound reproduction because of the high shunt capacitance of the cell itself, but this objection has been overcome by making the cell sufficiently small.

The corrected cell gives a sound response as good as the better type radio-gramophone, and requires only three-stage amplification. The amplifier is more or less the same as that used with a carbon microphone.

Though the barrier-layer cell will function without a polarising voltage, a 1½-volt negative bias is recommended as this reduces the background noise of the film which it should be definitely understood does not originate in the cell but in granular inequalities in the black part of the film sound track. The small bias voltage desensitises the cell for all but the really large light impulses corresponding to the sound track.

Fig. 2 shows diagrammatically the arrangement of the S5 photo-cell behind the film, the light being projected on to the cell through the usual so-called optical slit. The lenses should be so arranged that the light rays cross in the sound track itself. The finer the image of the slit on the sound track, the better the intelligibility and quality of the sound reproduction.

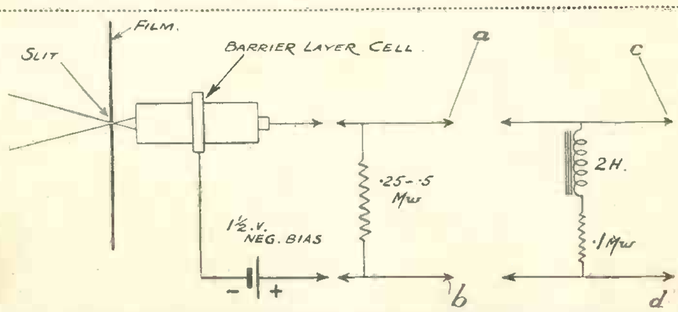


Fig. 2. Diagram showing how the cell is used with sub-standard film. a b and c d are points for amplifier connection.

A Russian correspondent informs us that the most powerful ultra-short wave television transmitter in the world, with a maximum power of 100 kws., is to be installed in the tower of the Palace of Soviets now under construction in Moscow. This, in conjunction with an aerial system 985 ft. above ground, it is contended, will make it possible for television programmes from the Palace of Soviets to be transmitted to great distances. One hundred and fifty receivers will be installed at different points in the building, including two projection receivers, one having a screen with an area of 478 square yards, and the other 120 square yards. The large screen receivers will be in the main hall with accommodation for 21,000 people.

THE IONISATION TIME OF THYRATRONS

An interesting account of research work has been given in a paper with the above title by A. E. Harrison, of the California Institute of Technology (A.I.E.E. Technical Paper, 39-116). The work is concerned with measurement of ionisation time of seventeen thyratrons and grid-glow tubes, representing twelve different types, by means of a special circuit employing a cold cathode oscillograph. The main object of the study was to determine the effect upon ionisation time of grid overvoltage defined as the difference between the potential applied to the grid and the critical potential necessary to prevent firing.

The ionisation time of a grid-controlled gasfilled rectifier, or thyratron, is the time elapsing between the instant that the grid potential becomes equal to the striking value and the instant when the voltage drop across the arc patch reaches the value corresponding to normal conduction. This period depends upon the type of tube and the nature of the applied grid potential, and under different conditions may vary between a fraction of a microsecond and several hundred microseconds. In previous tests it was found that ionisation times as small as 0.3 microsecond could be obtained with mercury-vapour thyratrons if the grid were driven sufficiently positive. This discovery opened the possibility that such tubes might be used in the blocking circuits of high-speed oscillographs, an application which has hitherto been closed to thyratrons owing to their inherent ionisation time.

In the present investigation this time was measured by a cathode-ray oscillograph connected between anode and cathode of the tube under test so as to record the variations in its voltage drop during the striking period. The records were of the general form shown in Fig. 1, where the beginning of the ionisation time is represented by the slight rise in anode voltage at the beginning of the record, corresponding to the instant of application of the grid impulse. It is seen that the final condition is reached in two stages; firstly a gradual and uniform drop in voltage during the period t_1, and secondly a more sudden drop during the period t_2. The total ionisation time is represented by T.

The test circuit was arranged so that a positive voltage impulse of approximately square-wave form and of predetermined magnitude could be applied to the grid through the medium of a second thyratron acting as a tripping tube. The oscillograph measurement was initiated automatically after a short time lag following the operation of the tripping tube, so as to synchronise the record with the signal impulse.

The test results obtained from twelve different types of tube are given in the accompanying table. The ionisation times were determined photographically from the oscillograms, of which three or more were

(Continued on page 163)

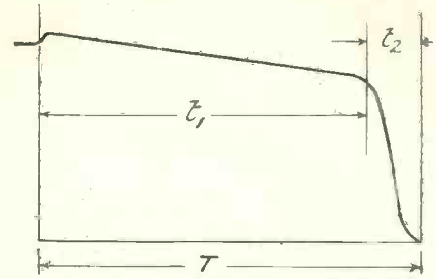


Fig. 1. Record of ionisation time of Thyratron.

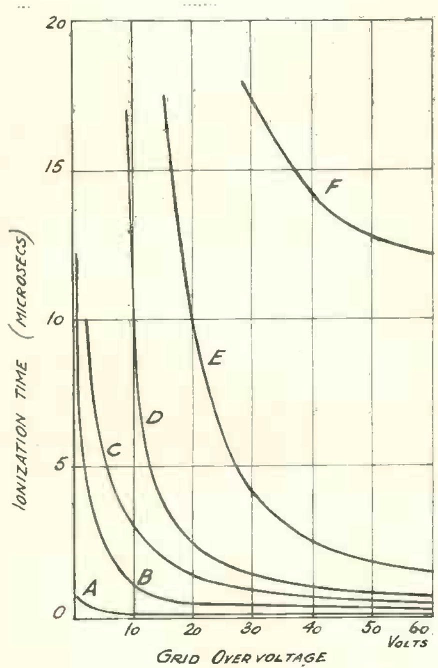


Fig. 2. Curves showing relationship between time of ionisation and grid overvoltage.

A = 885 (Argon), $V_a = 300$
B = FG81 (Argon, $V_a = 180$
C = KY21 (Mercury), $V_a = 1{,}000$
D = FG67 (Mercury), $V_a = 1{,}000$
E = KU610 (Neon), $V_a = 750$
F = Strobotron (Neon), $V_a = 350$ (cold cathode)

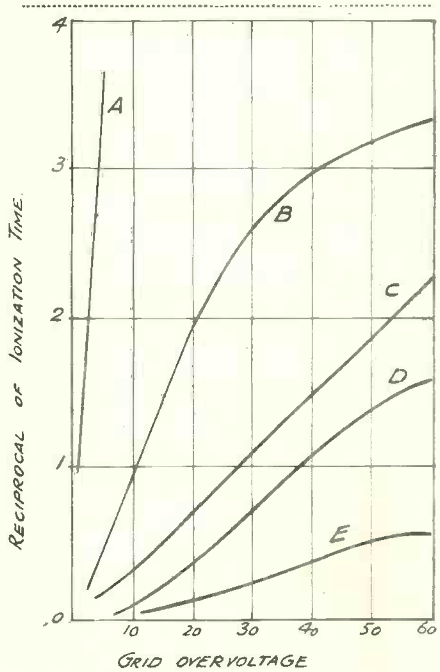


Fig. 3. Replotted curves showing the reciprocal of ionisation time as a function of grid overvoltage.

IONISATION TIMES OF THYRATRONS

Type	Number of Tubes Tested	Maker	Gas Filling	Anode Voltage	Ionisation Time Min. (Microsecs.)	Ionisation Time Max. (Microsecs.)
FG-17	2	General Electric	Mercury	1,000	0.50	50
FG-57	2	,,	,,	1,000	0.40	50
FG-67	1	,,	,,	1,000	0.60	150
WE 287-A	1	Western Electric	,,	1,000	0.65	50
KY-21	1	Eitel-McCullough	,,	1,000	0.45	20
866* Special	1	*	,,	1,000	0.35	20
885	3	R.C.A.	Argon	300	0.08	1
2A 4G	1	Raytheon	,,	300	0.10	10
FG-81	1	General Electric	,,	180	0.25	50
KU-610	2	Westinghouse	Neon	750	1.80	300
COLD CATHODE TUBES						
OA 4G	1	Raytheon	Argon	300	3.0	300-1,000
Strobotron	1	General Radio	Neon	350	12.0	300

* 866 tube with control electrode added. Maker unknown.

NEGATIVE FEED-BACK APPLICATIONS—I

By C. Lockhart

During the last few years the use of negative feed back has grown rapidly, and it is now extensively employed in radio receivers. It is the purpose of this article to discuss the lesser known applications of Negative Feed Back, but for completeness the more general applications are first briefly reviewed.

If we take an amplifier with an overall gain of "A" and return a fraction "B" of the output into the input circuit (Fig. 1) the overall gain will be modified as given below:

Amplifier gain without feed-back $= \text{“A”}$

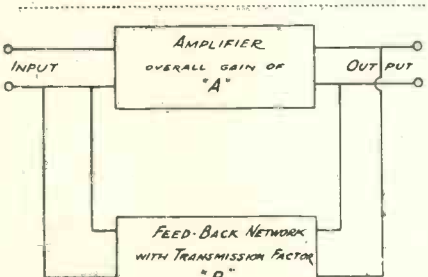


Fig. 1. Illustrating the principle of negative feedback.

Amplifier gain with feed-back $= \dfrac{A}{1-AB}$

Ratio of change of gain due to feed-back "r." $= \dfrac{1}{1-AB}$

"AB" is usually known as the "Feed-back Factor."

In a general case, both A and B are complex quantities and their amplitude and phase are functions of frequency. When $(1 - AB)$ is less than unity, the feed-back is said to be positive and when it is greater than unity, negative feed-back is present.

If negative feed-back is applied, the gain with feed-back becomes:—

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

and it will be seen that if AB is made large, the gain of the amplifier becomes independent of A and equal to $\dfrac{1}{B}$. Thus if we start with an amplifier having an overall gain of 100,000 without feed-back, and return 1/1000th of the output into the grid circuit, we have a "Feed-back Factor" of AB = 100, and the amplifier gain with feed-back equals

$$\frac{100{,}000}{1 + 100} = 1{,}000$$

and large changes in the value of the assumed gain of 100,000 will have little effect on the resultant gain of 1,000.

The importance of this result is that quite apart from being able to make an amplifier whose gain is independent of variations in valve characteristics and supply voltage fluctuations, the frequency response may be greatly improved, provided the transmission of the feed-back network has an amplitude and phase characteristic which is independent of frequency over the desired range.

In addition to the above improvements, the application of negative feed-back will reduce the harmonic output in the same proportion as the reduction of gain. However, this last statement is only true provided the feed-back network has a constant phase frequency characteristic up to the frequency of the highest harmonic it is desired to reduce, and that no valve in the amplifier is run either into grid current or off its characteristic.

Negative Feed-back in L.F. Amplifiers

The major application of negative feed-back in broadcast receivers has been the provision of negative feed-back in the L.F. amplifier section of receivers, fitted with pentode or tetrode output valves, in order to provide one or more of the following performance features.

(a) Reduction of the harmonic content in the output.

(b) Provision of tone correction in the L.F. amplifier.

(c) Reduction of the anode impedance of the output stage, in order to damp out the low-frequency cone suspension resonance of the loudspeaker (which is one of the main causes of "boomy" reproduction).

Fig. 2 illustrates three alternative methods of introducing negative feed-back into the output stage.

For the circuit shown in Fig. 2a, the sensitivity and harmonic output are reduced in the ratio of:—

$$r = \frac{1}{1 + gR}$$

where g is the slope of the anode-current grid-voltage characteristic at the working point.

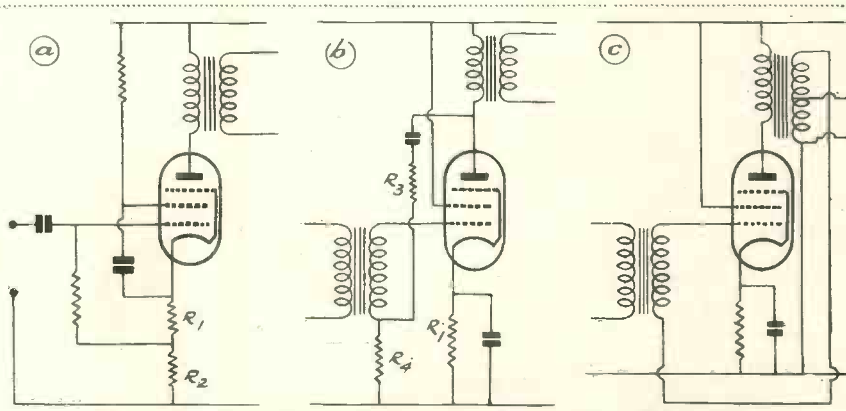


Fig. 2. Three methods of introducing feedback into the output stage.

$R = R_1 + R_2$ is the total resistance in the cathode circuit.

If R_2 is omitted, that is, if R is made to include only the cathode bias resistance R_1, the value of gR will usually lie between 1 and $1\frac{1}{2}$, and the gain and harmonic output are reduced by $\frac{1}{2}$ to 2/5. If a greater reduction is required, R_2 must be given a finite value.

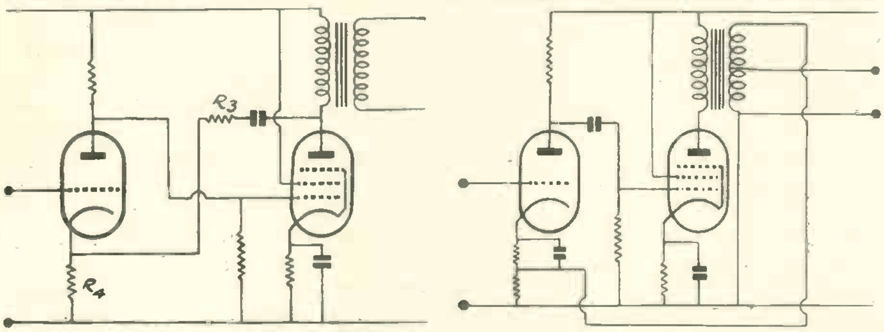


Fig. 3. Two methods of feeding back into a preceding stage. 3b corresponds to b of Fig. 2. and 3c to c of Fig. 2.

The disadvantage of this type of feed-back for the output stage is that the anode A.C. resistance is not reduced (it is actually increased by the factor $(1 + gR)$ and that the screen must be decoupled to the cathode if the expected reduction in the harmonic output is to be realised.

With the circuits shown in Fig. 2b and 2c, the anode A.C. resistance of the valve may be reduced at the same time as the harmonic output and gain. If we call R_L the effective working load transferred across the primary of the output transformer, the stage gain without feed-back is given by

$$A = gR_L$$

and the transmission of the feed-back network for Fig. 2b is

$$B = \frac{R_4}{R_3 + R_4}$$

the ratio of gain reduction due to feed-back is therefore

$$r = \frac{1}{1 + \left(\frac{R_4}{R_3 + R_4}\right) gR_L}$$

As in the majority of output pentodes or tetrodes, the anode A.C. resistance is many times the optimum anode load, its shunting effect can usually be neglected. With this approximation, the anode A.C. resistance Ra, due to the feed-back is given by:—

$$Ra = \frac{1}{Bg}$$

$$= \frac{R_3 + R_4}{R_4 \times g}$$

provided $(R_3 + R_4)$ is made large compared with Ra, which condition is easily met in practice.

In Fig. 2c the negative feed-back is obtained by using the output transformer to provide the required step-down voltage ratio.

At first sight circuit 2c appears much more satisfactory as it automatically corrects any falling off of the frequency response of the output transformer. This superiority is only obtained in practice by careful design of the output transformer in order to limit the phase shift in the feed-back network. Phase shift in the feed-back network is particularly important when dealing with transients, which are very prolific in high harmonics; in extreme cases of bad design, the phase shift may be sufficient to provide positive feed-back to the higher harmonics.

On the other hand, circuit 2b will allow mains hum ripple on the H.T. supply line to be developed across the secondary of the output transformer. The amount of hum present will be a function of the degree of feed-back, the greater the negative feed-back, the smaller the hum voltage across the secondary.

We can differentiate fundamentally between the circuits shown in Fig. 2. In (a) the feed-back is such as to provide a constant current through the load, while in (b) and (c) a constant voltage across the load.

The amount of feed-back that can be applied to the output stage is usually limited by overload of the preceding stage. When a large amount of negative feed-back is required, it is therefore necessary to apply feed-back over more than one stage, and Fig. 3 (b) and (c) illustrates the method of doing this to the circuit shown in Fig. 2. The above equations apply to these circuits provided A is the overall gain without the feed-back network.

In the preceding examples, we have only discussed methods of improving the frequency response of the L.F. amplifier. Many instances occur, however, when a predetermined shape of frequency response is required in the L.F. amplifier, either to compensate for high-note attenuation in the I.F. amplifier, or, say, to compensate for deficiencies in the loudspeaker response. These non-linear gain-frequency responses are most readily obtained with negative feed-back by incorporating suitable frequency discriminating circuits in the negative feed-back network.

Damping of Loudspeaker Resonance

Boominess in the reproduction of a loudspeaker is usually due to resonance of the cone surround.

The simplified circuit of the loudspeaker and valve at low frequencies is shown in Fig. 4 where

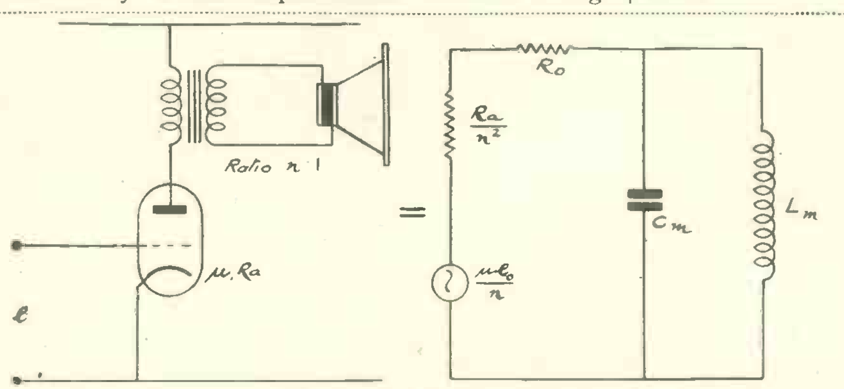


Fig. 4. Equivalent circuit of output valve and loudspeaker at low frequencies.

$\frac{Ra}{n^2}$ is the value A.C. resistance referred to the secondary

n is the output transformer ratio.

Ro is the resistance of the moving coil
Cm Motional Capacity
Lm Motional Inductance.

The resistance of the primary and secondary of the output transformer are assumed small compared with the valve and moving coil respectively.

It will be seen that if we make

$$Ro + \frac{Ra}{n^2} \text{ sufficiently small,}$$

oscillations in the tuned circuit will be damped out and the circuit will be aperiodic.

This condition is satisfied by

$$1 + \frac{Ra}{n^2 Ro} < \frac{l^2 Bg^2}{2 w m Ro}$$

where:—
Bg = flux density in the gap
w = resonant frequency × 2π
l = length of wire in moving coil
m = mass of cone (including accension)

Now in the case of a pentode without feed-back, the term $\frac{Ra}{n^2 Ro}$ is large, usually about 5 and sometimes higher, and the required damping is not provided. In the case of a triode $\frac{Ra}{n^2 Ro}$ is usually about ½.

With feed-back, the value of $\frac{Ra}{n^2 Ro}$ may be reduced at will. It should, however, be noted that below about $\frac{Ra}{N^2 Ro} = \frac{1}{2}$, the improvement is very slow, due to the transferred valve anode resistance having become lower than the moving coil resistance, and a much greater effect will be obtained by increasing Bg.

For any desired value of $\frac{Ra}{n^2 Ro}$ the amount of feed-back and the loss of gain required can be simply calculated, as from the expressions given earlier it is seen that:—

$$AB = \frac{n^2 Ro}{Ra} = \frac{R_L}{Ra}$$

$$r = \frac{1}{1 + \frac{N^2 Ro}{Ra}} = \frac{1}{1 + \frac{R_L}{Ra}}$$

If a damping effect equivalent to the use of a triode output valve is desired, a feed-back equivalent to a gain reduction of three times will have to be provided.

