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and SHORT-WAVE WORLD

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LONDON, W.C.2.

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Made possible by the new light relay: First published account.

SIR NOEL ASHBRIDGE

B.B.C. Chief Engineer on Television Development.

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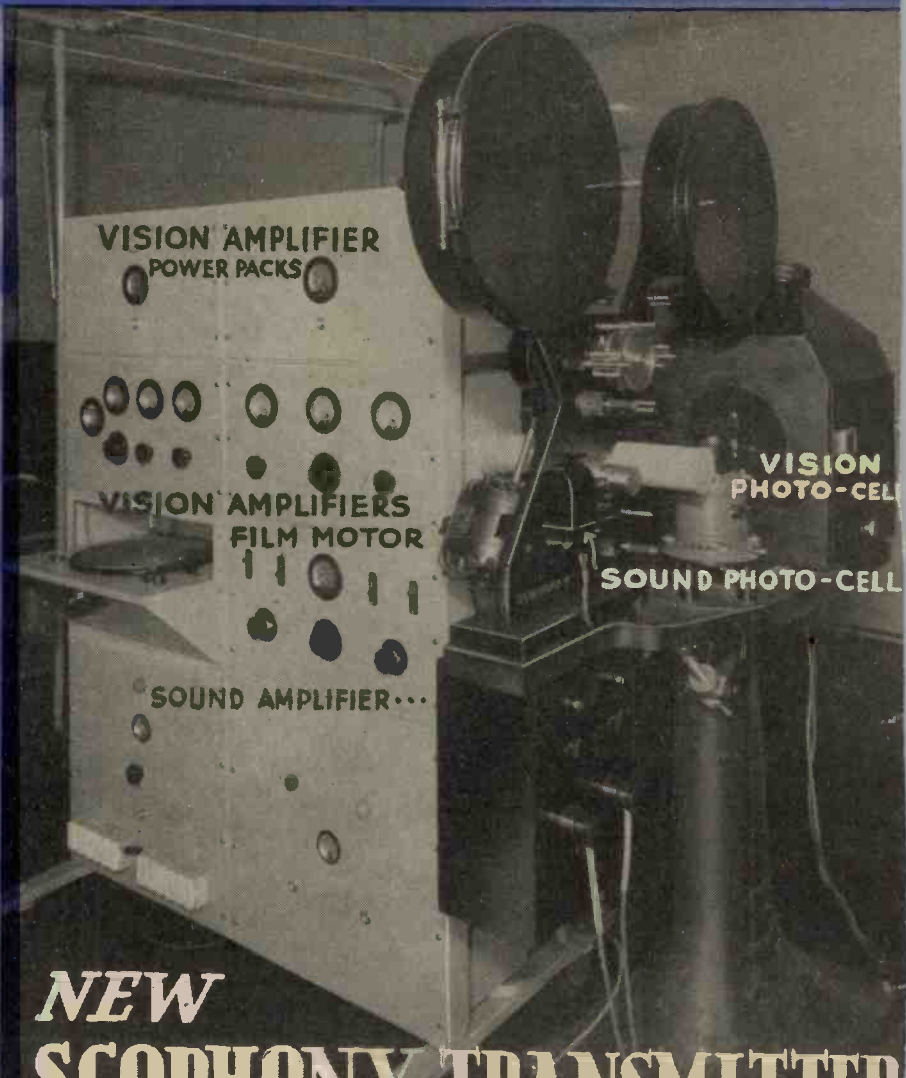

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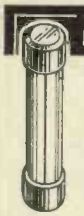

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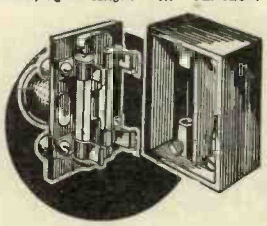

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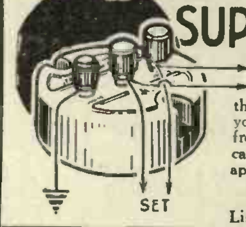

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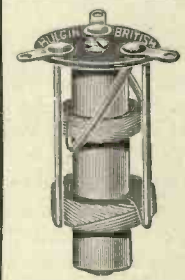

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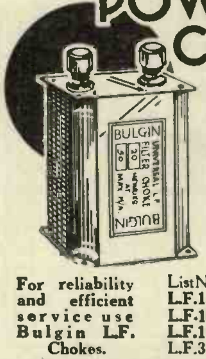

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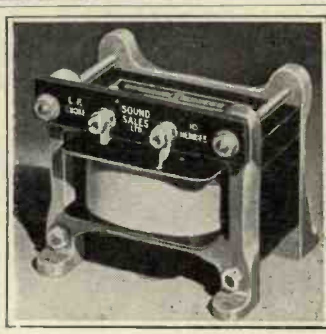

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No. 99 VOL. IX MAY, 1936.

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COMMENT OF THE MONTH

Mechanical Systems.

IT is no secret that when the recommendation of the Television Committee was made that 240 lines should be the minimum standard of definition, there was a certain amount of perturbation among those who had made mechanical methods the line of attack in the solution of the television problem. No experiments had been carried out with light modulation at the frequencies involved, and a number of experts contended that known methods would be quite inadequate and that no other solution appeared possible. A further bombshell was dropped when the Television Advisory Committee made known the intention of using two scanning standards. As Sir Noel Ashbridge, the B.B.C. Chief Engineer, has pointed out, the Committee itself felt that this procedure was undesirable, but that it was the only practicable way of giving two systems which were ready to be put into operation a fair test. A deputation waited on the Committee in the hope of getting this decision altered, for on the face of it, it seemed fatal to mechanical systems unless two different types of scanner were used alternatively for each type of transmission.

As the deputation failed to move the Committee in its decision there was nothing more to be done than to tackle the problem as such, and although very little, or nothing, has been heard of the lines of attack for the past few months, those interested in mechanical systems have not been idle. We are now able to announce that both the Scophony and Mihaly-Traub systems have been developed in such a manner that reception of high-definition television by mechanical methods is now entirely practicable.

Through the courtesy of Mr. S. Sargall, managing director of Scophony, Ltd., we are able in this issue to give our readers the first details of the new Scophony light control, which it is expected will make the projection of large pictures possible.

OUR COVER PHOTOGRAPH

The picture on the cover of this issue shows the Scophony 240-line sound-on-film television transmitter, using continuously moving film. A small arc lamp is used as the light source and the photo-cell is contained in a long screened tube projecting from the side of the amplifier. The amplifying gear consists of a complete vision amplifier with power supply and the sound-on-film amplifier. A non-synchronous playing turntable also forms part of the equipment and this can be seen on the left of the photograph.

THE SCOPHONY LIGHT CONTROL

By The Inventor, J. H. JEFFREE of the Scophony Laboratories

Readers will remember that this journal was the first to publish authoritative details of the Scophony system of television. We have now pleasure in presenting to our readers the first authoritative account, by the inventor, of the new Scophony Light Relay and its uses in television. Scophony Limited have had as their objective projected pictures of sizes suitable for all commercial purposes, either home and cinema, and it would appear that they have successfully realised their ambition. The Scophony-Jeffree Light Control is one of the most outstanding contributions to television technique in recent years. The claims that are made for this new Light Control can briefly be summarised as follows: All present-day television, whether employing optico-mechanical scanning means, or cathode rays, is based on one aperture being operative at any given time. The Scophony Light Control makes as many as fifty or even a hundred apertures operative at any given time. In conjunction with other fundamental features of Scophony optical systems, this Light Control makes possible commercial apparatus with adequate brilliancy, achieved with low power and low voltage.

IN the development of mechanico-optical systems of television one of the chief problems has been that of the light relay in the receiver. This has to vary the brightness of the light which scans the receiver screen, within periods which for high-definition television may be as short as one five-millionth of a second.

J. H. Jeffree of the Scophony Laboratories, the inventor of the new Light Relay.

First and Exclusive Description

Whatever physical movement we use to effect this variation, it must be small in amount to be practicable at such speeds. A favourite device has been the Kerr cell, where we may picture inter-molecular movements in the nitrobenzene as the means of operation. The Kerr cell has, however, certain disadvantages.

Another line of approach has been through interference of light. Beams of light, produced by apertures, lenses and so on, follow paths that can be calculated by assuming light to be waves of very short wavelengths, about one fifty-thousandth of an inch. When the lenses and apertures are of ordinary sizes, thousands of times larger than these wavelengths, light behaves for most practical purposes as rays, and travels in straight lines. When, however, it encounters small structures, of the order of size of these wavelengths, it may behave quite differently.

Preliminary Experiments

For instance, if we focus an image of a bright filament on a screen with a lens, we have a beam which we can consider as a bundle of rays of light, stretching from each point of the lens aperture to each point of the filament image. We may reflect this beam at some point by interposing a flat mirror, without otherwise disturbing the phenomenon. Suppose, however, we divide the mirror into a large number of small elements, about half of which, taken at random, are raised up one two-hundred-thousandth of an inch above the level of the remainder (without tilting them at all), then the result will be quite different from what we would expect of a bundle of rays of light. The filament image on the screen will now almost disappear, while round it, at some distance depending on the size and arrangement of the small elements into which we have divided the mirror, will be a coloured halo, formed of the light previously concentrated in the image.

If we raise the mirror elements gradually, from zero to one two-hundred-thousandth of an inch, we shall see the filament image gradually fade out and the coloured halo gradually appear. If we cut a hole in the screen, large enough to pass the filament image but not the halo, we can control the brightness of the light passing through it, from full brightness to fairly dark, by a movement of one two-hundred-thousandth of an inch in the mirror surfaces.

Supersonic Waves

This arrangement can be realised in practice, not by cutting a mirror into a number of pieces, but by laying on one flat mirror (surface silvered) a second silvered glass plate with half the silvering scratched away. The finer the scratches the better. Such an arrangement was actually tried in the Scophony laboratory and was the forerunner of the relay described in this article. It was not satisfactory, because no good way was found of controlling precisely the separation between the mirrors, but the effects occurred as expected from the wave theory of light.

It occurred to the writer, while experimenting with the above, that similar small differences would be produced in the path of a light beam if it were passed through a liquid in which supersonic waves were propagated. Supersonic waves of wavelengths down to a fraction of a millimetre are readily produced in liquids by the agency of piezoelectric crystal plates, for instance, of quartz or tourmaline, and are propagated from a flat crystal as plane wave-fronts of compression and rarefaction.

A light beam, passing through the liquid parallel to these wave fronts, would be retarded more by the compressed regions than by the rarified ones. The

MULTIPLE SPOT SCANNING

effect would be analogous to that of the raised parts of the mirror in our previous example, with the difference, that since the supersonic waves are regularly spaced, we get not a mere coloured halo, but a regular series of diffraction spectra with the colours in definite positions. The central image formed by the focused beam would fade out, however, in just the same way

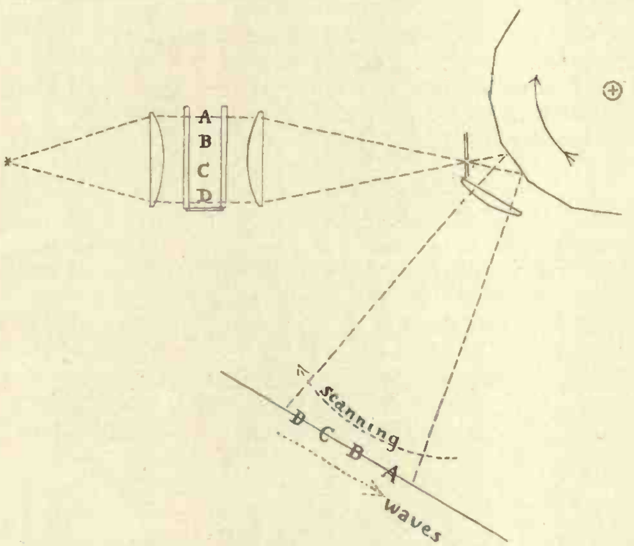


Fig. 1.—Diagram explaining simultaneous production of fifty picture details on the receiver screen.

as in the mirror experiments, as the amplitude of the supersonic waves increased. This could therefore be used as a practical light relay, either by passing the central beam through a screen which stopped the diffraction spectra or by letting the spectra pass and stopping the central image with a wire.

Moreover, the supersonic waves move in the liquid with a definite velocity of propagation. This means that when, in accordance with a television signal, we modulate the electric oscillation applied to the quartz crystal plate, we should get groups of supersonic waves moving along the liquid, each group corresponding to one of a series of successive modulation values, which are thus strung out in space in their correct order in the liquid.

Fifty Spots Simultaneously

Now it is a known idea, that if we had a series of light relays, controlling a series of scanning spots following one another on the receiver screen, and if we could delay the modulation of each relay after the first, by the amount of time by which its spot follows the first spot, then we would be able to scan the screen with several light spots instead of one, and get a proportionately brighter picture. This, however, is what the new relay automatically gives us. Any point in the liquid, at a certain distance from the quartz crystal, will modulate light with a delay equal to the time needed for the supersonic waves to travel from the crystal to that point.

If we arrange our optical system rightly, we do not even need to divide the liquid column into a series of separate light relays. We pass a beam of light through the whole column, along which supersonic waves are travelling, and then focus it on a slit to separate out the diffraction spectra. We then provide a scanning system which forms on the screen a line of light which is an image of the whole column of liquid.

The size and magnification of this image is such that the images of the supersonic waves, could they be seen in it, would be seen to pass in the opposite direction to that of scanning, and at the same speed. When this line of light (which may be fifty picture elements long, or more) is caused to scan the picture, the modulated groups of waves travelling along the liquid show up as stationary picture details, each produced by the co-operation of what is equivalent to a row of fifty light relays or more.

A simple arrangement is shown in Fig. 1, in which A, B, C, D represent successive picture details as transmitted to the receiver. (The scanner is supposed here to be a mirror drum. The most varied kinds of scanners can be used in practice.)

So much for the broad theory, which was worked out before it was known to the writer, that such optical effects of supersonic waves had ever been observed. Unknown to him, the diffraction spectra had already been studied (March, 1934), but apparently the extinction of the central beam had not been realised. It is easy enough, however, to demonstrate, and happens exactly as predicted from optical theory.

Practical Application

In working out the practical application one of the first things to decide is the order of frequency to use. The higher this can be, the shorter the wavelength of the waves in the liquid. This is advantageous, since the angle at which the diffraction spectra are spread out

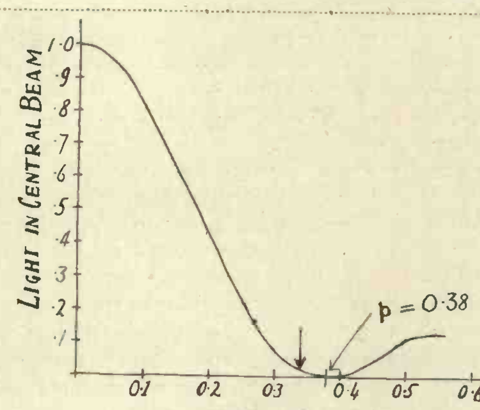


Fig. 2.—Light relay operating curve.

is inversely proportional to this wavelength, being given, in radians, by the ratio of the effective wavelength of light to that of the supersonic waves. (For the first order spectra.) Unfortunately a limit is set by the fact that high-frequency waves in liquids travel

FREQUENCY RESPONSE OF NEW LIGHT CELL

only a limited distance. At 10 mc. they are reduced to half their initial amplitude in about 20 cm. of water or 4 cm. of paraffin oil, and the attenuation increases as the square of the frequency. This makes 10 mc. the right order of frequency to use. The above two liquids are better than many others, in this respect.

At this frequency the wavelength in water is about 0.15 millimetre, in kerosene 0.13 mm. Visible light has an effective wavelength of about 0.00055 mm., so that the diffraction angle is about 1/280 radians for water, 1/230 for kerosene. Though this may seem small, we shall see that it is adequate in practice.

Length of Liquid

The length of the liquid column is settled by the number of picture elements it is desired to show simultaneously on the receiver screen. The important point, here, is that temperature changes affect the velocity of sound propagation in liquids; usually about 1 per cent. per 3° or 4° C. It is often advisable, therefore, to restrict the number of elements to about 50, so that normal changes of room temperature will not seriously impair the accuracy with which the scanning motion follows up the wave motion in the light relay. If 100 elements or more are used, an adjustment is needed in the optical system to compensate for temperature changes. In many cases fifty elements is an adequate number to use.

At 240 lines, 25 pictures per second, fifty elements (assuming one element equals one line width) are scanned in about 0.000026 seconds, during which time supersonic waves travel about 3.4 cm. in kerosene. This shows the order of length of the liquid column useful at high definition in simple sets.

It is instructive to compare the optical efficiency of such a cell, in the direction of scanning, with that of a slit device such as a Kerr cell. This we may do by reducing the aperture and increasing the angle of spread of the light in equal ratio. It is equivalent optically to a double-image Kerr cell passing an unobstructed beam 0.14 cm. wide at an aperture ratio of F/10. Quite a fair Kerr cell for television!

Such a cell, however, would need a scanning device able to concentrate all its light into one picture point. The new light relay divides it among fifty, and therefore demands a scanner only one-fiftieth as efficient to work with it. Such scanners are easily arranged.

The actual scanning arrangements used with it, which provide for a further great increase of light beyond what is indicated here, are described later in this article.

Resonance of Quartz Crystals

The next point is frequency response. Quartz crystals are sometimes supposed to be inherently unsuitable for light relays owing to their sharp resonance in air, but it is all a question of damping. If one worked *in vacuo*, a loudspeaker might behave as a sharply tuned device! Crystals generating supersonic waves in liquids are fairly heavily damped and show reasonably flat resonance curves. Parallel with this, they cease to show double tuning, irregular response over different parts of the surface and other such puzzling phenomena produced in air: all these are connected with lack of damping and vanish, in practice, when damping is considerable.

Sharpness of resonance depends on what we may call the " acoustic refractivities " of crystal and liquid. This quantity is the mass of substance traversed by unit area of sound wave-front in unit time; the product of sound velocity and density, for each body. The ratio between the values for crystal and for liquid is the acoustic " refractive index " between them, and determines the resonance curve. For quartz-water it is about 9, for quartz-kerosene about 14, for quartz-air about 30,000. This explains the much sharper resonance in air.

To a first approximation the percentage off resonance, at which response falls to 71 per cent, is

$$\frac{100}{(n - 1)\pi}$$

Where " n " is the acoustic refractive index. This gives 4 per cent. for water, 2.4 per cent. for kerosene. (The crystal is assumed to vibrate at fundamental frequency, not at harmonics, and to have one face in contact with the liquid.)

At an operating frequency of 10 mc. this means modulation frequencies of 400 kc. and 240 kc. respectively, for 71 per cent. response. Though sufficient for medium definition television this is not good enough for high definition. The obvious expedient of increasing the operating frequency is not a pleasant one owing to the increasing attenuation of the waves, even in water: the other expedient of increasing the damping artificially in some way is also not attractive, since the vibration amplitude for a given voltage would be reduced in the same ratio. Is there another way out?

Analogous problems are familiar in electricity and acoustics: for instance, band-pass filters and the mechanical gramophone sound box. The solution in this case cannot yet be published for reasons connected with patent applications, but it may be stated that very simple means permit the extension of the frequency response to ± 23 per cent. of the operating frequency, with 71 per cent. response, and of this range ± 15 per cent. of the operating frequency is covered with a practically flat-topped curve, the response varying only between 97 per cent. and 103 per cent. of that at resonance. These means have been used in Scophony for the greater part of a year with full success. They give an undistorted response over ± 1.5 megacycles for a 10 mc. crystal, at a cost of a mere doubling of the operating voltage for kerosene.

Such doubling is fully permissible, as the voltages needed are fairly low. To calculate them involves many factors. First among them is the amount of optical retardation needed.

Calculation of Characteristic Curve

In the stepped mirror case, we could assume, for full black, that half the area of the light beam was retarded one-half wavelength relative to the other half. In the present case, however, the retardation is not in abrupt steps, but varies sinusoidally round a mean value. If the maximum and minimum retardations are ± p wavelengths of light, their values along the liquid at any moment are given by

$$p \sin x$$

OPTICAL RETARDATION

wavelengths, where "x" is length along the liquid column in suitable units. The light from each element dx is then thrown out of phase by an angle 2π p sin x, and the resultant intensity of the central beam is

$$\left\{ \frac{1}{2\pi} \int_0^{2\pi} \cos(2\pi p \sin x)\, dx \right\}^2$$

of its full brightness. (By usual optical theory. Space hardly permits the full statement of all the calculations in this article. Only the outlines and their results are given in most cases.) This expression, approximately evaluated for different values of p, gave the curve of Fig. 2, which is the theoretical operating curve of the light relay. According as one uses either the central beam or the diffraction spectra one may consider either top or bottom as full black, but the shape of the two ends is not very dissimilar. How far it is realised in practice will be described below.

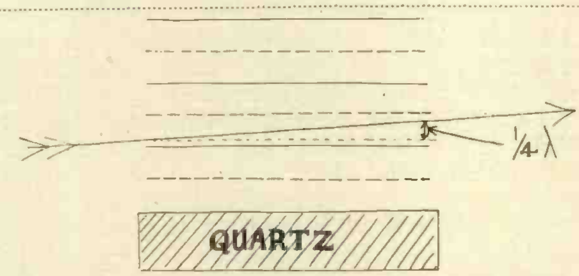


Fig. 3.—Oblique passage of light ray between supersonic wave crests.

These optical retardations depend on the changes of refractive index of the liquid with compression. Here the Lorentz and Lorenz law should hold, connecting refractive index with density, namely

$$\frac{\mu^2 - 1}{\mu^2 + 2} \cdot \frac{1}{d} = \text{constant.}$$

From it we derive that a proportional increase q in density should produce an increase in refractive index of

$$\frac{(\mu^2 + 2)(\mu^2 - 1)}{6\mu} q$$

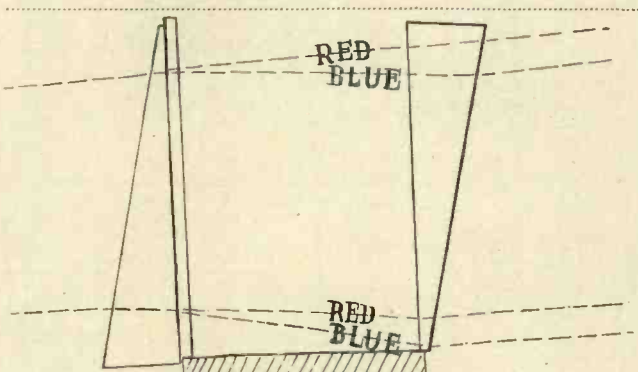


Fig. 4.—Arrangements for colour correction.

Now the retardation of an optical wavefront produced by a body of thickness T is

$$(\mu - 1)\,T$$

from which we see that the variation of retardation produced by proportionate change of density q should be

$$\frac{(\mu^2 + 2)(\mu^2 - 1)}{6\mu} qT$$

Now the pressure in the supersonic wavefront needed to produce a compression q is qE, where E is the elastic coefficient of the liquid. To calculate what voltages on the crystal will produce this pressure, at resonance, in the liquid we can, very fortunately, use an accurate short cut. Instead of calculating how the *amplitudes* of vibration are built up in the quartz we can deal directly in vibration pressures, which build up according to similar laws. We know that a steady

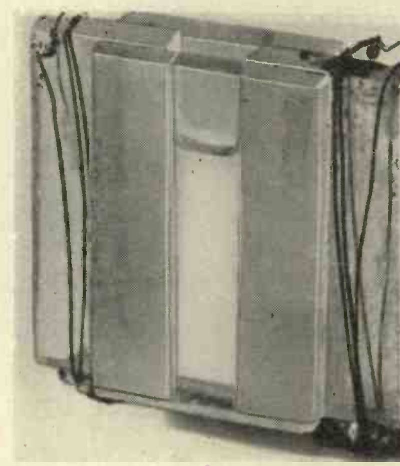


Photo 6.—An early experimental light relay.

voltage V applied across a quartz plate (cut perpendicular to the electric axis) produces an extension or compression of

$$\frac{6.4 \times 10^{-8}\, V}{300} \text{ centimetres}$$

(6.4×10^{-8} = piezo-electric coefficient quartz), which

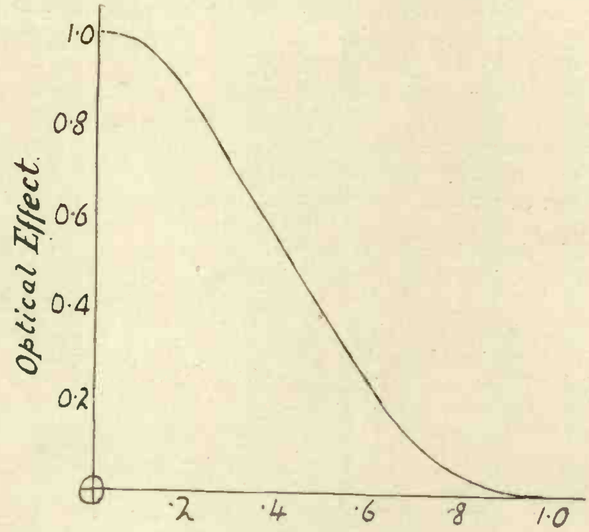


Fig. 5.—Effect of skew rays.

CALCULATION OF VOLTAGE

corresponds to an internal pressure or tension of

$$\frac{6.4 \times 10^{-8}V}{300} \cdot \frac{7.8 \times 10^{11}}{d}$$

where d is the thickness of the plate and 7.8×10^{11} the Young's modulus of quartz along this axis.

Now let the voltage vary sinusoidally at the quartz resonance frequency. Pressure oscillations, so to speak, varying between plus and minus the above value, are generated in the quartz, and by reflection at the

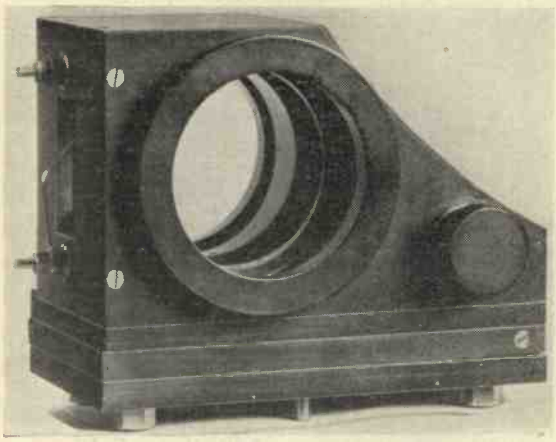


Photo 7.—An example of a commercial form for medium screen high-definition receivers.

two more or less free surfaces build up until *the loss of pressure to the liquid is equal to that produced at each swing by the electrical oscillation.* The above expression for static pressure gives directly the pressure transmitted to the liquid by a quartz plate in contact with it on one side only *at resonance.* With liquid on both sides the pressures would be halved, and off resonance the formula does not apply.