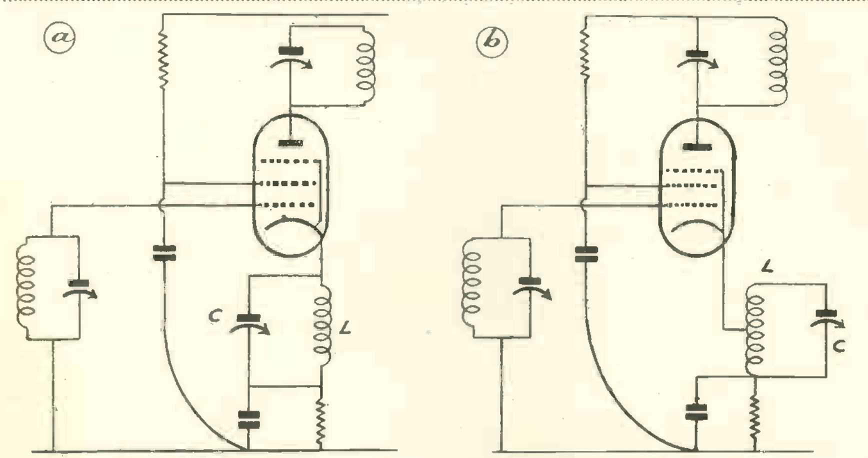


Fig. 5. The application of negative feedback to r.f. amplifiers, with cathode tuned circuit.

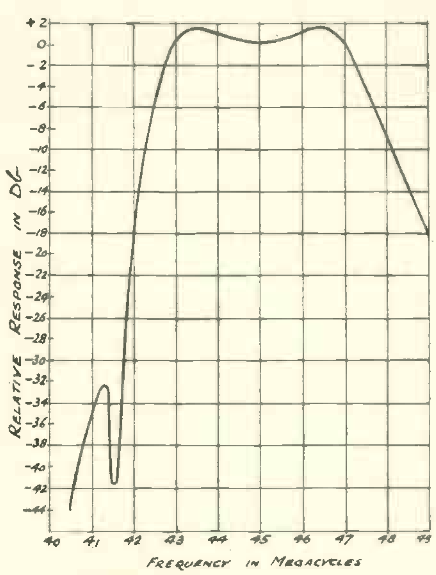


Fig. 6. Overall response curve of a television receiver showing the attenuation of the sound signal by using one of the circuits of Fig. 5.

Negative Feed-back in R.F. Amplifiers

Negative feed-back in R.F. amplifiers is usually incorporated to reject one or more unwanted signals.

While most types of negative feed-back can be employed, the type most generally used and the most fool-proof is shown in Fig. 5a and 5b. In principle it is similar to Fig. 2a, and by suitably designing the tuned cathode circuit LC, large ratios of attenuation of the undesired signal can easily be obtained. Whether circuit 5a or 5b is employed will depend mainly on the undesired frequency, the loss in the heater cathode insulator and the heater cathode capacity. In general circuit 5b is preferable at very high frequencies. Fig. 6 illustrates the overall response curve of the vision section of a television receiver. The extra attenuation of the sound frequency was obtained by the incorporation of a tuned cathode circuit in the last vision I.F. stage.

(*To be concluded next month.*)

"Ionisation Time of Thyratrons"

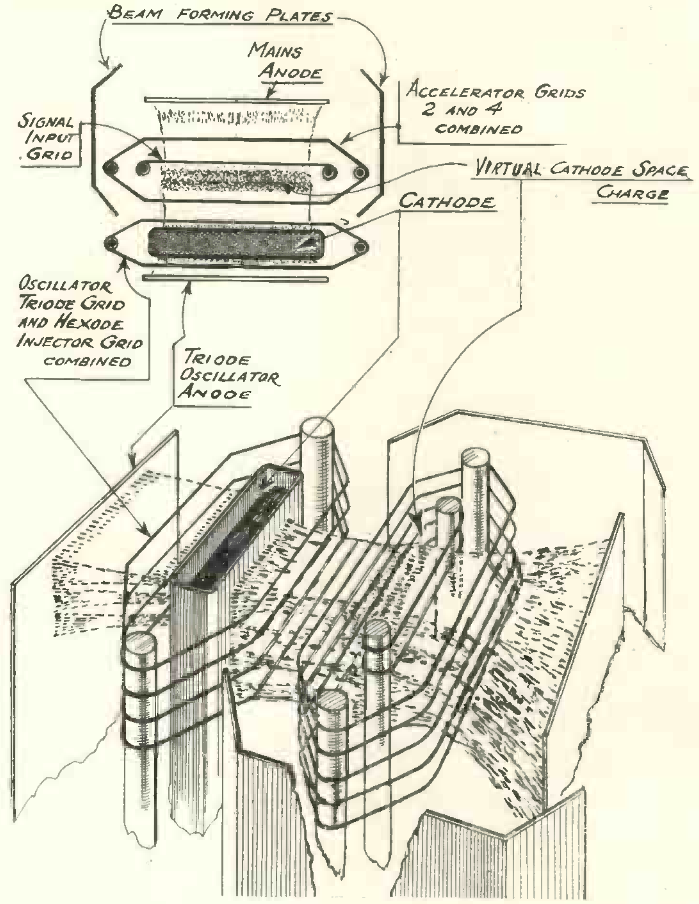
(*Continued from page 160*)

taken for each value of grid overvoltage with a fixed anode voltage. It was found that with low values of grid overvoltage the ionisation time was not much affected by the temperature of the mercury in the bulb. This temperature was measured with a mercury thermometer wrapped with tinfoil and tied against the base of the bulb, so that it was possible to obtain only qualitative indications of changes in temperature of the mercury.

The curves in Fig. 2 show the relationship between ionisation time and grid overvoltage for six of the tubes mentioned in the table. The close approximation of these curves to hyperbolic form was demonstrated by replotting them to show the reciprocal of ionisation time as a function of grid overvoltage, as shown in Fig. 3. It will be seen that these curves are of practically straight line form, with the exception of curve B, relating to a tube whose maximum grid overvoltage is high compared with the anode voltage.

All the argon-filled tubes showed a low ionisation time with overvoltages of 20 or 30 volts, and this time was not appreciably reduced by further increase of the impulse voltage. The neon-filled tubes had rather high ionisation times, as will be seen from the curves.

The Principle of The New Beam Mixer Valve



These diagrams show plan and perspective views of the electrode structure of the 6K8G new beam mixer valve, the electron trajectories being indicated by the dotted lines.

A VALVE of some considerable interest is the 6K8G which embodies design principles arrived at on the basis of efforts to eliminate the disadvantages of the old-fashioned pentagrid, type 6A8G, which as is generally known has practically the same design as its original prototype 2A7 first introduced in 1933 in the States.

It was obvious that this first pentagrid, whilst being a very great advance on all previous mixer valves nevertheless could not be considered the final solution of the problem.

Due to the fact that the 2A7 and 6A8G have rod like triode anodes situated in the shadow of the oscillator grid side rods, no direct electron can reach it and the triode anode derives its electron current from the space-charge located between the first screen grid and the signal grid.

It is obvious to those knowing the structure of this old valve that for the electrons to reach the triode anode they have to follow a parabolic trajectory causing transit time lag in the anode voltage phase relationship with reference to the oscillator grid.

This has no detrimental effect on medium and long waves though this phase lag tends to make the oscillator work at a lower frequency than the resonant frequency of the tuned oscillator circuit, which is of serious consequence on the shorter bands.

As the exact lengths of the electron trajectories are a function of the positive electrode potentials, it is obvious that the oscillator frequency will vary with the mains supply voltage. This fault is quite well known and stimulated designers to eliminate this long electron trajectory.

The New Beam Valve

In the 6K8G the triode anode obtains its electrons by straight paths direct from one side of the flat cathode and no electron can get round to the triode anode from the hexode side.

Though in America this valve is referred to as a triode hexode, a name it truly deserves, this may lead to some misunderstandings in this country as we refer to a valve as a triode hexode if the third grid of the hexode is internally connected to the triode grid.

This is not the case in the 6K8G, as will be seen from the plan and perspective sketch, as in this valve the first grid of the hexode is common with the triode grid. This means that from a circuit and operational point of view the 6K8G is really a beam pentagrid.

This valve embodies most of the new principles involved during recent years in valve manufacture, i.e., the various grids are aligned, enabling the electrons to pass through the interstices of the grids and accelerator screens in substantially straight lines, the beam formation being further assisted by the so-called beam forming plates.

The anode of the hexode is spaced somewhat remotely from the last positive grid so as to leave sufficient room between these electrodes for the formation of a negative space charge near the anode to act as a suppressor grid, just as in the 6L6G type beam power valve.

Structural Improvements

This valve also embodies some most ingenious structural refinements making it considerably more rigid than the old 6A8G and less microphonic, which is particularly useful on short-waves.

Instead of large circular grids the grids are very rigid oblong affairs, held together by mica end pieces which in turn are rigidly held together by the two anodes and the two beam-forming electrodes. The latter are not mounted on side rods as in the older valve, but have small tags which protrude through slots in the mica to which they are fixed by bending over.

The entire structure is surrounded by the usual " nutmeg grater " cage screen just as in the 6K7 H.F. pentode, thus permitting the valve to be used without an external screen, if desired.

The 6K8G has the same base connection on the usual American octal base as the 6A8G, and in most cases can be substituted without alteration.

News Brevities—

Commercial and Technical

NEW studios for the Columbia Broadcasting System are patterned on the fundamental principles of a violin, with panels of hard wood on one side and soft porous wood on the reverse. These panels have something of the appearance of aeroplane wings and are set up about two feet from the actual walls for the purpose of obtaining variable acoustics. They can be turned singly, either wholly or partly, from a central control, according to the wish of the producer.

The "acoustivanes" are the result of a series of experiments for means to facilitate governing of a variety of shading of sound quality.

* * *

Investigation has shown that there are instances where diathermy equipment which has been "keyed" so as to identify it at distant points, can be picked up thousands of miles away. Range, however, which though remarkable, is not the most serious side of the problem. The spread of this interference "all over the dial" is an even greater trouble.

* * *

The first commercial television programme to be transmitted was, it is believed, that of the Roma Wine World's Fair Party on March 2, which was broadcast simultaneously over radio and television from the Don Lee station, W6XAO.

* * *

Valves have the unique property of amplifying small voltages at low frequencies without absorbing power from the input circuit. Electrons leaving the cathode pass the grid so soon after starting out that their time in passage is usually negligible in respect to the length of a cycle. When higher frequencies are considered, however, there comes a point where an electron, leaving the cathode when the grid is at one point in the cycle, arrives when the phase of the grid voltage has changed. This state of affairs is such that the grid acts as though there were a leak from it to the cathode, and power from the input circuit is necessary. Even when the grid is biased beyond the point where grid current flows, this conductance or input admittance appears and damps the input circuit as if a resistor had been placed across it. A type 57 or comparable valve, when hot, is equivalent to 75,000 ohms across the input circuit at 15 mc., 20,000 at 30 mc., and 5,000 at 60 mc. The loading effect increases approximately with the square of the frequency. An R.C.A. 954, using much closer spacing, has an input resistance of about 55,000 ohms at 60 mc., and 15,000 at 112 mc. Large transmitting triodes may have an input resistance of only 3,000 ohms at 15 mc.

* * *

WMAL, owned by the *Washington Star*, of Washington, D.C., has been named the winner of the annual engineering efficiency award given by the General Electric Company to the N.B.C.-operated station with the lowest total of lost time through technical failures. It marks the second consecutive year WMAL has received the award. WMAL was off the air only one minute and two and one-half seconds during its regular operating schedule of more than 6,600 hours during 1939.

* * *

Some time ago we reviewed in this Journal a system of inter-communication developed by the Edison Swan Co. for use in offices. A similar equipment produced in U.S. has the addition of pilot lights, showing whether the point called is engaged and annunciator tabs to show if the station has been called during the absence of the owner. An additional handset enables the called person to cut out the loudspeaker and carry on a conversation in private.

An especially interesting installation is the Bogen communi-phone system which permits communication between elevators in a building. These are units of the "wireless" type and utilise the earthed side of the power line for one side of the circuit and actual earthing (through the car) for the other side. This arrangement eliminates the drawback in many power-line carrier systems of not being able to communicate between different phases of a power system, opposite sides of a three-wire system or between A.C. and D.C. power lines. Such a system as this, operating two-way, can solve many problems involved in the efficient operation of elevators.

* * *

The American Time Products Co., of U.S.A., use an ingenious apparatus for checking the timekeeping qualities of clocks and watches. A two-channel amplifier is used, one portion of which is connected to a standard tuning fork. The output of this is used to drive a drum from a small synchronous motor at a speed of 300 r.p.m. The other amplifier is fed from a microphone and actuates a stylus which marks the drum. When the watch to be regulated is placed on the microphone the tick causes a dot to be marked on the drum, and if the watch is beating at 300 ticks per minute (an average rate), there will be one mark per revolution.

If the watch is neither gaining nor losing the dots made on the drum will be in a straight line across the paper, the stylus being made to travel slowly across the drum as it revolves.

A losing or gaining watch will cause the dots to form a line which slopes across the drum, the inclination of the line showing the rate at which the watch differs from the standard timing.

* * *

A correspondent, Mr. W. I. Flack of Fulham, makes the following suggestion regarding the use of television receivers during the period of the war. He says:—

Now that it is certain that the television service will not be resumed during the war, I would suggest a new field of interest to television enthusiasts.

It has long been known that so-called freak reception of television signals at long distances is possible, amongst them being such occasions as the reception of vision and sound signals from the Alexandra Palace by N.B.C. engineers in New York, the reception of sound signals in South Africa, the continuous reception of sound signals in the Channel Islands, and also vision signals from Rome received there.

More recently there was brought to my notice the reception in England of sound signals of the N.B.C. programmes from New York; doubtless there are other occasions on which long-distance reception has been attained, but the above instances, in my opinion, are sufficient to show great possibilities in this direction.

I would suggest, therefore, that some endeavour be made to receive signals from both America and Italy where regular television programmes are being transmitted.

I do not suggest that regular programme reception is possible, but if sufficient data were to be obtained of signals received and results collated, then it might be a great step to the eventual reception of long distance television, even though at the moment it is considered as freak reception.

Short-wave enthusiasts would also find this a new field of interest.

* * *

The N.B.C. television programmes are transmitted on five days a week as follows :—

English Summer Time.

Wednesday.—8.30-9.30 a.m.
2.30-3.30 p.m.
Thursday.—2.30-4.0 p.m.
Friday.—8.30-9.30 a.m.
2.30-3.30 p.m.
Saturday.—8.30-9.40 a.m.
3.0-5.0 p.m.
Sunday.—8.30-9.46 a.m.
2.30-3.30 p.m.

The vision frequency is 45.25 mc. and the audio frequency 49.75 mc. The programmes are transmitted via New York City, under the call sign W2XBS. The periods in New York are, of course, afternoon and evening.

The Institution of Electronics

Lecture on Wave Mechanics

On April 4, Professor D. R. Hartree, M.A., F.R.S., will give a lecture on "Wave Mechanics" before the Institution of Electronics. The meeting will be held in the lecture hall of the Royal Society of Arts, John Street, Adelphi, London, W.C.2, at 6 p.m., and tickets of invitation can be had on application to Mr. Alex. H. Hayes, the secretary of the Institution, at 27 Fetter Lane, London, E.C.4.

Book Review

Television To-day and Tomorrow, by Sydney A. Moseley and H. J. Barton Chapple (Sir Isaac Pitman and Sons, Ltd., 10s. 6d.).

This book is a fifth edition of a publication which has for its purpose a complete survey of television development in this country. It is, therefore, to a considerable extent historical but it does at the same time provide adequate explanation of each item of progress that has been made. This edition has, of course, been brought up to date and includes such developments as big-screen and colour television. It is very well illustrated with photographs and diagrams.

A Projection Kaleidoscope for Television

A "VISUAL curtain" for television, with changing multiple patterns, is described in "Communications" (New York). The device has been developed by William C. Eddy, video effects engineer of the National Broadcasting Company.

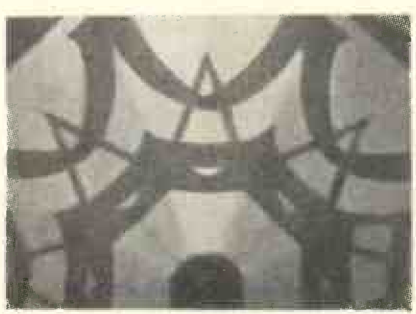
A combination of projectors, mirrors and a lens system constitutes the projection kaleidoscope. The instrument has been used during N.B.C.'s television programmes and has met with enthusiastic audience approval.

The device projects the moving and abstract designs directly on to the plate of the Iconoscope. Eddy describes his device as "a projection kaleidoscope in which pictorial material is multiplied quadrentially by means of mirrors placed at angles to each other.

Although the whole device simulates the general action of the common form of kaleidoscope, new arrangements of mirrors and lenses were necessary to adapt it for television work. Through the use of more than one projector, it is possible to superimpose a second design against the moving kaleidoscopic pattern.

Any design can be reproduced and multiplied in the projection kaleidoscope.

Since the patterns consist, essentially, of shifting light values,



Example of a pattern produced by the projection kaleidoscope.

manual control of light volume is impossible. An automatic gain control is, therefore, incorporated in the unit.

The material to be multiplied in the kaleidoscope is recorded on film, the film being fed continuously through an intricate gate system, thus permitting the constant movement necessary for the formation of this type of abstract design. The rate of feed is less than one foot of film a minute and it has been reduced to as low as the equivalent of three motion picture frames a minute, or five minutes to the foot of finished film. The usual rate of feed is about one one-hundredth the speed of film in motion picture projection.

Nearly a year was spent in perfecting a satisfactory method of recording material for projection on film and synchronising it against a musical score. It is stated that practically any musical device may be given a visual counterpart through the kaleidoscope method.

New Tungsram Frequency Changer

Type 6E8-GM.

A new octal-based triode-hexode has recently been introduced for use in conjunction with the American type octal range valves.

It is very useful for the manufacturer of modern all-wave receivers for either A.C.-A.C./D.C. or vibrator battery supplier, as owing to its 6.3 volt 0.3 amp. heater it can be run either in parallel or in series heated circuits.

The characteristics are as follows :—
Conversion conductance = 0.65 mA/V.
Optimum heterodyne voltage = 10 volts r.m.s.
Hexode anode voltage = 250 volts.
Hexode screen voltage = 100 (or fed through 50,000 ohms from 250 V.).
Signal grid voltage = −2 to −20 volts.
Triode conductance = 2.8 mA/V.
Triode anode voltage = (fed through 30,000 ohms from 250 volts).
Optimum triode grid leak = 50,000 ohms.
Total screen current = 3 mA.
Hexode anode current = 2.3 mA.
Triode anode current = 3.3 mA.

The 6E8-GM has a floating screen voltage characteristic resulting in a conversion conductance curve which is practically pure logarithmic function of the input voltage and hence the valve has considerably reduced cross modulation and lower noise level. Due to the separation of the two systems in the valve the frequency drift on short waves due to A.V.C. or variation of supply voltage is reduced to a negligible quantity.

Transit time effects have been reduced so that at 25 megacycles the kinetic grid current at normal grid bias is only 2-3 uA. The input impedance at this frequency is of the order of 15,000 ohms.

The price of the Tungsram 6E8-GM is 11s. 6d., the same as that of other frequency changer valves.

Horizontally Polarised Waves and Wide-band Loop Antennas

FOR some time now it has been recognised that in the reception of waves of a few metres length the use of a horizontal polarisation is attended by certain advantages. It is found, for example, depending on circumstances, that a quite appreciable reduction in "noise" interference is

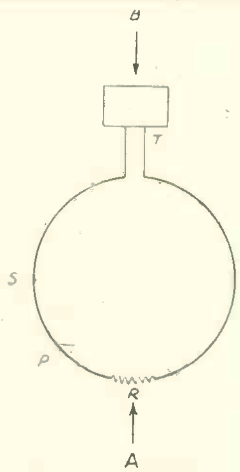


Fig. 1. Diagram showing principles of loop form of Beverage antenna.

very often obtainable; and if the receiving antenna is placed at a sufficient height above the ground, say, at least about five metres, then on account of the difference in the reflection coefficients at the ground for horizontal and vertically polarised waves there is a considerably greater field strength available by using a horizontally polarised wave.

In the United States these advantages have been seized upon in the field of television and an antenna in very common use is the horizontally arranged dipole with reflector for the purpose of giving the antenna a certain amount of directivity. Such an antenna is relatively sensitive, but in regions of fairly high field-strength where sensitivity is not so important an improvement from the point of view of selectivity can be obtained by utilising, instead of a dipole antenna, an antenna of loop form operating on the general principles of the old Beverage antenna.

The ordinary dipole, as is well known, is a resonant system, and therefore, unless special precautions are taken, tends to attenuate the outer side bands of any wide-band transmission such as that of television. There, therefore, tends to be a loss of the higher frequencies and consequently of fine detail in a television image. Any Beverage type of antenna, however, is essentially characterised by its aperiodicity, and so is particularly suited to the wide-band television type of transmission. Moreover, it can be designed to possess a usefully directive diagram, and therefore does not suffer any disadvantage as compared with a dipole on that score.

The principles of the loop form of Beverage antenna referred to may be made clear from a discussion of the antenna indicated diagrammatically in Fig. 1. The antenna is simply a circular loop having at one point on its circumference the transmission line T connected to it for feeding received signals to a receiver and at an opposite point a resistance R inserted of such value that any waves travelling round the loop in the direction of the resistance R are completely absorbed by it; in other words the resistance R is matched to the characteristic impedances of the arms of the loop.

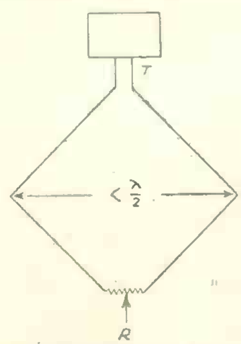


Fig. 2. Rectangular arrangement of loop antenna.

The transmission line T is likewise matched. If a wave is incident upon the loop in the direction shown by the arrow A there will be induced at any point, shown as P in the loop, current disturbances which will immediately propagate away from the point P, one in the direction of the resistance R and the other in the direction of the transmission line T. The former is absorbed in the resistance R, but the latter on reaching the line T is fed to the receiving apparatus. The total signal that travels down the line T is thus the sum of all the disturbances arising at points such as P.

Those disturbance currents arriving at T from points nearer R will be advanced in phase on account of the fact that they have been generated at points nearer the source of the incidental wave, but they will be retarded more so by reason of the fact that they have had to travel over the length of arc PT which is considerably greater than the distance the incident wave travels between the points P and T; thus there is a continual lagging in the phase of currents arriving at T the nearer to R their origin. This is true, bearing in mind that at the mid-point between R and T, the point indicated by S, there is an abrupt change of phase of 180 degrees. At this point the induced-current amplitude is zero; on either side it increases as the point is moved away from and the amplitudes are equal for equal distances from S.

With such a system of induced cur-

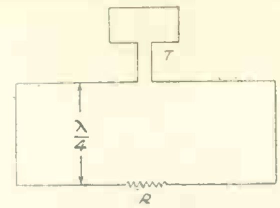


Fig. 3. Another rectangular arrangement.

rents it is possible so to dimension the loop that the resultant current arriving at the line T is zero. This will *not* entail, of course, that the system of currents due to a wave arriving in the direction indicated by the arrow B will also add up to zero; in this case there is actually a maximum signal fed into the line T. The system of currents at T for this case is of the same general nature as in the already-described case, except that there is a much more rapid lagging of phase as the point of origin is taken nearer to R; this is due to the fact that not only is there retardation on account of the wave having to travel from the point of origin to T, but there is also retardation in view of the fact that the point of origin of the disturbance is further removed, not nearer as

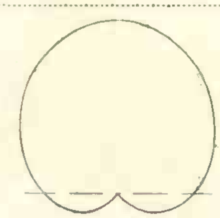


Fig. 4. Directional diagram of cardioid form.

in the previous case, from the source of incident wave.

It would, of course, be possible to arrange that this system of currents should add up to zero, but in that case there would be a maximum of sensitivity for waves arriving in the direction of the arrow A. Fig. 4 gives an indication of the kind of directional diagram obtainable with the antenna. The cusp shown corresponds to the direction of zero sensitivity. To obtain this zero, various sizes of loop are possible, but the minimum possible diameter is somewhat less than half a wavelength, and it is for this case that the directional diagram is of the cardioid form shown in Fig. 4.

(*Continued in 3rd column of page 170*)

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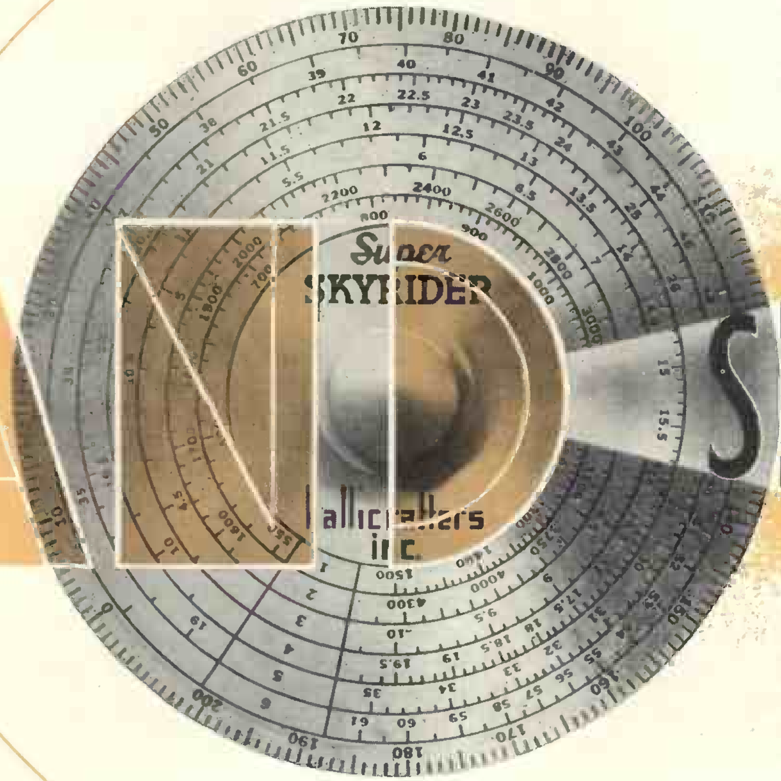

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1940 is destined to bring to the "above the ordinary listener" an instrument which is known and used throughout the professional radio world as a "communication receiver." These receivers differ considerably from the "broadcast" type of instruments with which we have endeavoured to obtain efficient short wave results—often of a very disappointing nature.

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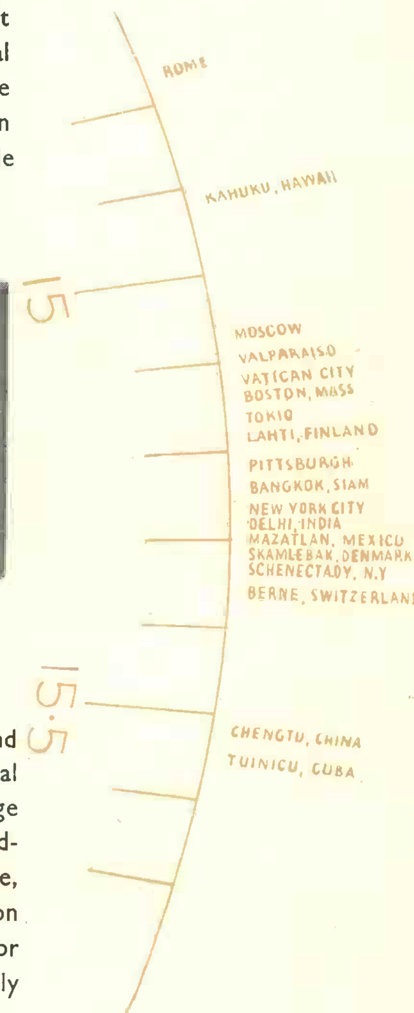
The Hallicrafter SX-24 incorporates many new features besides the new electrical BANDSPREAD and Dickert Noise Limiter. A built-in frequency meter and accurate calibration of the main dial assure extremely easy location of stations whilst the double-balanced crystal filter gives knife edge selectivity. Provision is made to plug in headphones, thus automatically disconnecting the loudspeaker. Overall sensitivity and signal-to-noise ratio are both very high and the audio response, broad. The SX-24 offers performance that can be favourably compared to any communication receiver regardless of price and it has all the desirable features and qualities that are needed for outstanding reception. The metal cabinet is finished instrument grey and all controls are cleanly marked.



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Television Transmission over Telephone Wires

By G. L. Weis, Bell Telephone Laboratories

THE utilisation of ordinary telephone circuits to link remote pick-up points to the television studio is difficult because of the much wider band of frequencies employed and certain exacting requirements for television transmission. Because of the experimental state of television at the present time, no arrangements for transmitting from remote pick-up points have as yet been standardised though experimental circuits of this nature have been provided for by the National Broadcasting Company, and the Columbia Broadcasting System.

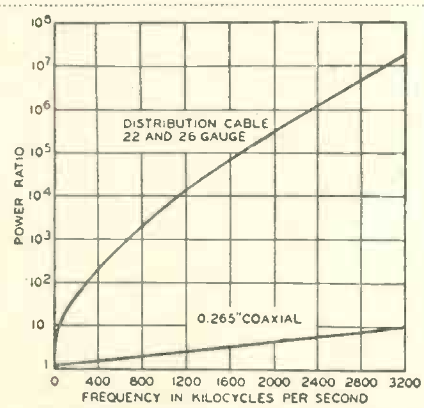


Fig. 1. Curves showing losses in one mile of experimental telephone and coaxial-cable circuit over the television frequency range.

The difficulties encountered in transmitting over telephone circuits are due largely to the very wide frequency band required. For ordinary telephone circuits a frequency band of about 3,000 cycles is sufficient, while for television transmissions the band extends from 45 to over three million cycles—a range of a thousand times greater than the ordinary broadcast band. The effect of the difference in frequency range on loss is indicated in Fig. 1. This shows the energy loss in one mile of local telephone cable made up mostly of 22 and 26 gauge paper-insulated pairs. The loss in a co-axial cable, which is especially suited for television transmission, is shown in the same illustration for comparison.

At three million cycles, a mile of cable pair gives a loss a million times greater than that of a coaxial conductor of similar length. For satisfactory television transmission, equalisers must be provided to make the overall loss essentially the same for all frequencies. The variation in loss over the equalised line is within plus or minus one-half db.

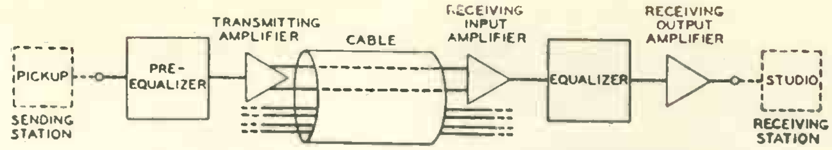


Fig. 2. Block diagram showing arrangement of equalisers.

Besides this variation in loss with frequency, there is also a variation in the time of transmission. This variation is too small over the sound range to require correction for ordinary telephone circuits. For television transmission, however, if it is not kept extremely small the detail of the picture will be blurred, and spurious transients and "ghosts" will appear. Before a cable pair can be used for television, therefore, it is necessary to measure the transmission time, and then to provide phase equalisers to correct it. The equalised line maintains the same transmission time to within plus or minus 0.1 microsecond.

In addition to the phase and attenuation equalisers required by such circuits, high-gain amplifiers are needed to overcome the very large losses encountered. These amplifiers provide a flat gain over the entire range of frequencies from 45 cycles to 3,000,000 cycles. Their design is complicated by the fact that the cable pairs are balanced, that is, each wire of the pair has the same impedance to earth, while the television apparatus—in common with most high-frequency apparatus—is earthed on one side.

Relatively large currents are likely to be induced on both conductors of a cable pair from nearby power circuits and other noise sources. These currents flow equally over both conductors of a pair, which with the earth return comprise the longitudinal circuit. If the circuit, including its termination, is balanced throughout, these currents cannot affect the signal currents flowing in the metallic circuit.

With an unbalanced amplifier terminating the circuit, the longitudinal currents would enter the metallic circuit, and appear as bar patterns on the received picture. This difficulty is avoided in this case by applying negative feedback in the amplifier to the longitudinal circuit but not to the metallic circuit currents. This, in conjunction with vacuum-tube balances, results in a reduction of 75 db in these induced currents. This feedback is applied both to the output stage of the transmitting amplifier and to the input stage of the receiving amplifier.

The arrangement of the apparatus for the C.B.S. television experiment is indicated schematically in Fig. 2. Amplification and equalisation were provided at both ends of the circuit. The effect of the equaliser at the transmitting end is to predistort the signals, sending out the high frequencies at a level much higher than if equalisation were not employed. This tends to decrease the effect of any high-frequency noise, since the induced currents become smaller relative to the higher level of the signal currents. At the receiving end, the equaliser is placed between two sections of the receiving amplifier. This results in a higher level at the input to the receiving amplifier and minimises the valve noise, the mains hum, and the microphonic disturbances. The two amplifiers divide the total gain of about 75 db. They operate on power circuits, and with their equalisers and power supply are mounted in small portable cabinets.

"Horizontally Polarised Waves and Wide-band Loop Antennas"

(*Continued from page 167*)

It is not necessary that the form of the loop should be circular for the principle employed is quite a general one and Figs. 2 and 3 illustrate rectangular arrangements. In Fig. 2 to obtain the cardioid of Fig. 4 it is necessary that the diagonal should be somewhat less than half a wavelength, and in Fig. 3 all the linear conductors from which the loop is formed are about a quarter of a wavelength in length.

The loops may be constructed of tubing of about half an inch in diameter and may therefore be practically self-supporting. A suitable value for the resistance R with this type of conductor is about 700 ohms. An antenna constructed on these lines was found to possess an almost constant diagram for as wide a range of frequencies as from 45 to 100 megacycles per second.

This development is reported from the R.C.A. laboratories.

A RECORD OF PATENTS AND PROGRESS

RECENT DEVELOPMENTS

PATENTEES

The M-O Valve Co., Ltd., and G. W. Warren :: Kodak Ltd. :: Kolster-Brandes Ltd., and C. N. Smyth :: Marconi's Wireless Telegraph Co., Ltd., and G. B. Banks :: Marconi's Wireless Telegraph Co., Ltd., and L. E. Q. Walker :: The British Thomson-Houston Co., Ltd., H. Trencham and F. A. Tuck :: Societa Anonima Fimi.

High-impedance Valves
(Patent No. 508,724.)

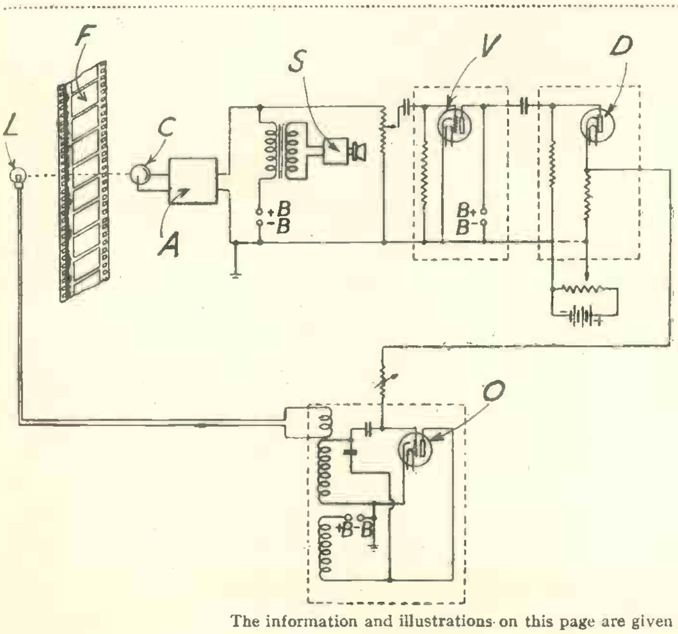
RELATES to a valve in which a cathode, a control grid, an auxiliary electrode, an accelerating electrode, and an anode are set in line, and the auxiliary electrode is so biased that it drives the electrons through gaps formed in the accelerating electrode, thus preventing them from striking it. The present improvement consists in so arranging matters that any secondary electrons liberated by impact from the anode are almost wholly prevented from returning to the accelerating electrode, even when the latter is at a relatively-high positive potential.

Such a valve is said to have certain advantages over the ordinary tetrode or pentode type. It may, for instance, be given an anode impedance of over one megohm. At the same time, owing to the very small secondary current from anode to accelerator, the " noise level " of the valve is very low.—*The M-O Valve Co., Ltd., and G. W. Warren.*

Photo-electric Reproducers
(Patent No. 508,950.)

The figure shows a sound reproducer for a talking film in which the frequency-range is automatically expanded in order to secure greater fidelity. The light from a lamp L passes through the film F on to a photo-electric cell C, the output from which, after being amplified at A, is fed to the loudspeaker S.

A part of the output from the cell C is also passed to an amplifier V and a detector D, and the resulting voltage is used to control the power generated by an oscillator valve O. The oscillator O, in turn, controls the amount of light emitted from the lamp L, so that any increase in the amplitude of sound in the loudspeaker thus serves to strengthen the sound still more. In other words the volume is automatically "expanded" in such a way as to offset the contraction which inevitably occurs when the original studio performance is recorded on the sound-track of the film. —*Kodak, Ltd.*



Talking-film reproduced with automatic frequency-range expander. Patent No. 508950.

" Contrast " Control
(Patent No. 510,715.)

Contrast control is applied to a television receiver through the negative feed-back developed across a resistance common to the anode and cathode circuits of the vision amplifier. At the same time the D.C. component required to reproduce slow changes of illumination is restored by a diode valve, which is shunted across the anode of the vision amplifier to a point on a potentiometer bridging the feed-back resistance.

The method has the advantage that regulation of the contrast does not noticeably affect the frequency response of the pentode amplifier. Similarly the method of restoring the D.C. component does not result in undesirable changes in the mean brightness of the picture. The latter is controlled by a tapping from the grid of the cathode-ray tube to a potentiometer bridging the H.T. supply.—*Kolster-Brandes, Ltd., and C. N. Smyth.*

Electron Multipliers
(Patent No. 511,449.)

The invention relates to the use of an electron-multiplier as a means of improving the performance factor or mutual conductance of a thermionic amplifier. An external winding applies a magnetic field which causes the primary electrons to leave the cathode of the valve in two oppositely-curved paths. They then pass through a positively-biased grid, which forces them through an "open" anode on to a target electrode, which is coated with a substance having a high coefficient of secondary emission.

As a result of the impact, each primary electron releases several secondary electrons, and the resulting stream, multiplied several times, is finally collected by the anode. The special arrangement of the electrodes is designed to prevent any barium atoms given off by the indirectly-heated cathode from reaching the sensitised target electrodes and so spoiling their emissivity.—*Marconi's Wireless Telegraph Co., Ltd., and G. B. Banks.*

Television Systems
(Patent No. 512,571.)

It is usual to transmit sound and

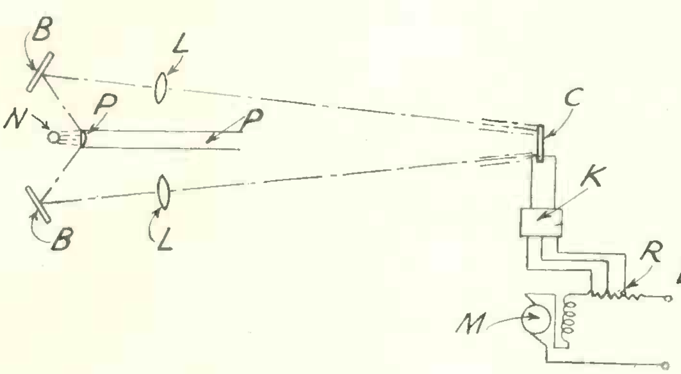
picture signals on separate carrier waves, one of which is modulated with a frequency-band of, say, 1½ megacycles, whilst the other carries a signal-band of only 10,000 cycles. The latter presents no difficulties in amplification, but it is very difficult to design amplifiers capable of dealing faithfully with the wide band-spread of the picture signals.