The pressures so communicated have to produce compressions q which yield retardations p equal to ± 0.38 wavelengths of visible light (from the operating curve, Fig. 2). This will give us full black or full white, as the case may be. Omitting the working out, we arrive at voltages (reduced to r.m.s. values) of approximately

$$\frac{E}{20\,vT}$$

for liquids of refractive index about 1.43, such as kerosene.
(E = elastic coefficient of liquid, T = thickness of column of waves, v = operating frequency.)

This formula agrees pretty well with observation. The variation due to refractive index is not very important in practice, but if one takes it into account most liquids agree fairly closely with calculation. Water is an exception: the observed voltages are considerably higher than those calculated.

We may note in passing that the pressures needed for full control are not very great, being of the order of half to one atmosphere in practical cases. Effects such as have been observed for higher pressures (where the liquid fails to follow the quartz vibration) are consequently not troublesome. The amplitude of vibration is also of interest: it is of the order of 10^{-6} centimetres or less, or hardly more than of atomic dimensions.

Permissible Thickness of Liquid

It will be noted that the voltages go down with increasing frequency, for a constant thickness of active liquid. Owing to a further complication, now to be considered, they go up, however, in practice, because the permissible thickness of liquid decreases inversely as the square of the frequency. This arises as follows:

To control as much light as possible, the central beam should have an angular spread about equal to the angle of diffraction of the first order spectra. This enables one just to separate the beam from the spectra when focused on a slit or screen. This angular spread causes component rays of the beam to stray from a crest of the supersonic waves towards a hollow, or vice versa, in passing through the liquid: they are not all parallel to the supersonic wavefront. The shorter the supersonic waves, the greater the angle of diffraction, which is the desirable angle of spread for the central beam, and the less room there is between successive supersonic wave crests for the light rays to spread. Hence we have to reduce the liquid thickness in proportion to the square of the supersonic wavelength.

Reference to the operating curve of Fig. 2 shows that for a supersonic amplitude 90 per cent. of that

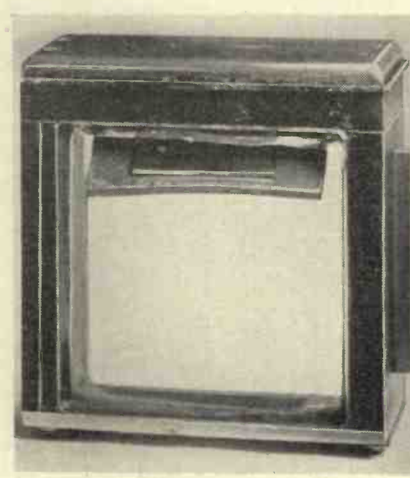


Photo 8.—An example of a commercial form for large screen high-definition demonstration receivers.

producing full control, the optical effect is 98 per cent. of the full effect. We may adopt this as a limit to the permissible error caused by spreading of the light between the supersonic wavecrests. A simple vector calculation shows that if rays spread across a quarter wavelength of supersonic waves in their passage through the liquid the effect of the supersonic waves will be reduced to 90 per cent. Fig. 3 illustrates such a ray.

The permissible thickness of liquid in accordance with this criterion is about

(*Continued on page* 310.)

THE SALIENT FACTS OF UP-TO-DATE TELEVISION

A Compendium of All the More Important Features of Modern Television.

THE cathode ray is an electron stream or beam. The term was coined by early experimenters before the electron arrived on the scene. In the early vacuum tubes the electrons produced used to give the effect of an invisible ray proceeding from the cathode, and the name " cathode ray " applied to this effect has stuck to the more modern tube.

Cathode is the name given to the source of electrons —heated metal. The attracting plate which is mounted a little distance away from the cathode is called the *anode*.

The speed with which the electrons fly to the anode is increased by increasing the attractive force of the anode, i.e., by applying a high *potential*.

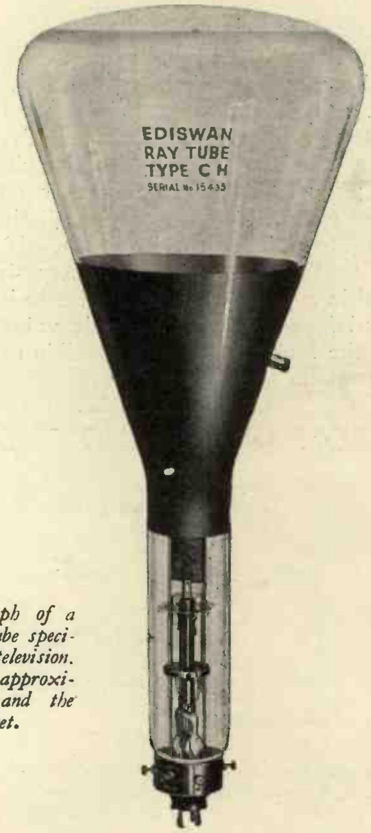
CATHODE-RAY TERMS

Confusion is sometimes caused by the use of different terms to describe the electrodes of the cathode-ray tube. Cathode for the electron emitting electrode is standard, but the anode is either called the anode or sometimes the " gun."

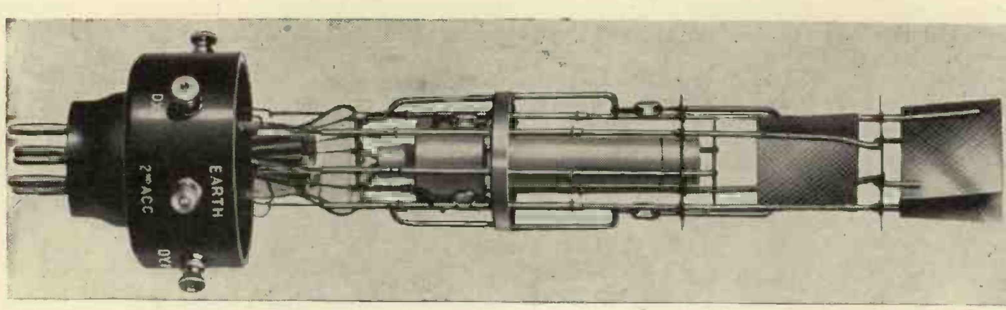
The control of the electron stream is obtained from the small cylinder which surrounds the cathode and is maintained at a negative or slightly positive potential. This is given a variety of names. It is called the Wehnelt cylinder or simply the cylinder, the shield, the control electrode, the modulating electrode, and so on.

There is need for an agreement as to the correct name for this electrode. Shield is probably the most general. Names such as control or modulating electrode are not good because in hard tubes two anodes are provided and some measure of control may be introduced on the first anode or gun.

place of the grid is taken by a cylinder which completely surrounds the cathode and which is negatively biased. The purpose of the negatively charged



This is a photograph of a typical cathode-ray tube specially manufactured for television. The screen diameter is approximately 10 inches and the total length 2 feet.



This is a picture of the electrode assembly of a modern cathode-ray tube; it shows in detail the component parts of the tube shown above.

THE CATHODE-RAY TUBE

There is a certain amount of similarity between the valve and the cathode-ray tube. Both are for the purpose of producing electrons, but in the latter they are required as a thin pencil, or beam, capable of being directed against the fluorescent screen at the end of the tube where their presence is made visible by causing the screen to fluoresce. On this account the cylinder or " shield " as it is called is to compress the electron stream from the cathode and cause it to pass through a central hole in the anode.

By applying a potential to the shield the electrons can be made to form a "jet" of fine dimensions which will pass up the tube and produce a tiny fluorescent spot where they hit the screen. An increased anode voltage will naturally cause more electrons to pass through the hole and thus produce a brighter spot.

THE CATHODE-RAY TUBE

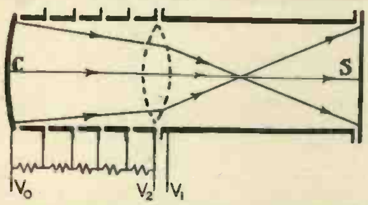
The electron " beam " thus produced behaves like a conductor carrying a current and therefore can be deflected by an electro-static or magnetic field in the neighbourhood. As the beam is a collection of negatively charged particles, it will be attracted by a positively charged plate, or repelled from a negatively charged one, and it is this method which is usually used for causing the beam to move and trace a pattern on the screen.

In the usual type of tube above the electrode structure are two pairs of parallel plates mounted at right angles to each other, and the beam passes between them on its way up the tube. As the beam passes between them it will be attracted by the positively charged one and repelled by the other.

If an alternating voltage is applied to one pair of plates the beam will be deflected first one way and then the other, conforming to the change of polarity on the plates. The spot will now appear as a line, since the eye will not be able to distinguish the rapid swinging to and fro of the beam. If the potential is applied to the other pair of plates the beam will be deflected in a plane at right angles to its original direction, and by applying a suitable value of potential to each of the four plates, it is possible to move the beam to any spot on the screen.

ELECTRON OPTICS AND THE CATHODE-RAY TUBE

Electron optics is the term given to the new science of control of the electron beam. It has a parallel in



A diagram of a simple electron lens system. Focusing of the electrons from the cathode C is accomplished by applying potentials V and they form an image on the screen S.

the optics of light, but instead of refractive materials being used the beam is influenced by electrostatic and magnetic fields.

In modern hard vacuum cathode-ray tubes a concentrating device or electronic lens is used to obtain a sharp focus—such lenses may be either magnetic or electrostatic. The principle of these lenses makes use of the fact that electrons move at right angles to magnetic lines of force and along electrostatic lines of force. A simple magnetic lens consists of a coil of insulated wire wound round the neck of the C.R. tube. When a current flows through this coil the magnetic lines of force exert an inward pressure on the electrons focusing being carried out by varying the coil current.

The electrostatic lens operates on the following principle. There are two accelerating electrodes and the potential difference of about 1,500 volts between them together with their construction causes a converging field to be formed. The beam is brought to a focus by adjusting the potential of the first anode. Electronic lenses are exactly analogous to optical lenses and the same laws hold good for both types.

The spot on the fluorescent screen is an image of the active surface of the cathode and the relative sizes of image and object are dependent on the distances between cathode, lens and screen.

THE HARD CATHODE-RAY TUBE

Until comparatively recently cathode-ray tubes were what was termed soft—that is, a certain amount of gas was allowed to remain in the envelope. Nowadays the hard tube is universally used for television purposes. The high-vacuum tube overcomes many of the disadvantages of the gas-focused type, particularly " origin distortion " and loss of focus at high traversing speeds.

With the high-vacuum tube focusing is a function of the ratio between the first and second accelerator potentials and is independent of the negative cylinder potential. This means that the modulation of the intensity of the beam by a signal on the negative cylinder does not produce loss of focus on strong signals as was the case in the gas-focused tube. Origin distortion is the effect produced by the non-linear response of the beam to small deflecting potentials. This on a television line screen produces what is usually known as the " white cross."

THE FLUORESCENT SCREEN

The inner surface of the wide end of the cathode-ray tube is coated with a material that glows or " fluoresces " when electrons impinge upon it, thereby producing a bright spot of light. The material is usually bound on with pure waterglass.

Several different materials, and combinations of them, are used for the coating. The most active material for producing visual light is zinc silicate (in the form of the powdered mineral *willemite*). This glows a bright yellow-green, to which the human eye is most responsive. For oscillograph use, where the trace of the cathode-ray beam is to be photographed, calcium tungstate, which glows a bright blue colour, is better, since its light is about thirty times as active on a photographic plate as is that from zinc silicate. Cadmium tungstate may also be employed and mixtures of these substances are often used to produce a fluorescence fairly well suited for joint visual and photographic requirements.

The electronic impact energy varies as the square of the speed of the electrons, or, in other words, with the square of the voltage on the anode, so the fluorescent-spot brilliancy increases rapidly as this voltage is increased.

Deterioration of the active material with which the screen is coated will occur if the spot is too intense, due to intense bombardment resulting at the point of impact of the electron stream on the coating of the screen. The electron stream bombards the screen much as rapidly-fired machine-gun bullets would bombard a target, excepting that the machine-gun bullets would have a muzzle velocity of only about 2,000 miles per hour, whereas the electrons in an ordinary cathode-ray tube operated with 1,000 volts on the plate have a velocity of approximately 42 million miles per hour!

The beam should never be allowed to remain motionless, for, if this occurs, the full impact energy of the

ELECTRONIC SCANNERS

electrons will be concentrated at the focused spot on the screen, causing the fluorescent material to disintegrate. A black spot will be observed in the screen after this occurs.

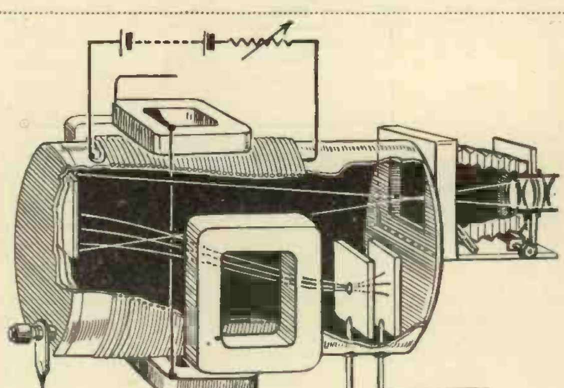
THE ELECTRON-IMAGE CAMERA

The broad working principle of the Farnsworth electron-image camera will be understood by reference to the diagram and the following explanation. The

A photograph of the Farnsworth electron-image camera.

diagram shows a cylindrically shaped vacuum tube, one end of which is coated on the interior surface with photo-electric material and is connected to the negative pole of a source of potential. Upon this coating, which is in the form of a diaphanous layer upon a translucent conducting backing, there is focused an optical image, by means of a lens, of the object or scene to be scanned.

At the other end of the tube there is an anode punctured with a small aperture Q, and electrons given off



Cut-away sketch showing the internal arrangement of the electron-image camera and its method of operation.

by the photo-electric material on the cathode are attracted to this anode under the influence of electrostatic acceleration.

Assuming that all the electrons are emitted from the cathode at right angles to its surface, these, under the influence of the electric field, will be accelerated in straight lines towards the anode and will preserve their relative density-configuration all the way to it. A fluorescent screen placed in the path of the electrons, or upon the anode, would light up with the same tone distribution as that existing in the original optical image.

As electrons come off *en bloc* they can be deflected, as shown, by suitably placed deflector plates or magnetic coils fed with scanning potentials in exactly the same way as the electron beam in a receiving cathode-ray tube.

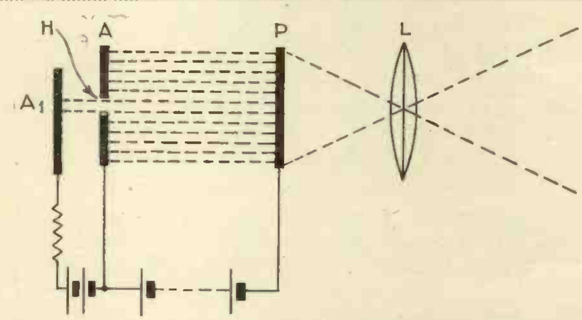


Diagram showing the operating principle of the Farnsworth dissector.

The electrons which would normally strike the anode at Q pass through the aperture, and can be collected on an additional electrode, behind the anode, to yield an electrical signal corresponding with an elemental area of the image. It will be apparent, therefore, that scanning is accomplished by movement of the electron image as a whole, and the electrons are collected only from that portion which is over the aperture at any given instant. The scanning motion is imparted to the electron-phalanx by Farnsworth, not with electrostatic deflector plates, but with magnetic coils in pairs on opposite sides of the tube.

THE ICONOSCOPE

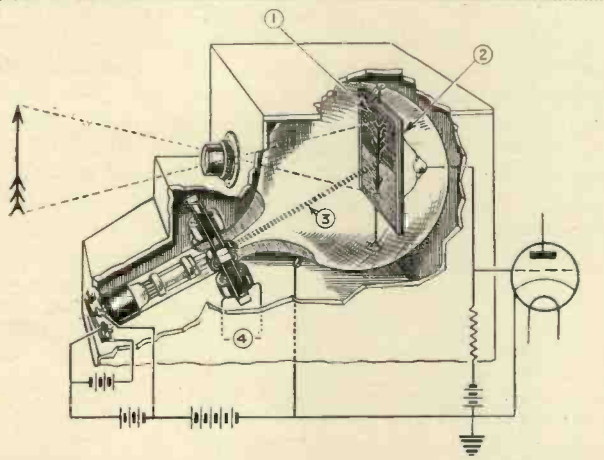
The Iconoscope is a special form of cathode-ray tube which is shown by the drawing. The glass envelope is of a somewhat different shape from the normal cathode-ray tube. The electron beam is produced by an " electron gun " system in a similar way to that of the ordinary cathode-ray tube. The novel feature is the square plate seen in the drawing. This consists of a metallic coating on one side of a sheet of mica. The other side of the mica sheet—the side exposed to the electron beam—is covered with a fine mosaic of minute particles of photo-electric material deposited on the mica.

The metal plate is in two parts, the actual photo-electric mosaic and the back metal plate, called the signal plate. The narrow neck of the tube and a part of the spherical bulb are metal-coated internally, this acting as a second anode for the electron beam which is directed on to the photo-electric mosaic in the usual manner.

Two local oscillators supply the energy to deflecting magnets which surround the neck of the tube. These can be seen in the drawing on the following page.

THE SCANNING CIRCUIT AND SCANNING

An image of the object to be transmitted is focused on the mosaic by a lens system, as shown in the diagram. The mosaic is, of course, systematically swept

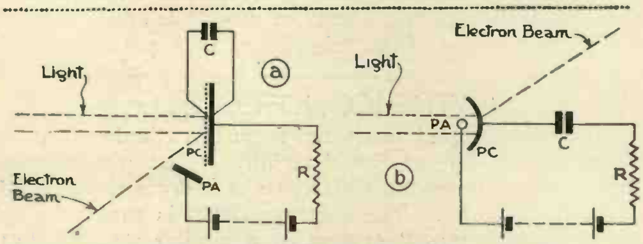


Sketch showing the general construction of the Iconoscope and its method of operation. The reference letters are: 1, Mosaic; 2, Signal plate; 3, Electron beam; 4, Deflecting coils.

by the electron beam under the influence of the framing and line-scanning "saw-tooth" currents applied by the coils.

The cross-section of the electron beam which scans the photo-cell plate must be held within very accurate limits. It must be equal in size to the area of one picture unit. The greater the number of elements into which the picture image is divided, the greater the definition of the received image.

The photo-electric elements of the mosaic are of microscopic size, it being estimated that there are some three million elements on the mica sheet. The scan-



Two diagrams explaining the principle upon which the Iconoscope functions. The second diagram makes the electrical action clear.

ning spot of the electron beam is thus large compared with each photo element, so that a large number of the elements is instantaneously under the influence of the beam. The mosaic itself is made up of minute silver globules each of which is photo-sensitised.

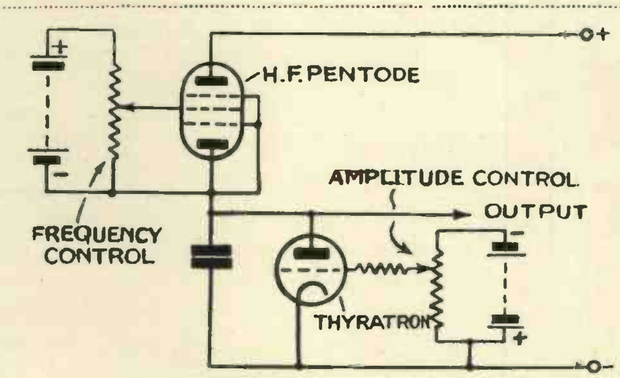
The second two diagrams will make clear the following explanation of the electrical action of the Iconoscope. The first diagram (a) shows the various parts in their actual physical relations. PC is the photo-electric cathode (mosaic) while PA is the metal coating of the tube which acts also as the anode of the photo-electric combination. The photo-electric material is insulated from the back metal plate by the mica sheet, but has a capacity to the metal plate which is shown by the condenser C.

The same elements are shown at *b* as a conventional photo-electric cell and condenser, in order to simplify the explanation. When light from the projected picture falls on the mosaic, each element of it (PC) emits electrons and charges the condenser. When the electron beam impinges on a photo-electric element that element *receives* electrons from the beam and discharges or partially discharges the condenser.

The discharge current will, of course, depend on the charge on the photo-electric condenser element and therefore on the light-intensity on that particular element. The charging and discharging currents into and out of the condenser are thus transformed into signal voltages across the resistance R and applied to the grid of the first amplifying valve. The Iconoscope, therefore, contains all the elements necessary for television scanning of a picture. Thus when a picture is focused on to the mosaic, the regions of light and shade are progressively scanned by the electron beam and varying currents (corresponding to these graduations of light and shade) are set up in the resistance R. In accordance with the normal arrangements of television these currents are amplified and used to modulate the carrier.

SCANNING CIRCUITS

To produce the horizontal scan on the fluorescent screen of the cathode-ray tube the electron beam is caused to move at a steady rate across the fluorescent



An example of a typical scanning circuit.

screen of the cathode-ray tube. Having completed the scan the beam is rapidly returned to the commencement of the next scan.

In order to carry out this operation a waveform of the "saw-tooth" type is required. The vertical traverse is carried out in a similar manner, but at a lower frequency. These saw-tooth waveforms are conveniently obtained by charging a condenser through a constant current device and rapidly discharging it through a valve or mercury relay such as the Thyratron. The first operation represents the scan and the second the return stroke of the scanning cycle.

The scanning waveforms may be applied to the electron beam electrostatically by means of deflecting plates within the tube, or electromagnetically by deflecting coils outside the tube. Both methods are in general use.

PHOTO-ELECTRIC CELLS

A typical scanning circuit is shown opposite in which an H.F. pentode is used as the constant-current device. When the condenser is charged to a given potential the Thyratron breaks down and a discharge takes place. The breakdown voltage depends on the negative bias applied to the grid of the Thyratron, and this bias controls the amplitude of the scan. Similarly the positive potential on the screen of the pentode controls the charging rate and hence the frequency of the circuit.

SCANNING SPOT SPEEDS

With a screen 6 ins. wide scanned by 240 lines 25 times per second, the spot travels 125 ft. per picture and 3,125 ft. per second, which is 2,130 miles per hour or about half as fast again as the muzzle velocities of a rifle bullet.

INTERLACED SCANNING

The method of interlacing which is to be used at the Alexandra Palace will be made clear from the diagram which represents the top and bottom portions on the scanned area with the distance between the lines very much enlarged.

The lines show the track of the scanning spot which moves under the influence of a regular downward

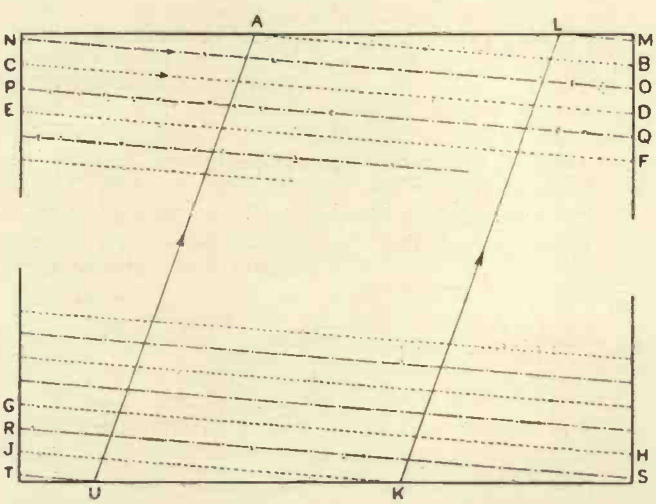


Diagram explaining the method of interlaced scanning employed by the E.M.I. system at the Alexandra Palace.

motion (frame scan) with quick return and a regular left to right motion (line scan) with very quick return (not shown on drawing). The combination of these motions produce the slightly sloping scanning lines. Starting at A, not necessarily at the beginning of a line, the spot completes the line AB, returns to the left and traverses line CD, then EF and so on down the "dotted" lines on the drawing. At the bottom of the frame the spot travels along line GH and then starts at J and travels to K. At this point the return stroke of the frame motion begins and returns the spot to L at the top of the frame. A complete frame scan has now been made since leaving A, so that 202½ lines have been completed, and the point L is half a line away from A.

The downward frame motion now starts again causing the spot to travel along LM completing a single line motion JKLM. The spot then returns to the left and traces out line NO, which, due to L being half a line ahead of A, will lie between lines AB and CD. Similarly the next line PQ will lie halfway between CD and EF. The spot now traces down the chain dotted lines to RS and finally traces out TU, at which latter point the frame return causes the spot to rise again to the top. When the spot reaches the top it will have completed two frames, since leaving A, and, as two frames occupy the time of exactly 405 complete lines, the spot will return exactly to A, after which the cycle begins again.

It will be clear that the complete picture is scanned in two frames, but as each frame contains an integer number of lines, plus a half, the two frames will interlace. The system does not require the short return times shown for the line and frame scans, nor need the lines begin in the positions shown. Provided the line and frame traversals are regularly recurrent and have the correct frequency ratio (two frames = odd number of lines), an interlaced picture will be obtained.

THE ACTION OF THE PHOTO-ELECTRIC CELL

To understand the action of a photo-electric cell it is necessary to appreciate that electrons are minute particles of negative electricity, which, under certain influences, can be put in motion; the heated cathode of a valve, for example, will emit a cloud of electrons which can be made to travel to a neighbouring anode if attracted by a positive potential on the latter. A flow of electrons constitutes an electric current and the strength of the current will depend on the number of electrons moving at the same time.

A small type of caesium photo-electric cell. This has a plate cathode and is suitable for televising films.

SYNCHRONISING AND MODULATION

Heating a metal, as in the case of a wire filament in a valve, causes an emission of electrons, but heat is not the only force that will produce such an effect. A number of metals will respond in a similar way under the influence of light, the most important, in the order of their sensitivity, being caesium, rubidium, potassium, sodium. These materials are very active chemically in air and it is necessary to contain them in an evacuated glass tube. If a surface of one of these metals is deposited on the glass wall of the tube and a light is shone on to it, the number of electrons released per unit time at the photo-electric surface is directly proportional to the intensity of the incident light.

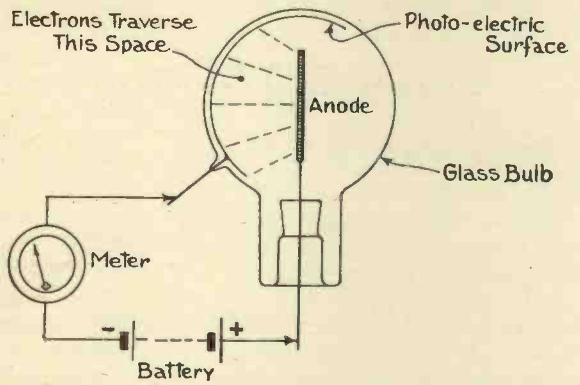


Diagram showing the elementary principle of the photo-electric cell.

If within the tube there is an anode (a small metal disc, rod or ring) to which a positive potential is applied. the negative side of the battery being similarly connected to the caesium surface, the electrons emitted when the light falls on the surface can be collected to the anode by virtue of its attractive positive charge. (The anode must be small or it would obstruct too much of the light.) Since a flow of electrons is an electric current we can produce a current proportional to the light, which is exactly what is required for television.