The problem is solved, according to the invention, by distributing the total band of signal frequencies more equally between the two carrier-waves.

For this purpose, the band of picture signals is first divided into two halves, and the upper half is allotted to the first carrier-wave. The lower half is then heterodyned, and so converted into the same frequency as the first half. A band of frequencies corresponding to 10,000 cycles is then abstracted from this second band —so as to make room for the sound frequencies—and the two are then modulated on to the second carrier-wave. The process is, of course, reversed in reception.—*Marconi's Wireless Telegraph Co., Ltd., and L. E. Q. Walker.*

Below : Photo-electric arc control. Patent No. 513,851.

Right : Photo-electric remote control. Patent No. 517,033.



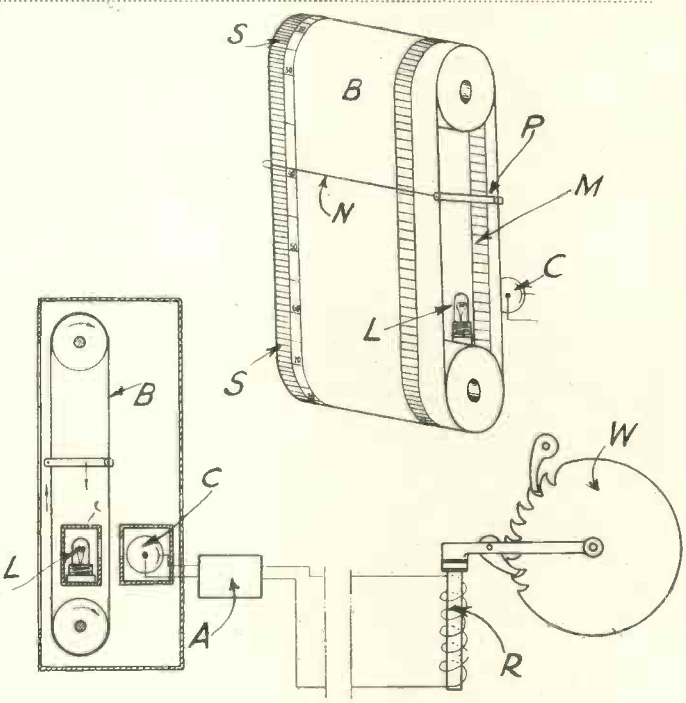


Photo-electric Arc Control

(Patent No. 513,851.)

In a projection arc-lamp the positive carbon must be gradually fed forward towards the negative carbon, so as to compensate for the gradual burning away of the positive carbon by the crater formed in it. It is also desirable to control this movement so that the crater is always accurately positioned with respect to the optical system associated with the arc-lamp.

According to the invention, the feed is automatically controlled by means of a photo-electric cell. As shown in the drawing, the positive carbon P is normally driven forward by a motor M. To regulate the speed of the latter, some of the light from the discharge-gap between the positive and negative electrodes P, N is focused by mirrors B and lenses L on to the opposite edges of a photo-electric cell C. Should any abnormal shift of the crater occur, the effective amount of light falling on the cell C will alter, so that a relay K is operated to cut in or out some of the resistance R in series with the field-winding of the motor M. The use of two mirrors prevents the motor M from responding if the crater merely shifts to one side or other of the centre of the positive carbon.—*The British Thomson-Houston Co., Ltd., H. Trencham, and F. A. Tuck.*

Photo-electric Remote Control

(Patent No. 517,033.)

Relates to an arrangement for controlling movements step by step at a distance by photo-electric means. The scheme can, for insance, be used for the remote tuning control of a wireless set.

The endless band B, Fig. 1, is marked on one side with a tuning scale or station-indicators, and on the opposite side is provided with a number of perforations or slits M. As the pointer F is moved to bring the needle N opposite to a desired station, it causes a certain number of the slits M to pass between a lamp L and a photo-electric cell C.

Each slit produces a current impulse in the photo-electric cell. These are amplified at A, as shown in Fig. 2, and are then applied to operate an electromagnetic relay R, which drives a ratchet wheel through a corresponding number of steps. The spindle of the tuning condenser of the wireless set is thus caused to rotate, step by step, so as to tune the circuits to the selected programme.—*Societá Anonima Fimi.*

Summary of Other Electronic Patents

(Patent No. 507,270.)

Valve cathode formed with a number of straight or curved emitting surfaces each of which is associated with parallel rod-like control grids and anodes.—*Standard Telephones and Cables, Ltd.*

(Patent No. 508,065.)

Piezo-electric oscillator for applying supersonic pressure waves to a light-modulating cell.—*Scophony, Ltd., J. Sieger and F. Okolicsanyi.*

Patent No. 508,373.)

Rotating disc scanner for film television adapted to be driven from the electric mains.—*Radio-Akt. D. S. Loewe.*

(Patent No. 508,995.)

Preparing the sensitive electrodes used in television transmitters of the Iconoscope type, and in electron multipliers.—*Electrical Research Products Inc.*

(Patent No. 513,157).

Electron-optical arrangement of electrodes for focusing the beam in a cathode-ray tube.—*O. Klemperer.*

PHOSPHORESCENT PHOSPHORS

By Leonard Levy, M.A. (Cantab.), D.Sc. (Lond.), F.I.C., and Donald W. West, A.C.G.I., A.I.C.

The following is an abstract from a recent lecture by the authors named above given before the Institution of Electronics at the Royal Society of Arts, Adelphi.

IT was the authors' original intention that the subject matter dealt with should have been concerned with the more recent developments in the uses of luminescent substances for television, lighting, etc., but owing to the outbreak of hostilities it was decided to deal with one class only of luminescent substances, namely, those that are produced primarily for their phosphorescent, as distinct from their luminescent qualities.

When uniform ultra-violet radiation is absorbed by a luminescent substance, the latter generally emits visible radiation. The intensity of this radiation builds up rapidly to a maximum; the time interval elapsing between the incidence of the exciting radiation and the attainment of this maximum is in most cases very short. In the case of most of the zinc and zinc cadmium sulphide phosphors, a moderate period of time elapses before this maximum is attained. The illumination then remains at a constant value (except in certain circumstances) until the exciting radiation ceases to function.

In the case of luminescent substances which display only fluorescent effects, and are practically devoid of phosphorescence, the illumination falls to zero in an extremely small fraction of time after the source of radiation has ceased to function. In the case of phosphorescent phosphors, energy is stored in the molecule and is emitted slowly over a subsequent period of time. The intensity of the emitted radiation declines exponentially, but the shape of the decay curve varies very greatly with the type of phosphor employed.

The first luminescent substance to be produced artificially was prepared by strongly heating barium sulphate mineral, and as organic matter or some other reducing agent was present, a certain amount of barium sulphide was produced, thus giving the luminescent properties.

The majority of luminescent substances are required for their fluorescent rather than phosphorescent effects, and can be classified as follows:

(a) Phosphors which are required for their fluorescent effects, in which the presence of phosphorescence is immaterial; for example, phosphors for radio-active luminous paint, for gas discharge tubes and for illumination by longwave ultra-violet light.

(b) Phosphors required for their fluorescent effects, in which absence of any appreciable phosphorescence is essential; for example phosphors required for the manufacture of X-ray screens and for cathode-ray tube screens for television.

(c) Phosphors required for their fluorescent effects, in which a relatively intense phosphorescence of the same colour as that of the fluorescence and of short duration is desirable. Such phosphors are of utility in gas discharge tubes, as they assist in reducing flicker caused by the use of alternating current.

(d) Phosphors in which the phosphorescence is the main or only requirement. Certain types of cathode-ray tubes employed for electro-cardiographs and other purposes are required to show a visible trace on the screen after the exciting beam has ceased to function. Such screens must be constructed of phosphors showing considerable phosphorescence. The most suitable one is a zinc sulphide phosphor with a copper activator.

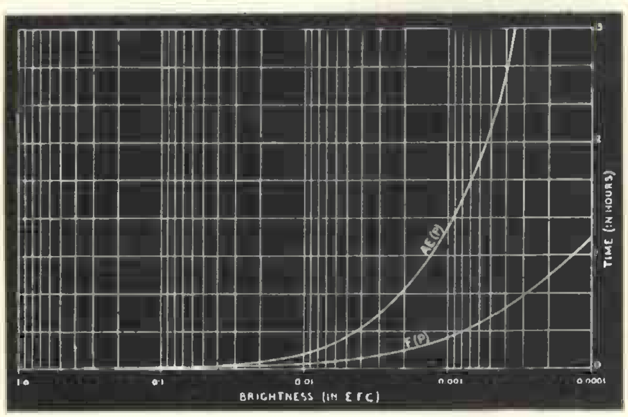


Fig. 1. Decay curves for AE(P) and F(P) type powders excited by standard source described in B.S./A.R.P./18, Dec., 1939.
F(P) coating Density = 0.28 kg. per sq. metre. AE(P) coating density = 0.2 kg. per sq. metre.

The most extended use of phosphorescent phosphors is for the manufacture of luminous paints, plastics and the like, which are now finding extensive application owing to the black-out.

In this instance the fluorescence of the phosphor is of no importance; the main factor required is an ability to store as much energy as possible and to emit it slowly in the form of luminous radiation over a period of at least 12 to 14 hours. It is furthermore essential that the luminosity at the end of the 12 to 14 hours period is still sufficient to enable the paint or plastic to be perceived readily by a sensitive eye. Two different types of phosphor are employed for the production of phosphorescent paints and plastics:—Zinc and zinc cadmium sulphide phosphors and alkaline earth sulphide phosphors. These two types differ very considerably in their properties.

Zinc and Zinc Cadmium Sulphide Phosphors

Zinc and zinc cadmium sulphide phosphors display the following characteristics: they are relatively stable and can be used in a variety of paint media. They display a very intense fluorescence followed by a strong initial phosphorescence which, however, declines from that of the fluorescence and is always of greater wavelength. The most intense phosphorescent effects are displayed by phosphors fluorescing from orange to green. The phosphorescent effects displayed by red and blue fluorescing phosphors are very slight.

Fig. 1 shows the decay curve of the phosphorescence of copper-activated zinc sulphide phosphor known as F (P). The initial brightness of this material after irradiation by an Osira black glass ultra-violet mercury vapour lamp of 125 watts at a distance of 3 feet is about 5 equivalent foot candles.

Alkaline Earth Sulphide Phosphors

Alkaline earth sulphide phosphors constitute the oldest types of luminescent materials known. Their chemical stability is very low. They are readily attacked by moist air with the evolution of sulphuretted hydrogen and gradual loss of luminescent properties. The fluorescence is not particularly good, even the highest is not equal to

Excitation

that displayed by the best zinc and zinc cadmium sulphide phosphors.

The initial intensity of the phosphorescence of the best preparations is not quite so great as that of the zinc and zinc cadmium sulphides, but the intensity curves cross in a very short space of time, after which the intensity of the phosphorescence of the alkaline earth sulphide phosphors is much greater than that of the zinc and zinc cadmium sulphide types. (See Fig. 1). The intensity of the phosphorescence is high enough to be of utility for as long as 12 to 14 hours after final exposure to light.

The slow rate of decline of the phosphorescence of the alkaline earth sulphide phosphors is a very valuable property, but the intensity after a few hours after excitation has, until recently, been too low to render these substances of much practical value.

Considerable advances have recently been made in the preparation of phosphors of this type and the best of them has proved to be strontium sulphide phosphor, which displays a slightly greenish-blue fluorescence and phosphorescence of similar colour.

The best barium sulphide phosphors so far prepared do not exhibit phosphorescent properties of practical interest. The phosphorescence is reddish orange, but is of lowish intensity and persistence.

The phosphorescence displayed by strontium sulphide phosphors is much greater. It is intensely luminescent for some time after exposure, and even after 12 hours is brighter than calcium sulphide phosphor after a comparatively short period.

The barium and calcium sulphide prosphors are now of little or no practical importance, and the remainder of this paper is confined entirely to the consideration of certain characteristics of the most modern type of strontium sulphide phosphors.

Strontium sulphide phosphors can be excited by various light sources, the spectral composition of which is naturally very different. For example, daylight, light from gas-filled tungsten filament lamps, gas discharge tubes containing carbon dioxide or the ultraviolet radiation transmitted through nickel oxide glass (the so-called "black lamp") can all be employed as exciting sources. The shape of the decay curves (Fig. 2) of the phosphorescence excited by these various types of radiation differs, but this difference is not believed to be due to any actual difference in the shape of the curve, but rather to the initiation of the illumination commencing on different parts of the first portion of the same curve.

The most intense initial phosphorescence is obtained by daylight excitation, on account of the much greater amount of energy incident on the surface, the illumination immediately after excitation by average daylight being of the order of 1.5 equivalent foot candles, depending upon the actual specimen of powder, thickness of coating, mode of application, etc. The initial brightness of strontium sulphide phosphor excited by other sources is as follows:

B.S.I./18 Standard Source 3ft. 0.1 e.f.c.
125 W. Black Glass Lamp 3ft. 1.0 e.f.c.
200 W. Tungsten Black Glass Lamp 3 ft. 0.02 e.f.c.

Strontium sulphide phosphors are not excited well by wavelengths shorter than about 3,000 AU, the limiting wavelength causing excitation is 4,500 AU. This can be simply demonstrated by projecting a continuous spectrum upon a screen of the phosphor.

The majority of artificially produced phosphors are very sensitive to mechanical stresses. Grinding, for example, in many cases, greatly reduces the intensity of the luminescent effects displayed by them. This phenomenon is displayed by alkaline earth sulphide phosphors to a rather greater extent than by other types, although some of the zinc and zinc cadmium sulphide phosphors are very sensitive to grinding as well.

The energy stored in the molecule is released much more rapidly if the phosphor is warmed; thus the brightness produced is much greater, but persists for a much shorter period of time. This effect is also produced by infra-red radiation of long wavelength, which, on absorption, increases the temperature. This must be contrasted with the effect produced by exposure to infra-red radiation of short wavelength. In this case the result is totally different, the phosphorescence being more or less completely extinguished.

Alkaline earth sulphide phosphors do not attain their maximum fluorescent and phosphorescent intensity until they have been exposed to the incident radiation for a period of time. This period varies with the type of incident radiation. It is quite short with strong ultra-violet radiation given by a black lamp, but is much longer if the source of radiation is the light from a tungsten filament lamp (after passing through a suitable filter to remove most of the visible radiation). The final brightness attained with different types of radiation is also different.

The instability and other qualities of alkaline earth phosphors have necessitated the development of special paint media in which they are incorporated. Such media must be without any action upon the phosphors and must therefore obviously be free from acid. They must also be of a highly waterproof nature, as otherwise atmospheric moisture will gradually attack the phosphors.

The weight of phosphor per unit area of painted surface affects the maximum brightness obtainable. The brightness increases with increase of coating weight when the amounts are small, rising to an approximate maximum value after a certain coating weight has been attained. This amount represents the most effective coating weight for the phosphor in question. Large increases of coating weight above this amount, even to double, only increase the brightness by 2 to 3 per cent.

Phosphorescent paint can be applied either by painting or by spraying, but in the latter case a finer particle size is required and the resulting maximum illumination obtainable is diminished.

Owing to their instability it is more difficult to produce a satisfactory phosphorescent vitreous enamel from alkaline earth sulphide phosphors than in the case of the zinc sulphide phosphors, and a satisfactory enamel has not yet been produced containing an alkaline earth sulphide.

The question of incorporation of alkaline earth sulphide phosphors in plastics has now been satisfactorily solved, and two or three special plastics are

(*Continued at foot of page* 179)

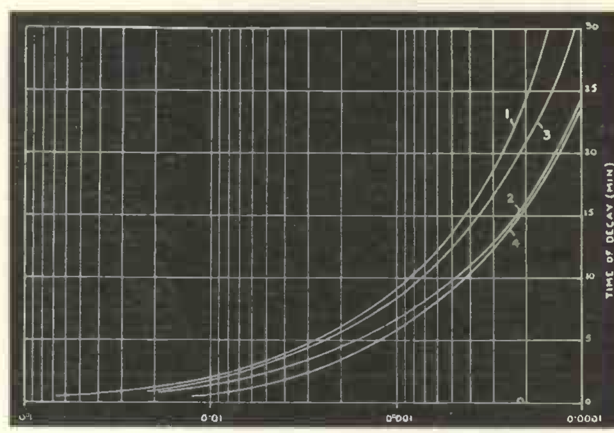


Fig. 2. Decay curves for luminescent vitreous enamel F(P) activated by different sources.

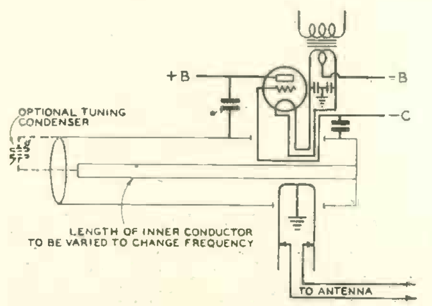
(1) Daylight Illumination = 350 f.c.'s.
(2) CO_2 = 60 f.c.'s.
(3) 125-W. black lamp at 3 ft. from specimen; Initial B = 4.0 e.f.c.'s
(4) 500-W. Tungsten projector lamp + Wratten 18 A filter (not B.S.I.) at 3 ft. from specimen; Initial B = 0.1 e.f.c.'s.

THE SHORT-WAVE RADIO WORLD

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

Coaxial Wires for U.H.F. Circuits Give Higher "Q"

THE use of coaxial wires for tuned circuits at ultra-high frequencies offers several advantages, according to a report by the American Civil Aeronautics authority. The inductive reactance of a line of fixed length is proportional to the frequency but the resistance is proportional to the square root of the frequency. For a given inductance the Q therefore increases with the square root of the frequency, as compared with a coil in which the Q decreases at ultra-high frequencies.



Single-tuned-circuit oscillator, cathode-above-earth type. The frequency can be varied either by the optional tuning condenser shown or by varying the length of the inner conductor of the concentric line.

A duralumin conductor $2\frac{1}{8}$ in. inside diameter and an internal copper conductor $\frac{1}{2}$ in. diameter by $8\frac{1}{2}$ in. long have an inductance of .06 microhenry and a calculated Q at 60 mc. of 3,000. The Q at 120 mc. is 4,100. The Q is, of course, reduced when the valve is taken into account, an acorn of the 994 type reducing it to 1,300 with no aerial loading. The final Q becomes 650 at 60 mc. and 145 at 120 mc. for optimum aerial coupling.

A ratio of diameters of conductors of $3\frac{1}{2}$-4 is recommended for an oscillator where Q is important, but a higher ratio (6-10) would increase the tuned circuit impedance.

A typical circuit is shown in the diagram of a 1 kW oscillator designed by R.C.A.

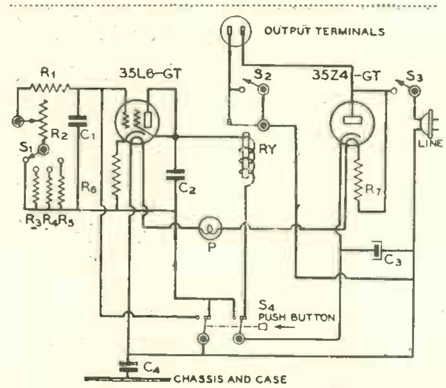
The anode is earthed to the outer conductor, through a by-pass condenser. Both the grid and the cathode (filament) are coupled to the line with $\frac{1}{2}$-turn links insulated from the outer conductor through which they pass, extending close to the inner conductor to which they are parallel.

In a power oscillator, the aerial coupling can be handled in the same manner. The grid loop must be longer and closer to the inner conductor than the cathode loop in order to accomplish the same condition found in electron coupled oscillators. With this circuit, there are no long leads from the valve to the taps on the line. Interesting variations of this circuit are possible.

An Electronic Timer for Photographers

In the March issue of *Radio*, L. Norton describes a simple circuit which can be used for timing camera exposures, bromide printing, etc., by switching on illumination for a predetermined time. The range of exposure obtainable is from 3 secs. to $1\frac{1}{2}$ mins., which is ample to take account of ordinary printing and camera work.