SELF-GENERATING PHOTO-CELLS

A layer of copper oxide on a copper disc acts as a tiny primary battery when light strikes its surface. The current generated is measured in micro-amperes but is sufficient to be extremely useful. The current output is directly proportional to the intensity of the light which strikes it and retains this property indefinitely. Its response to coloured light is another interesting characteristic. The response is almost exactly the same as that of the human eye. Thus a coloured light which seems bright to the eye seems bright to this type of photo-cell. This type of cell is the basis of the light-intensity meter and the transparency meter.

THE BEST VIEWING DISTANCE

The most suitable viewing distance for an image built up of a number of lines can be calculated from the formula: $d = .00058d$, where d = distance between dots, and d = viewing distance.

With a cathode-ray tube producing a picture 10 inches square with 240 scanning lines, the width of each line on a 10-inch screen would be 1/24th of an inch, and by applying the formula we get d =72 inches, or 6 feet, which is a viewing distance convenient for the average room. At this distance the definition will approximately equal that of the cinema screen viewed from an average seat.

SECONDARY EMISSION

An electron impacting on a conducting surface will, under certain suitable conditions, release a number of secondary electrons. The number of secondary electrons released by the impact depends on the velocity of the primary electron and on the physical and chemical nature of the surface. Under normal conditions the number of secondary electrons emitted is about two or three, and rarely exceeds ten. The secondary electrons are emitted in all directions and have low initial velocities.

Secondary emission depends largely on the physical and chemical properties of the surface of the material. All conductors contain a great number of free electrons which are able to move about in the metal. To enable an electron to leave the surface of a conductor work has to be done in overcoming the attraction between the metal and the electron, and this quantity is different for each substance.

LINE AND FRAME SYNCHRONISING

The cathode-ray tube requires two synchronising frequencies—line and frame. Mechanical systems need only one, the line frequency, because, being mechanically coupled, the picture or frame cannot help being in synchronism provided the lines are. The frame-frequency in mechanical systems is determined by the rate of rotation of the scanner, and so is the line-frequency which the number of mirrors on the drum automatically arranges.

With the cathode-ray tube we have two pairs of deflector plates, one pair for making the lines and the other for the frames. There is no mechanical or electrical coupling between them and it would be quite possible to have one pair working without the other. To make them provide a line screen it is necessary to apply separate frequencies to each pair and in order to ensure that these two frequencies are both of exactly the correct value each has to be controlled or synchronised by special impulses sent from the transmitting end along with the image signal.

Both transmitting systems used at the Alexandra Palace have provision for the two synchronising frequencies. In the case of the line frequency this is accomplished by sacrificing a certain percentage of each line.

D.C. MODULATION

D.C. modulation is the picture brightness component. In simple language it means that the average brightness of an image is transmitted, so that at the receiving end pictures having different average brightnesses at the studio end will not all appear the same. A convenient way of transmitting a component pro-

ULTRA-SHORT WAVE RECEPTION

portional to the average brightness, which, of course, varies continually from picture to picture, is to make the strength of the carrier current so proportional. When the modulation ceases the carrier drops to a low value, though not to zero,. A bright picture will send up the carrier strength more than a dull one, and if at the receiving end rectified carrier current is made to operate the biasing potential of the cathode-ray tube or other modulating device proper contrasts are secured.

MAGNIFYING THE IMAGE

Undoubtedly one of the greatest drawbacks of the cathode-ray system is the inability up to the present to produce large pictures. There is a limit to the size of tubes which it is practicable to produce and a screen diameter of about sixteen inches appears to represent the maximum. Reprojection and consequent enlargement of the image on the screen of the tube is possible, but it necessitates increasing the light value and using voltages of the order of 10,000. The life of the tube is also likely to be shortened by the use of such high voltages. Combinations of mechanical devices and the cathode-ray tube have also been suggested but no practical results have been obtained so far. A promising scheme is the introduction of a light valve into the tube and to use the cathode beam to "trigger" this, the actual light being provided by an exterior source.

THE ULTRA-SHORT WAVES

Owing to the extremely wide band of frequencies required to broadcast high-definition television it is quite essential to use the very short waves. Actually for the vision transmissions from the Alexandra Palace a wavelength of 6.67 metres will be used. These very short electromagnetic waves are almost optical in character; they travel in very nearly straight lines and are unable to follow the curvature of the earth's surface to any extent.

For this reason, no matter what power may be used, the range of an ultra-short wave transmitter is limited and depends on the height of the transmitting and receiving aerials and the nature of the intervening ground. Assuming the latter to be "flat," it will be apparent how the curvature of the earth's surface limits the range of a short-wave broadcasting system. If r is the radius of the earth (approximately 4,000 miles , h and h^1 the heights of transmitting and receiving aerials, and d and d^1 the horizon distance of transmitter and receiver respectively. It will be seen that

$$d^2 + r^2 = (r + h)^2$$

$$d^2 = 2rh + h^2, \text{ neglecting } h^2 \text{ we have}$$

$$d = \sqrt{2rh}$$

$$= \sqrt{8,000} \text{ miles.}$$

$$\text{Similarly } d^1 = \sqrt{8,000^1} \text{ miles.}$$

In the case of the Alexandra Palace transmitter, which has an effective aerial height of about 600 ft., it will be seen that this transmitter has a horizon of a little over 26 miles.

If the receiving aerial is elevated the range will be increased accordingly. It will be seen that a receiving aerial 25 ft. high has a horizon of 6.2 miles and could receive the Alexandra Palace transmissions up to a distance of 26 + 6.2 = 32.2 miles, assuming level ground between the two stations.

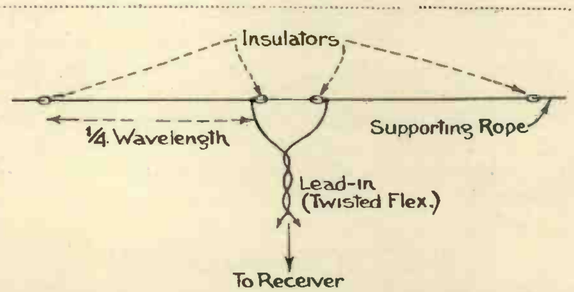
Actually the range is somewhat in excess of the figures given owing to the fact that these waves are not quite optical in character and do not have a sharply defined shadow. On the other hand, intervening high ground or buildings will reduce the range, and where the receiving aerial is in the shadow of a hill reception may be impossible.

TRANSMISSION CHANNELS

In television it is necessary to transmit three components (as compared with only one in ordinary sound broadcasting). These are vision signals which provide the tone values of the various parts of the picture; the synchronising signals which at the receiving end are used to reform the picture; and thirdly, the sound accompaniment. If the transmission is by radio then it is necessary to have two radio transmitters, two separate wavelengths for transmission and two radio receivers. If cable transmission is employed then two cables are necessary, one of which must be capable of carrying a sufficiently large range of frequencies without loss; the sound cable need be nothing more than an ordinary telephone line.

ULTRA-SHORT WAVE AERIALS

There are many types of ultra-short wave aerial, but from experiments that have been made a half-wave aerial of the di-pole type appears to be the most satis-



General scheme of half-wave di-pole aerial for ultra-short wave reception.

factory. Usually a great increase in signal strength can be effected by elevating the di-pole, especially in congested areas. In this case the aerial may be connected to the receiver by means of an ordinary twisted flex of low resistance. It may be connected to the receiver by means of a single-turn coupling coil.

SOUND DELAY WITH INTERMEDIATE FILM

With the use of intermediate-film systems of transmission there is, of course, a time interval between an actual occurrence and its transmission due to the time taken for the film to pass through the developing, washing and fixing tanks. This time has variously been stated to be up to thirty seconds, but a minimum of eleven seconds has now been achieved. This time interval means that the sound must be delayed a corresponding amount so that sound and vision coincide at the time of transmission. The sound is delayed by recording upon a steel tape and placing the magnetic

ELECTRON MULTIPLIERS

pick-up at a point on the tape which represents a suitable amount of delay. The rate of travel of the tape is approximately 100 yards a minute, so it is an easy matter to calculate the correct position of the pick-up.

KEYSTONE EFFECT IN THE ICONOSCOPE

Due to the position of the scanning plate in the Iconoscope, if scanning is accomplished in the normal way a keystone effect is produced with consequent distortion. In order to correct this the beam is deflected by the scanning action in such a way that if the beam fell upon the plate at right angles it would produce a reversed keystone pattern; this, however, is cancelled out by the arrangement of the plate and the result is a rectangular area.

SCANNING CIRCUIT TROUBLES

The mercury vapour relays used in scanning circuits are occasionally liable to erratic performance since it is rather difficult to control the behaviour of a vapour-filled bulb. Temperature is liable to upset them, for instance, and it may happen that the speed of the time-base circuit alters slightly as the set is run.

To obviate this special relays have been developed with a filling of helium or argon gas instead of mercury vapour, and these are more reliable at high speeds of discharge. Even then an occasional " riccup " is met in the running of the relay which causes one or more lines to be shorter than the normal length.

If the effect is only momentary the picture will flicker, but a continuation will give a displacement of part of the picture as though a slice had been shifted out of alignment. A great deal of time and trouble has been spent in designing scanning circuits which shall be as reliable as possible, and some of these use ordinary hard valves which avoid the peculiarities of the gas-filled relay.

VELOCITY MODULATION

A system of television reproduction by a cathode-ray tube has been devised which is quite different from the conventional scanning systems. This is known as the " variable velocity " and is made possible by the property of the cathode-ray itself. Briefly, the principle is that the amount of light produced by the passage of the beam across the fluorescent screen depends on the rate at which it moves. The faster it moves, the less is the amount of illumination. By this means the modulation effect is obtained.

ELECTRON MULTIPLIERS

The theory upon which electron multipliers operate is comparatively simple, but the actual construction of these devices is a difficult problem. The few stray electrons which are present due to photo-electric effects are bombarded against a surface especially prepared to have the best possible secondary emitting properties. As a result of these original electrons striking this surface the emission of more electrons, than were in the original bombardment, results and this procedure is repeated many times until the desired "electron amplification " is reached.

Secondary-emission tubes may be used as amplifiers, oscillators, frequency multipliers, detectors, in short—wherever filament tubes are used to-day. A characteristic is the practically " noiseless " amplification.

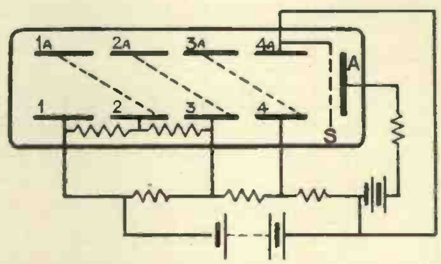


Diagram showing the operating principle of the electron multiplier.

ELECTRONIC LAWS

The two laws governing the velocity and direction of electrons as applied to electron tubes are:

(1) Electrons travel in straight lines in a uniform field. The velocity is not constant but there is a uniform acceleration.

(2) The velocity and the direction of electrons are changed when the beam passes from one field of electrical intensity to another and different field.

SENSITIVITY OF CATHODE-RAY TUBES

The distance moved by the beam on the screen for one volt of potential applied to the deflecting plates, varies inversely as the anode voltage.

For a given design of tube there is a formula from which the sensitivity can be found. This is usually given in the form Sensitivity = K/V, where K is the figure given by the makers of the tube and V is the anode voltage at which it is operated. Suppose K is 750, an average figure. Then at 1,500 volts the sensitivity is 750/1,500 or ½ mm. per volt of deflecting potential. At 3,000 volts the sensitivity will obviously be one-half of this or .25 mm. per volt.

THE SOUND OF A TELEVISION TRANSMISSION

The variations of the scan which produce the different tone values in a television image are at such a high frequency that they are above audible limits and therefore not heard. A high-pitched whistle is produced by the line synchronising frequency, which in the case of a 240-line picture is at the rate of 6,000 per second. Imposed on this there is a sort of burble which is due to the picture synchronising impulse with a frequency of 25 per second. This latter, in the case of the 405-line transmission, is a hum of the same tone value of A.C. mains hum. This is the frame frequency of 50 per second.

HIGH-FREQUENCY CABLES

Ordinary cables will not carry the high frequencies necessary for television transmission and therefore special cables have been designed which are capable of carrying high-frequency currents. In one, the outer conductor is formed of overlapping copper strips held in place with a binding of brass tape. The insulation consists of a cotton string wound spirally around the inner conductor, which is a solid copper wire. The outer conductor may be surrounded by a lead sheath, especially when used as an individual cable.

The other type has an outer conductor in the form of a lead sheath which surrounds the inner conductor, the latter being supported by hard rubber discs spaced at intervals along the inner wire. There is an optimum ratio of diameters which gives a minimum attenuation and, at high frequencies, is practically independent of frequency. The value of the optimum diameter ratio is about 3 to 6.

PHOTO-CELL TYPES

There are two main types of photo-cell—the vacuum and the gas-filled. The anode current of the vacuum cell is dependent only on the intensity of the impinging light. This characteristic renders vacuum cells particularly suitable for accurate measurement and for use in photo-electric amplifiers.

The gas-filled cell exhibits much higher sensitivity than the vacuum cell if the loads are equal.

Collisions occur between the gas particles and the electrons emitted by the cathode. As soon as the latter have attained a certain velocity, further electrons will be liberated from the gas-particles and will pass to the anode. This type of cell is suitable for purposes which call for large variations in photo-electric current, rather than a high degree of accuracy.

LUMINESCENT MATERIALS

Luminescent properties are exhibited in many natural and artificial substances when subjected to cathode-ray bombardment, though only a few are suitable for coating cathode-ray tube screens. The following are the principal substances employed—synthetic willemite, calcium tungstate, cadmium tungstate, zinc phosphate, zinc sulphide and zinc-cadmium sulphide. Very special precautions are necessary in the preparation of these materials if the best results are to be obtained and it is necessary for most of the luminescent substances to be in crystalline form. Some of them, as, for example, calcium tungstate and cadmium tungstate, display their maximum luminescence when perfectly pure. In the case of zinc sulphide and zinc-cadmium sulphide, zinc silicates, and zinc phosphates, very little luminescence is displayed unless an activator is present. The amount of the activator required is very small, generally about 1 in 10,000 to 1 in 100,000 parts by weight.

BRIGHTNESS OF SCANNING SPOT

The brightness of the scanning spot which is produced by a cathode-ray beam of high intensity is very great. In the case of a television transmitting tube with a scanning spot 0.3 mm. in diameter this has a candle-power of 1.2 and therefore its luminosity is 17 candles per mm^2. The intensity of illumination of the filament in a tungsten vacuum lamp is 1.25 candles per mm^2., and of the gas-filled lamp 5 to 13 candles per mm^2., according to the type and size of the lamp. The intrinsic illumination of the scanning spot is thus high though very much below that of the arc crater of a plain carbon arc, which is of the order of 170 candles per mm^2.

LARGE PICTURES WITH THE CATHODE-RAY TUBE

By L. S. Kaysie.

This article describes an ingenious combination of the cathode-ray tube and the Kerr cell with the object of making a large amount of modulated light available and the possibility of projecting large pictures without the aid of mechanical devices.

IN spite of its many advantages as a television receiver, the cathode-ray tube is handicapped by the fact that the picture is projected on to a fluorescent screen, which at its best will only produce a relatively low level of light. It has not been found possible to magnify the fluorescent image to any substantial extent by optical means, and as the screen must be mounted inside the tube, the final size of the picture as seen by the eye is limited by the dimensions of the bulb.

This limitation is unfortunate, and various attempts have been made to overcome it. Inventors have, for instance, tried to find new compositions, capable of producing a more intense fluorescent effect. They have also suggested the use of X-rays to bombard the screen instead of electrons, and tried other methods of intensifying the light produced. But none of them appear to have proved successful in actual practice.

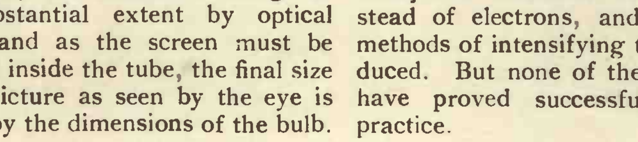


Fig. 1.—Diagram illustrating the action of a Kerr cell.

Light Control with Cathode-ray

An inventor named K. P. Pulvermacher has recently atttacked the problem on distinctly ingenious lines. He abolishes the fluorescent screen altogether, and in its place puts a light-sensitive relay, which under the action of the electron stream, controls the intensity of a powerful beam of light located outside the tube.

In order to explain the new arrangement, it will be necessary to recall the action of the well-known Kerr-cell type of light-valve. This depends upon the fact that certain substances, such as nitrobenzine, as well as various kinds of crystal, possess the property of rotating the plane of a polarised ray of light.

As shown, for instance, in Fig. 1, a

ray of light from a source S is passed through a Nicol prism N so that the emerging waves are "polarised." In other words, they are all oriented to vibrate in the same plane. They then pass through the "cell" K, and proceed, still vibrating in the same plane, until they meet the second Nicol prism N1. This is "crossed" relatively to the first Nicol, so that in the ordinary way it would extinguish the whole of the light.

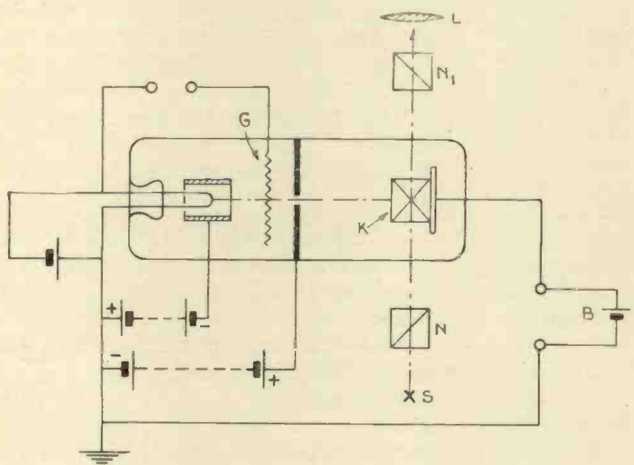


Fig. 2.—A Kerr cell inside a cathode-ray tube.

But when signal voltages are applied to the electrodes of the Kerr cell K, the plane of polarisation of the light passing through the cell is twisted to a certain extent, so that when the waves reach the second Nicol their passage is no longer completely barred. Actually the intensity of the light that succeeds in getting through the second Nicol depends directly upon the strength of the signal voltage applied to the sensitive cell K.

Suppose now that the light-sensitive cell K is mounted, as shown in Fig. 2, inside a cathode-ray tube, and that the two crossed Nicols N and N1 are placed outside the tube, so that they lie in the path of a powerful beam of light coming, say, from an arc lamp S.

It must be remembered that the electron stream from the cathode of the tube actually represents an electric charge in motion. If it is modulated in intensity by applying signal voltages to the control electrode G, then it will impart a varying charge to the face of the cell K on which it impacts. The opposite side of the cell is anchored, as shown, to a fixed biasing voltage B.

The arrangement is, in fact, on all fours with that shown in Fig. 1, and an observer at L will be able to see a ray of light which varies in intensity with the signal voltage.

So far, of course, the arrangement is not suitable for receiving television. But the inventor points out that various crystals, such as quartz, can be used to rotate the plane of a polarised ray of light. Further, it is possible to arrange a large number of "active" crystals on a transparent backing-plate so as to form a "mosaic" screen or surface. They could, for instance, be fused into a plate of lower melting-point, or deposited upon it from an emulsion. Each individual point of such a screen can then be regarded as a small Kerr cell capable of handling any light that may reach it.

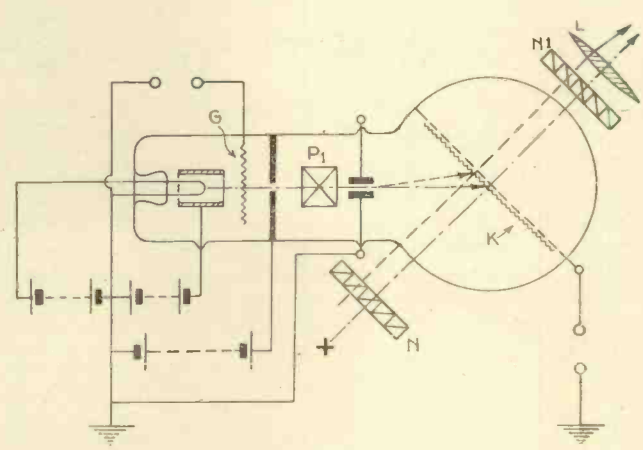


Fig. 3.—A multiple Kerr cell inside a cathode-ray tube. The screen consists of quartz crystals used to rotate the plane of a polarised ray of light. The Nicols are placed outside the tube.

Fig. 3 shows a screen K made in this manner and mounted in a cathode-ray tube for receiving television. The single crossed Nicols are of course replaced by a series of prisms as shown at N, N1 so as to give a wider angle of view, and the whole system is illuminated by a powerful source of light S located outside the tube.

In addition to the control grid G which receives the signals and varies the intensity of the electron stream, the cathode-ray tube is also provided with two pairs of scanning-electrodes P, P1, so that the modulated stream is swept from side to side and from top to bottom of the mosaic screen in the usual scanning motion.

At each point of its impact, the stream influences one or other of the individual crystal cells on the screen K, and causes it to rotate a part of the ray of polarised light from the sources to an extent which is controlled by the incoming signal voltage. The other cells of the screen are, for the moment, not affected by the stream, so that an observer at L only receives light from one point after another, as each small cell is "opened up" by the passage of the electron stream. Owing to the speed at which the scanning takes place, this is of course quite sufficient to produce the usual kinematographic effect of motion.

But instead of depending upon the relatively-feeble light of a fluorescent screen, the received picture is now built up of rays from an intense source of direct illumination. There will, of course, be certain losses in the Nicol prisms and the crystal screen, but the resulting image is stated to be sufficiently bright to admit of considerable enlargement by means of lenses. In addition, the operating voltages required are lower than usual so that the normal life of a cathode-ray tube is increased.

Scannings and Reflections

By THE LOOKER

Progress at the Alexandra Palace

IT is expected that a Press visit to the Palace will be arranged for about the third week of May; in the meantime admission is strictly forbidden. However, I managed to pay a visit recently—though how I got in I am not prepared to say—and here are the results of my observations of the progress already made—that is until approximately a week before these notes are published.

First of all the exterior. The aerial tower—that is the metal part which is being placed upon one of the existing Palace towers is about half way up. As a matter of fact progress with this appears to be quite rapid for all the constructional work has been carried out, and it is merely a matter of placing the parts in position, and riveting them together. I should imagine that a couple of weeks, that is somewhere about the middle of May, will see it completed.

The Concrete Apron

Another outside feature is what may be described as a concrete apron which is roughly semi-circular and about sixty feet by thirty feet. The object of this is the staging of outdoor demonstrations and in warm weather it is expected that it will be used by bands; it is so placed that the background is a pleasant vista of trees. The one other exterior feature of any note is a large roller shutter type of door to enable large properties and any other large objects which it is wished to demonstrate to be taken into the Palace.

Inside there is still a considerable amount of confusion and the only room which is absolutely finished is one of the projector rooms. Practically all the structural alterations have now been made and the studios are finished with the exception of decoration. Some of the apparatus is installed in the film studios, and so far as I could ascertain this was B.B.C. stuff, but as my visit was very unofficial I was unable to make sure. The Baird people have installed some of their apparatus, but there were few signs of E.M.I. gear and no one appeared to know when the rest of the gear was likely to arrive.

There was one other part completed which I omitted to mention, and this is the whole of the offices, which will be occupied by the administrative staff. The only thing lacking here is the actual furniture. The canteen is not finished though the boilers have been installed, and when I was there these were going in order to dry the place out. The theatre has not been touched—or rather that is not quite correct for when I was there cleaners were just commencing an onslaught on years of grime. It is not proposed to make any alterations to this for it has not really been decided to what use it will be put.

Discreet inquiries revealed that the hope of putting out test transmissions some time in June still prevails, though it is difficult to phophecy, at all events until the gear is in place.

Staff Appointments

I hear that it is practically certain that Cecil Lewis is to be given the appointment of Special Programme Director, and Moore O'Farrell will be the assistant producer at the Palace. Hyam Greenbaum is to be the Musical Director. These names were only given to me tentatively, but it is fairly certain that confirmation will soon be forthcoming. And then, of course, there are the lady announcers. The selection of these has been narrowed down to such an extent that we may say the appointments have been decided upon, but the names are for the present being kept a close secret.

Mr. Eustace Robb

Many of my readers will be wondering how it is that Mr. Eustace Robb, the Television Producer during the thirty-line days, has not come into the scheme of things. Mr. Robb, as most readers will know, did some most valuable work in showing what could be done even with limited facilities—and it may be said, in the face of a good deal of opposition, for television was ever the Cinderella at Broadcasting House. Well, as far as I can ascertain the B.B.C. and Mr. Robb could not come to any suitable arrangement, and he has therefore entirely severed his connection with the B.B.C. I understand that at present he is on the Continent, though whether for pleasure or business I do not know.

The Television Society Secretary

I am sorry to learn that Mr. W. G. W. Mitchell, B.Sc., one of the founders of the Television Society, has been compelled by ill-health and pressure of work to relinquish his honorary secretaryship of the Society. Its present flourishing condition (it has a membership of over 300 and is increasing weekly) is due in no small way to the enthusiasm of Mr. Mitchell and his colleagues. It is good to know that he is retaining his interest in the Society's Journal, which has a wide circulation.

The duties of Hon. Lecture Secretary are now being carried on by Mr. G. Parr, whose name will be familiar to readers as the author of articles in this journal on cathode-ray practice. His address is 68 Compton Road, N.21, and he will be pleased to send particulars of the Society's activities to intending members. Mr. J. J. Denton, of 25 Lisburne Road, Hampstead, is continuing his duties as General Secretary. Mr. Denton is equally well-known to audiences over the country as a fluent lecturer on television.

The Commercial Use of Television

Captain E. H. Robinson, speaking at the Television Society meeting the other night, gave it as his opinion that the future of television lies in

MORE SCANNINGS AND REFLECTIONS . .

its commercial possibilities rather than the entertainment side. He had in mind the recent Berlin experiment of telephone and television, and he pictured the time when a television receiver will be included in every telephone installation. Apart from the telephone, television has other commercial possibilities which are not being overlooked. For instance, I know of two instances in which visual information of happenings some distance away is desirable, and experiments are being made to obtain this by television. Now comes the news that television will be employed for the control of the locks of the Moscow-Volga Canal in Russia. All these locks are to be centrally controlled and, if the report is correct, the operator will watch the approach of ships and their positions when in the locks and know exactly when to operate the controls.

Televising the Coronation

I have not been able to obtain any official confirmation of the reports that the Coronation will be broadcast by television next May, but it does seem a likely supposition that the televising of the procession rather than of the ceremony might well form the first important public television broadcast. Even in the state of present developments the televising of an outdoor event of this nature would be possible and we may be sure that before next May, as the result of experience and further developments, it will be quite practicable. I understand that Mr. Gerald Cock has already considered the scheme in some detail.

Who Leads?

Quite a keen sense of rivalry in the television race is becoming apparent between this country, Germany and the United States. America claims that the more recent major developments have all seen the light in that country and that the state of science there only needs putting upon a commercial basis to place America right ahead. Germany makes the claim that she has a service actually in being, and here—well, we may be a bit slow in getting things going, but it is contended that when we do get a start we shall certainly be the first country to have a real public service and to have placed television upon a commercial basis.

Television Parties

Many of us remember that in the early days of broadcasting, ownership of a receiver attracted quite a lot of visitors, and no doubt history will repeat itself in the case of television. Perhaps it will solve entertaining problems, until the novelty wears off. Even during the time of the thirty-line transmissions I was inundated with requests to "see television," often from almost total strangers, and as a rule for these late night transmissions there was quite a small crowd to witness them.

Edison Bell Television

In the June issue of last year the Edison Bell television receiver was described in TELEVISION AND SHORT-WAVE WORLD. Since that time the company has continued experiments with a view to further developments. The Edison Bell Company, it may not be generally known, was the first concern in this country to make sound records, which were of the old cylindrical type. Later they produced the disc type, and now they have concentrated on television. A new public company with a capital of £150,000 is in process of formation and it is expected that there will be an offer of shares to the public.

Football and Television

According to the daily press a feature of the new stand for the Arsenal Football Club, which is to be erected during the summer months at a cost of £100,000, will be a permanent broadcasting box and installation and a control tower for the installation of television equipment. The B.B.C. Television Director is not, I know, overlooking the possibilities of broadcasting football and other important sporting events, and it is fairly certain that they will be featured in the programmes at an early date.

Television and Schools

I see that television is being considered by education authorities as a new factor for the class room. Its possibilities in this direction are to be discussed at the conference of the National Association of Head Teachers to be held in Lincoln at Whitsuntide. The Association may be overlooking the fact that at present the range will be limited to the London area, but even with this limitation there is obviously plenty of scope and no doubt the B.B.C. would co-operate with educational films and demonstrations.

Televising the Olympic Games

Dr. Carl Diem, Secretary of the Organising Committee of the 1936 Olympic Games, recently announced that television transmitters were to be installed in the Berlin Stadium. This, of course, is not the first occasion in Germany when television has been employed for public events, in fact, the Germans are devoting a lot of attention to this side of television. The opening of the last Radio Exhibition was televised and no doubt other outdoor events would have followed had not the disastrous fire put an end to all activities in this direction for the time being.

The Baird control panels for the Alexandra Palace.

USING THE 37-56 MEGACYCLE SIGNAL GENERATOR

Last month we described a low-power signal generator which produces any frequency from about 37.5 to 57.5 megacycles and can be modulated with eight different frequencies at different points in the frequency band of the new television service which is to be started shortly. This article deals with the operation and practical application of the apparatus.

FIRST, let us take the carrier oscillator. Put the variable grid leak, 2, Fig. 1, to maximum resistance and switch on by 9 (Fig. 1) so that the H.T. supply to the carrier oscillator passes through the meter; the current will be of the order of .25 ma. with 66 volts H.T. and, if a pair of 'phones are put in circuit via the jack, a low rumbling sound will be heard.

The circuit is now oscillating but the high value of the grid leak is causing the circuit to " squegger." On reducing the value of the leak the " squegger " tone goes up in pitch, with an accompanying rise of H.T. current. When the current reaches the value of about 5 ma. the " squeggering " ceases, though it is advisable to lower the grid resistance till the anode current reaches 7.5 ma. Any increase above 10 ma. produces no increase of radiation, which is sensibly the same with anode currents between 7 and 10 ma. It should be mentioned that when the oscillator is " squeggering " it may be used as a source of modulated carrier.

Having got our oscillator oscillating we must next turn to the question of the frequency generated. As previously stated, the apparatus has a variable range of about from 37.5 to 57.1 megacycles; that is from 5.3 to 8.0 metres.

The actual frequency is arrived at by the absorption wavemeter incorporated in the instrument. This circuit, if constructed to the details given last month, will have a calibration curve as shown in Fig. 2, the wavemeter condenser being fitted with an Eddystone dial and pointer, the scale of which is 0-100. It will be noticed that the frequency is given in terms of wavelengths (Fig. 2) as this is more handy to plot as the condenser is a straight line wavelength type.

This calibration curve is best drawn on inch graph paper ruled in tenths, 5.3 metres equalling 35 on condenser scale and 8 metres equalling 85 on condenser scale, the curve

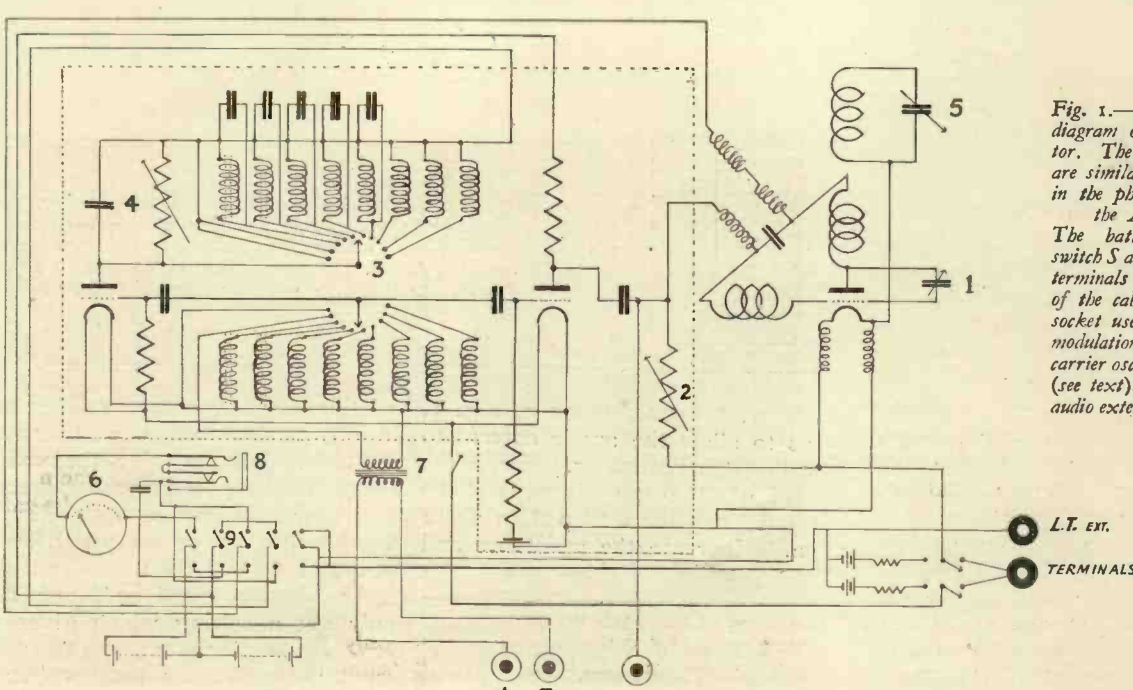


Fig. 1.—Complete circuit diagram of signal generator. The numbers 1 to 9 are similar to the controls in the photograph Fig. 1 the April issue. The battery change-over switch S and L.T. external terminals are at the back of the cabinet. T a test socket used for measuring modulation volts across carrier oscillators grid leak (see text). A socket for audio external signal input.

THE SIGNAL GENERATOR AND TELEVISION RECEIVER DESIGN

being a straight line between these points. To get the oscillator to a given frequency, set the absorption meter to, say, 60.05, that is 6.66 metres, and gradually tune the oscillator, when suddenly the anode current will fall to about 3 ma.

Further increase (or decrease) in the value of the tuning condenser will just as suddenly produce a rise in

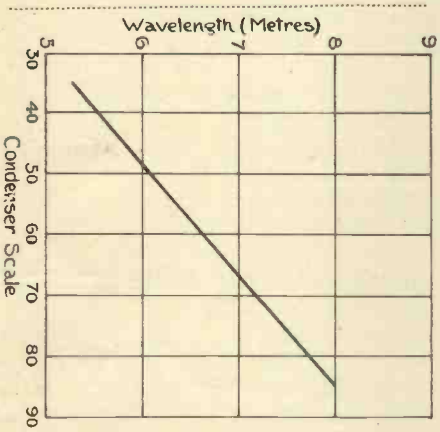


Fig. 2.—Wavemeter curve of the signal generator.

current. The actual point of resonance of the oscillator with the wavemeter is when the anode current is at its lowest. Having obtained the re-

face, and was built for use as a wavemeter, though provision was made (by including a jack, as shown in Fig. 3a), so that a pair of 'phones could be plugged in if desired.

If such a circuit is placed in close proximity to the signal generator and tuned to the frequency of the generator, a rise of about .3 ma. in the rectifier current will indicate resonance. The exact positioning of the loop, however, makes considerable differences in pick up, the current rising as high as 1 ma. in some positions, the standing current being of the order of .05 ma.

If we make the oscillator "squegger," our wavemeter-detector will indicate a decided fall in radiated power, but the "squeggering" will be audible if a pair of headphones are plugged in. On moving the wavemeter-detector away from the signal generator, the signal will be audible long after the meter has ceased to indicate anything but the standing current.

Now we must turn to the modulation side. The strength of each of the frequencies generated can be controlled by 4, Fig. 1, which is scaled from 0 to 10, 0 being minimum resistance. To test the modulation signal

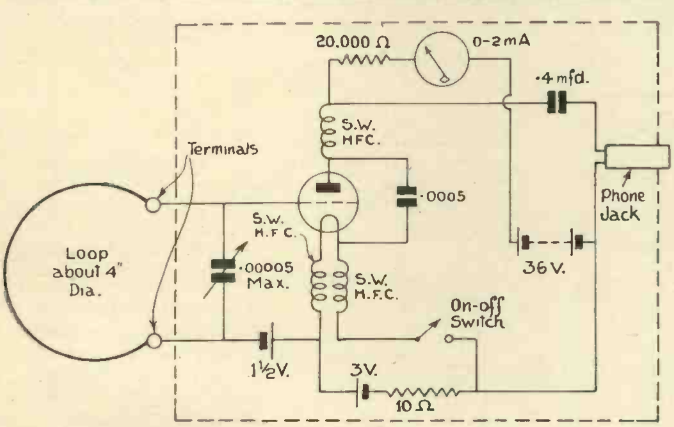
the current will fall to about 1 ma., which indicates that oscillations are being produced. Further increase of the resistance will produce "squeggering" on most ranges.

The table gives in column 1 the range number; in column 2 the frequency; in column 3 the value of the control on the scale mentioned to give oscillations; and in column 4, the value to generate 0.5 volt. This table only gives the writer's instrument results, and is published only to give readers an idea what to expect. They will, of course, have to calibrate their own instruments, which is quite easy.

I. Range Number.	II. Frequency.	III. Value of Volume Control to Produce Oscillation.	IV. Value of Volume Control to Produce 0.5 volt.
1	2,000,000	5.75	9
2	1,500,000	3.75	4
3	1,000,000	3.6	4
4	500,000	4.1	5
5	100,000	3.6	3.6
6	50,000	4.0	4.0
7	3,000	4.0	5.0
8	25	0.5	1.25*

* This produces 0.1 volt.

All that is required is a simple valve voltmeter which need not be calibrated. If the wavemeter-detector (the circuit of which is given in Fig. 3a) is made up, this can be used, simply by removing the loop and con-



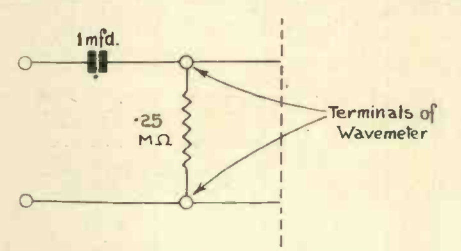


Fig. 3a (right).—Wavemeter with anode-bend rectifier as resonance indicator. The short-wave chokes (S.W.C.) consist of 55 turns of 24 S.W.G. wire closely wound on a ¾ in. former. The dotted lines indicate complete screening. Fig. 3b (above).—Wavemeter connected to valve voltmeter.

quired frequency reduce the capacity of the wavemeter, when the anode current will rise again to normal.

At this point it will be found both useful and interesting to make up the circuit shown by Fig. 3a. This is an anode-bend rectifier coupled to a tuned circuit. The instrument of this type which the writer has used was entirely shielded except, of course, for the loop inductance and meter

oscillator, turn the switch 9, Fig. 1, so as to allow the anode current to pass through the meter. With the control 4 at 0 no signal will be generated and the feed will be about 2 ma. Increase the resistance and

Our Policy
"The Development of Television."

necting a condenser and resistance as in Fig. 3b, the tuning condenser being set to its minimum value, the modulation volts being read across the carrier oscillator grid leak, a test socket being brought out on the panel for the purpose.

As already mentioned, one need only get a setting which gives the same reading on all ranges to ensure constant modulation depths, though when making these tests a fixed value of the carrier oscillator grid leak must, of course, be adhered to.

In the table it will be noticed that range 8 only produces 0.1 volt; this is not due to the actual oscillator, but to the potentiometer effects of condenser and leak feeding the buffer valve, plus the condenser and carrier oscillator grid leak which for 8 m.a. of anode current has a value of about 10,000 ohms. On most of the ranges it is quite easy to over-modulate, a point which must be carefully watched. One volt seems about the maximum necessary for modulation purposes, always remembering the lower the anode current of the carrier oscillator, the more deeply will a given signal modulate it. Before leaving the modulating section it must be stated that the frequencies of the different ranges are only approximate, being arrived at by calculation only.

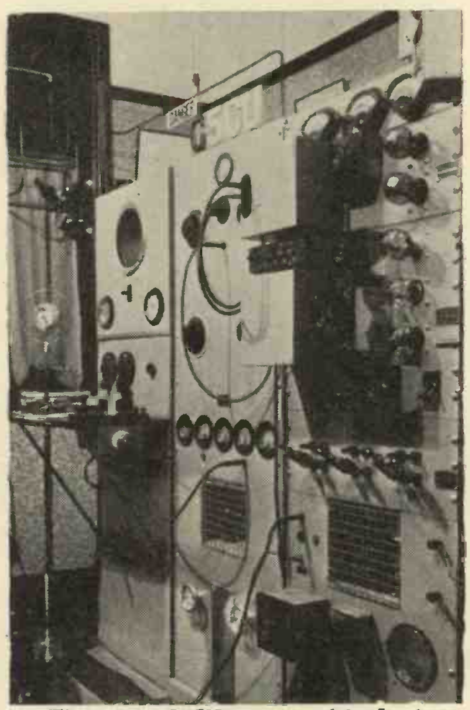
Now just a few notes on using the signal generator as an aid to design a television receiver. Supposing one starts with the detector, which will probably be of the anode-bend type, we tune the grid to, say, the 45 megacycles produced by the apparatus, note the rectified current. Now we start on our circuit for high-frequency amplification and again note the rectified current, which we hope will be considerably more and so on. Having produced a satisfactory pre-detector stage, we are ready to start on the low-frequency side. Low frequency is perhaps a misnomer in the usual sense of the word, so what about the term post-detector?

Start with the seventh range, because it is nicely audible on headphones. Measure the signal across the output on the valve voltmeter and note the reading of the meter. Then try out the other ranges, taking care, of course, to modulate to the same depth, also keeping the carrier constant; if the meter indicates the same signal on all ranges we shall have gone a long way towards the design of our receiver for high-definition television.

The 1936 International DX Tests

By B. Worthington.

We are very glad to be able to give these advance notes on the recent DX tests. The best total so far appears to be W4DHZ with 91,000 points



The station, G5CU, is operated by J. A. Cuthbertson and the QRA is Scarborough.

THROUGHOUT the week before the commencement of the International DX Tests we were repeatedly told by American stations, " Sorry O.M., QRM from locals tuning up for the tests," so we began to anticipate things being very lively.

Promptly, at 00.01 G.M.T., Saturday, March 14, we switched on to 14 mc. and sat back waiting for something to happen. It did! At every kilocycle on the band was a W at R9; directly he stopped six others at R7 could be heard in his place, and so apparently adinfinitum.

A short test call brought about half the band back in reply, but interference was indescribable, signals being reported R9, QSA3.

Not only were the regular code stations on, but also most of the phone people had forsaken the microphone for the key, and it seemed funny to hear W1ZD calling on C.W. instead of the usual " Double you one zee dee!"

At 02.30 W6CXW was heard calling G, but although we called him on break-in, our luck seemed to be out until we found W61BQ calling us! DX seems to be a series of flukes!

A similar instance occurred during the week when we called a " W5 " to no avail, but a " test W5 " brought him back straight away.

The afternoon of March 14 was remarkable on 28 mc. W's were coming in until 20.30 G.M.T. at exceptional strength, but after this, as most of them had worked their quota of "G's," it was very difficult for British stations to raise them.

It is, of course, early to try and forecast the winner. Enormous scores were mentioned, but nothing definite was discovered until our old friend W2GWE was contacted. He informed us that W4DHZ had scored " 91 grand " (91,000 points), working 68 countries. A simply terrific total. W4DHZ was apparently working in conjunction with W4CBY. W2GWE was disappointed as he was called away just before the contest, and so could not participate, but informed us that W6GRL had scored 66,000 points. When it is realised that this station is on the Pacific Coast and so has all America to traverse before reaching Europe, the magnitude of this score seems almost incredible.

W7AMX, so well known for his excellent work on 28 mc., told us he had made 19,800 points, using 460 watts input to a HK354 valve.

Well, it's all over now, and we have all enjoyed it, but perhaps we may offer a few suggestions for next year.

In America and Canada, the amateur is granted 1.7, 3.5, 7.14 and 28 mc. as a matter of course, with 1 kW input, but in this country the beginner is restricted to 7 mc. and 14 mc. Furthermore, he is compelled to start his transmitting career with a power of but ten watts. His maximum multiplier is then 28 (14 districts × 2 wavebands), but his more experienced competitor, having obtained a big advantage by being allowed to use higher power, also has the use of 28 mc. and 3.5 mc. with the opportunity of having a multiplier of 56!

We do feel that the low power beginner should be given some chance of showing his worth in designing and operating his station. We suggest that in future contests the score made in each band be indicated separately, so that the figures might show a truer comparison than under the present arrangement.

A second comment we would make is that under the present rules, if a station works one " W6," his multiplier is the same as if he worked ten W6's. So, W6's being rare, he is not going to waste his time working for more, but is going to make up his score by working a large number of stations in the Atlantic Coast districts. It is one thing to " fluke " working one W6, but quite another matter to work three of them. We accordingly suggest that the competitor be compelled to work at least three stations in a district before being allowed to count this district in his multiplier, so proving the reliability of his contacts.

It is not within our province to discuss the rules for American stations, but the " quota " of three stations in each country was certainly hard on British stations, many of whom gave up after the first week-end because no-one would work them!

RECENT TELEVISION DEVELOPMENTS

A RECORD OF PATENTS AND PROGRESS
Specially Compiled for this Journal

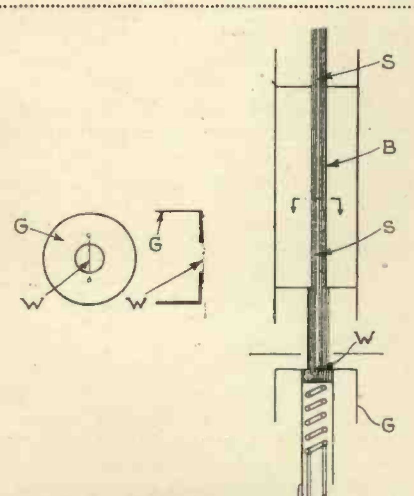
Patentees :—J. D. Riedel Haen A.-G. :: Marconi's Wireless Telegraph Co. Ltd. :: Radio Akt. D. S. Loewe :: C. O. Browne :: J. L. Baird and Baird Television Ltd.

Fluorescent Screens
(Patent No. 440,350.)

In order to minimise the "after-glow" effect which tends to blur definition, and, at the same time, to secure a natural or untinted light, the fluorescent screen of a cathode-ray tube is made of a mixture of zinc and cadmium sulphides. These are first thoroughly purified, and traces of silver and copper are then added in carefully calculated quantities in order to serve as "activating agents" which emphasise the effect of the electron beam. The mixture is finally crystallised by keeping it for one and a half hours at a temperature of 1,000° C.—(*J. D. Riedel-Haen A.-G.*)

Modulating Systems
(Patent No. 440,390.)

In order to prevent the applied signal voltage from altering the effective size of the spot of light projected on to the fluorescent screen of a cath-

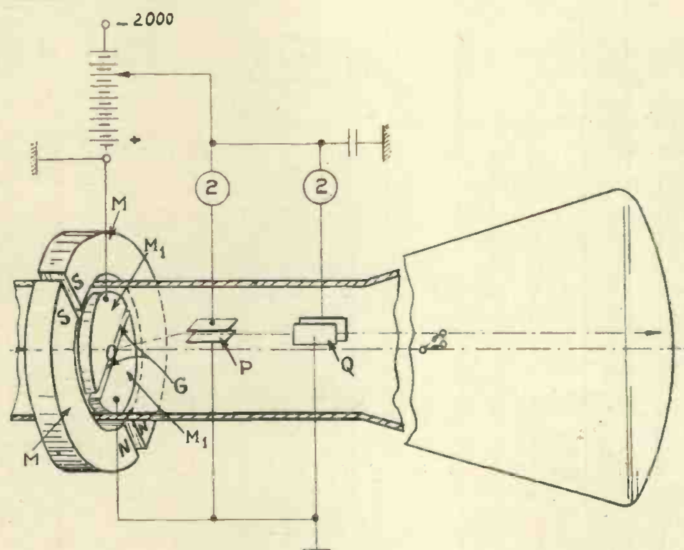


A method of modulating the cathode beam by altering the density at the centre. (*Patent No.* 440,390.)

ode-ray receiver—and so producing "streakiness"—the intensity of the beam is varied by altering the density of its centre, whilst leaving the outer diameter constant.

The required result is obtained by applying the signal voltage to a thin wire W, stretched across the centre of the aperture in the control grid through which the beam passes after leaving the filament. The apparent size of the wire (i.e., the electric field surrounding it) alters with the applied signal voltage. This in turn cuts out a larger or smaller slice S from the centre of the beam B, and so varies the intensity of the light produced by it on the screen.—(*Marconi's Wireless Telegraph Co., Ltd.*)

Controlling the Electron Stream
(Patent No. 440,560.)



A scheme for minimising the effects of stray magnetic fields on the cathode beam. Patent No. 440,560.

The effect of stray fields from the magnets or windings used to concentrate or deflect the electron stream in a cathode-ray tube is minimised by arranging the magnetic system partly outside the tube and partly inside. As shown, two permanent half-ring magnets M are arranged outside the lower end of the tube, with their like poles adjoining, so that the field is concentrated around the gap. Inside are two similar pole-pieces M1, which are set as close to the glass and to the outer magnets M, as possible.

The inner magnets apply a field to the stream along the inclined gap G so as to deflect the electrons out of the straight and between the two pairs of scanning electrodes P, Q. This prevents the formation of the well-known "ionic cross," which tends to appear on the fluorescent screen, superposed over the picture. The inner pole-pieces may also be used in place of the usual anode, and may be given an electrostatic charge. —(*Radio Akt. D. S. Loewe.*)

Combined Sound and Picture Transmissions
(Patent No. 440,729.)

When televising from a "talkie" film, it is necessary to keep the film moving at the standard rate, since otherwise the reproduction from the sound track on the film will be distorted. But if the film is to be scanned by "interleaving," the usual practice is to transmit at the rate of 50 frames a second, which is just double the standard speed for the sound record. In addition each frame must contain an "odd" number of lines, say, $121\frac{1}{2}$ (or 243 for the pair), so as to ensure correct interlacing of the two frames on the screen.

The problem is solved by driving the film F from one synchronous motor M, and compounding the speeds of two other synchronous motors M1 and M2 through epicyclic gearing G. This enables the scanning drum D to be rotated at the required fractional rate.—(*C. O. Browne.*)

Magnetic Scanning Control

(Patent No. 440,810.)

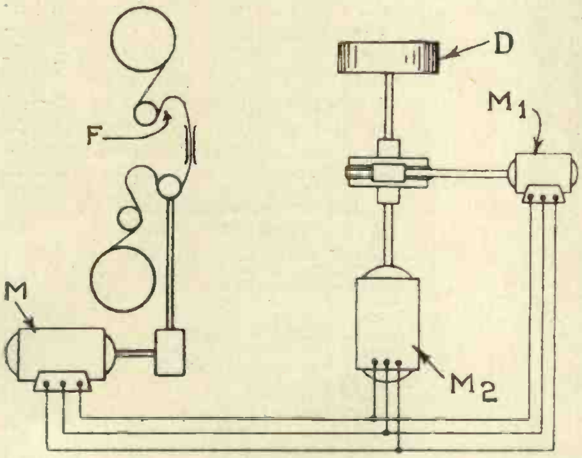
It is usual to control the scanning movements of the electron beam in a cathode-ray tube electrostatically, that is, by applying saw-tooth voltages to both pairs of deflecting electrodes. Alternatively one can use magnetic fields of force for the same purpose. The latter are found to be quite satisfactory for the framing frequencies, which are relatively slow; but in the case of the more rapid line-scanning frequencies difficulties arise on account of eddy current losses in the magnetic system.

The diagram shows a magnetic circuit consisting of an outer core C set close to pole-pieces P, P1 located inside the cathode-ray tube. The controlling fields are produced by a winding W and an A.C. source S. According to the invention the core C is made of powdered iron mixed with an insulating binder, so as to reduce the eddy-current and hysteresis losses. At the same time the permeability is high, so that an intense control-field at high frequency is produced. The winding W and supply leads are screened at K and K1 to prevent stray fields from influencing the electron stream.—(*Radio Akt. D. S. Loewe.*)

Scanning Discs

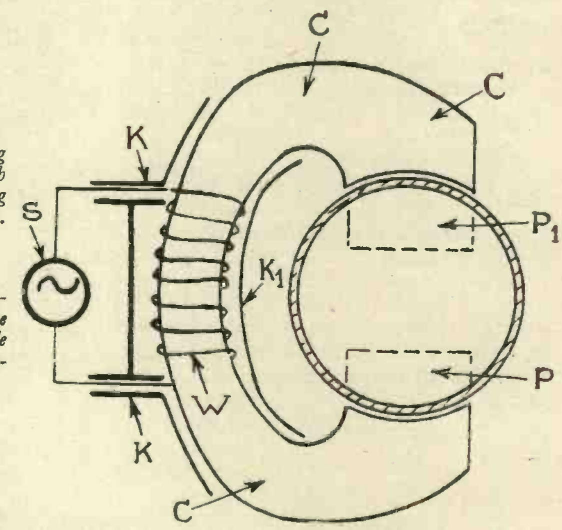
(Patent No. 440,917.)