The circuit which is shown in the diagram is based on the well-known time delay circuit of a charging condenser.



Wiring diagram of the printing timer.

C_1—4-μfd. 600-volt paper.
C_2—0.1-μfd. 400-volt tubular.
C_3—8-μfd. 150-volt electrolytic.
C_4—0.1-μfd. 400-volt tubular.
R_1—250,000 ohms, $\frac{1}{2}$ watt.
R_2—3-megohm potentiometer.
R_3—3-megohms, $\frac{1}{2}$ watt.
R_4—6 megohms, $\frac{1}{2}$ watt.
R_5—9 megohms, $\frac{1}{2}$ watt.
R_6—200 ohms, 10 watts.
R_7—300 ohms, 10 watts (or 320-ohm line cord).
S_1—4-position selector switch.
S_2—S.p.s.t. toggle (focusing switch).
S_3—S.p.s.t. (on R2).
S_4—D.p.d.t. P.B. switch (non-locking).
RY—Low-current normally-closed relay. Should operate on 10 to 20 m/A.
P—250 m/A. 6.3 v. pilot light.

When the unit is switched on the half-wave rectifier (35Z4) applies 100 volts D.C. to the anode of the 35L6 control valve. The anode and screen current of this amounts to 40 mA. which passes through the relay coil and holds its contacts open. When the button S_4 is pressed the rectifier voltage is applied to the grid condenser C_1 so that the grid is negatively biased. Simultaneously the anode circuit is opened and the relay connects the mains voltage to the output terminals. Releasing the push button re-applies the H.T. to the anode but since the grid is negatively biased, the relay continues to be closed.

The time required for the grid condenser to be discharged depends on the resistance across it, and the bias slowly decreases until the current through the relay is sufficient to open the contacts again.

A 3-meg. resistance is used across the condenser and an additional 3, 6 or 9 megohm resistance controlled by a stud switch. R_1 prevents the mains from being short-circuited when S_4 is pressed with all the resistance out of circuit. This also controls the minimum time which may be obtained.

Radio-checking in U.S.A.

In administering and enforcing laws, regulations, and international treaties pertaining to radio, the Federal Communications Commission depends largely upon its field staff of 26 offices located strategically throughout the United States and its possessions.

The 115 inspectors in the Field Division are radio engineers and, in addition, are capable radio operators, many having had previous experience in maritime, aviation, and other communications services. They are familiar with the procedure employed by authorised stations, including the military, and this assists them in uncovering illicit operations.

Besides investigating unlicensed stations these experts inspect all classes of radio stations—broadcast, police, ship (domestic and foreign), amateur, aviation, and television; examine radio operators for various classes of licences; monitor radio transmissions for adherence to frequency, quality of emission and compliance with prescribed procedure; and investigate complaints of interference to radio reception.

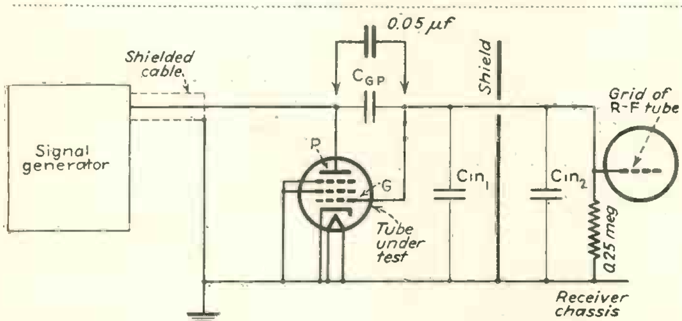
Frequently, an unlicensed station operating in the amateur bands first comes to the attention of an inspector when investigating a complaint of interference in the home of a broadcast listener by recognising the interference as originating from key clicks in a telegraph transmitter even though the frequency of operation may be in a band many kilocycles removed from the broadcast band. Field offices also receive tips from the monitoring stations concerning the operation of illegal stations.

Resourcefulnes, keen power of observation, and patience on the part of investigators have been of invaluable aid in the locating of transmitters, as for example, observing that a certain light circuit on a porch was nearly resonant and became incandescent each time the key of the transmitter was closed.

Measuring Valve Capacities with a Signal Generator

The method of measuring valve capacities described here employs equipment found in most radio laboratories. It may be used to measure capacities of a few thousandths of a micromicrofarad between two terminals which are both above earth potential, and is fast enough for production testing.

The essential apparatus required includes a good standard signal generator, a sensitive well shielded radio chassis and a means of measuring input capacities of the order of 10 to 30 micro-microfarads (a Q meter or ordinary capacity bridge). The test socket is mounted in a shielded compartment placed as near to the R.F. stage of the radio chassis as possible. The grid of the R.F. valve is disconnected from the aerial circuit and wired to the test socket as shown in the diagram. The valve under test is then made to serve as a capacity attenuator, and the grid-anode capacity is calculated from two values of input microvolts and the total input capacity of the radio chassis and the valve under test.



Circuit for determining valve capacity with a signal generator and radio receiver as measuring equipment.

The signal generator is connected to the test socket with a shielded cable and all elements except the anode and grid are earthed. The input capacity of the test set-up (C_{IN_1}) and the input capacity of the valve under test (C_{IN_2}) are then measured on a Q meter or ordinary capacity bridge.

Set sensitivity (μV_G) is obtained by feeding the signal generator direct to the grid of the R.F. stage, and this is most conveniently done by connecting the anode and grid prongs together through a large codenser of about 0.05 μf. The condenser is then removed and the valve to be measured is inserted in the socket and the microvolts input (μV_P) required for standard output again determined. It can be readily shown that for C_{GA} very much smaller than $C_{IN_1} + C_{IN_2}$

the value of $C_{GA} = \frac{\mu V}{\mu V_A}(C_{IN_1} + C_{IN_2})$

Hygrade Sylvania, Inc.

Frequency Modulation

A great deal has been written and many claims have been made about the advantages of frequency modulation. Our American contemporary *Electronics* summarises the known facts about the system as follows:

Channels available for frequency modulation, each 200 kc. wide, number 13 in all, four from 26,300 to 26,900; five from 42,600 to 43,400; and four from 117,190 to 117,910 kc.

Man-made static is a factor on the ultra-high frequencies to be considered in comparing A.M. and F.M., with an advantage of 10 to 30 db in favour of frequency modulation at 5 to 1 deviation.

Valve and circuit noise is a factor for consideration, assuming equal degrees of fidelity in the two systems, with an advantage of 30 db in favour of frequency modulation.

Quality of transmission may be achieved in either system, if power is disregarded. With a given expenditure of peak power, however, a programme of given quality may be sent by frequency modulation over an area some 10 to 30 times as great as that covered by amplitude modulation on the same frequency band.

A frequency-modulated signal occupies from two to five times the ether space required by double-sideband amplitude-modulated signal of the same quality.

The established desired-to-undesired signal ratio, below which interference on amplitude modulation is said to be negligible, is 40 db (F.C.C. regulation).

The established desired-to-undesired signal ratio, below which interference is negligible on frequency modulation, is 6 db.

New Wire-wound Resistors

Sprague Koolohm resistors, made by the makers of Sprague condensers, have the wire used in the winding uniformly insulated with a hard, moisture-proof insulation developed specially for this purpose. It conducts heat away from the wire with great rapidity and is not damaged even by bright red heat. They can be mounted in direct contact with chassis or other earthed parts.

This insulation makes possible interleaved windings wherein wires touch but do not short. Interleaved windings also permit a guaranteed accuracy of 5 per cent. or better.

Another feature is the fact that each resistor has an automatic red Teledot wattage indicator, which automatically changes colour when a 25 per cent. overload occurs. When the overload is removed, the Teledot returns to its original colour.

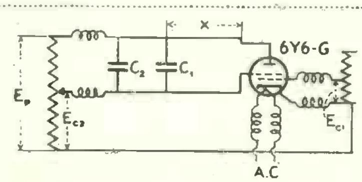
The resistors are available in 5-watt fixed types; 10-watt adjustable, and 10-watt non-inductive.

Beam Power Valves as U.H.F. Generators

As a result of the occurrence of high-frequency parasitic oscillation in circuits employing beam power valves, an investigation has been conducted into the mode of generation of ultra-high frequency oscillation and methods of enhancing as well as of eliminating such oscillation were studied.

Preliminary investigations showed that the beam oscillator was of the simple regenerative type similar to that in triode circuits, but with the screen taking the part of the grid in the triode. This conclusion was verified when it was found that the wavelength characteristics of the beam tetrode, as a function of the tank circuit dimensions were precisely like those of the triode in a simple regenerative circuit.

In order to obtain experimentally the wavelength characteristics of beam tetrodes the oscillating circuit shown below was used. The tank circuit consists of a length of parallel rods connected at one end of the anode and screen terminals of the tetrode, and bridged at the other end by a large blocking condenser, C_1. A second condenser, C_2, serves to detune the length of rod extending beyond C_1.



Schematic wiring diagram of the 6Y6-G ultra high frequency generator.

The generated wavelength was measured on a parallel wire system loosely coupled to the tank circuit. The anode and screen were operated at the same potential and this voltage was well below the maximum rated value for the particular valve in question (6Y6-G).

A comparison of the wavelength curve of the beam tetrode with the triode curve indicates that they are entirely alike. Oscillation may be obtained over a wide range of potentials, except at the lowest generated wavelength. In spite of the relatively large size of the electrodes in the beam tetrode, the upper frequency limit for both the 6Y6-G and the 6V6-G is about the same as that of a small triode such

(*Continued at foot of page 179*)

ELECTRONICS AND TELEVISION & SHORT-WAVE WORLD

Comprehensive Guide

to

THE WORLD'S SHORT-WAVE STATIONS

Mc/s.	Metres.	Call.	Station Name.
31.60	9.494	W1XKA	Boston, Mass.
31.60	9.494	W2XDV	New York City.
31.60	9.494	W3XKA	Philadelphia.
26.55	11.3	W2XGU	New York City.
26.55	11.3	W2XQO	New York City.
26.05	11.51	W9XH	South Bend, Ind.
25.95	11.56	W6XKG	Los Angeles, Cal.
25.72	11.664	WCAB	Pennsylvania.
25.60	11.719	WRUW	Boston, Massachusetts.
21.65	13.857	WLWO	Mason, Ohio.
21.64	13.86	GRZ	Daventry, England.
21.63	13.8	WRCA	Bound Brook, N.J.
21.59	13.895	WGEO	South Schenectady, N.Y.
21.57	13.91	WCBX	Wayne, N.J.
21.565	13.92	DJJ	Berlin.
21.55	13.92	GST	Daventry, England.
21.54	13.93	WPIT	Pittsburgh, Pa.
21.54	13.93	W8SK	Pittsburgh, Pa.
21.53	13.93	GSJ	Daventry, England.
21.52	13.94	12RO16	Rome, Italy.
21.52	13.94	WCAB	Philadelphia.
21.50	13.95	WGEA	Schenectady, N.Y.
21.48	13.96	PH13	Huizen, Holland.
21.47	13.97	GSH	Daventry, England.
21.46	13.98	WRUL	Boston, Mass.
21.45	13.99	DJS	Berlin.
19.02	15.77	HS6PJ	Bangkok, Siam.
18.48	16.23	HBH	Geneva, Switzerland.
17.85	16.8	TPB3	Paris, France.
17.845	16.81	DJH	Zeesen.
17.84	16.82	HVJ	Vatican City.
17.84	16.82	—	Moydrum, Athlone, Eire.
17.83	16.83	WCBX	New York City.
17.82	16.84	2RO8	Rome, Italy.
17.81	16.84	GSV	Daventry, England.
17.80	16.85	OIH	Lahti, Finland.
17.80	16.85	XGOX	Chungking, China.
17.79	16.86	GSG	Daventry, England.
17.785	16.86	JZL	Tokio, Japan.
17.78	16.87	WNBI	Bound Brook, N.J.
17.78	16.87	WPIT	
17.77	16.88	PH12	Huizen. Holland.
17.76	16.89	WLWO	
17.76	16.89	DJE	Zeesen.
17.755	16.9	ZBW5	Hongkong.
17.75	16.90	LKW	Oslo, Norway.
17.31	17.33	W2XGB	Hicksville, N.Y.
17.280	17.36	FXE8	Djibouti, French Somaliland.
15.55	19.29	CO9XX	Tuinicu, Oriente, Cuba.
15.51	19.34	XOZ	Chengtu, China.
13.37	19.52	HAS3	Budapest, Hungary.
15.36	19.53	DZG	Zeesen, Germany.
15.36	19.53	—	Berne, Switzerland.
15.34	19.56	DJR	Zeesen.
15.33	1956	WGEA	Schenectady, N.Y.
15.33	19.56	KGEI	San Francisco, California.
15.32	19.58	OZH	Skamlebak, Denmark.
13.30	19.6	GSP	Daventry, England.
15.3	19.61	YDB	Soerabaja, Java.
15.3	19.61	XEBM	Mazatlan, Mex.
15.3	19.61	12RO6	Rome, Italy.
15.29	19.62	VUD	Delhi, India.
15.29	19.62	LRU	Buenos Aires.
15.28	19.63	DJQ	Zeesen.
15.27	19.65	HI3X	Ciudad, Trujillo.
15.27	19.65	WCAB	Phila., Pa.
15.27	19.65	WLWO	Mason, Ohio.
15.27	19.65	WCBX	Wayne.
15.26	19.66	GSI	Daventry, England.
15.25	19.67	WRUL	Boston, Mass.
15.245	19.68	TPA2	Paris, France.
15.24	19.68	12RO	Rome, Italy.
15.24	19.68	CR7BD	Lourenco, Marques, Mozambique.
15.23	19.7	OLR5A	Podébrady, Bohemia.
15.23	19.7	HS6PJ	Bangkok, Siam.
15.22	19.71	PCJ2	Huizen, Holland.
15.21	19.72	WPIT	Pittsburgh, Pa.
15.2	19.74	DJB	Zeesen.
15.195	19.74	TAQ	Ankara, Turkey.
15.19	19.75	OIE	Lahti, Finland.
15.18	19.76	GSO	Daventry, England.
15.18	19.76	RW96	Moscow, U.S.S.R.
15.17	19.77	TGWA	Guatemala City, Guat.
15.166	19.78	LKV	Oslo, Norway.
15.16	19.79	JZK	Tokio, Japan.
15.16	19.79	XEWW	Mexico City.
15.155	19.79	SM5SX	Stockholm, Sweden.
15.15	19.8	YDC	Bandoeng, Java.
15.140	19.82	GSF	Daventry, England.
15.135	19.82	JLU3	Tokio, Japan.
15.13	19.83	TPB6	Paris, France.
15.13	19.83	WRUL	Boston, Mass.
15.13	19.83	WRUW	
15.120	19.84	HVJ	Vatican City.
15.120	19.84	CSW4	Lisbon, Portugal.
15.11	19.85	DJL	Zeesen.
15.1	19.87	CB.1510	Valparaiso, Chile.
15.1	19.87	12RO12	Rome, Italy.
15.08	19.95	RKI	Moscow, U.S.S.R.
14.96	20.05	RZZ	Moscow, U.S.S.R.
14.93	20.09	PSE	Rio de Janeiro, Brazil.
14.92	20.11	KQH	Kahuku, Hawaii.
14.78	20.28	IQA	Rome, Italy.
14.60	20.55	JVH	Nazaki, Japan.
14.535	20.64	HBJ	Geneva, Switzerland.
14.44	20.78	—	Radio Malaga, Spain.
14.42	20.80	HCIJB	Quito, Ecuador.
14.166	21.15	PIIJ	Dordrecht, Holland.
13.997	21.43	EA9AH	Tetuan, Spanish Morocco.
12.862	23.32	W9XDH	Elgin, Ill.
12.486	24.03	HIIN	Trujillo City, Dominica Rep.
12.460	24.08	HC2JB	Quito, Ecuador.
12.310	24.37	VOFB	St. Johns, Newfoundland.
12.235	24.52	TFJ	Reykjavik, Iceland.
12.230	24.53	COCE.	Havana, Cuba.
12.2	24.59	—	Trujillo, Peru.
12	25	RNE	Moscow, U.S.S.R.
11.970	25.06	CB.1180	Santiago, Chile.
11.97	25.07	HI2X	Ciudad, Trujillo, D.R.
11.94	25.13	TI2XD	San Jose, Costa Rica.
11.94	25.13	XMHA	Shanghai, China.
11.90	25.21	CD.1190	Valdivia, Chile.
11.9	25.21	XGOY	Chungking, China.
11.895	25.23	12RO13	Rome, Italy.
11.885	25.24	TPA3	Paris, France.
11.87	25.26	WPIT	Pittsburgh, Pa.
11.87	25.26	VUM2	Madras, India.
11.87	25.26	WLWO	Mason, Ohio.
11.865	25.28	—	Berne, Switzerland.
11.86	25.3	GSE	Daventry, England.
11.85	25.31	DJP	Zeesen.
11.85	25.32	OAK2A	Trujillo, Peru.
11.84	25.35	KZRM	Manila, P.I.
11.84	25.35	CSW	Lisbon, Portugual.
11.84	25.35	OLR4A	Prague, Bohemia.