The ray of light thrown by a rotating disc across the viewing-screen is generally slightly curved, owing to the fact that it is produced by an aperture that is rotating around a fixed axis. This, in turn, causes the scanning-lines to become congested at one end of the screen whilst they spread out at the other end, thereby producing "gaps" which become particularly noticeable in the case of interlaced scanning. One suggested remedy is to make the scanning apertures of such a size that the lines are strictly parallel in the centre of the screen, though they inevitably overlap at each end. This is, at best, only a compromise.



(Left) Synchronising sound and vision with interlaced scanning systems. Patent No. 440,729.

(Right) An arrangement for producing the line scan of the cathode ray magnetically. Patent No. 440,810.



According to the invention, the difficulty is overcome by making the disc apertures wedge-shaped in outline, instead of circular, so that as they intersect with the fixed aperture, the area of the resulting spot of light gradually increases from one end of the line to the other. This fills in the gaps and so produces a cinema film for television.—(*J. L. Baird* and *Baird Television, Ltd.*)

Summary of Other Television Patents

(Patent No. 435,567.)

Interlocked scanning system for transmitting picture signals.—(*Marconi's Wireless Telegraph Co., Ltd.,* and *S. B. Smith.*)

(Patent No. 436,734.)

Amplifier which discriminates between the higher and lower frequencies so as to handle slow fluctuations without being subject to static interference.—(*A. D. Blumlein* and *C. O. Browne.*)

(Patent No. 440,386.)

Cathode-ray viewing-screen on which the picture is made visible by the heat produced by the bombardment of the electron stream.—(*J. L. Baird* and *Baird Television, Ltd.*)

(Patent No. 440,577.)

Lens system used for scanning a cinema film for television.—(*J. L. Baird* and *Baird Television, Ltd.*)

(Patent No. 440,818.)

Preparation of a fluorescent material which is practically free from after-glow.—(*L. A. Levy* and *D. W. West.*)

(Patent No. 441,410.)

Mirror scanning-drum designed to produce a continuous spiral track, suitable for use in "interleaved" scanning.—(*J. C. Wilson* and *Baird Television, Ltd.*)

(Patent No. 441,558.)

Making a sound and picture record of events to be subsequently reproduced by television.—(*C. P. Hall* and *H. Flynn.*)

(Patent No. 441,761.)

Television system in which synchronising impulses are transmitted on the same carrier wave as the picture signals, and are used to change the level of a positive bias applied to the receiver.—(*Radio-Akt D. S. Loewe.*)

(Patent No. 441,813.)

Fluorescent screens for cathode-ray tubes.—(*N. V. Philips, Gloeilampen-Fabrieken.*)

Electron-coupled Frequency Meter for Battery Operation

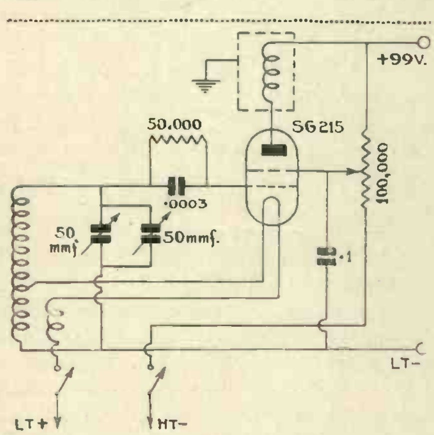
This meter designed by 2BZN is the counterpart of the mains operated meter described on pages 213—214 of the April issue.

A FREQUENCY meter, if it is to be of any use at all, must be stable and accurate. A meter that is likely to vary is worse than useless and can cause many complications. Some amateurs still use the tuned-plate tuned-grid oscillator, although it is almost impossible to keep a constant calibration.

Battery frequency meters are very difficult to keep steady owing to voltage variation, but the electron-coupled meter using a screen-grid valve is the most stable of the various types.

The circuit shown is one that I have used very successfully. Small variations in frequency can be made by adjusting the voltage applied to the screen of the valve, while at the same time this alters the strength of the generated oscillation.

It is essential, if this meter is to be satisfactory, for a low reading m/a. meter to be available. A meter has not been shown in the circuit owing to expense, but it must be remembered that the calibration must be made at a predetermined anode current. If, for example, the meter is callibrated with an anode current of 2 m/a., if this current is kept constant, irrespective of voltage the frequency will remain sensibly constant.

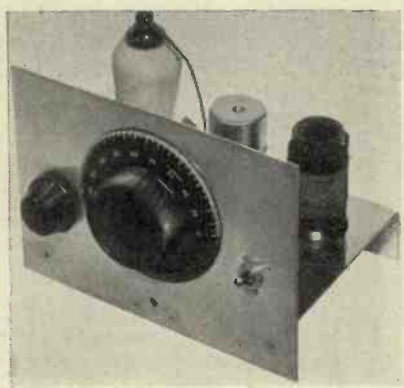


The choke in the positive lead is of a special type obtainable from Eddystone.

The coil of the plug-in type can be obtained from Eddystone already wound. Simply ask for a frequency-meter coil, but it can be made very simply by using a type 934 Eddystone coil form and some 26-gauge enamel-covered wire. For the 160-metre coil, however, 32-gauge wire will be required.

Altogether four coils will be needed to cover wavelengths between 10 and 200 metres. Coil 1, covering a frequency of 1,400 to 30,000 kc., consists of $3\frac{5}{8}$ turns with the cathode tap one complete turn from the earthy end.

The second coil for 6,600 to 14,500 kc. needs $10\frac{1}{4}$ turns with a cathode tap two turns from the earthy end. Coil 3, for 3,250 to 6,800 kc. should be wound with 31 turns with a cathode tap $3\frac{1}{2}$ turns from the earthy end. Top band coil needs 48 turns wound solenoid without any space between the turns, and a cathode tap six turns from the earthy end.



A plain 4-in. dial is quite sufficient for this type of metre.

These coil formers specified, except for top band, are all slotted so that correct gap between windings is automatically obtained. This makes construction even more simple.

It will be noticed from the theoretical circuit that an H.F. choke is connected to the L.T. positive circuit. This choke is obtainable from Eddystone, but can be home-constructed in the usual way. The anode choke is also an Eddystone type 982.

The whole coil is tuned with a 50 mmfd. band-setting condenser with a 50mmfd. bandspread condenser. In the case, however, of those readers only using the meter on the higher-frequency bands then the bandspread condenser should be reduced in capacity to about 20 mmfd.

Since the unit was designed I have received an advance sample of a new Eddystone bandspread tuning unit. This consists of a tank condenser having a capacity of 10 by 14 mmfd. The bandspread condenser is graduated from zero to 100 degrees so that 1,800 degrees are really obtained over the whole tuning scale. This tuning outfit can be included in this meter to advantage.

It is most important that the grid condenser and leak be of the specified values. If variations are made they must be within very narrow limits which will simply alter the pitch of the note.

In operation there is no need to attach any aerial to the meter unless it is more completely screened. It can be fixed on to a shelf, for the radiation is sufficient to be picked up by an average receiver in a normal sized room. It is advisable when frequency checking to make the receiver oscillate, when not certain as to the frequency of the station to be checked. In this way the oscillation is easily picked up when it beats with the oscillation in the receiver.

As the current consumption is so low there is no need to worry about power supply as the smallest high-tension battery will be entirely satisfactory.

It is suggested that a curve be plotted on graph paper one curve being made for each coil and, then, providing the anode current is kept constant, these curves will be accurate over a long period.

Every amateur should invest in a meter of this kind for it will so greatly help in the location of broadcast signals on a new receiver. Also new stations can be recognised by frequency check.

Electron-coupled Battery Frequency Meter.

CABINET AND BASEBOARD.
1—Cadmium plated to specification (B.T.S.)
CONDENSERS, FIXED.
1—.0003-mfd. type M (T.C.C.).
1—.1-mfd. type 4513 (Dubilier).
CONDENSERS, VARIABLE.
1—.00005-m.mfd. type 2041 (J.B.).
1—.00005-m.mfd. type 2144 (J.B.).
COIL FORM.
1—Type 934 (Eddystone).
CHOKE, HIGH-FREQUENCY.
1—Type 982 (Eddystone).
DIAL.
1—4-in. plain (Eddystone).
HOLDER, VALVE.
1—Type 949, 4-pin (Eddystone).
RESISTANCE, FIXED.
1—50,000-ohm. type 1-watt (Erie).
RESISTANCE, VARIABLE.
1—100,000-ohm potentiometer (Reliance).
SUNDRIES.
2—Wander plugs marked H.T. pos., H.T. neg. (Clix).
2—Spade terminals marked L.T. pos., L.T. neg. (Clix).
Wire and sleeving (Scientific Supply Stores).
Small quantity of nuts and bolts (Scientific Supply Stores).
SWITCH.
1—Type S88 (Bulgin).
ACCESSORIES.
ACCUMULATOR.
1—Type DTG (Exide).
BATTERY.
1—99-volt type standard (Vidor).
VALVE.
1—SG215 (Hivac).

SIR NOEL ASHBRIDGE ON DEVELOPMENTS IN TELEVISION

An abstract of a lecture by the B.B.C.'s Chief Engineer at the Annual General Meeting of The Television Society on March 25th.

This photograph shows Sir Noel Ashbridge delivering his address before The Television Society. Sir Ambrose Fleming, who took the chair is seen on his left.

ON March 25, at the annual general meeting of the Television Society, Sir Noel Ashbridge gave an address on some aspects of the high-definition television system.

His remarks are reported in full in the Journal of the Television Society, which is being published at the end of this month, and the following is a resumé of some of the salient points of his talk.

In his opening remarks, Sir Noel regretted that he could not tell the audience much about the technical details of the station at present being built at the Alexandra Palace, nor could he make any comment on either of the two systems to be used there. As a member of the Advisory Committee on television he was necessarily impartial, and any discussion of technical details would be doing an injustice to one or other of the firms concerned.

"The primary object of the station," said Sir Noel, "was to provide a television service somewhere in England—obviously in London, because it stood the best chance of attracting the maximum number of subscribers. It was not intended to be an ordinary service—one would not normally begin a service of television with two sets of technical data for the conditions under which it would operate, nor would one use two different systems at the same station. It is desirable to explain what was intended in making these decisions. You will know, of course, that there were two firms who had developed television to a high degree of practicability. It was impossible for any person to say which of these two systems would actually prove the better when operated as a regular service and, as the two systems were different in many respects, it was desirable to obtain experience in operating both of them."

The Reason for Two Standards

After dealing with the reasons which led to the choice of the site at the Alexandra Palace as the transmitter, the question of the number of lines and frames per second was discussed. He said "People have often wondered how the Committee ever came to adopt two different standards. It ought not to be necessary, but if two different systems are to be on trial, the designers of these systems must be allowed to a certain extent to choose the number of lines with which they scan their pictures. That is how it came about that in the end it was decided to use the two different sets of technical data.

"It is worth while considering for a moment the relative merits of, say, 240-line and 405-line pictures, and also the relative merits of a larger number of frames per second, or a smaller number. One may say, if it is possible to transmit a larger number of lines, why consider anything else? It might be argued that in the present state of the art you can do as much justice in the receiving of a picture of, say, 240 lines, as you can one of much higher definition, in that there are various factors which prevent taking full benefit from the higher number of lines. It might therefore be submitted that there is no object in using a higher number of lines, and it is true that this does not appear necessary until the standard of the art has advanced sufficiently to take advantage of all the benefits resulting from the higher definition. Whether this is the case or not I do not know, but it is one of the contentions in favour of the lower number of lines. Another contention is that higher definition may possibly mean a more expensive receiver, and that, of course, is obviously not a desirable thing. Television must eventually appeal to all classes, and not merely a few rich people.

"The new station at the Alexandra Palace has a section with an area comparable with that of Broadcasting House, but there is not the same accommodation, because there are not the same number of floors. A kind of minimum working accommodation is being provided, and for each system there are two large rooms about 70 ft. by 40 ft., in which there will be a separate transmitter for each system. This was necessary because the modulation systems to a large extent are bound up with the transmitter itself, and there is very little common to both.

It was therefore considered better to have an entirely separate transmitter for each system.

"Above these rooms there are two more large rooms, one for the Baird studio and one for the E.M.I. studio. These are about the same size and are provided with gear for special lighting, ventilation, etc. In addition, there are rooms and apparatus for film scanning, and a room for viewing films, like an ordinary miniature cinema. There are also a number of dressing rooms, offices and a restaurant. In the tower will be offices for the programme staff.

"For both systems there will be a common sound transmitter which is similar to a standard broadcasting transmitter except with regard to the wavelength. The power will be about 3 kW following the ordinary rating. The two vision transmitters cannot be rated in that way because the modulation is peculiar. These are best rated in terms of the peak power, and this will be approximately 17 kW."

Motor-Car Interference

Sir Noel's remarks on the question of interference were interesting, as touching on an aspect of the subject which has not apparently received a great deal of consideration.

He stated that, when television first started, he was under the impression that interference would make lines and blots on the picture which would destroy its interest and entertainment value. When the picture is actually on the screen, however, the specks due to interference from motor-car sparking plugs, etc., become masked to a certain extent.

On the other hand, in sound reproduction, motor-car noises are intolerable, and it is possible that the power of the sound transmitter would have to be increased to compensate for this trouble.

It was difficult to say how the interference could effectively be suppressed, as it cannot be supposed that all motor-cars can be fitted with suppressors. In the States, the problem is solved, because so many cars are fitted with ordinary radio that they automatically have suppressors fitted, and it is thought that by the time a television service is in being, the interference problem will not exist.

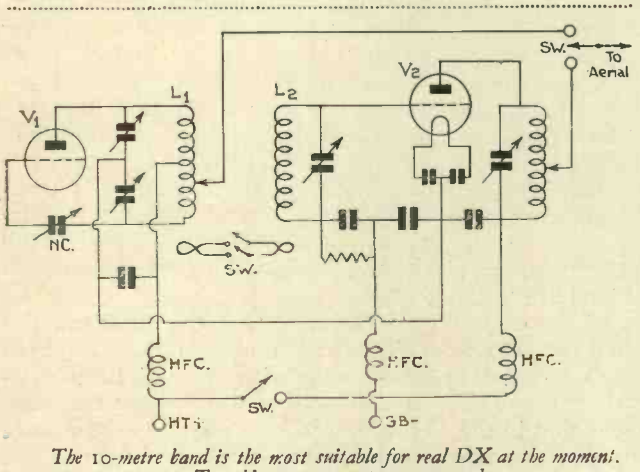
The chair at the meeting was taken by the President of the Society, Sir Ambrose Fleming, and at the conclusion of the address he tendered the thanks of the Society and the visitors present to Sir Noel for his kindness in coming to deliver his address.

Making a Start on 10 Metres.

By Eric Adcock G2DV.

PUBLICITY given to the recent good work by G5BY and G2YL will undoubtedly encourage many amateurs who have 20-metre transmitters to move down to the 28-mc. band. For several years very disappointing results have been obtained by the few enthusiasts who have operated regularly on this band—and there is nothing more discouraging than listening to an empty background of mush after every test call! Chiefly due to the increased activity on the band, more than to any great change in conditions, signals are now to be heard during daylight hours most days whenever the receiver is switched on.

Various methods of obtaining ten-metre output can be adopted, according to the construction of the 20-metre transmitter. It is assumed that a crystal-controlled signal is required, although a self-excited ultra-audion rig, as used by W9GFZ, will give a good account of itself providing mechanical stability receives due consideration.



The 10-metre band is the most suitable for real DX at the moment. Try this arrangement as suggested.

Undoubtedly the simplest solution is to operate the final stage as a doubler. To obtain the best efficiency from this arrangement, the valve should be biased to something like four or five times the value of cut-off bias. This additional bias may be obtained from a 20,000-ohm grid-leak connected in series with the negative bias lead, and shunted by a .002-mfd. condenser. High-impedance valves usually give the best output with this arrangement. At the writer's station, the 20-metre final amplifier uses a very low impedance valve of high inter-electrode capacity, which proves most inefficient as a doubler. A spare SW1 being on hand, an additional high-power doubler stage was built up on the top of the rack housing the 20-metre rig. The circuit arrangement is shown by the diagram. By throwing the three switches controlling H.T., link coupling and aerial, band change is accomplished with a minimum of trouble, resulting in a good 50 watts of 28 mc. output. L_1 and L_2, consisting of twelve turns of copper tubing 3 ins. diameter, are permanently tuned to 14 mc. Plate doubling being employed, L_3 consists of five turns of 2½-in. diameter, with the single wire aerial feeder tapped on three and a half turns from the anode of V_2.

Those using push-pull output stages should not attempt to employ them as push-pull doublers for 28-mc. operation. Except with small valves of the '46 type, self oscillation and general instability will result.

It is unlikely that many will attempt the addition of a further doubler in the early stages of the transmitter, to operate the final stage as a neutralised 28 mc. amplifier, but where this is done link coupling to the grid circuit of the final stage *must* be employed. A metal shield between grid and anode circuits will assist neutralising, and all earth returns should be individually taken direct to the centre point of the filament by-pass condensers.

Depending on the valve employed, the turns required in the tank circuit will vary between four and six. To keep the efficiency as high as possible, the highest possible inductance and smallest capacity should be used.

A regenerative receiver will give a good account of itself on 28 mc. although the lower background noise and discrimination of motor-car and vacuum-cleaner interference of the well designed superhet, demonstrates its very definite superiority.

There have been numerous cases of readers having spent a considerable time listening to find the band. This can easily be avoided by building up a small oscillator to tune to 20 metres.

The Amateur Bands Single-signal Super

By E. J. Pickard, G6VA

In the April issue we described the principles governing the design of a super-het suitable for the amateur. We now have pleasure in giving the full constructional details of a receiver making use of the points previously mentioned.

BEFORE embarking on the constructional details there are a few remaining theoretical points of interest.

What Single Signal Implies

With the autodyne detector circuit is obtained the familiar double whistle, on either side of the central zero point, so C.W. morse signals are unnecessarily duplicated. If the receiver is made to respond to one side only of zero beat it can be seen that the effective width of the amateur bands for morse is doubled. This is in effect what "Single Signal Reception" means.

If a self-oscillating second detector is used it will give double response as does the oscillating detector in the straight receiver. With a separate oscillator mistuned by about 1,000 cycles to produce an audible beat, and providing the selectivity of the I.F. amplifier is of about the same value (i.e., 1 kc.) as the mistuning, one side of the signal carrier is eliminated. The ratio of elimination of the unwanted side is the measure of the efficiency of the circuit. With the regenerative I.F. arrangement a signal R8-9 on the wanted side should be down to R2-3 on the "blind" side, in fact, with critical adjustment of the I.F. trimmers this ratio may be bettered.

Importance of the 2nd Detector

It is possible for a badly damping second detector to nullify the high selectivity achieved in the I.F. channels. For example, a diode detector was found to flatten the tuning, so for this reason an anode-bend detector was decided upon. A straight H.F. pentode with its appropriate cut-off bias gives minimum damping and provides good strength for telephones. However, if a receiver primarily intended for telephony is contemplated a double-diode-triode offers advantages.

Chassis Construction

The complete chassis is available from the Scientific Supply Stores, but the following dimensions are given for the handy-man to build himself. Chassis $18\frac{1}{2}$ ins. by $10\frac{3}{4}$ ins. by 3 ins. deep. Panel $18\frac{3}{4}$ ins. by 10 ins.

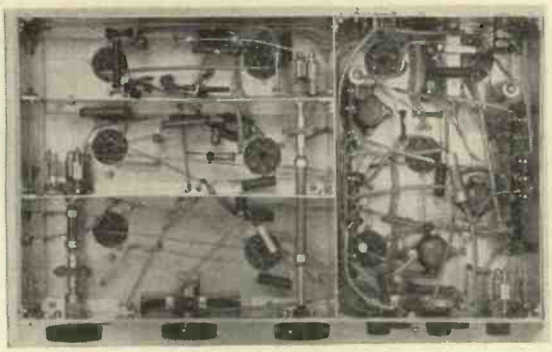
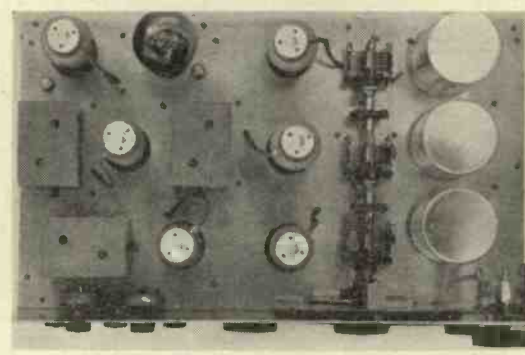


Fig. 1.—On the left is a view of the under baseboard wiring. Notice how the various sections are carefully screened.

Fig. 3.—On the right is a plan view of the chassis. The three-gang condenser is made up of separate units.

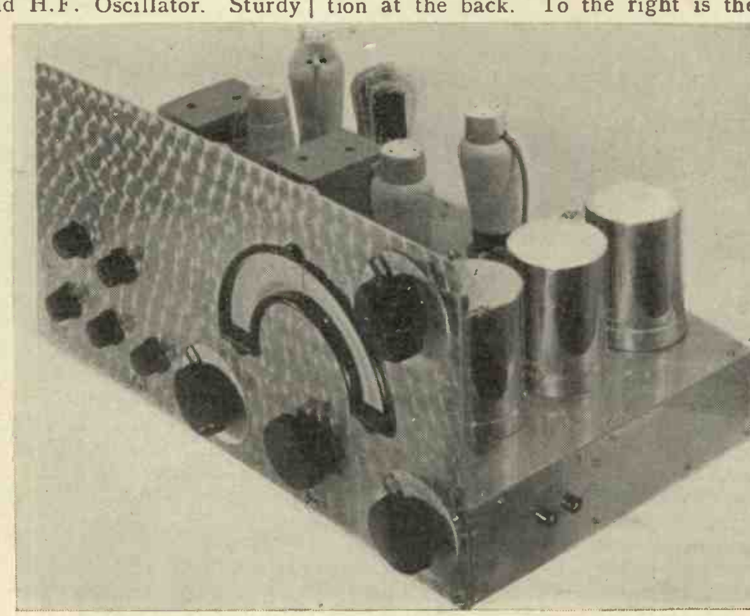


The chassis is sub-divided as shown in the underside view (Fig. 1) the right-hand section housing the I.F. and L.F. portions (measuring $10\frac{3}{4}$ ins. by 7 ins.) while the H.F. side is divided lengthwise to give three sections, shielding in order from front to back, H.F. stage, detector, and H.F. Oscillator. Sturdy chassis construction is vital, and if undertaken at home No. 14 gauge aluminium is recommended, which may be screwed together by angle, or better still lengths of $\frac{1}{4}$ in. square brass drilled and tapped. The holes for the drive escutcheon and valveholders may easily be cut with a fret-saw providing the saw is kept lubricated with oil or turpentine.

Controls

Front panel controls (Fig. 2) from left to right are :—Beat oscillator vernier (C18), I.F. regeneration (R30), detector regeneration (R31) while the top two small knobs are I.F. gain (R29) and H.F. gain (R28). The H.F. oscillator band setting (C6) is to the left of main tuning, and is carried by flexible coupler and extension to the oscillator section at the back. To the right is the

Fig. 2.—All the panel controls can be seen from this illustration. How the controls are used is mentioned in the text.



Beat-note Oscillator Circuit

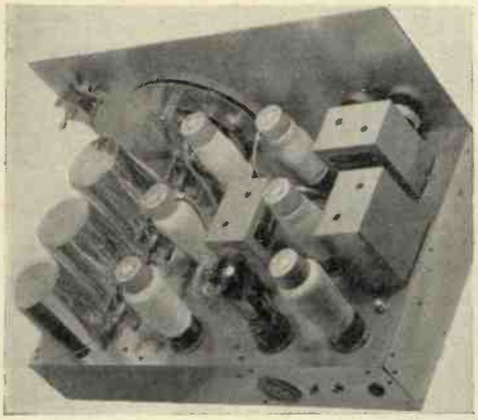


Fig. 4.—The receiver presents a very workmanlike appearance.

detector band setter (C5) coupled in similar fashion to the middle screening section, but fitted with a slow motion device. On the top-right of panel is the H.F. band-setter (C4). Immediately below the control knob of the main tuning is a switch for breaking all H.T., while the beat oscillator on-off switch is below the regeneration controls.

Layout

Fig. 3 shows the top view, and on the H.F. side the three circuits can be identified, each comprising valve, band-spreading condenser and canned coil. To the left of the detector in a line are the two I.F. transformers with the I.F. valve between, back left is the second detector and L.F. pentode. The third I.F. transformer in the front houses the beat oscillator coil and trimmer, with the B.O. valve next to it. A 4-pin volve holder is mounted on the back of the chassis for H.T. and L.T. connection from the power pack (Fig. 4) and to the right of this are a humdinger across the filament supply and the two jacks for phones or L.S. respectively.

Regenerative I.F. Circuit

Before mounting, the first I.F. transformer needs a small additional winding to produce the reactive effect. This can be slipped on without taking the transformer assembly down, and consists of six turns next to the grid coil (*not* between the two coils) and in the same direction of winding. Use 26 d.c.c. and providing I.F. transformer connections are made according to maker's markings the beginning of the winding goes to R8/C7 and the end to cathode/C8. Note that the regeneration control R30 is connected in opposite fashion to normal volume control, that is, maximum resistance when turned to the right.

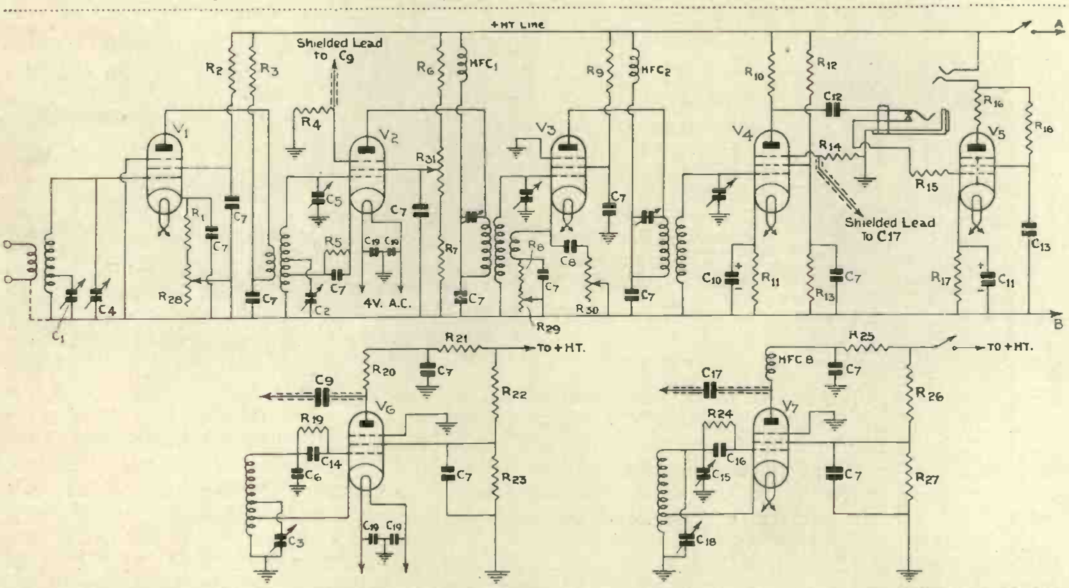


Fig. 5.—There are no complicated components in this circuit even though it uses all the features the amateur requires for good DX reception.