GUIDE TO WORLD'S SHORT-WAVE STATIONS—II

Mc/s.	Metres.	Call.	Station Name.
11.83	25.36	W9XAA	Chicago, Illinois.
11.83	25.36	WCBX	Wayne.
11.81	25.4	12RO4	Rome, Italy.
11.805	25.41	OZG	Skamlebak, Denmark.
11.801	25.42	DJZ	Berlin.
11.80	25.42	COGF	Matanzas, Cuba.
11.80	25.42	JZJ	Tokio, Japan.
11.795	25.42	DJO	Zeesen.
11.79	25.45	WRUL	Boston, Mass.
11.78	25.47	HP5G	Panama City.
11.78	25.47	OFE	Lahti, Finland.
11.77	25.49	DJD	Zeesen.
11.76	25.51	TGWA	Guatemala City, Guat.
11.76	25.51	XETA.	Monterey, Mexico.
11.76	25.51	OLR4B	Prague, Bohemia.
11.75	25.53	GSD	Daventry, England.
11.74	25.55	HVJ	Vatican City.
11.74	25.55	CR6RC	Loanda, Angola.
11.735	25.57	COCX	Havana, Cuba.
11.735	25.57	LKQ	Oslo, Norway.
11.73	25.58	WRUW	
11.73	25.57	PHI	Huizen, Holland.
11.73	25.58	WRUL	Boston, Mass.
11.725	25.58	JVW3	Tokio, Japan.
11.720	25.6	CJRX	Winnipeg, Canada.
11.72	25.60	ZP14	Villarica, Paraquay.
11.71	25.62	—	Saigon, French Indo-China.
11.705	25.63	SBP	Motala, Sweden.
11.7	25.64	HP5A	Panama City.
11.70	25.65	CB.1170	Santiago, Chile.
11.766	25.7	IQY	Rome, Italy.
11.402	26.31	HBO	Geneva, Switzerland.
11.04	27.17	CSW5	Lisbon, Port.
11.00	27.27	PLP	Bandoeng, Java.
10.95	27.40	—	Tananarive, Madagascar.
10.67	28.12	CEC	Santiago, Chile.
10.66	28.14	JVN	Nazaki, Japan.
10.53	28.48	JIB	Taihoku, Taiwan.
10.40	28.85	YSP	San Salvador.
10.36	28.96	EAJ43	Teneriffe.
10.35	28.99	LSX	Buenos Aires.
10.33	29.04	ORK	Ruysselede, Belgium.
10.26	29.24	PMN	Bandoeng, Java.
10.1	29.7	—	Deutche Freiheits Sender.
10.05	29.85	TIEMT	San Jose, Costa Rica.
10.05	29.16	DZC	Zeesen, Germany.
10.04	29.87	DZB	Zeesen, Germany.
9.995	30.02	COBC	Havana, Cuba.
9.92	30.24	JDY	Dairen, Manchukuo.
9.892	30.33	CPI	Sucre, Bolivia.
9.955	30.45	EAQ	Madrid, Spain.
9.83	30.52	IRF	Rome, Italy.
9.815	30.57	COCM	Havana, Cuba.
9.785	30.66	HH3W	Port-au-Prince, Haiti.
9.753	30.75	ZRO	Durban, S. Africa.
9.735	30.82	CSW7	Lisbon, Portugual.
9.73	30.83	CB.970	Valparaiso, Chile.
9.705	30.92	—	Fort-de-France, Martinique.
9.7	30.93	HNF	Baghdad, Iraq.
9.69	30.96	LRAI	Buenos Aires.
9.69	30.96	ZHP	Singapore, Malaya.
9.69	30.96	GRX	Daventry, England.
9.685	30.96	TGWA	Guatemala City.
9.675	31.01	DJX	Zeesen.
9.67	31.03	WRCA	Bound Brook, N.J.
9.665	31.04	12RO9	Rome, Italy.
9.66	31.06	LRX	Buenos Aires.
9.66	31.06	HVJ	Vatican City.
9.65	31.09	WCBX	Wayne.
9.65	31.09	CS2WA	Lisbon, Portugual.
9.65	31.09	IABA	Addis Ababa, Ethiopia.
9.645	31.10	JLT2	Tokio, Japan.
9.64	31.12	CXA8	Colonia, Uruguay.
9.635	31.13	2RO3	Rome, Italy.
9.62	31.19	CXA6	Montevidale, Uruguay.
9.618	31.20	HJ1ABP	Cartagena, Col.
9.61	31.22	LLG	Oslo, Norway.
9.606	31.23	ZRL	KLipheuval, S. Africa.
9.6	31.25	RAL	Moscow, U.S.S.R.
9.6	31.25	CB.960	Santiago, Chile.
9.6	31.25	GRY	Daventry, England.
9.595	31.27	HBL	Geneva, Switzerland.
9.59	31.28	HP5J	Panama City.
9.59	31.28	VUD2	Delhi, India.
9.59	31.28	PCJ	Huizen, Holland.
9.59	31.28	VK6ME	Perth, W. Australia.
9.59	31.28	VK2ME	Sydney, Australia.
9.59	31.28	WCAB	Philadelphia, Pa.
9.59	31.28	WLWO	Mason, Ohio.
9.58	31.32	LRX	" El Mundo," Buenos Aires.
9.58	31.32	GSC	Daventry, England.
9.58	31.32	VLR	Melbourne, Australia.
9.57	31.35	KZRM	Manila, P.I.
9.57	31.35	WBOS	Millis.
9.57	31.35	WPIT	Pittsburgh, Pa.
9.56	31.36	CXA8	Belgrano, Buenos Aires.
9.566	31.37	OAX4T	Lima, Peru.
9.56	31.38	XGAP	Peking, China.
9.56	31.38	DJA	Zeesen.
9.55	31.41	HVJ	Vatican City.
9.55	31.41	TPB11	Paris, France.
9.55	31.41	WGEA	Schenectady, N.Y.
9.55	31.41	OLR3A	Prague, Bohemia.
9.55	31.41	XEFT	Vera Cruz, Mexico.
9.55	31.41	YDB	Soerabaja, Java.
9.55	31.41	VUB2	Bombay, India.
9.54	31.45	DJN	Zeesen.
9.538	31.46	VPD2	Suva, Fiji.
9.53	31.46	—	Schwarzenburg, Switzerland.
9.53	31.48	WGEO	Schenectady, N.Y.
9.53	31.48	KGEI	San Francisco, Cal.
9.53	31.48	BUC2	Calcutta, India.
9.526	31.49	ZBW3	Hongkong, China.
9.525	31.49	LPC	Jeloy, Norway.
9.523	31.5	ZRG	Roberts Heights, S. Africa.
9.52	31.51	OZF	Skamleboaek, Denmark.
9.52	31.51	RV96	Moscow, U.S.S.R.
9.51	31.55	GSB	Daventry, England.
9.51	31.55	HS8PJ	Bangkok, Siam.
9.51	31.55	—	Hanoi, French Indo-China.
9.503	31.57	XEWW	Mexico City.
9.50	31.58	PRF5	Rio Janeiro, Brazil.
9.50	31.58	HJU	Buenaventura, Columbia.
9.5	31.58	VK3ME	Melbourne, Australia.
9.5	31.58	OFD	Lahti, Finland.
9.497	31.59	KZ1B	Manila, Philippine Islands.
9.488	31.6	EAR	Madrid, Spain.
9.465	31.70	TAP	Ankara, Turkey.
9.445	31.77	HCODA	Guayaquil, Ecuador.
9.437	31.8	COCH	Havana, Cuba.
9.390	31.95	OAX5C	Ica, Peru.
9.370	32.02	XOY	Chengtu, China.
9.355	32.05	HCIETC	Quito, Ecuador.
9.35	32.08	COCD	Havana, Cuba.
9.345	32.11	HBL	Geneva, Switzerland.
9.340	32.12	OAX4J	Lima, Peru.
9.295	32.28	HI2G	Ciudad, Trujillo, D.R.
9.280	32.33	LYR	Kaunas, Lithuania.
9.2	32.61	ZMEF	Sunday Island.
9.2	32.61	COBX	Havana, Cuba.
9.188	32.65	HC2AB	Ecuador.
9.17	32.72	HC1G	Quito, Ecuador.
9.125	32.88	HAT4	Budapest, Hungary.
9.124	32.88	HC2CW	Guayaquil, Ecuador.
9.12	32.89	CP6	La Paz, Bolivia.
9.100	32.61	COCA	Havana, Cuba.
9.091	33.00	PJCI	Curacao, D.W. Indies.
9.03	33.32	COBZ	Havana, Cuba.
8.965	33.44	COKG	Santiago, Cuba.
8.841	33.5	HCJB	Quito, Ecuador.
8.830	33.98	COCQ	Havana, Cuba.
8.7	34.46	HKV	Bogota, Columbia.

GUIDE TO WORLD'S SHORT-WAVE STATIONS—III

Mc/s.	Metres.	Call.	Station Name.
8.665	34.64	COJK	Camaguey, Cuba.
8.665	34.64	W2XGB	Hicksville, N.Y.
8.652	34.67	HJ4DAU	Medellin, Colombia.
8.580	34.92	YNPR	Managua, Nicaragua.
8.572	35.02	—	Bucharest, Roumania.
7.894	37.99	YSD	San Salvador.
7.870	38.1	HCIRB	Quito, Ecuador.
7.854	38.2	HC2JSB	Guayaquil, Ecuador.
7.797	38.48	HBP	Geneva, Switzerland.
7.614	39.39	CRAA	Lobito, Angola.
7.520	39.89	KKH	Kahuku, Hawaii.
7.49	40,05	EAJ43	Teneriffe, Canary Islands.
7.45	40.27	TI2RS	San Jose, Costa Rica.
7.44	40.32	FG8AH	Point-a-Pitre, Guadeloupe.
7.41	40.46	HCJB4	Quito, Ecuador.
7.31	41.01	GIG	Port Moresby, Papua.
7.28	41.21	TPB12	Paris, France.
7.26	41.32	CSW8	Lisbon, Portugual.
7.22	41.55	HKE	Bogota, Col., S.A.
7.22	41.55	YDX	Medan, Sumatra.
7.177	41.75	CR6AA	Lobita, Angola.
7.128	42.09	YN3DG	Leon, Nicaragua.
7.1	42.25	FO8AA	Papeete, Tahiti.
7.088	42.3	PI1J	Dordrecht, Holland.
6.97	43.05	XPSA	Kweiyang, China.
6.96	43.10	Z2ZB	Wellington, N.Z.
6.88	43.60	XOJD	Hankow, China.
6.79	44.16	PZH	Paramirabo, Surinam.
6.775	44.26	HIH	San Pedro de Macoris, Dom. Rep.
6.73	44.58	HI3C	La Romana, Dominica Rep.
6.72	44.64	PMH	Bandoeng, Java
6.69	44.82	TIEP	San Jose, Costa Rica.
6.675	44.94	HBQ	Geneva, Switzerland.
6.625	45.28	PRADO	Riobamba, Equador.
6.565	45.70	HI5P	Puerto, Plata.
6.55	45.8	XBC	Vera Cruz, Mexico.
6.49	46.2	TGWB	Guatemala City, Guat.
6.47	46.36	YNLAT	Granada, Nic.
6.384	46.99	ZIZ	Basseterre, W.I.
6.335	47.33	OAXIA	Ica, Peru.
6.324	47.4	COCW	Havana, Cuba.
6.28	47.77	HIIG	Trujillo City, D.R.
6.235	48.12	HRD.	La Ceiba, Honduras.
6.23	48.15	OAX4G	Lima, Peru.
6.19	48.47	JLK	Tokio, Japan.
6.19	48.47	HVJ	Vatican City.
6.19	48.47	WGEO	South Schenectady, N.Y.
6.19	48.47	KGEI	San Francisco, Cal.
6.17	48.62	HJ3ABF	Bogota, Columbia.
6.17	48.62	WCBX	Wayne.
6.153	48.75	HI5N	Moca City, D.R.
6.15	48.78	VPB	Colombo, Ceylon.
6.15	48.78	CJRO	Winnipeg, Canada.

Mc/s.	Metres.	Call.	Station Name.
6.148	48.8	ZTD	Durban, S. Africa.
6.147	48.8	ZEB	Bulawayo, Rhodesia.
6.14	48.83	—	Leopoldville, Belgian Congo.
6.14	48.86	WPIT	Pittsburgh.
6.137	48.87	CR7AA	Laurenco Marques, E. Africa.
6.13	48.94	VP3BG	Georgetown, British Guiana.
6.13	48.94	CHNX	Halifax, N.S., Canada.
6.125	48.98	CXA4	Montevideo, Uruguay.
6.122	49	HP5H	Panama City.
6.122	49	FK8AA	Noumea, New Caledonia.
6.12	49.02	WCBX	Wayne.
6.117	49.03	XEUZ	Mexico City.
6.115	49.05	OLR2C	Prague, Bohemia.
6.10	49.18	WNBI	
6.097	49.2	ZRK	Klipheuvel, S. Africa.
6.097	49.2	ZRJ	Johannesburg.
6.095	49.22	JHZ	Tokio, Japan.
6.09	49.26	CRCX	Toronto, Canada.
6.083	49.31	VQ7LO	Nairobi, Kenya, Africa.
6.08	49.34	CRY9	Macao.
6.077	49.35	OAX4Z	Lima, Peru.
6.075	49.35	VP3MR	Georgetown, British Guiana.
6.07	49.42	CFRX	Toronto, Canada.
6.07	49.42	VE9CS	Vancouver, B.C.
6.065	49.46	SBO	Motala, Sweden.
6.06	49.5	YDD	Bandoeng, Java.
6.06	49.5	WCAB	Philadelphia, Pa.
6.06	49.5	WLWO	Cincinnati
6.057	49.53	ZHJ	Penang, Fed. Malay States.
6.05	49.59	GSA	Daventry, England.
6.045	49.6	XETW	Tampico, Mexico.
6.04	49.65	WDJM	Miami Beach, Florida.
6.04	49.65	WRUL	Boston, Mass.
6.033	49.75	HP5B	Panama City, Pan.
6.03	49.75	CFVP	Calgary, Alta, Canada.
6.03	49.75	RW.96	Moscow, U.S.S.R.
6.03	49.75	OLR2B	Prague, Bohemia.
6.023	49.82	XEUW	Vera Cruz, Mexico.
6.02	49.83	DJC	Zeesen, Germany.
6.01	49.92	OLR2A	Prague, Bohemia.
6.01	49.92	VK9MI	S.S. Kanimbla.
6.01	49.92	CJCX	Sydney, Nova Scotia.
6.007	49.94	XYZ	Rangoon, Burma.
6.007	49.94	ZRH	Roberts Heights, South Africa.
6.005	49.96	CFCX	Montreal, Canada.
6.005	49.96	VE9DN	Drummondville, Quebec Canada.
6.00	50.00	CXA2	Prieto, Buenos Aires.
5.990	50.08	ZEA	Salisbury, Rhodesia, Sth. Africa.

"Short-wave Radio World"

(*Continued from page* 176)

as the type 56. The lower wavelength limit of the 6L6-G is about 4½ metres, which is considerably in excess of that for the other varieties of beam tetrodes. The author explains this as a result of shielding of the beam-forming plate between the anode and the screen, the area of the plate exposed to the screen in the 6Y6-G is not much greater than the anode area exposed to the grid in the cylindrical 56. Since the average distance between the anode and screen in the beam tetrode is nearly double that of the triode, the effective anode-screen capacity of the former cannot be larger than the anode-grid capacitance of the latter. It is concluded that by reducing the resistance of the circuit within the valve by shortening and thickening the anode and screen leads, efficiencies approaching a total power conversion efficiency of 25 per cent. may be obtained in the external part at a frequency as high as 150 mc. With the 6Y6-G in its present design, a maximum efficiency of only 7 per cent. is obtained in terms of the external part of the circuit.

(King—Jour. Appl. Phys.).

"Phosphorescent Phosphors"

(*Continued from page* 174)

available in which alkaline earth phosphors can be satisfactorily incorporated without any sensible depreciation of their luminescent qualities.

B.S.I. Specification

The interest in phosphorescent preparations which has been aroused owing to the black-out regulations, has led to the compilation of a specification by the British Standards Institution, designed to control the quality of fluorescent and phosphorescent paints for A.R.P. purposes. The specification calls for a minimum brightness of 0.05 equivalent foot candles for a phosphorescent material of the zinc or zinc cadmium sulphide phosphors, one minute after irradiation by a standard test lamp. The brightness after the lapse of a period of time after irradiation which it is left to the manufacturer to specify, during which the preparation must be kept in the dark, must not fall below 0.0001 equivalent foot candles.

Cathode-ray Tube for High-voltage Applications

RECENT developments in cathode-ray tube technique tend to constructions in which the electrodes have a common supporting system, a particularly useful arrangement being provided by four or more insulating rods which are slid through the electrodes or through suitable extensions thereof. By this means the whole system may be assembled before introduction into the envelope, and subsequent difficulties as regards adjustment are avoided.

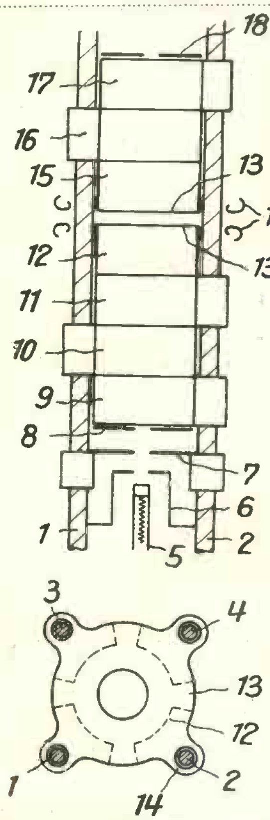


Fig. 1. Electrode supporting system of high-voltage cathode-ray tube shown in elevation and plan.

When, however, the tube is to withstand very high voltages, special precautions have to be taken, since in that case the high potential differences between neighbouring electrodes involve very serious danger of arcing and corona discharges. Such corona discharges start from the points where the electrodes touch the insulators, for example, where the electrodes are secured to the insulators.

It is of course a well-known device to minimise the danger of breakdown between electrodes carrying a high potential difference by curving back the ends of the electrodes or by providing them with curved rims. But this step is not in itself sufficient to provide the requisite degree of security with very high potentials.

As an additional safety measure, therefore, it is now proposed to fit electrodes carrying these high potential differences with a special type of guard plate, curved back in the usual manner, and arranged so as to surround the support rods, but not to touch them. This arrangement provides along the support rods a field-free space, within which the electrodes may safely be connected to the support rods.

Looking at Fig. 1, which illustrates a particular type of supporting system, the support rods, which may be of glass, ceramic, etc., are indicated by 1, 2, 3 and 4. The cathode is shown at 5, but its supporting means is not relevant to this discussion, and is therefore not indicated. The same applies to the Wehnelt cylinder 6. 7 is a diaphragm which is independently secured to the support rods, whereas 8 is a diaphragm secured to the adjacent cylinder 9, which again forms a unit with the further cylinders 10, 11 and 12.

These individual cylinders have flanges or lugs by means of which they are connected with each other and with the associated diaphragms. The cylinders again have special clamps fitted in such a way that each cylinder is supported by two diagonally opposite rods, while adjacent cylinders are supported by alternate pairs of rods. Thus, in the illustration, the cylinder 9 is supported from rod 2 and (hidden) rod 3, whereas the cylinder 10 is secured to rods 1 and 4.

Fig. 2 shows more clearly how the cylinder is assembled from two parts, the join being indicated at 22. This assembled electrode is then pushed over the rods, the drawing being intended to indicate that the electrode 10 is supported not on the rod 2, but on the rod 4 which is to be imagined behind the rod 2. In Fig. 1 the cylinders 9, 10, 11 are secured in this manner, whereas the cylinder 12 is merely fitted to cylinder 11. This cylinder 12 has a guard plate 13, having openings through which the insulating rods pass without touching, the edges of these openings being curved back as previously described. Similarly, the next electrode 15 has also a guard plate 13, and is secured to the following electrode 16 instead of direct to the support rods. The electrodes 15, 16, and 17 thus form a further unit which is assembled and secured as before and terminated by a diaphragm 18.

It will be seen that the arrangement illustrated does in fact enable the electrodes to be secured to the support rods at points where there is no electrical field, and hence no danger of corona discharges. Thus, the guard surfaces 13, 14 serve the double purpose of reducing the field strength itself, by eliminating corners and providing curved surfaces, and also of constraining the field along the insulating rods into regions where no electrodes touch these rods.

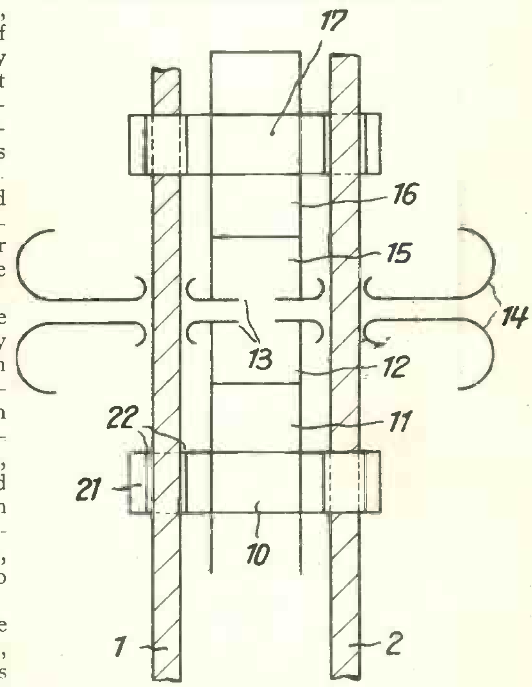


Fig. 2. Diagram showing how the cylinder is assembled in two parts.

Such tubes are obviously very useful not only for television, but also for oscillograph applications, high intensity being desirable in the former case for projection purposes, and in the latter case for the recording of isolated phenomena of short duration. As compared with tubes in which deflection takes place after the acceleration of the electron beam, these tubes have the advantage of providing a high field at the cathode, so that both the number of electrons and their final velocity is high, and the brightness of the screen is correspondingly great.

HOME INSTRUCTIONAL COURSE

THE PURPOSE OF THIS SERIES

With the object of filling the gap which has been temporarily caused in the education of the radio student, we are providing a series of articles on various theoretical aspects of radio engineering.

The present position has led to the suspension of evening classes in many of the Technical Institutes and added to the difficulties in attending those that are available. Some thousands of students of radio will miss the opportunity of increasing their knowledge of the theoretical side of the subject. Practice is not always enough to keep abreast of the subject, and the radio engineer or serviceman must understand fully the theory underlying the practice in order to cope with the frequent "out of the ordinary" jobs that come his way.

The articles are not intended to compete with or in any way displace the "correspondence course" in which the subject is dealt with fully from beginning to end, but are aimed to give concise information on certain fundamental theories which will be of direct use to the student in his work.

Each article will be complete in itself and in order to give mental exercise, examples will be given at the end. While we cannot enter into correspondence with readers on the subject matter of the articles, it will be found that the examples given are answered in the succeeding article and numerous explanatory footnotes should make the discussion as clear as possible.

Suggestions are invited from students for special aspects of the subject to be dealt with in later articles.

VALVE CHARACTERISTICS

IN designing radio apparatus for a specific purpose, in addition to correct component values, the valve performance must be studied and the operating conditions adjusted to obtain the maximum efficiency in conjunction with the rest of the circuit.

The performance of a valve, whether as an amplifier or detector in a receiver, or oscillator in a transmitter, can be determined from the characteristic curves which are supplied with it.

These curves are not approximations—they are carefully drawn from results obtained over a large number of valves selected from manufacture and represent the average figures which may be expected to be realised. A slight discrepancy between the readings on an individual valve and the published figures does not necessarily mean that the valve is bad. A certain tolerance on figures is essential, in the same way that a tolerance is permissible on the performance of a car or the diameter of a steel rod. If all products were made to conform exactly to a definite specification they would be many times more costly than they are at present. Due allowance can always be made for difference in valve characteristics, and it is part of the designer's job to ensure that the success of the receiver does not depend on too critical an adjustment of the operating conditions.

Valves as Amplifiers

Dealing with the simplest application of the valve first—that of amplifying an audio-frequency signal, there are three factors which require to be taken into account in matching the valve to the circuit to obtain best results. These factors are the magnification, the sensitivity (or " slope " as it is better called) and the impedance.

All these quantities can be deduced from the characteristic curves of the valve, so we can commence by studying a typical example.

It is assumed that the elementary theory of the valve is well known—how that the negative potential applied to the grid neutralises the attractive field of the positively charged anode and prevents electrons being drawn across the filament. Since the grid is nearer to the filament, a low negative potential will suffice to neutralise a much higher potential on the anode, and it is this effect which gives rise to the magnification of the valve.

To estimate this magnification we use the characteristic curve connecting anode current and grid voltage, which is shown in Fig. 1.

The curve can be plotted easily by means of the circuit shown in Fig. 2. A milliammeter is connected in the anode circuit of the valve and the grid is connected to a potential divider so that the negative bias can be varied. The H.T. applied to the anode is kept constant and the value of anode current corresponding to various values of bias is noted. Another curve is then plotted with a different value of anode voltage, and in this way a " family " of curves can be drawn as in Fig. 1. During the readings, the filament voltage should be checked to see that it remains constant, or errors will be introduced due to the variation in electron emission from the filament.

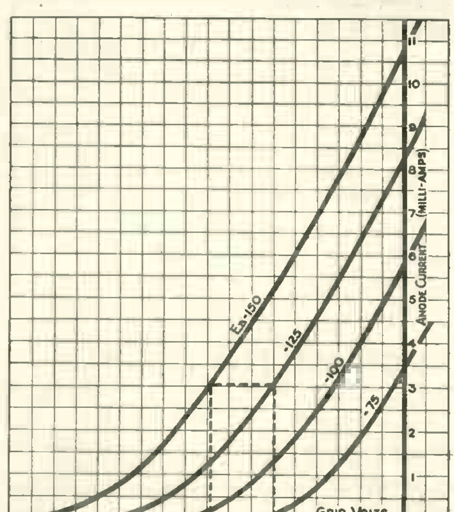


Fig. 1. Characteristic of triode from which the various constants can be measured.

Having plotted the curves, the following point can be noticed:—

Wth 150 volts on the anode, the current at a grid bias of $-3\frac{1}{2}$ is $4\frac{1}{2}$ mA. The same current is obtained at 125 volts on the anode if the grid bias is reduced to -2 volts.

This means that the effect of reducing the anode voltage by 25 is offset by reducing the bias by $1\frac{1}{2}$. Taking another case, $-1\frac{1}{2}$ bias at 100 volts on the anode gives approximately 3 mA., and the same current is obtained at -3 volts and 125 volts. Again, we have $1\frac{1}{2}$ volts on the grid equivalent to a change of 25 volts on the anode.

This ratio of anode voltage change to grid voltage change to maintain the anode current constant is the *magnification factor* of the valve. In the valve whose curve we have been measuring, the magnification factor is numerically $25/1\frac{1}{2}$, or approximately 17.

The rule for finding the magnification factor from the curve is then: Measure the distance between two curves at a given value of anode current and find this distance in terms of the grid volt scale. Divide this value into the difference in anode volts between the curves and the result is the magnification factor. The dotted lines on the curve show one position at which

a reading can be taken. Note that magnification factor is practically constant where the curves lie parallel to one another, but at the lower part it varies considerably as the bias is increased.

Slope

The slope of the curve is literally measured by finding the increase in anode current for a change of 1 volt on the grid bias scale. From the curve of Fig. 1, we can note that at $-3\frac{1}{2}$ volts bias the anode current is $4\frac{1}{2}$ mA., while at $2\frac{1}{2}$ volts bias it is 6 mA. on the same curve. This means an increase of $1\frac{1}{2}$ mA. for 1 volt change in bias or a slope of $1\frac{1}{2}$ mA. per volt.

This figure obtained from the curve may vary according to the points between which the rise of anode current is measured. For example, at the lower part of the curve of 150 volts the slope is only 1.2 and at the bottom bend it is as low as 0.4. For greater accuracy in measurement the current should be taken for a change in grid voltage of $\frac{1}{2}$ volt instead of 1 volt.

To obtain the slope by direct measurement on the valve the same circuit as Fig. 2 may be used. The bias is adjusted to a normal working value, say, -5 volts for 150 volts on the anode. The voltage is then altered to $-4\frac{1}{2}$ and the alteration in anode current noted. This alteration is doubled to give the slope in mA./V. Great care should be taken that the anode voltage does not alter between the two readings or the value will be wrong. This is particularly liable to happen when a series resistance is in the anode circuit, as the increase in current will cause increased drop in the resistance and a lowered anode voltage at the terminals of the valve.

Note also that for the purposes of taking readings the anode voltage is considered that of the H.T. battery, whereas in practice the H.T. voltage is always higher than the anode voltage by the amount dropped in the anode resistance. It is always important to distinguish between anode voltage and H.T. voltage.

Impedance

If the grid bias on the valve is fixed and the anode voltage is varied, the anode current will vary in conformity with the characteristic as shown in Fig. 1. For a bias of -4 volts, the anode current increase from 0.5 mA. at 100 volts anode to 1.75 mA. at 125 volts. This gives a current change of 1.25 mA. for 25 volts change in anode voltage, or .05 mA. per volt change in the anode circuit.

The ratio of anode-voltage change to anode-currents change can be considered as expressing the "impedance" of the valve since it shows how the current varies with a change of voltage and is of the same form as the formula $Z = V/I$ for an A.C. impedance.

Although the term is still frequently used it is not satisfactory, as impedance implies a quantity which alters with frequency, whereas the constants of the valve are independent of frequency within very wide limits. A more usual term nowadays is "A.C. resistance" and it is measured as given above by taking the change in anode voltage for a small change in anode current. In the example given the A.C. resistance is 25/1.25 mA. or 20,000 ohms.

This value can also be obtained by dividing the amplification factor by the slope of the valve. The reason for this is that the amplification factor can be expressed by the formula dV_a/dV_g where "d" denotes a small change in the voltage of the anode (V_a) and grid (V_g). The slope is similarly given by $DI\ /dV_g$ where dI_a is a small change in the anode current. Dividing one by the other, we get

$$\frac{\text{Magnification factor}}{\text{Slope}} = \frac{dV_a/dV_g}{dI_a/dV_g} =$$

dV_a/dV_a which is the A.C. resistance as given above.

In order that the three readings may agree and cross-check they should all be taken at the same region of the curve, or discrepancies will be found.

The slope of the valve is sometimes referred to as the "mutual conductance," and in America as the "transconductance."

Each of the constants has a standard symbol allotted to it, magnification being denoted by the Greek "μ," slope by "g" and A.C. resistance by "r" and these symbols will be used in future where necessary.

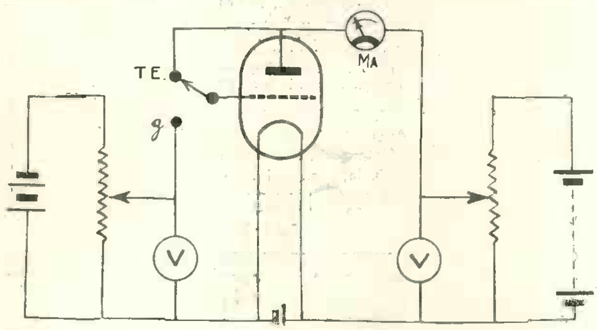


Fig. 2. Typical circuit for measuring static characteristics. The switch in the grid circuit enables measurements of total emission from the cathode to be obtained.

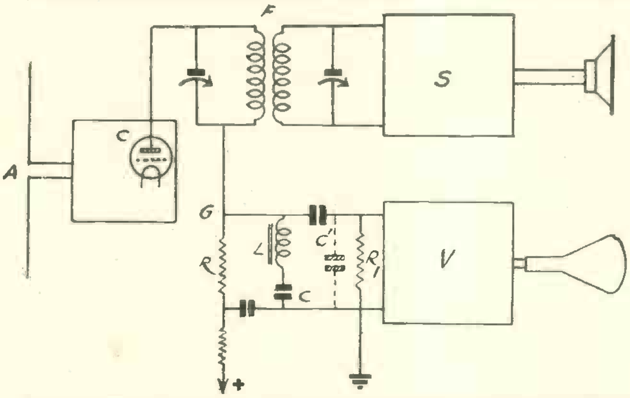
Separating Vision and Sound Signals

IN the interests of economy it is a common practice in television receivers of the frequency-changing type to use a single local oscillator in a channel common for both vision and sound carriers, and thereafter to separate out the two carriers feeding one to a vision intermediate-frequency channel and the other to a sound intermediate-frequency channel.

A receiver of the type just referred to, which has been proposed by the General Electric Co. of America, is illustrated in the figure and is of interest by reason of the separating circuit it contains for separating the two intermediate-frequency carriers. The general layout of the receiver is quite obvious. An aerial A feeds the frequency-changing valve C and in the anode circuit of C are connected in series a sound frequency filter F and a vision-frequency filter G which feed the sound and vision circuits S and G respectively containing the sound and vision intermediate-frequency amplifiers with their detectors and other appropriate circuits. As stated, it is the filter circuits F and G that are of special interest.

The filter F consists of a pair of lightly damped coupled resonant circuits which pick out sharply the sound carrier and its side bands by offering a high impedance to them, but which present only a low impedance to the vision signals and so allow them to pass. On the other hand, the vision filter G by reason of the series resonance circuit formed by the inductance L and capacity C tuned to the sound intermediate-frequency carrier takes negligible account of the sound signals, but offers a relatively high impedance to the whole range of vision signals.

In building up this high impedance, the series circuit L C is utilised and is arranged to resonate in conjunction with the stray parallel capacity C′, inevitably present, to the vision intermediate-frequency carrier, and the resistances R, R′ are chosen so as to damp this resonance and obtain a response wide enough to include all the vision signals. In this way sound signals almost entirely free from vision signals are fed to the sound channel S and vision signals from which practically all sound interference has been eliminated are fed to the vision channel V.



Circuit for separating the two I.F. carriers.

A Public Address Current-fed Microphone

A microphone which is particularly suited to P.A. equipment has recently been put on the market by the General Electric Co., Ltd. It is a current-fed portable hand microphone, catalogued as BCS.2290.

A 12-volt accumulator is the sole means of power supply required, a valve amplifier not being necessary, and direct connection is made to the loudspeaker.

The head of the microphone is made from zinc-lacquered aluminium, and the handle is connected with the head so that the automatic return switch is placed just where the thumb falls when the microphone is grasped in the hand.

As the current consumption, 1½ amps., is so low, the proper use of this convenient switch can ensure absolute economy in operation. The instantaneous response of the microphone makes this intermittent use possible.

The quality of reproduction provided is incisive and well defined, and the output is ample to load a public-address type loudspeaker.

A microphone of this type by virtue of the simplicity of installation has innumerable uses at the present time particularly in A.R.P. work or for police use in the control of traffic and the issue of instructions in the black-out.

Iron-cored R.F. Chokes

It is pointed out by Bligh & Proctor* that satisfactory chokes for the prevention of R.F. interference can be made from standard thicknesses of Stalloy stampings, the effective permeability of the core at R.F. being still sufficiently high to be beneficial, while the losses in the iron produce only a slight reduction in impedance at frequencies near the resonant frequency.

A suggested design for a choke of 0.8 mH. to carry 1 amp. consists of 283 turns of No. 26 s.w.g. enamelled and single-silk covered wound on a bobbin through which are threaded Stalloy stampings to ¼ in. thick, 1¼ in. long by ¼ in. wide.

Very little is gained by the use of closed iron circuits, and this type of choke increases its inductance much more rapidly with decreasing frequency. It may, however, be necessary to use closed circuit chokes in proximity to metal cases in preference to "bar" type chokes.

* G.E.C. Journal, Feb. 1940.

AN ICONOSCOPE PRE-AMPLIFIER

By Allen A. Barco, R.C.A. Licence Laboratory

This paper describes a video-frequency pre-amplifier designed for use with the standard silver-caesium sensitized studio-type Iconoscope. This unit constitutes a portion of the equipment used by the R.C.A. Licence Laboratory to generate a complete standard television signal for laboratory test purposes.

THE nature of the Iconoscope load impedance and the first amplifier-stage circuit merit greatest consideration in Iconoscope pre-amplifier design, for it is here that the ultimate limits of signals-to-noise ratio and frequency response are almost wholly determined. It is impossible to remove noise once it has been mixed with the video signal. Hence, it is desirable to amplify the signal as much as possible in the early stages, and to bring about this amplification with the introduction of a minimum of noise and frequency distortion.

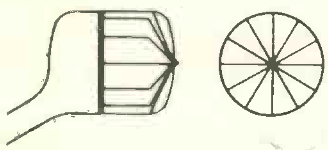


Fig. 1.

These problems permit of more simple solutions than would, at first thought, seem possible. This is true because it has been found possible, and often entirely practicable, to permit the frequency response of the Iconoscope load circuit to depart from a flat characteristic and then, by means of proper correcting circuits, to restore the desired frequency characteristic in some subsequent stage. In other words, the process consists of first obtaining a good signal-to-noise ratio, with little regard to frequency characteristics, and then, after the signal is well above the noise level, correcting the frequency response to conform with the desired characteistic.

For a given value of Iconoscope output-signal current, there are only two ways in which the signal-to-noise ratio may be improved without destroying the desired overall flat frequency-response characteristic. First, the value of the capacitance shunting the Iconoscope load may be reduced, thus permitting the use of a higher value of load resistor. Second, after obtaining minimum capacitance, the value of the load resistor may be further increased, disregarding the effect on frequency response for the present, but with the thought of correcting it in some subsequent stage.

Measurement revealed that the Iconoscope output capacity could be separated into two parts. The first is the direct internal capacity between signal plate and collector—about 5 $\mu\mu$f. The second is the capacity between signal plate and the shielded case in which the Iconoscope is housed. This also was found to be about 5 $\mu\mu$f. Mathematical analysis of the cathode-loaded type of circuit shows that the apparent reduction in input capacity is due to the fact that the cathode-signal voltage has approximately the same amplitude and phase as the grid-signal voltage.

In accordance with this concept an electrostatic shield for the Iconoscope was constructed of fine wires, spaced about a half-inch and placed as shown in Fig. 1. The shield was connected to the cathode of the first amplifier (Fig. 2). This arrangement places the signal plate and its surrounding shield at nearly the same potential (signal voltage, not D.C. potential). Hence any capacitive current, which would tend to flow between signal plate and earth in the unshielded arrangement, is reduced in the shielded circuit by the ratio of the grid-cathode voltage to the signal voltage (grid-earth). This very materially reduces the effective capacity between signal plate and ground. Note, however, that the capacity between shield and earth is effectively placed across the cathode-load resistor of the first stage, but that this has no undesirable effect because it is characteristic of such degenerative amplifiers that the output impedance (at cathode) is approximately $\frac{1}{g_m}$. In the case of the 1851 this is about 110 ohms. Hence, the 20 $\mu\mu$f. (approximate) of capacity between shield and earth may be neglected for most practical purposes (reactance at 5 mc. is 1,590 ohms).

By proper mathematical analysis it may be shown that the effective values of the Iconoscope load components using constants given in the complete circuit diagram shown in Fig. 3 are R = 300,000 ohms and C = 8 $\mu\mu$f. The value of 300,000 ohms (effective value) for the Iconoscope load resistor was chosen for the best possible signal-to-noise ratio commensurate with the ability to equalise the frequency response at the third amplifier stage.

These values were checked by actual measurement and found to be substantially correct. There was, however, a slight increase in both R and C at the higher video frequencies because of slight phase shifts due to the net capacity of approximately 40 $\mu\mu$f. shunting the cathode-load resistor in the first amplifier stage. The increase in effective load resistance is caused by the introduction of a negative resistance component which, at very high frequencies, may be sufficient to permit oscillation. Hence, it was found necessary to include the 100-ohm series grid resistor in the cathode-loaded stage (see Fig. 3). The resistance should be of the non-inductive type and placed as near the grid pin as possible.

Theory and quantitative measurement have indicated that both the Iconoscope load-resistor thermal noise and the first amplifier valve noise are of the same order of magnitude.

Previous investigations of valve noise have indicated that some reduction may be obtained by operating the first amplifier as a triode rather than as a pentode. This requires that the screen-grid by-pass of the cathode-loaded stage be returned to earth rather than to the cathode. While this practice results in a slight increase in effective input capacity it affords about 30 per cent. reduction in overall noise voltage. The effect of the undesirable increase in input capacity (caused by control-grid to screen-grid capacity) may easily be compensated in the third stage.

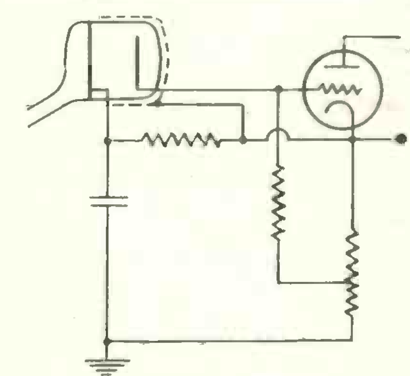


Fig. 2.

Shading Signal Insertion

The need for shading signals arises from the fact that the Iconoscope has the characteristic, inherently due to its principle of operation, of having appear in its output a number of spurious signals in addition to the desired video signal. It is the purpose of the shading signals to neutralise the undesired spurious signals. Since the spurious signal may have an amplitude comparable to that of the video signal, it has

* The use of the electrostatic shield was proposed independently at the laboratories of Electric and Musical Industries, Ltd.

been found desirable to neutralise this undesired signal at as low a level as possible.

The method used for inserting shading signals is shown in Fig. 4. Here, the shading signals, produced in a separate unit, are fed into a 7,500-ohm resistor which serves as the apparent constant-voltage source of shading signals for the Iconoscope proper. The shading signals are then applied to the grid of the first amplifier through a 5-megohm resistor. This must be done in order to make the shading signals at the first-amplifier grid appear as being derived from a constant-current source. In other words, the source of shading signals must not act as an appreciable shunt upon the Iconoscope load impedance.

Second Stage.—The second-stage amplifier consists of an 1851 pentode amplifier employing the conventional shunt peaking to extend the frequency characteristic. This stage is compensated to 5 mc. and affords a gain of approximately 13.

Third Stage.—This stage is unique in regard to its anode load and the method of coupling into the following stage. It is the function of the third stage to correct for the alteration in frequency response which occurs in the Iconoscope load circuit. The Iconoscope load consists, effectively, of 8 $\mu\mu$f. and 300,000 ohms in shunt. Assuming the Iconoscope to be a constant-current source, and that the composite gain of the first and second stages is of magnitude A (constant throughout the video band), the output characteristic of the second stage may be represented by

$$E = I\left[\frac{R_1 \times \dfrac{1}{J\omega C_1}}{R_1 + \dfrac{1}{J\omega C_1}}\right]A$$

where

E = output voltage of the second stage.
I = Iconoscope output current.
R_1 = Iconoscope load resistance (effective value).
C_1 = Iconoscope load resistance (effective value).