Fig. 6.—Below is a view of the coils without screens. They have to be changed for each band, but this is the most efficient method.

Beat Oscillator Coil

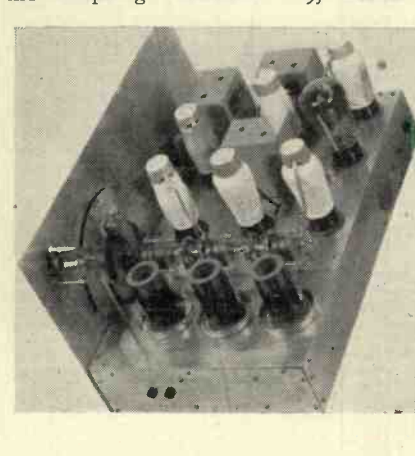
The tapped cathode coil for the electron-coupled beat oscillator is made from a standard I.F. transformer. First remove the larger of the two I.F. coils, then join outside of remaining coil to a length of 26 to 30 gauge d.c.c. wire and hank-wind 30 turns on the I.F. former adjacent to the coil and in the same direction of winding.

The joint becomes the cathode tap to V7, while the end of the hank winding goes to earth. The two air trimmers should be joined in parallel to form beat oscillator setting capacity. The grid leak R24 and condenser C16 should be wired in position inside the can.

Wiring Up

It is not policy to rely on the chassis itself to which to take earth return connections; before starting any other wiring lengths of 16 gauge tinned copper should be run in convenient positions and bonded to chassis every three inches or so. All the earth returns should then be taken direct to this earth wire. It is also important to see that all the R.F. by-pass condensers (C7) be connected direct to the screens, etc., making the shortest possible R.F. path to earth.

The .01 tubular condensers by-passing the H.T. feed to the I.F. transformers should be mounted inside the transformer assembly. Particular care should be taken to ensure rigid wiring in the H.F. oscillator section, 16 gauge wire is preferable here, while the stamp-type grid condenser C14 and its resistance R19 are mounted on a small ebonite pillar. Additional support with small pillars or stand-off insulators should be given to any wiring likely to vibrate in this section. The slightest suspicion of vibration in the wiring will cause a peaked signal to "wobble." A short shielded lead is run through the partition from suppressor of V2/R4 to the coupling condenser C9, which is



Coil Construction and Testing

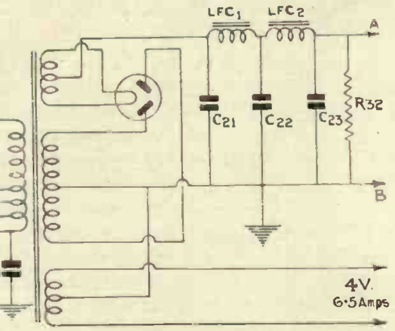


Fig. 7.—The power pack is conventional as can be seen from this circuit.

also supported on a small pillar.

Coming to the I.F. and audio section, a bakelite strip is mounted either side of the compartment on spacing washers, the strip at the end of the set carrying in order from front to back, C17, R12, R13, R11, R10, C12, while the strip on the dividing shield has mounted on it R6, R27, R26, R8, C7, R9, R17. The wiring from the regeneration coil on the I.F. should be carried out in metallised sleeving, including the lead to the control R30.

Also every wire connected with the beat oscillator circuit should be carefully shielded, and the metalising bonded to earth.

COIL DATA.

	TURNS.			
	10 m.	20 m.	40 m.	80 m.
H.F. Primary	3	4	5	10
,, Grid	$3\frac{1}{2}$	$8\frac{1}{8}$	$17\frac{1}{2}$	29
Tuning Tap	1	$2\frac{7}{8}$	$7\frac{7}{8}$	None
Detector Primary	3	4	$6\frac{1}{2}$	10
,, Grid	$3\frac{1}{2}$	$8\frac{1}{8}$	$17\frac{1}{2}$	29
Tuning Tap	1	2	$7\frac{7}{8}$	None
Cathode Tap	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{2}$
Oscillator	—	$7\frac{7}{8}$	$16\frac{1}{4}$	25
Tuning Tap	—	$2\frac{5}{8}$	$7\frac{1}{8}$	23
Cathode Tap	—	$1\frac{1}{8}$	$2\frac{3}{4}$	5

Grid wound with 22 enamelled, primaries 36 D.S.C.
20 m. and 40 m. primaries wound between bottom turns of grid coil.
10 m. and 80 m. primaries slot wound $\frac{1}{8}$ in. from bottom of grid coil.

Components for THE AMATEUR BANDS S.S. SUPER-HET

CHASSIS.
1—Aluminium chassis and panel to specification (Scientific Supply Stores).

CONDENSERS, FIXED.
12—Type .01-mfd. N.I. tubular C7 (T.C.C.).
1—.1-mfd. type N.I. tubular C8 (T.C.C.).
2—.0001-mfd. type " M " C9 and C14 (T.C.C.).
1—.006-mfd. type " M " C13 (T.C.C.).
2—.0002-mfd. type " M " C16 and C17 (T.C.C.).
2—25-mfd. type " C " C10 and C11 (T.C.C.).
1—.05-mfd. type 250 C12 (T.C.C.).
1—.001-mfd. type 340 C20 (T.C.C.).
1—.004-mfd. type 340 C21 (T.C.C.).
2—8-mfd. type 802 C22 and C23 (T.C.C.).
1—.002-mfd. type " M " C19 (T.C.C.).

CONDENSERS, VARIABLE.
3—40-mfd. type 900 C1, 2, 3 (Eddystone).
3—.0001-mfd. type 900 C4, 5, 6 (Eddystone).
1—.00002-mfd. type 900 C18 (Eddystone).

COIL-FORMERS.
6—Type 6-pin (B.T.S.).

COIL-HOLDERS.
3—Type SP. (B.T.S.).

COIL SCREENS.
3—Type 3 (Goltone).

CHOKES, HIGH-FREQUENCY.
3—Type H.F.P.J. (Wearite).

CHOKES, LOW-FREQUENCY.
1—Type 8W (Keston).
1—Type 9W (Keston).

DIALS, SLOW-MOTION.
1—Type 1036 S.M. (Eddystone).
2—1026 knob dial and cursors (Eddystone).
1—Type 973 (Eddystone).

HOLDERS, VALVE.
7—7-pin valve holders type SW42 (Bulgin).
1—5-pin type SW41 (Bulgin).

PLUGS, TERMINALS, ETC.
6—Type P64 valve caps (Bulgin).
1—Type P25 fuse plug (Bulgin).

RESISTANCES, FIXED.
2—300-ohm. type 1 watt R1, R8 (Erie).
2—20,000-ohm. type 1 watt R2, R9 (Erie).
2—5,000-ohm type 1 watt R3, R15 (Erie).
2—25,000-ohm type 1 watt R4, R14 (Erie).
2—1,000-ohm type 1 watt R5, R11 (Erie).
4—100,000-ohm. type 1 watt R6, R13, R19, R22, R24 (Erie).
2—10,000-ohm. type 1 watt R7, R18 (Erie).
7—50,000-ohm. type 1 watt R10, 20, 21, 23, 25, 26, 27 (Erie).
1—75,000-ohm. type 1 watt R12 (Erie).
1—100-ohm. type 1 watt R16 (Erie).
1—400-ohm. type 1 watt R17 (Erie).
1—15,000-ohm. type P.R.12 R32 (Erie).

RESISTANCES, VARIABLE.
1—10,000-ohm. potentiometer R28 (Erie).
2—2,500-ohm. potentiometer R29, 30 (Erie).
1—100,000-ohm. type potentiometer R31 (Erie).

SUNDRIES.
2—Extension rods type 1008 (Eddystone).
1—Humdinger (Claude Lyons).
2—Couplers type 1009 (Eddystone).
1—Type 66 jack (B.T.S.).
1—Type 71 jack (B.T.S.).

SWITCHES.
2—Type S80T (Bulgin).

TRANSFORMERS, I.F.
3—Type 1014 (Eddystone).

TRANSFORMERS, MAINS.
1—Type 11W (Keston).

VALVES.
2—Type AC/VP1, V1, V3 (Mazda).
4—AC/S2/PEN V2, V4, V6, V7 (Mazda).
1—AC/PEN V5 (Mazda).
1—UU/120/500 V8 (Mazda).

Choke Input Power Pack

To prevent a large variation of voltage when changing from phones to loudspeaker operation with the L.F. pentode it is necessary to pay special attention to the eliminator circuit. That shown in Fig. 7 employs choke input method, and providing a suitable surge-input choke is used, and the smoothing choke and mains transformer have low resistance, there is only a rise of 8 volts when cutting out the L.F. pentode.

Coil Winding

Complete coil winding data is given in the table and it should be noted that on ten metres no coil is quoted for the oscillator position, the 20-metre oscillator coil proving very satisfactory for this position. On 80 metres there is no tuning tap for the H.F. and detector coils, the condenser tuning across the entire coil; this connection must be made between appropriate pins on the coil itself. Primary windings for the 20- and 40-metre coils are wound between the grid turns at the bottom end, but the 10- and 80-metre primaries are both slot wound $\frac{1}{8}$ in. away from the bottom of the grid winding.

When testing it is advisable to make inoperative the regeneration on both the detector and I.F. valves to ensure that no misleading instability is present. To do this take R5/C7 straight to earth (disconnect tap) and break both I.F. reaction connections, taking cathode direct to R8. Check up with the 20-metre coils, putting all three band setters to about the same capacity. See that all four I.F. trimmers have their plates about half way in, then a little searching on the main tuning should produce one of the more powerful commercial morse stations. Trim the I.F.'s for maximum volume, leave the oscillator band-setter and trim the detector and H.F. The oscillator band-setter will, of course, produce two channels, the higher frequency one of which should be used.

The coils have been wound to give good tracking on the respective amateur bands with an I.F. of 465 kc., but in addition operation will be found very satisfactory on the various S.W. broadcast bands. Band-spread is adequate, the total coverage of the main tuning dial on 7 mc. being 370 kc. and on 14 mc. 500 kc. approximately.

With the detector regeneration connected, signals strength should increase smoothly, making the detector trimming sharper and giving very good second channel rejection. As the single-signal effect will depend on the I.F. regeneration, particular attention should be paid to this control (R29). If the I.F. valve goes into oscillation with only a small movement of the control, reduce the number of turns on the reaction coil to five. The important point to remember is that oscillation should not occur until the control is at least half-way round. Make final adjustments to the I.F.'s with the B.O. switched in, and peak up a signal by regeneration while trimming. All these adjustments can be made with the I.F. gain at maximum.

Tobe Short-wave Kit Receivers

WE are very pleased to be able to give first details of the new Tobe Deutschmann short-wave kit receivers which are now available in this country. At the moment there are two kits in this series, both embodying the Tobe Super Tuner.

The first kit designed by Glenn Browning is known as the Browning 35 and consists of seven valves and covers between 22.6—.45 Mc. Valve sequence consists of an H.F. pentode pre-selector stage, pentagrid detector oscillator, single stage of intermediate-frequency amplification, a double diode triode, output pentode and beat note oscillator. Valve rectification is employed.

According to reports from American amateur stations it appears that this tuner is one of the most popular and efficient made in America. It consists of 12 coils and trimmers with a three-gang condenser all combined in one unit.

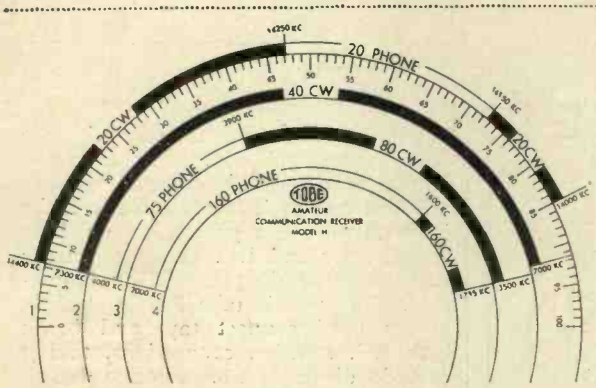
The well-known troubles of ganging and matching have been overcome in a very effective way by fixing low capacity trimmers across each coil. This means that each waveband has to be trimmed separately, which although is a lengthy business, when completed means that the tuner matches perfectly on all wavelengths.

This Browning 35 is primarily intended for short and all-wave receivers and not as an amateur bands receiver. The high-frequency stage operates on all wavelengths, and in addition to increasing the sensitivity results in a very material increase in signal to noise ratio. It also results in rejection of image frequencies.

The local oscillator is electronically coupled to the incoming signal through the pentagrid valve. This precludes any locking-in effect between the aerial or H.F. stage and the oscillator, which is sometimes very noticeable at the higher frequencies.

A beat-frequency oscillator is incorporated as an integral part of the receiver for C.W. A switch in the anode circuit of the oscillator valve switches off the H.T. while the beat frequency is continuously adjustable. Automatic colume control has been incorporated, the voltage for this being obtained from the diode detector. A short circuiting switch is included so that the A.V.C. can be cut out when the beat note oscillator is in use.

The volume control in the I.F. stage allows for regeneration while the main volume control is connected in the diode circuit.



Every amateur will want a receiver using this amazing dial. The 20-metre band spreads over 6 ins. A receiver on these lines is almost completed and will be published in an early issue.

Overall sensitivity of the circuit is better than 1 microvolt on all wavebands, and after making some tests we discovered that the sensitivity curves are more or less identical for the four bands.

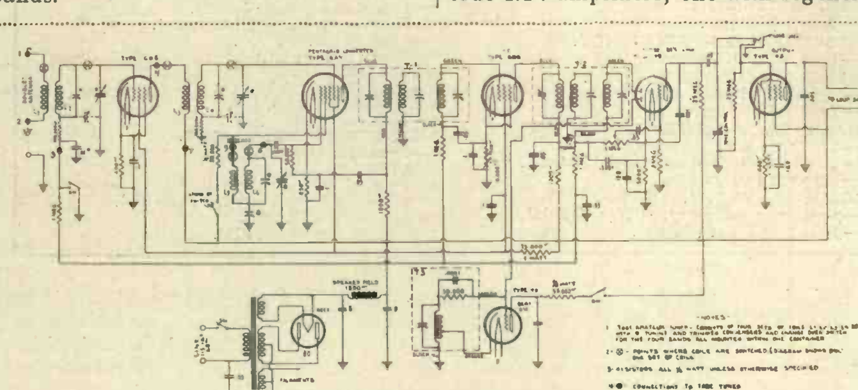
Every amateur will be enthusiastic over the Tobe Amateur Super-het. It includes the special Tobe amateur bands tuner complete with air-spaced trimmers. It is only for amateur use, covering wavebands as shown by the illustration of the dial on this page.

We have never seen a more efficient band spread action or a more useful tuner covering the amateur bands. The actual dial is 6¼ in. across, while each band is split up into C.W. and phone sections. It is certainly an achievement to be able to spread the 160 metre band and at the same time obtain wide coverage on the 20 metre band using the same condenser. In addition to the callibrations of phone and C.W., frequencies are also given, while the top scale is callibrated in degrees from zero to 100. The 20 metre band covers from 14,400 kc. to 14,000 kc. The 40 metre band from 7,300 k.c. to 7,000 k.c.; the 80 metre band from 4,000 kc. to 3,500; and the 160 metre band from 2,000 kc. to 1,715 kc. In practice there are slight tolerances at either end of the band.

This tuner is called the Tobe Model H. It is suitable for use with pentagrid, heptode, triode hexode or separate oscillator circuits. Any amateur wishing to make for example a 12-valve super simply has to connect 7 wires from the tuner to the I.F. amplifier.

We are at the moment designing two receivers using these tuners. One is for all-wave reception and the other for amateur bands use only. Amateurs have complained very bitterly about the lack of a good British short-wave set, and consequently many have bought receivers of American origin. We have no hesitation in claiming that our new super-het, to be published in a forthcoming issue, will fulfil the requirements of almost every short-wave amateur in this country.

Amongst the features embodied are a single stage of pre-selection, pentagrid detector, a pentode oscillator, two pentode I.F. amplifiers, one with regeneration, double-diode-triode second detector A.V.C. control and L.F. amplifier, electron coupled beat note oscillator, and pentode output.



This is the circuit of the all-wave super using the standard Tobe tuner.

Controls include H.F. and L.F. manual volume control, beat-frequency switch and frequency adjustor, automatic volume control gain and cut-out switch, I.F. selectivity control, band switch, on-off switch and tone corrector. Many of these controls are combined, but the receiver is absolutely flexible in every respect.

Transmitting amateurs will also appreciate the inclusion of a stand-by switch or receiver de-sensitiser.

THE CATHODE-RAY SCANNING CIRCUIT FOR BEGINNERS

By G. PARR

This article is a simple practical illustration of the manner in which the cathode-ray scanning circuit is built up.

ALTHOUGH scanning circuits differ greatly in construction they have all the same object in view—to provide a means of drawing a line-screen on the end of the cathode-ray tube.

If the method by which this is accomplished is fully understood there will be no difficulty in understanding the various forms that the scanning circuit takes and in appreciating the various developments which take place in improving the operation of the circuit.

The beam of the cathode-ray tube can be caused to move in any direction by applying a deflecting potential to one or other of the plates in the path of the beam. To draw the line-screen we have to provide a deflecting potential which shall deflect the beam to-and-fro across the screen and at the same time move it in an upward or downward direction so that each succeeding movement shall be a little displaced with respect to the last.

There are thus two movements to consider:
The horizontal movement of the beam which draws a line of the picture. The rate at which this line is drawn is called the "line frequency."

The vertical movement which displaces the lines with respect to each other. This vertical movement is performed completely when the whole number of lines composing the picture has been drawn, and therefore takes place at "picture frequency."

To take an example, in 240-line scanning the picture is composed of 240 horizontal lines, which are repeated every 1/25th of a second. The time taken to draw one line is therefore 1 divided by 240 × 25 or 1/6,000th sec.

Taking the case of a single line of the screen, the beam is moved across by applying a voltage to the deflector plates which increases steadily from zero to maximum in 1/6,000th second. The movement of the beam is proportional to the value of the deflecting voltage at any particular instant, so if the voltage increases steadily the beam will move steadily.

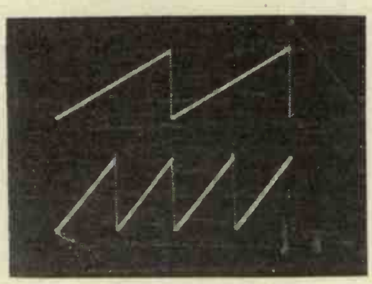


Fig. 1 (a) and (b).—The shape of the wave of deflecting voltage applied to the plates for producing the line screen.

Fig. 3.—Increasing the length of the line by increasing the bias applied to the relay.

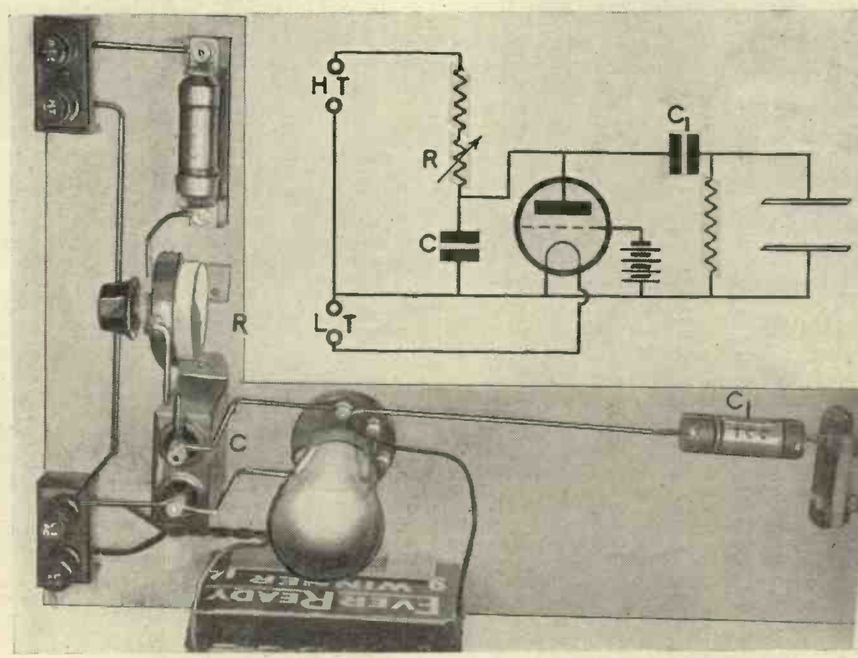


Fig. 2.—The simplest form of scanning circuit comprising a condenser and resistance with a relay for discharging the condenser.

This uniform increase of voltage is very important as if the beam does not cover equal distances on the screen in equal intervals of time the picture will be distorted. This, it may be added, is a common cause of distortion in line-screens.

At the end of the travel of the beam the voltage must fall abruptly to zero, allowing the deflected beam to return to its original position on the screen. During this time the vertical deflecting voltage applied to the other pair of plates is moving the beam upward, so that the next sweep will take place a little higher up the screen. At the completion of the 240th line, both the "picture" and "line" deflecting voltages fall to zero and the beam starts to draw the lines over again.

Deflection Characteristics

The characteristics of the deflecting voltage can be

CATHODE-RAY DEFLECTING CIRCUITS

represented by the lines of Fig. 1 in which the thick white line represents a voltage which steadily increases from zero to some value, and then falls rapidly to zero again. From the shape of the curve the name " saw-tooth " has been given to the voltage wage.

As said at first there are a number of circuits which can give rise to a voltage changing as Fig. 1, but we will here deal with the simplest form of circuit and point out its limitations later. Fig. 2 shows diagrammatically and in layout an arrangement of resistance R and condenser C which is connected to a H.T. supply.

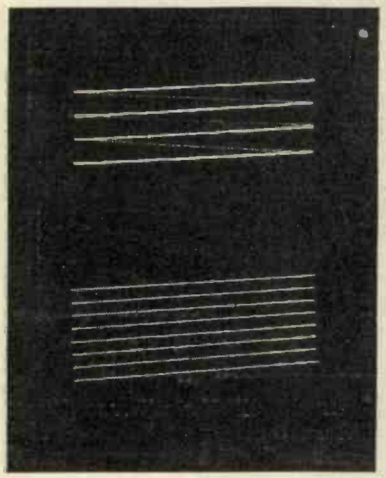


Fig. 4 (a) and (b) (above).—The lines become less sloped by an alteration in the relative speeds of vertical and horizontal movement.

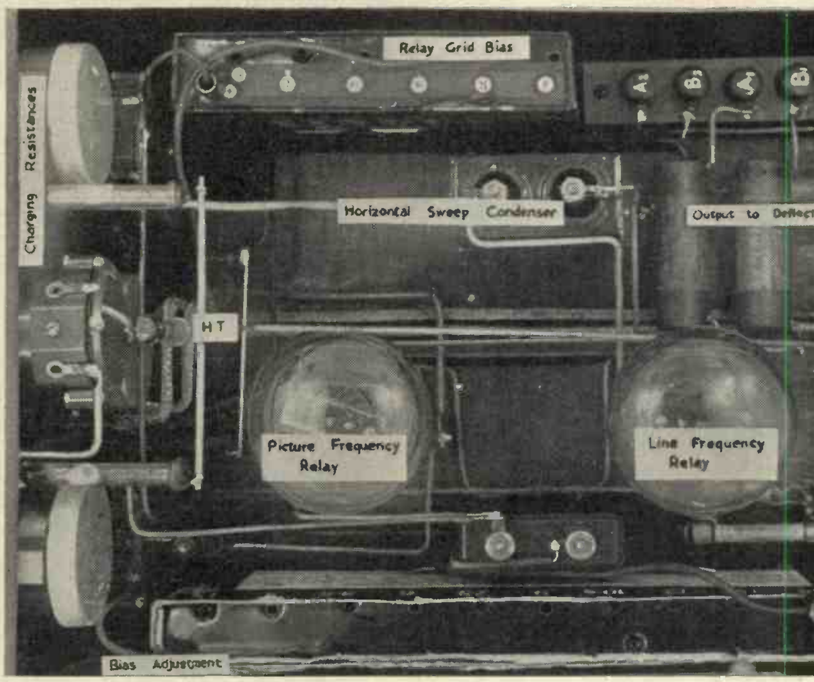


Fig. 6 (right).—A simple scanning circuit which is a duplication of the one shown in Fig. 2. The principal components are marked.

The current flows into the condenser at a rate which is governed by the value of the resistance R and can be adjusted to charge the condenser in 1/25th second, for example. While the condenser is charging, the voltage across it is rising, and this voltage is applied to the deflector plates of the tube through the condenser C_1. The valve connected across the condenser is a gas-discharge relay which is arranged to short-circuit the condenser at a given value of voltage and thus discharge it rapidly. The value of voltage at which the condenser is discharged is set by the value of the bias applied to the grid of the relay from the battery shown.

The Two Deflecting Circuits

To produce a complete line-screen two such circuits are required, one set to give a deflection in 1/25th second and the other to give one in the horizontal plane in 1/6,000th second.

The speeds of the charge and discharge of the condenser are controlled by the resistance and by the value of the capacity, so the resistance is usually made variable to give a range of speed. The effect of varying the resistance is shown in Fig. 1 (b). If the value is halved the speed of charge and discharge is doubled, so that twice as many lines are drawn on the screen in the same time.

The length of the lines of the screen is determined by the proportion of the picture, which in the case of Baird high-definition is 4:3. The length of the line is set by altering the voltage at which the condenser begins to discharge, and this in turn is controlled by the grid bias of the relay. If the bias is increased, the length of the line is increased, as shown in Fig. 3.

Now suppose that the values of the resistances have been set to give 1/6,000th second and 1/25th second respectively.

During the drawing of one line in the horizontal plane the beam will be shifted slightly upward by 1/240th of the whole height of the picture. The line will thus be a little sloped, as in Fig. 4. This does not matter in practice as the tube can easily be turned so that the

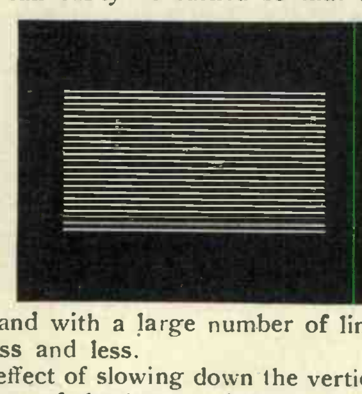


Fig. 5.—The line screen produced by a slow vertical movement and a rapid horizontal movement.

lines are horizontal, and with a large number of lines the slope becomes less and less.

Fig. 4b shows the effect of slowing down the vertical (" picture ") movement of the beam. A larger number of lines are drawn in the same time, and they are thus closer together.

When the relative movements are rightly adjusted the lines will become even closer, as shown in Fig. 5. It will be noticed in Fig. 3 that the beam returns across the picture at the end of its travel, leaving a bright trail. This is due to the fact that the discharge

(Continued on page 320).