After due simplification, the output characteristic may be seen to be of the form

$$E = K\left(\frac{R_1}{1 + J\omega C_1 R_1}\right)$$

The output obviously varies in phase and in amplitude as a function of frequency. If a third stage were used having a plate load of the form $R_2 + J\omega L_2$ the gain over three stages would be

$$K^1\left(\frac{R_1}{1 + J\omega C_1 R_1}\right)(R_2 + J\omega L_2)$$

(Continued on next page)

where K^1 is a new constant taken to include the g_m of the third stage. Simplification of this expression gives

$$K^1R_1R_2\left[\frac{1+\dfrac{J\omega L_2}{R_2}}{1+J\omega C_1R_1}\right]$$

Thus, if $\frac{L_2}{R_2} = C_1R_1$, the output of the third stage will be of constant amplitude and free of phase shift throughout the video band.

By making the load impedance of the form $R_2 + J\omega M_2$, it is possible to eliminate the effect of power-supply impedance by means of the circuit in Fig. 5. The reactances of the windings are made to have their resonant periods (resonance with shunt-circuit capacities) fall well outside the video-frequency band. The time constant of the components R_1 and C_1 is made sufficiently large to eliminate any appreciable attenuation or phase shift at low frequencies. The same is true of R_3 and C_3, which constitute a conventional grid-coupling circuit. The resistor R_2 is made variable (about 25 ohms total resistance), and its final value determined by observation of the picture after the unit is placed in operation.

One excellent type of picture subject matter, for use when adjusting the low-frequency gain-control resistor R_2, consists of film titles, the high degree of contrast being particularly desirable. Incorrect adjustment of R_2 will be indicated by a smeared appearance of the picture. That is, an appearance of black or white shadows following the vertical edges of the letters. Upon correct adjustment of R_2 the edges become clear and sharp.

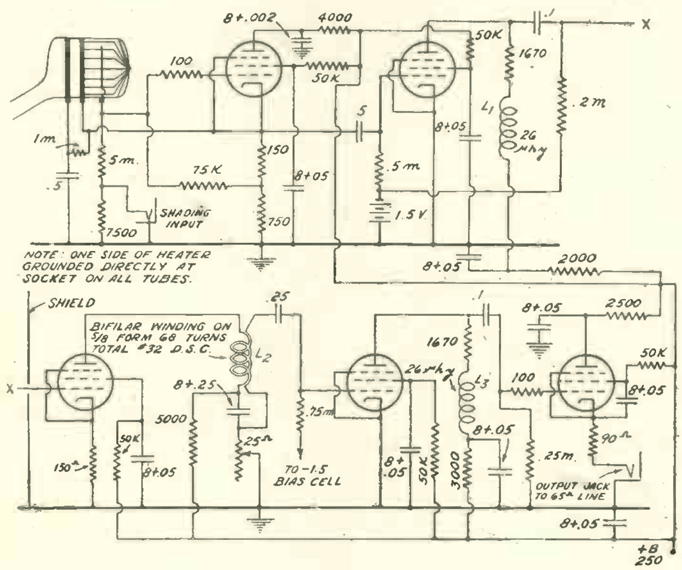


Fig. 3.

The response of the first three stages to a 15-kc. square wave may be made perfect on either positive or negative grid swings by the adjustment of R_2, but perfect response on both swings is possible only upon the inclusion of a 150-ohm unbypassed cathode load as shown in Fig. 5. Here again is employed another of the useful features of cathode-loaded amplifiers—improvement in linearity of the amplitude characteristic.

While there are many other methods of compensating frequency response, this one has been found to be most desirable in regard to ease of adjustment, permissible gain per stage, and ability to correct accurately large variations in frequency response (about 50 : 1 in this case).

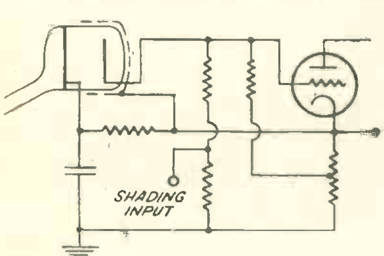


Fig. 4.

Fourth Stage.—The fourth stage is similar to the second stage. It too is in general a conventional video amplifier. However, it utilises a somewhat higher value of load resistor by virtue of the lower value of shunt capacity appearing in its anode circuit. The reason for the reduction in capacity will be apparent upon consideration of the fifth stage.

Fifth Stage.—In most practical applications it is desirable to locate the pre-amplifier in the camera head proper, directly beneath the Iconoscope. In such cases the output leads may range from 5 ft. to 50 ft., or in some cases even longer. It is convenient to have this output lead take the form of a concentric cable, all or a portion of which may be flexible.

It is also desirable to be able to couple into, or out of, this cable without having to resort to excessively large blocking condensers, or other undesirable coupling means which are usually necessitated by low-impedance lines. Again it is found convenient to use the degenerative or cathode-loaded amplifier. In this case, the principal reasons for using it are to provide a low-output impedance, and also to maintain the cable near ground potential insofar as direct current is concerned.

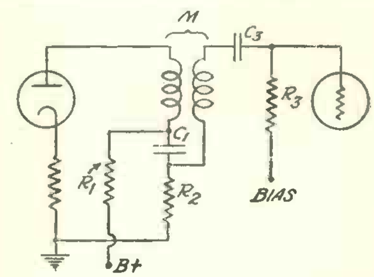


Fig. 5.

The cathode-loaded output stage is shown in Fig. 6. Here C_1 and R_1 are the conventional grid-coupling components. The value of R_2 is chosen so that R_2 plus the cable impedance is sufficient to furnish the correct value of bias necessary to maintain the zero-signal anode current of the 1851 at about 10 mA. This total value will normally be about 160 ohms. It has been found sufficient to terminate the cable at one end only.

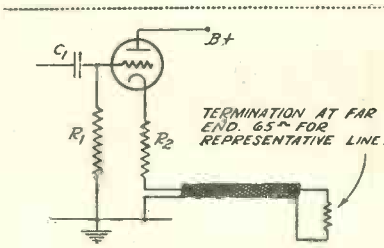


Fig. 6.

Power Supply

The plate-voltage supply for the pre-amplifier should be capable of delivering about 60 milliamperes at 250 volts. It is highly desirable that this supply be of the voltage-regulated type, not necessarily because of the low output impedance afforded by such supplies, but rather because of its low hum level and its ability to remove the effect of line-voltage variations and surges which might cause changes in the plate voltage, and hence shifting of the picture background or brightness level. As an additional safeguard toward greater stability, ample use has been made, throughout the pre-amplifier, of adequate plate-circuit decoupling filters.

All electrolytic condensers are by-passed by small paper or mica condensers. This must be done because electrolytics have been found to show appreciable impedance at the higher video frequencies.

This amplifier, when used in conjunction with an f: 3.5 lens and a studio-type Iconoscope operating at about 0.1 microampere beam current (combined signal-plate and collector currents) is capable of producing an excellent picture. With outdoor pickup on a very cloudy day the noise level is so low as to be unnoticeable. Under the aforementioned conditions the output level is about 0.2 volt (peak to peak). Overload occurs at about 1.5 volts (peak to peak) output. However, this condition is rarely met in practice and may be prevented in cases of excessive illumination by stopping down the lens.

New Osram Valves

DC/AC Power Pentode

The General Electric Co., Ltd., has just released a new indirectly-heated power tetrode, the Osram KT35, which has been specially designed for the output stage of DC/AC sets. This valve has a heater rating of 0.3 amp. 26 volts, and can, therefore, be used in series with other valves of the same current consumption as an efficient output stage.

The heater is also centre-tapped, permitting the convenient use of a 12-13 volt battery supply if desired. The maximum anode dissipation is 10 watts, and at an anode and screen voltage of 175 the normal power output is of the order of 4½ watts per valve. A slope of 10 milliamps. volt results in high sensitivity. It is therefore a DC/AC output valve of very considerable efficiency.

It is fitted with the international octal base and is listed at 10s. 6d. An important feature of this valve is that it does not require a G.P.O. permit, and a receiver in which it is used can, therefore, be sold and purchased without restriction.

New Mercury Vapour Rectifier

The Osram mercury-rectifier, type GU5, is now replaced with a new design to be known as the GU50.

(*Continued in 3rd col.*)

The GU50 has characteristics identical to its predecessor, and can be employed in all apparatus for which the GU5 has been specified. As a result of considerable research, it incorporates many modifications in design, however, which will improve the reliability factor under maximum conditions of operation. This new valve can be recommended as a reliable rectifier where an output up to 250 milliamps. per valve (with delayed switching) is required. It is rated up to 1,500 volts R.M.S. and priced at 25s.

VMP4O Replaces VMP4

The G.E.C. also states that valve type VMP4, the 4-volt indirectly heated variable-mu H.F. pentode, is now obsolete. To meet the requirements of servicing receivers in which this valve was used, the more recent VMP4G will now be supplied fitted either with a 5-pin or 7-pin base as required. The VMP4G will replace the VMP4 with perfectly satisfactory results.

Tuneray Indicators

The well-known Osram Tuneray Indicators types Y63 and Y64 have been replaced by improved types known as Y61 and Y62.

The new types are enclosed in a small tubular bulb, in place of the dome-shaped bulb hitherto employed. This facilitates mounting in position in the receiver by obviating the necessity for using a rigidly held valveholder, a simple clamp round the tubular bulb serving to hold the tuning indicator in position. The new tuning indicators, types Y61 and Y62 can be used to replace the Y63 and Y64 types.

The characteristics of the Y61 and Y62 are similar, but the Y62 type is designed to operate with sufficient brilliance at lower voltages such as are met with in D.C. or A.C./D.C. receivers. Both valves are fitted with an international octal base and are listed at 8s. 6d. each.

1.4-*Volt Dry-battery Valves*

To meet the increasing demand for 1.4-volt battery valves of the low consumption type, created by the growing popularity for all dry battery receivers, the G.E.C. also announce that four new valves in this category will shortly be made available.

These comprise a range for superhet receivers, and will consist of :—

Frequency changer—Osram type X14. List price 10s. 6d.

H.F. pentode—Osram type Z14. List price 9s.

Single diode-triode—Osram type HD14. List price 7s. 6d.

Output pentode—Osram type N14. List price 9s.

With the exception of the output valve, the filament consumption of each type is only 0.05 amp., the output pentode N14 taking 0.1 amp. and rated for an output of 250 milliwatts.

The International octal base is used for the Osram 1.4 volt range, and the four types have characteristics similar to well established American valves, counterparts as follows :—

Osram type X14—Counterpart of American type 1A7G.

Osram type Z14—Counterpart of American type 1N5G.

Osram type HD14—Counterpart of American type 1H5G.

Osram type N14—Counterpart of American type 1C5G.

The Ear in Relation to Talking Pictures

Abstract of a paper entitled " The Physiology of the Ear in Relation to Talking Pictures," read by Dr. A. F. Rawdon-Smith, M.A., before the British Kinematograph Society, February 26, 1940.

A VERY large section of Dr. Rawdon-Smith's paper dealt in great detail with the physiological construction of the ear and an explanation of the physiology of audition. The following abstracts are those relating to physical considerations only. On this aspect of the subject of the paper, Dr. Rawdon-Smith said :—Both visual and auditory experience have dimensional attributes in common. Of these we may first consider the psychological dimension of brightness or loudness which corresponds, in the physical sphere, to the intensity of the stimulus. An increase in amplitude of vibration results, for the two senses, in an increase in the brightness of a light or the loudness of a sound. In this respect, evidently, the two senses are quite strictly comparable.

But now let us look at the physical dimension of wavelength. Psychologically, this corresponds, of course, to colour (or more strictly hue) and to pitch. Here again, the two senses appear at first sight to be comparable. But in this instance the similarity is in large part illusory, and for this reason. The importance to the two senses of the physical attribute of wavelength is altogether incomparable. In no sphere is the truth of this statement better illustrated than in the talking picture.

The colour film is a relatively recent introduction. We are well used to films in which the total of possible attributes of the visual sensation is reduced in several ways, but most notably perhaps by the omission of colour—by the reduction of the many hued experience to which we are accustomed in everyday life to a simple series of greys, the so-called black-grey-white continuum. Now white (or grey) light is produced by allowing a large number of stimulus wavelengths to act upon the eye simultaneously. In the auditory sphere, a comparable situation exists when the ear is stimulated by a hissing sound, such as that produced, for example, by applying amplified thermal noise to a loudspeaker of linear characteristic. And thus, we may see how great is the difference between the eye and the ear.

For years we have enjoyed films in which the visual stimulus was characterised by the possession of light and shade, and of form, but not of colour. To the ear, such a stimulus would be no more than a hissing sound, getting louder and softer in some rhythmic manner. Even the earliest talkies were not altogether as bad as this

It would be interesting to pursue our analogies between the two senses further, to compare wavelength composition with timbre, stereoscopic vision with stereophonic audition. We have, I think, seen enough to be convinced that we may expect both similarities and differences in our comparison of the two organs.

So far as I can see, very little of the considerable mass of data relating to the physiology of the ear has so far been made use of by the sound engineer in any field. Indeed, the only obvious example which springs to mind lies in the knowledge concerning the upper and lower frequency limits of reproduced sounds. The limits indicated both by measurements of the frequency sensitivity of the ear may be set roughly at 30 and 15,000 c.p.s. Now, though these limits are far from being achieved in an average cinema installation—whether at the studio or the cinema end—they are certainly already within the bounds of practical achievement. There is in existence at least one experimental film recording and reproducing equipment in which they are slightly exceeded, and we may not unreasonably hope that they may in the normal process of development become general within the next few years.

Turning next to the problem of harmonic distortion, it appears to me that auditory physiology indeed has something of interest to say here. Inspection of the harmonic distortion curves reveals that, at high sound intensities, the distortion introduced by the ear is sufficiently great to mask any slight additional distortion in the reproduced sound. I suggest that, provided the distortion in the reproducing equipment does not exceed 2 or 3 per cent., 2nd or 3rd harmonics (with higher harmonics correspondingly less) at maximum output, and further provided that this maximum output corresponds to a loudness level of not less than 80 phons to the listener, then reproducer distortion will be completely masked by the 10 per cent. or more 2nd and 3rd harmonic distortion for which the ear will be responsible. It is very clear that this specification is well within the limits of practical achievement.

It seems to me that the two most important desiderata in sound reproducing apparatus are now well within sight of fulfilment even in relatively modest equipment. The steady improvement in the width of the reproduced frequency band, and the steady reduction in harmonic distortion will, if maintained as they have been in the past, render this possible within the next few years. The progressive sound technician will, therefore, if my interpretation of the data of auditory physiology is correct, now seek major improvements elsewhere.

The second suggestion which I wish to make, for future research work, is in regard to stereophonic reproduction. The field here seems to me to be ripe for development, since the increased fidelity which stereophonic reproduction offers would be strikingly great. It may perhaps be argued that the necessity for separate earphones for each member of the listening audience would render the attainment impossible—to this objection I would answer that, for the achievement of a sufficient degree of auditory perspective, earphones are not necessary at all. Many will be familiar with the remarkable experiment in stereophonic reproduction carried out in 1933 by the Bell Telephone Laboratory staff. In this a performance of several orchestral works was relayed by a three-way high-fidelity land-link from Washington to Philadelphia. In this system three microphones were linked by separate channels to three loudspeakers—as would clearly be easily practicable in film reproducing equipment.

The sense of perspective thus obtained

though not strictly to be termed stereophonic, is none the less an extremely close approximation. To the untrained observer, indeed, the effect is little short of astounding, and is certainly sufficient to warrant a trial of this system under moving picture conditions. It might well be discovered, I believe, that such sound reproduction would in some degree compensate for the absence of perspective in the visual sphere—though this could be employed in addition, of course, using any of the techniques which have already been evolved.

It is evident that the use of multi-channel reproducing equipment of this type would necessitate an improvement in the acoustics of many cinemas. Indeed, such an improvement would often be merited under present conditions.

Book Review

Cathode-ray Oscillographs. J. H. Reyner, B.Sc (Sir Isaac Pitman and Sons, Ltd.), 8s. 6d.

At the present time when the cathode-ray oscillograph is proving itself an almost indispensable instrument for test purposes, this book will fill a definite want, for it is written as a simple guide to the practical application of the cathode-ray tube for the study of wave-forms.

The first two chapters are devoted to an explanation of the oscillograph, including discussions on tube types, time bases, synchronism, focus, distortion, etc., and the remainder of the book to the practical use of the instrument. The explanations are easily understandable, and the book will prove useful to all those who use an oscillograph or wish to understand the many applications of this device. The book contains 180 pages and is illustrated with 128 photographs and diagrams.

Engineering Training

A B.T.H. Scheme

ONE of the most comprehensive schemes for training young people in electrical engineering is that of The British Thomson-Houston Co., Ltd., and evidence of this is given in an attractive sixty-page brochure, entitled "Engineering Training," of which a new edition has just been published. The B.T.H. Co. was one of the pioneers to evolve planned courses of training best suited not only to the industry but to the candidates themselves. This firm to-day caters for every kind of candidate for training, from the boy in his early 'teens desirous of learning a trade, to postgraduate courses for honours-degree men.

Many parents who are faced with the problem of deciding upon careers for their sons will find this brochure of great assistance as the information has been compiled to present as simply and clearly as possible the various methods which may be followed, and to afford guidance in choosing a plan best suited to individual cases, with special reference to the training courses which have been instituted by the Company as a result of many years of experience.

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The Company has never accepted premiums for any of its Courses, being of the opinion that a boy of ability should not be handicapped by such financial consideration.

Copies of the brochure may be had free upon application to the publicity department, The British Thomson-Houston Company, Ltd., Rugby. The B.T.H. Company has works at Rugby, Willesden, Birmingham, Coventry and Chesterfield.

Space-charge Coupling

On Feb. 20, Mr. J. A. Sargrove, F.T.S., N.C.M.E., M.I.B.E., M.Brit.I.R.E. (Chief Engineer of the British Tungsram Radio Works, Ltd.), delivered a paper to the University of Birmingham Radio Society entitled "Further Applications of Space-charge Coupling," which was a direct continuation of the previous paper delivered on November 7 to the same society entitled "Parasitic Oscillations and Space-charge Coupling as a By-product of the Mixer Phenomenon, and Its Practical Utilisation for the Generation of Ultra-short Waves," (reported in the Dec., 1939, issue).

Mr. Sargrove referred to some of the diagrams previously introduced showing the phase relationship of the first control grid voltage and the space-charge potential, as well as the second control grid voltage resulting from influence between the space-charge and the second control grid.

It was explained that a direct consequence of the various phase relationships that can exist between the two control grid voltages as a result of the loading of the second control grid, i.e., whether the second control

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grid circuit is inductive, capacitive or ohmic, is that the D.C. anode current of the mixer valve is respectively higher than lower than or the same as the anode current would be if the second control grid were short-circuited to the cathode.

The change from a higher to a lower value of D.C. anode current as a function of oscillator frequency is very sudden and in fact can have a value as high as 1 milliamp. per 1 per cent. frequency shift. As it is very easy to alter the oscillator frequency by variation of capacity or inductance or phase angle, this peculiar characteristic can be used very advantageously for the amplification of the condenser microphone and any device in which a variation of inductance or capacity occurs, or as a null-indicator in an inductance or capacity bridge based on the substitution method.

Mr. Sargrove illustrated various circuits utilising a Tungsram octode type VO4, and also demonstrated the effect with experimental apparatus in which a change of as much as 5 mA. could be produced with a change of 10 $\mu\mu$F. He also explained the mathematical relationship of the various factors contributing to the effect.

In view of the very great sensitivity of this system it is essential that other factors such as variation of supply voltage, etc., should not interfere with the accuracy of its operation and hence he discussed numerous ways of counteracting drift by putting a further octode in opposition and by the use of neon lamps for stabilisation.

The utility of this phenomena for condenser microphone amplification is most advantageous as the output from the first valve across a 100,000 ohms anode load has a value of ½ volt, and further the condenser microphone requires no polarisation voltage and works into a D.C. short circuit, unlike the normal L.F. amplifier in which it works into an extremely high load resistance, having a value of some 10 megohms or more.

A direct consequence of this is a very good signal-to-noise ratio, a reduction of mains hum, and the possibility of using the condenser microphone without the amplifier being built into the sound head.

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