A Complete Phone Transmitter for the Beginner

Full Constructional Details

More than 100 contacts have already been made with this suppressor grid phone transmitter. The transmitting section has been designed by G5ZJ and the modulator which is suitable for A.C. and D.C. by 2BDN. A Post Office licence to build this transmitter can be obtained on request for a fee of 10/-

MANY of our short-wave readers have contemplated at one time or another building a simple phone transmitter. Although the actual transmitter itself has always been fairly cheap to build, the speech amplifier has proved a stumbling block to the majority of readers. During the past year several new valves and circuits have been introduced which, when applied to simple transmitting apparatus, has enabled us to design equipment costing very little more than a good receiving set.

When the 362 Company designed the 15-watt transmitting pentode we at once visualised its advantages to our readers. The main feature of a transmitting pentode is that it enables a smaller modulator to be built reducing the cost by at least two-thirds.

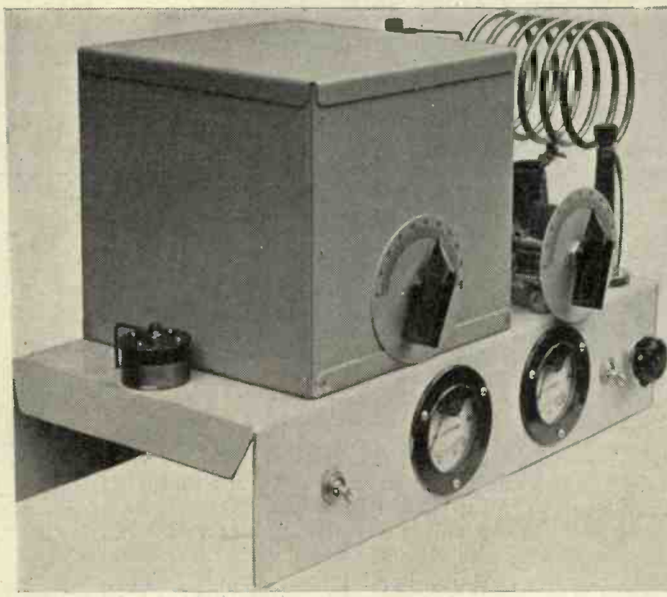


Fig 1. The oscillator provides ample drive for the RFP-15 pentode. The resistance across the modulator input has a value of 1,000 ohms. Although satisfactory results can be obtained with only 250 volts, 500 volts must be applied to obtain 15 watts input.

The Post Office issue transmitting licences of varying powers starting with a maximum of 10-watts on three wavebands. The most popular band is 40 metres, so for that reason we have designed the transmitter to use a 40-metre crystal.

Construction

The actual construction can be seen quite clearly in Fig. 1. The screening box houses the crystal oscillator stage except the crystal. The actual oscillator valve is a Tungsram P430 with a standard receiving type of plug-in coil tuned with a two-gang .00016-mfd. two-gang condenser. This stage is then capacity coupled to the pentode power amplifier. In the grid circuit of this amplifier is a high-frequency choke, 25,000-ohm resistance and grid bias battery. The uses of these three components will be explained later. The anode circuit of the output valve consists of a 40-metre coil made of either 9-gauge copper wire or 3/16 in. copper tube. This is mounted on two high stand-off insulators. A centre-tap is made to which a high-frequency choke is connected.

The screening grid of the pentode is connected directly to maximum high-tension through a fixed resistance of 10,000-ohms. This is de-coupled by means of a .1-mfd. condenser.

Refer to the theoretical circuit of Fig. 2. The crystal is connected directly between the grid of the oscillator valve and the chassis. A 25,000-ohm leak in parallel with it automatically provides grid bias owing to the grid current flowing through it. Across the filaments is a 30-ohm humdinger, the slider of which is connected to the chassis.

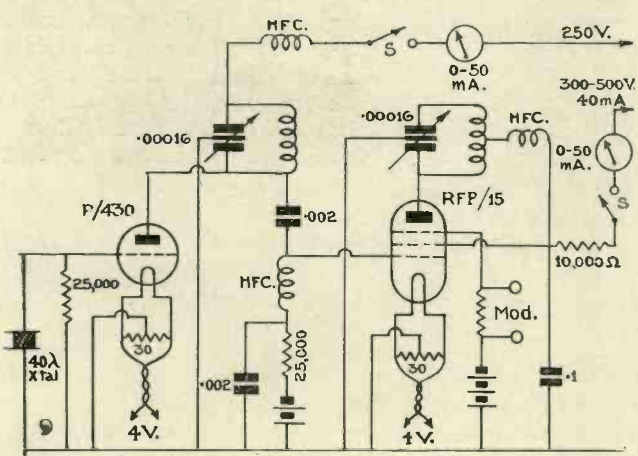


Fig. 2.—As split-stator condensers are used there is no need for anode by-pass condensers. Modulation is fed into the suppressor grid via the right hand jack. Make sure this jack is insulated from the panel. The tank coil shown is for the 20-metre band.

The two-gang condenser tuning the oscillator coil has the fixed plates connected across the coil, while the moving plates are joined to chassis. Although the moving plates are automatically connected via the screening box it is advisable to make a separate connection in case the enamel on the screening box acts as an insulator. The anode of the oscillator is coupled to the grid of the output valve through a .002-mfd. condenser. This must be suitable to withstand the voltage applied to the anode of the oscillator valve.

In normal circumstances a comparatively high voltage has to be applied to the grid of the pentode, but by connecting a 25,000-ohm leak in series with the grid return advantage is taken of the grid current flowing automatically to obtain a small percentage of the voltage required.

Layout

Fig. 3 shows quite clearly the layout of the components on top of the chassis

15 Watts Input on the 40-metre Band

and to where the connections are made to the oscillator tuning condenser. In the left-hand section can be seen the hum-dinger across the filament supply. Two large holes have to be drilled through the base of the screening box, but only one through the front. This can be more clearly seen from Fig. 4.

Assuming construction has been carried out on the lines indicated, the following points will have to be noted. First of all the oscillator coil. This is a standard Eddystone receiving coil which can be home-constructed if required. Simply wind 14 turns of 22-gauge enamelled covered wire on a 1½ in. former and space 1/16 in. The output coil, commonly called the tank or P.A. coil, consists of 14 turns of 9-gauge 3-in. diameter spaced the gauge of the wire.

If 9-gauge copper wire is used this will not require any supporting and will remain quite rigid. The tapping point must be made exactly in the centre, and can either be soldered on or made by means of an Eddystone tapping clip.

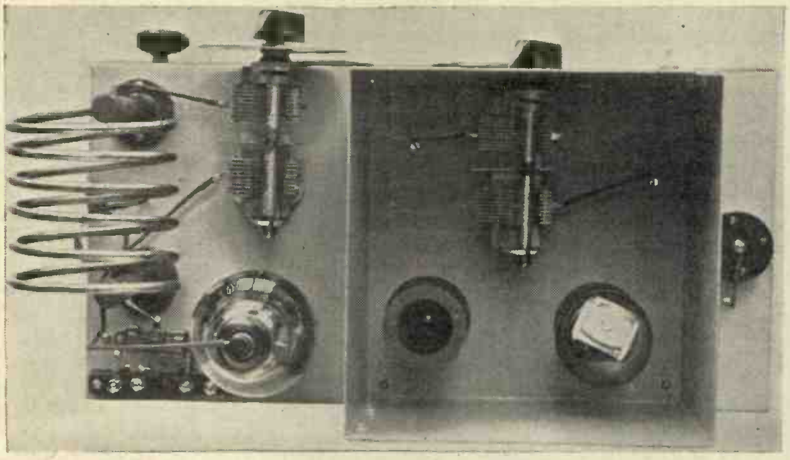


Fig. 3.—If the C.O. section is screened in this way there is no tendency for one circuit to pull the other. The Brookes crystal can be seen on the extreme right.

Then apply the four volts A.C. to heat the filaments of the two valves. Also 250 volts to the anode of the oscillator and between 300 and 500 volts to the anode of the pentode. This voltage should be connected but not actually switched on. The two switches on the panel that can be clearly seen in Figs. 1 and 4 should be in the off position.

The voltage to the oscillator should be switched on first. This is controlled by the left-hand toggle switch. The left-hand m/a. meter will probably read about 30 m/a., showing that the valve is not oscillating. Very quickly adjust the condenser mounted on the screening can and in one position it will be found that the anode current on the m/a. meter begins to drop. This condenser should be very carefully adjusted until the minimum reading is obtained on the meter. Then switch on the second toggle switch so applying H.T. to the pentode. Of course, before this is done the grid bias must be applied to this valve, and as a general rule about 40 volts will be ample. Unlike the oscillator, until the circuit is correctly tuned no anode current will flow. This is due to the fact that the grid has been heavily over-biased and is working as a Class B amplifier. Directly the circuit is brought into tune the anode current will peak up to a fairly high figure. This will probably cause a slight variation in oscillator tuning so a little care should be taken in readjusting the oscillator condenser to give minimum anode current following up by adjusting the P.C. condenser in exactly the same way.

The Looped Lamp

A useful gadget is a looped lamp. This consists of an ordinary flash lamp bulb across which is connected a 2 in. turn of wire, the whole being mounted on a piece of ebonite or wood about 9 in. long. When this is held against the P.A. or oscillator coils the lamp will light up even though there is no connection made through it. It is fairly simple to adjust the two condensers so as to obtain the maximum amount of light in the bulb.

Always make the adjustments stage

COMPONENTS FOR THE LOW POWER TRANSMITTER

CHASSIS AND SCREEN.
1—Cadmium Plated Chassis 14 by 7 by 3 in. (B.T.S.)
1—Metal screening box (Burne-Jones).
CONDENSERS FIXED.
3—.002 mfd. type Tubular (Dubilier).
1—1 mfd. type 500 volt working (Dubilier).
CONDENSERS VARIABLE.
2—type E two gang .00016 mfd. (Polar).
COILS.
1—type R-4 pin (Eddystone).
1—12 turn type 514 (Eddystone).
CHOKE HIGH FREQUENCY.
3—type CHS (Raymart).
CRYSTAL AND HOLDER.
1—7288 Kc (Brookes).
1—Holder type 4-B (Brookes).
DIALS.
2—type 1027 (Eddystone).
HOLDERS VALVE.
1—4-pin ceramic chassis type (B.T.S.).
1—5-pin ceramic type chassis (B.T.S.).
INSULATORS STAND-OFF.
2—type SW59 (Bulgin).
METERS.
1—type E 0-30 M/a. (Sifam).
1—type E 0-60 M/a. (Sifam).
PLUGS, TERMINALS, ETC.
2—type J2 Jacks (Bulgin).
1—saddle type 995 (Eddystone).
2—saddles type 996 (Eddystone).
RESISTANCES. FIXED.
1—25.000 ohm type 1 watt (Erie).
1—20.000 ohm type 1 watt (Erie).
1—10,000 ohm type 1 watt (Erie).
1—10,000 ohm type 3 watt (Erie).
2—30 ohm Nodalizers (Goltone).
SWITCHES.
2—S 80T toggle (Bulgin).
SUNDRIES.
3—coils of Quickwire (Bulgin).
VALVES.
1—0-15/400 Oscillator (Tungsram).
1—RFP15 (362).

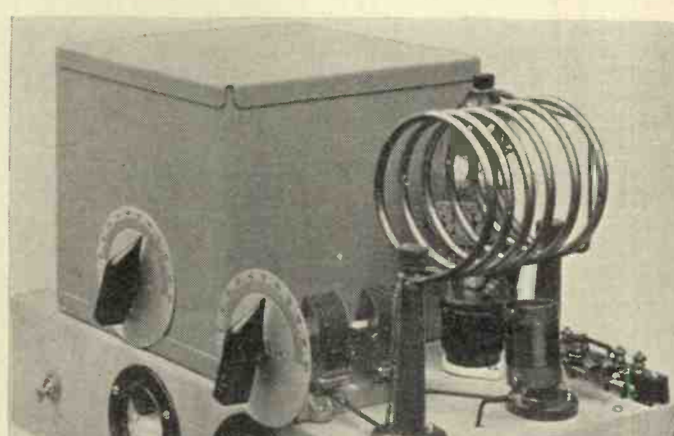


Fig. 4.—Two toggle switches are required, one in each anode circuit, so as to break the high-tension supply when required. The two meters measure the D.C. anode current.

An A.C.-D.C. Mains 3.5-watt Modulator

by stage. Hold the loop lamp over the C.O. coil with the H.T. to the P.A. switched off and then tune for maximum light. Follow up by switchng the H.T. to the P.A. coupling the lamp to the tank coil and then tuning again for maximum light.

P.A.

Bias

It is rather important to see that the bias to the P.A. is of the correct value. This should be sufficient to give double anode current cut off. The beginner should check this voltage in the following way. Switch off the H.T. to the C.O. and apply just enough grid bias to keep the anode current of the output valve to about 20 to 30 m/a. Then increase the bias until the current drops down to zero. Assuming this to be about 20 volts then double the applied voltage and the valve will then be correctly adjusted. It should, of course, be realised that no current will flow in the P.A. stage until the valve is excited by the oscillator.

During all these operations the suppressor grid, that is the centre contact to the pentode valve, should be connected to chassis, forgetting for the time being that no modulation is being applied. As has already been pointed out, before this apparatus can even be constructed a licence must be obtained from the Post Office. Any genuine experimenter can obtain what is termed an artificial aerial licence. This enables the transmitter to be built and adjusted but not connected to an open aerial. A call sign is also supplied which consists of a figure, generally 2, followed by three letters.

An artificial aerial consists of an inductance, resistance and capacity equal to the characteristics of a normal elevated aerial. The capacity is generally a coil identical with the P.A. coil while the capacity is a variable condenser of about .0003-mfd. connected in either series or parallel. The circuit is closed by means of a 20-ohms non-inductive resistance in series with a low reading hot wire meter. The whole of this circuit is coupled up to the tank coil and fixed by means of two more stand-off insulators. The transmitter can then be adjusted and experimented with just as if it were connected to an external aerial. The object of the whole series of tests is to obtain the highest possible reading in the hot wire amp. meter.

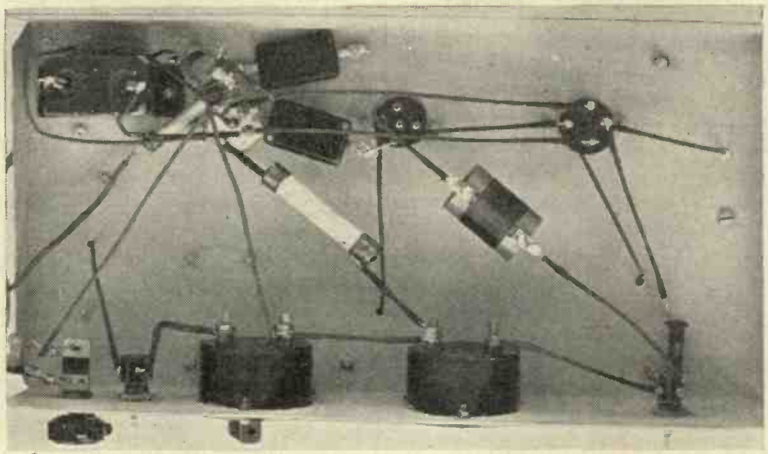


Fig. 5.—The wiring is even more simple than with the average receiving set. The fixed condensers shown are all of the .002 mfd. type.

The P.A.

Stage

With 500 volts applied to the P.A. the valve should draw a maximum of 30 m/a., this being equal to 15 watts, but it must be remembered that as a general rule the licence granted is for 10 watts only, so that this current should be reduced to 20 m/a. at 500 volts. The 0-15/400 with an anode voltage of 250 draws between 5 and 10 m/a. when oscillating fully, although when out of oscillation this current jumps to nearly 50 m/a. It will be appreciated from this that the oscillator valve must not be left out of oscillation for more than a second or so otherwise the emission will be impaired.

Constructing the Speech Amplifier and Modulator

All the previous points have been in connection with the transmitter but it must be remembered that a very important part of a complete transmitter is the speech amplifier and modulator. Generally speaking, this consists of two or three stages of conventional low-frequency amplification, either resistance or transformer coupled. This, unfortunately, is the largest item of expense, for such components as mains transformers, smoothing chokes and high voltage condensers generally cost more than all of the components in the actual oscillator put together. With a normal transmitting valve of 10 watts dissipation a modulating valve with an audio

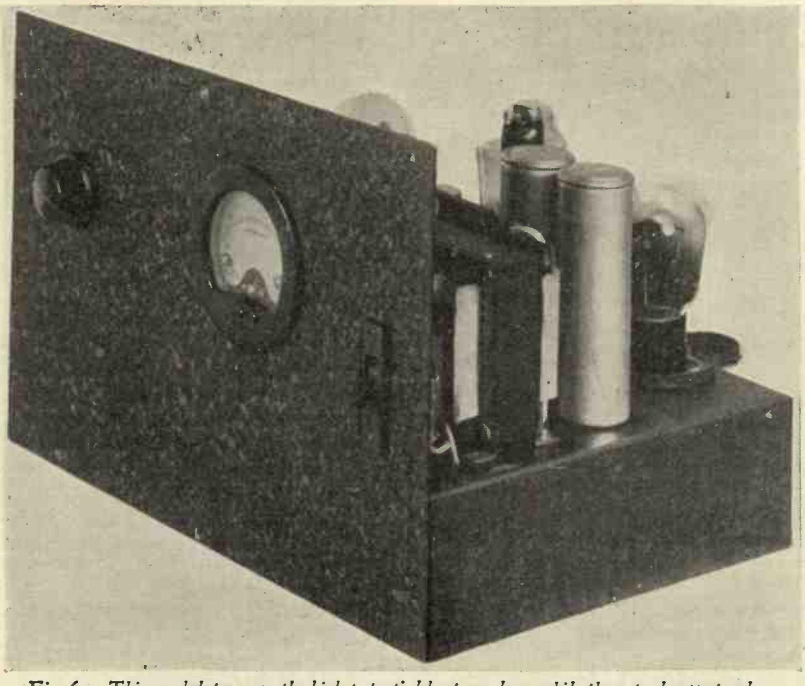


Fig. 6.—This modulator uses the high potential heater valves, while the actual output valve is a pentode giving between 3 and 4 watts on either A.C. or D.C.

Low-power Modulator

output of 5 watts will be required. This is an equal to a valve such as the PP5/400 type or DO26 500 volt type triode. However, by using an RF pentode as an oscillator and injecting the modulation in to the suppressor grid the amount of output required is reduced by as much as 75 per cent. In practice this means that instead of having a 500 volts main transformer and all the other expensive components of a power amplifier, a simple pentode of a low voltage type will deliver sufficient A.C. output to modulate up to 100 per cent.

Cost

So as to keep cost to a minimum special care was taken in designing the amplifier. First of all valves were chosen which did not require any mains transformer or barretters. The valves chosen, a triode and a pentode, are fitted with high voltage heaters that can be run directly from A.C. or D.C mains. The theoretical circuit in Fig. 8 shows exactly how this circuit has been arranged.

The output from the microphone is fed into the grid of a triode amplifier via a half-megohm potentiometer. A 1 3.5 ratio L.F. transformer couples the triode to a steep slope pentode. Notice that a resistance is in series with the auxiliary grid so as to keep the voltage on the grid lower than that applied to the anode.

Bias for both valves is obtained automatically. In the case of the triode a 1,000-ohm resistance in the cathode circuit applies approximately 4-volts bias. This resistance is by-passed with a 16 mfd. condenser, the negative side of which automatically makes contact to the chassis. The pentode bias resistance has a value of 250 ohms, and to preserve base response is by-passed with a 50 mfd. condenser.

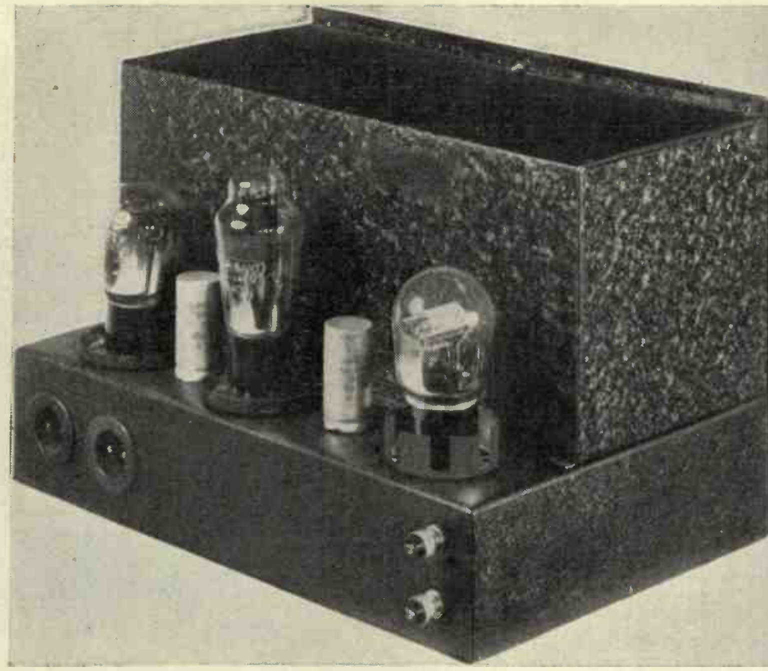


Fig. 7.—On the right is the triode amplifier followed by pentode modulator and half-wave rectifier. The first two terminals are for the microphone or pick-up input, the first set of sockets for mains input, and the second set for a monitor speaker.

It is essential that every trace of hum be eliminated from the modulator. Otherwise it will be fed into the transmitter, completely ruining the carrier.

During our tests we discovered that with this type of circuit, providing the L.F. choke was of a high inductance perfect smoothing was comparatively simple, so to that end we used type 30V Sound Sales by-passed with 16 mfd. capacity.

In the anode of the modulating pentode is connected the Savage type LL36PG pentode choke. This is tapped

(*Continued at foot of page 296*).

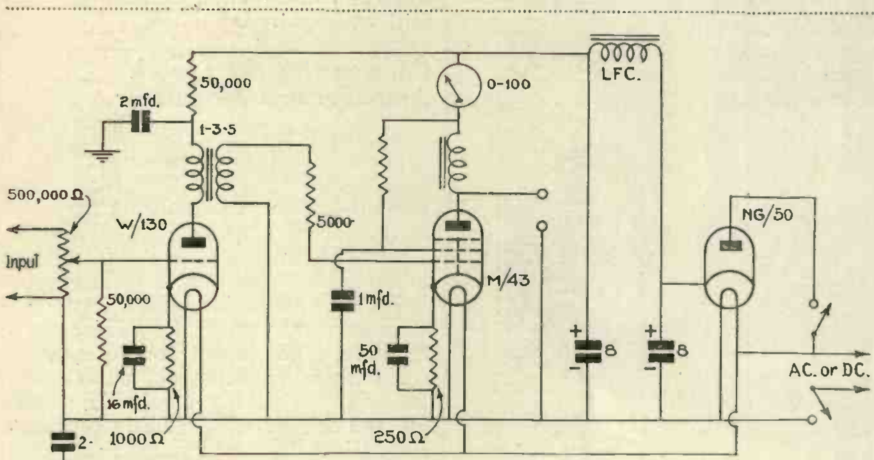
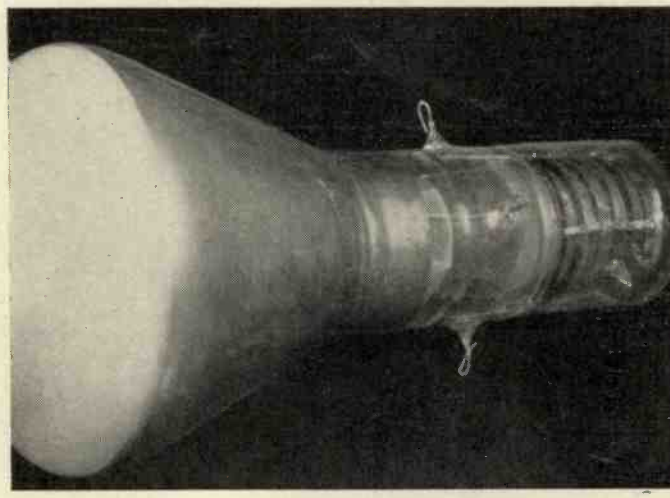


Fig. 8.—This circuit is quite conventional, but has proved very satisfactory with the high voltage valves. Notice how the heaters are wired in parallel.

Components for the Low-power Modulator

CHASSIS.
1—Special Cadmium plated 13 ins. by 9½ ins. with 3-in. sub chassis (B.T.S.).
1—Special Cadmium plated screening box, 13 ins. by 6 ins. by 6 ins. (B.T.S.).
CONDENSERS, FIXED.
2—8-mfd. electrolytic 500 volt working (Dubilier).
2—2-mfd. type 300 volt working (T.M.C.).
1—.0003-mfd. type tubular (T.M.C.).
1—15-mfd. type electrolytic 25 volt working (Dubilier).
1—50-mfd. type electrolytic 50 volt working (Dubilier).
CHOKES, LOW-FREQUENCY.
1—Type 30V (Sound-Sales).
1—Type LL36PG (Bryan Savage).
HOLDERS, VALVE.
2—5-pin chassis (Clix).
1—Type 7-pin chassis screened continental (Clix).
METER.
1—0-50 M/a. type flush mounting (Ferranti).
PLUGS, TERMINALS, ETC.
2—P20 Sockets (Bulgin).
1—T1 Terminal (Bulgin).
1—T2 Terminal (Bulgin).
RESISTANCES, FIXED.
2—50,000-ohm. type 1 watt Ohmite (Graham-Farish).
1—1,000-ohm. type 1 watt Ohmite (Graham-Farish).
1—5000-ohm. type 1 watt Ohmite (Graham-Farish).
1—250-ohm. type 1 watt Ohmite (Graham-Farish).
RESISTANCES, VARIABLE.
1—500,000-ohm. type potentiometer (Erie).
SUNDRIES.
Small quantities 6 B.A. nuts and bolts (Scientific Supply Stores).
Connecting wire and sleeving (S.S.S.).
9 ins. twin screened wire (Peto-Scott).
1 yd. twin 1-mm. flex (Peto-Scott).
TRANSFORMER, LOW-FREQUENCY.
1—Type A.F.3 (Ferranti).
SWITCHES.
1—Type S140 (Bulgin).
VALVES.
1—NG100 (Ostar-Ganz).
1—M43 (Ostar-Ganz).
1—W310 (Ostar-Ganz).
VALVE SCREENS.
3 standard screens with open tops (Colvern).

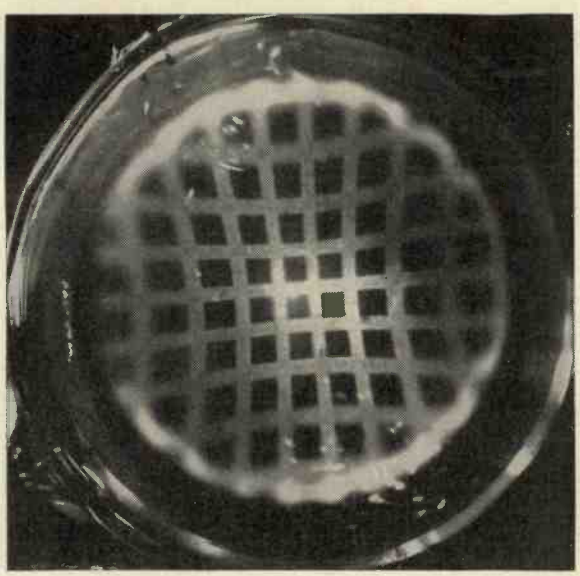
MORE ABOUT THE ELECTRON IMAGE TUBE



The Zworykin electron-image tube.

By George H. Eckhardt

WHILE the emergence of electronic television out of the laboratory stage is keenly awaited in the United States, the results of television research in fields other than the transmission and reproduction of scenes with the illusion of motion are already appearing. These results which promise to be exceedingly interesting and valuable may be regarded as by-products of television research.



Showing image distortion in uncorrected tube. Comparison with picture showing corrected image tube indicates how focusing is accomplished.

Dr. V. K. Zworykin and Dr. George A. Morton, of the Radio Corporation of America Laboratories, recently exhibited an electron tube which enables man to see in the dark. This tube, exhibited at a meeting of the American Association for the Advancement of Science, in St. Louis, also offers great promise in the field of microscopy. Dr. Zworykin will be remembered as the inventor of the Iconoscope, the " heart " of the R.C.A. system of television.

The activity of photo-electric substances, especially caesium on a silver base, in the infra-red and ultra-violet zones, is well-known. It is also a well-known fact that not only visible light, but also infra-red and ultra-violet cause the emission of electrons from a photo-sensitive surface. Therefore, a properly prepared photo-sensitive surface is more sensitive to light than the human eye. This, roughly, is the basic principle behind these electron tubes.

A photo-senstive coating on one end of a tube con-

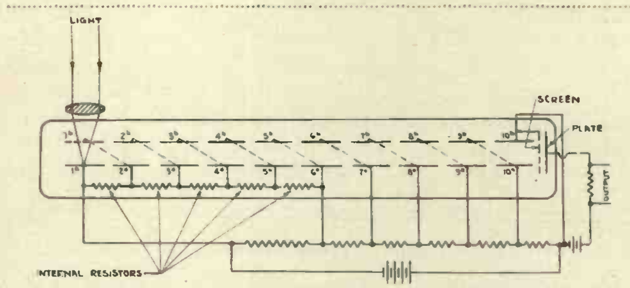
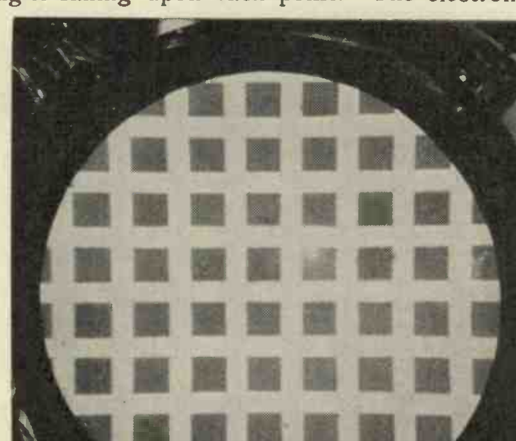
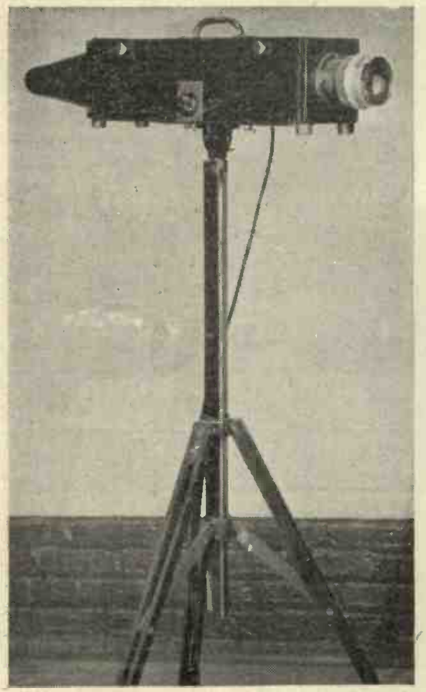


Diagram showing how potentials are applied to successive stages in the electron multiplier.

verted an optical image into electron emissions. These emissions, of course, were proportional to the amount of light falling upon each point. The electrons were



Undistorted image from corrected image tube showing the effect of electrostatic focusing.



A new electron telescope with which it is possible to see through fog by means of infra-red light.

" speeded " through the tube, and reproduced an enlarged picture when projected against a fluorescent screen at the far end of the tube. In short, the research men of R.C.A. produced a " television " pick-up and receiver, all in one tube.

One very striking experiment made by Dr. Zworykin was the focusing of motion pictures upon the "pick-up" end of the tube. These were reproduced in the " receiver " end. A filter which cut out all visible light, allowing only the passage of infra-red rays, was then placed in front of the motion-picture projector lens. It would seem to an observer that all light had been cut off by this filter. Yet the " receiver " end of the tube continued to reproduce the pictures with hardly any loss in clarity.

The electron images in this device are focused by electrostatic means. So similar does the focusing of the electron image by electrostatic means seem to opticall focusing, that Dr. Zworykin speaks of " electrostatic lenses." Focusing of the image is accomplished by varying the " electrostatic lenses " by means of a potentiometer. To carry the analogy one step further, the tube has been corrected for various distortions as with the lens of a camera.

This device seems to promise great possibilities in the realm of microscopy. By means of it researches can be extended in minute living organisms, which are now observatble only by means of intense light or stains, that often kill the germs the study of which is being pursued.

This new device, sensitive to infra-red rays, reveals details of tissue and cell structure not readily viewed by visible light, the use of stains may be obviated, and the natural development of heretofore baffling cells brought within the field of human vision.

The device can also be used as an " electron telescope " for seeing through fogs and atmospheric haze, which seriously handicap visible light by reflection from water particles, but do not impose the same limitations upon infra-red rays.

Although the electron image tube will operate on visible light waves, its most promising fields of application are in studies where the infra-red and ultra-violet rays are used.

"A Complete Phone Transmitter for the Beginner"

(*Continued from page* 294.)

and enables the modulator to be fairly well matched to the transmitter. It certainly increases the percentage of modulation when the correct tapping has been determined. It will be noticed that no means of connecting the modulator to the transmitter has been shown in either circuit. Actually a 1-1 ratio output transformer is connected between the two units. The output from the modulator goes into one side of the transformer, and the output of the transformer plugs into the jack on the panel of the transmitter. This is putting the speech frequencies into the suppressor grid of the pentode. The earthy side of this transformer is then connected to bias, the correct voltage having been determined by experiment. A good average is 60 volts negative.

The mains rectifier in the speech amplifier section is of the half-wave type. The A.C. is fed into the anode of the valve D.C. being taken out from the cathode. On D.C. mains this valve acts as a passenger simply passing through the D.C. supply directly to the smoothing circuit.

The layout is not particularly important, but the position of the various components can be seen from Figs. 6 and 7. The smoothing choke, output choke, and inter-valve transformer are mounted on the base plate and then completely covered with metal box. A point to remember is that the heater wires to the three valves should be joined up separately. These wires should also be twisted as this will reduce the hum level.

In the original modulator no trace of hum could be detected, but it is essential to rotate the inter-valve transformer to a position where hum fades out. If this transformer is in the wrong position hum level is quite high.

Mounting

It is suggested that both the transmitter and modulator be mounted in a small wooden framework. If three racks are provided the bottom rack can house the mains unit. This can be of the standard broadcast type and is perfectly straightforward.

Reverting to the transmitter, by using a tapped-on aerial no coupling coils and tuning condensers will be required. We suggest an aerial having a total length of 66 ft. which can be tapped directly on to the tank coil. Assuming the transmitter to be adjusted to give maximum light with the loop lamp, which will automatically mean minimum current in the second m/a meter, tap on the aerial at the H.T. end. This will mean a readjustment of the P.A. tuning condenser. Keep on tapping down the coil and readjusting until a point is found where there is a sharp rise in anode current. This is the optimum position.

With the modulator connected via the 1-1 transformer and a pick-up across the input, the modulation will be denoted by a definite flicker in the light of the loop lamp. This light should increase in brilliance as the modulation is raised. An alternative method is to connect the hot wire meter in series with the aerial lead. This will give a reading of about .3 to .4 and 100 per cent. modulation is obtained when this current can be increased by 25 per cent. This is a very approximate figure.

APOLOGY

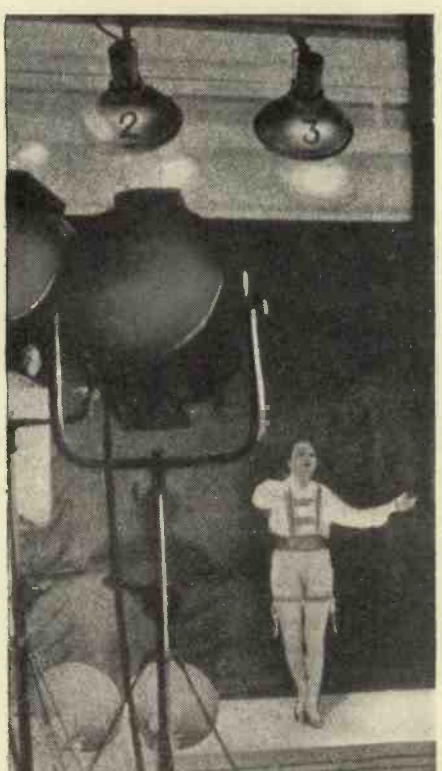
Owing to the demands that several special articles have made upon our space in this issue we regret that it has been necessary to hold over the third of the articles on Mechanical High-definition Film Transmission, Electron Optics and Transmitting for Beginners.

ARE THE EIFFEL TOWER TRANSMISSIONS A FAILURE?

A FRENCH CONTEMPORARY'S VIEWS

According to the *Haut Parler,* the Eiffel Tower television transmissions are a failure and this journal blames M. Mandel, the French Minister of Posts and Telegraphs for making an improper choice of the system to be used. It remarks that the performers are literally bathed in light and perspire and suffocate, whilst the method employed at P.T.T. is so costly that it constitutes a regrettable experiment from every point of view.

It appears that the Television Commission in April of last year suggested that Barthelemy and de France be asked to demonstrate their respective systems with a view to the inauguration of a television service. M. Mandel, ignoring this arrangement, excluded de France under the contention that he could not immediately transmit direct vision with 180 lines and yet he allowed another technician several months in which to achieve it.



The powerful projectors used at the P.T.T. studio make the heat almost unbearable.

Yet, it is contended, de France was surely one of the pioneers who ought to have been chosen on the basis of the chronological facts and the results obtained. The history of de France's television researches and achievements are given below.

August, 1931.—Official demonstration before MM. Herriot and Meyer (Mayor of Havre), 38 lines, mechanical system.

February, 1932.—Commencement of experimental transmissions at Radio-Normandy, 220 metres, 38 lines. Good reception at Havre.

June, 1932.—Attempts at transmission at Radio-Toulouse, 60 lines. Direct television and telecinema. Good reception at Havre.

November, 1932.—Establishment of the Research Laboratory at St. Cloud, near Paris. Demonstrations, 60 lines. Direct television. Reception on screen with crater lamps and Kerr cell. Telecinema, 90 lines.

February, 1933.—Telecinema demonstration, 90 lines, at the Lido in the Champ-Elysées, before well-known people of the cinematograph world.

May, 1932.—Transmission by wireless (175 metres). Telecinema, 90 lines and direct television, 60 lines. Reception in different parts of Paris.

July, 1933.—Reception with cathode-ray tube with high definition. First demonstrations, 120 lines.

January-March, 1934.—Public demonstrations of telecinema with high definition at the offices of the newspaper *Paris-Soir*.

April, 1934-April, 1935.—Production of a commercial receiver for 180 and 240 lines with 30-centimetre cathode-ray tube. Transmission by wireless on short waves and ultra-short waves, 180 lines.

Many research workers would have been discouraged on being confronted with the decision of the Minister for P.T.T., since transmission of pictures can only take place with the authorisation of the administration. The position of television is somewhat paradoxical because of the official support that is necessary.

The transmitter is in the base of the Eiffel Tower.

However, de France responded by beginning immediately on the design of a direct television scanner of 120 and then 180 lines. He was so successful and obtained such fine pictures that the construction of a private studio was decided upon.

One Kilowatt instead of Sixty

Here is the present position. It is known that the Paris-P.T.T. television studio is unique, in the strictest sense of the word: this is not a reference to quality, but an excuse.

To obtain "full-length" people, in spite of a slight increase in the area of the holes of the scanning disc which, regardless of all statements to the contrary, prevents achievement of a definition corresponding to 180 lines, the engineers of Paris-P.T.T. must shed floods of light on the performers with projectors consuming a total of 60 kilowatts!

It was necessary to install beneath the studio a refrigerating plant, the function of which is to cool overheated artists; studio performers compare the television studio of Paris-P.T.T. to a place of torments, and the fear is expressed that artists will suffer injuries to the sight. The method employed at P.T.T. is so costly that the construction of other television studios in France could not be faced, and yet it must be done. . .

The definition obtained, it is stated, is not of 180 lines in spite of the figure announced. Until quite recently there was no apparent difference between scanning with 60 lines and with 180 lines. The suppression of the former savours, moreover, of the exclusion of an undesirable witness.

De France, by mechanical devices, well-known in principle, but specially perfected, is able to obtain the same results as those of P.T.T., while using only one kilowatt instead of sixty.

By identical results with those of P.T.T. is meant full-length people on a two-metre screen; as regards the quality of the picture, it is very superior, since it is really a case of 180 lines.

Almost in Darkness

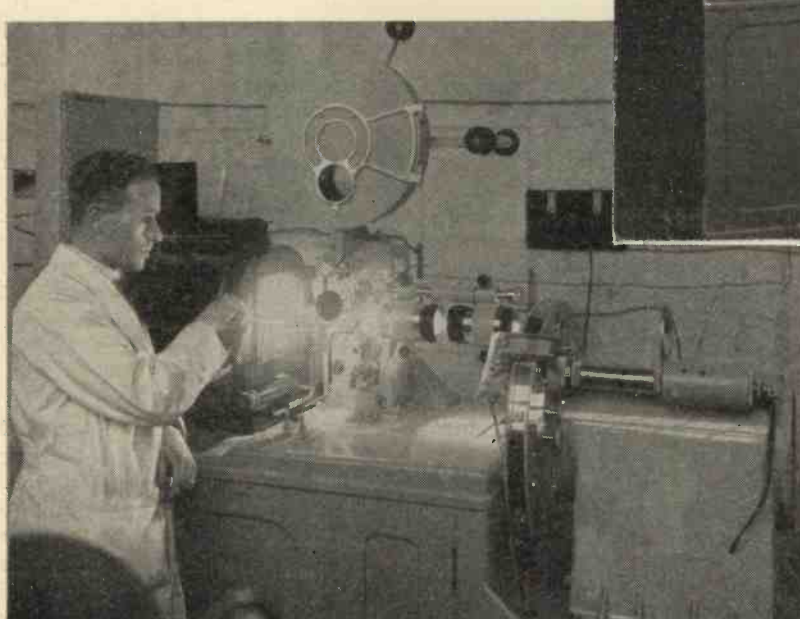
De France employs spot-light scanning and the studio is almost in darkness. The cost of the installation is very low, especially if consideration is given to the fact that air conditioning is not necessary. The pictures obtained are remarkably good and correspond exactly to what is called "180 lines." Without exaggeration, they are perfect in detail, perfectly stable and, what is more, pleasant to the eye.

No claim is made for originality in the system, for well-known methods are employed. The excellent results, it is stated, are due to improvement in detail regarding which secrecy is being maintained.

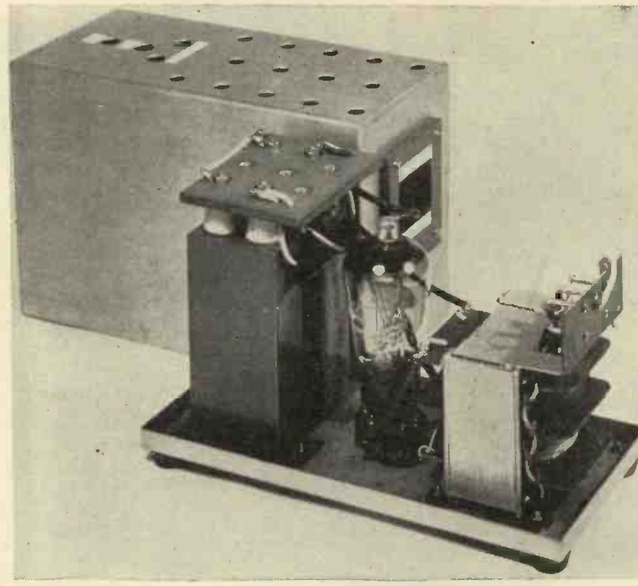
What is M. Mandel going to do? Justice demands that he should allow the two systems to compete, as has been done in England and Germany; public opinion in France would not easily permit ostracism of one system in favour of another.

BAIRD APPARATUS FOR ALEXANDRA PALACE

The photographs show some of the Baird apparatus actually to be installed at the Alexandra Palace. This comprises two band Telecine scanners for transmitting talking films. Each consists of film projector mechanism, with arc and film gate, 240-line scanning disc running in vacuum, photo-electric cell and A & B amplifiers in the large consoles. Below the projector box contains automatically controlled vacuum and water cooler pumps. Below the amplifier is the all-mains supply unit and behind the switchboard are the controls and sound panel. The photograph below shows the transmitter in greater detail.



BUILDING A CATHODE-RAY EXCITER UNIT

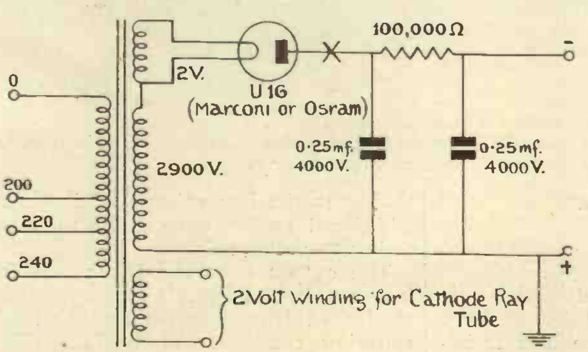


Here is a photograph of the unit with the cover removed.

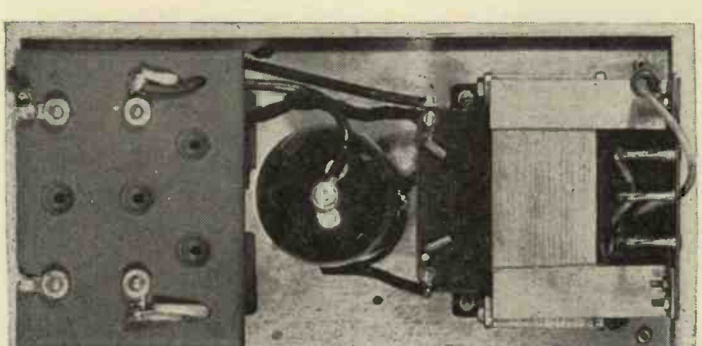
Here are constructional details of a cathode-ray tube exciter unit which will be suitable for use in any high-definition television receiver.

MUCH of the apparatus which is used for cathode-ray reception of high-definition television can be built in unit form; in fact the entire receiver consists largely of units. The first piece of apparatus required is the exciter unit and the purpose of this is to supply filament and high-tension current to the tube; the exciter unit does in fact fill the corresponding purpose of high-tension and filament supplies to an ordinary wireless receiver with the difference that in this case the H.T. voltage is much higher and approximates 3,500. A warning is therefore necessary that the greatest care is essential in wiring and insulation in order to avoid the risks of short-circuits and shocks; the latter may, of course, be dangerous.

As will be seen from the photographs the unit is totally enclosed in a metal case, the tappings being taken from sockets in a block of insulating material mounted over the condensers; the unit should only be operated with the cover of the case in position and then, providing that the leads are adequately insulated, there will be no risk in its use.



The circuit of the cathode-ray exciter unit.



A plan view showing the tappings on the insulated block.

The Circuit

The circuit is shown by the diagram and it will be seen that the unit consists of a special transformer provided with a high-voltage winding and two 2-volt windings, one of the latter for the filament of the rectifier valve and the other for the filament supply for the tube. The additional components are two .25-mfd. 4,000-volt working condensers and a 100,000-ohm resistance. The rectifier valve is a Marconi-Osram U16.

The valve holder for the rectifier valve should be of steatite (Eddystone short-wave type) as there are over 3,000 volts between the anode and filament sockets. The condensers used are B.I. specially designed for high-voltage working and it is essential that these or similar condensers be employed.

The wiring of the unit is quite straightforward and can easily be followed from the circuit diagram; all joints should be soldered and soldering tags used where possible; also every care should be taken to ensure that the joints are mechanically strong. Care must also be taken that the leads do not touch the metal chassis; good quality systoflex should be run quite close up to all joints.

The transformer has been designed to have a lower power factor than unity and adequate smoothing is provided by the resistance and condenser smoothing system. A feature of this unit is that the L.T. and H.T. may be switched together, no delay being necessary. It is, however, advisable

(Continued on page 320).

An A.C.-D.C. High-fidelity Amplifier

We have very great pleasure in presenting an amplifier that completely solves the problem of high quality and good output on D.C. mains. The circuit was made possible by the use of a new type of A.C.-D.C. indirectly heated triode valve.

Designed by Bryan Savage

HIGH power quality amplifiers have more or less been denied to the user of D.C. mains. Very few amplifiers with an input of 200 volts would give more than 4-watts audio output and still preserve quality. Triodes of the P.X.4 type are very popular, but there have been many readers who, wanting 5 or 6 watts of audio, and a frequency response reasonably good within 30 and 10,000 cycles, have used an A.C. amplifier with a rotary converter.

Of course, these remarks apply mainly to low voltage D.C., but even with 250 volts one cannot obtain the same output as from 500 volts to a triode valve of the PP5/400 type. To overcome these difficulties the Mazda Co. introduced a new indirectly heated triode valve that gives good quality and high output from a 200-volt supply.

This valve, the PP3521, provides a ready solution to nearly all of the difficulties associated with D.C. mains. The maker's characteristics are as follows:

Maximum anode volts, 250.
Slope, 9.0 mA/V.
Amplification factor, 6.0.
A.C. resistance, 660 ohms.
Max. dissipation, 15 watts.

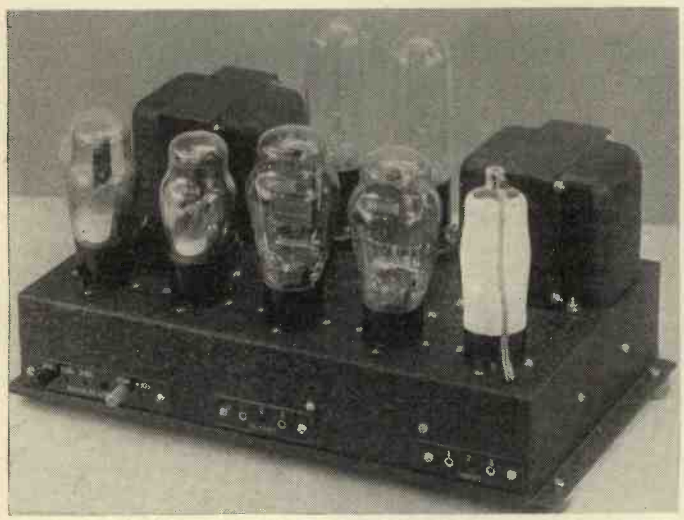
This valve is of the indirectly heated type bias being obtained automatically by means of a cathode resistance. This resistance normally has a value of 360 ohms and should be by-passed with a high capacity condenser. The filament rating is 35 volts at 0.2 ampere, so is suitable for A.C. or D.C. operation.

The manufacturers have also supplied the following particulars when using the valve with only 175 volts, which is about the average likely to be obtained after taking into consideration the drop across smoothing chokes.

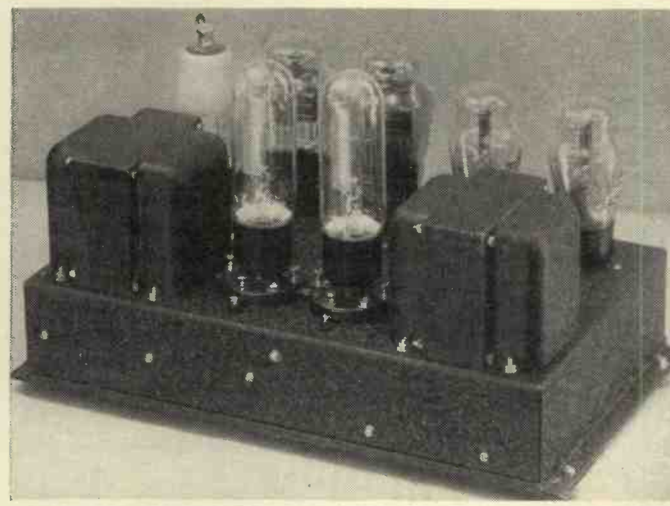
Anode volts, 175.
Anode current, 60 m/a.
Grid bias, 22.25 volts.
Optimum load, 2,800 ohms.
Power output, 1.5 watts.
Input, 15.8 volts r.m.s.

Dissipation

The maximum anode dissipation is 15-watts, but in this amplifier we have increased the value of the bias resistance to 400 ohms so as to run the valve within its rated capabilities.



Valves are from left to right two ID5 half-wave rectifiers, two PP3521 triodes, and an HL1320 medium impedance triode.

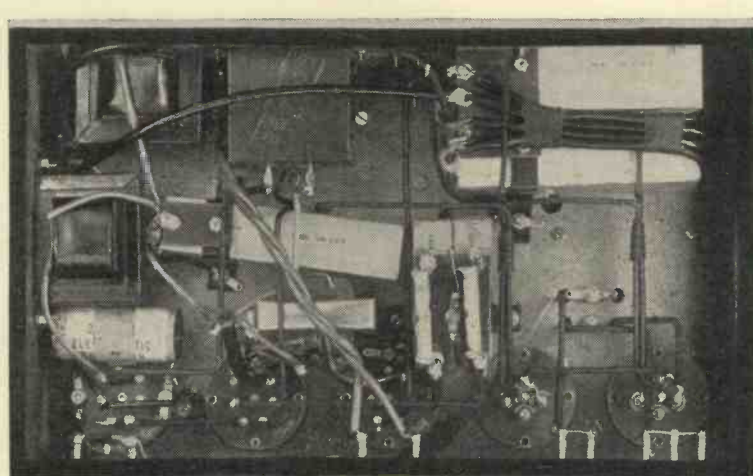


In the centre can be seen the two C1 Philips barretters. Resistances which plug in to valve holders can be used in place of the barretters which require the normal valve holder fittings.

Refer to the theoretical circuit of this amplifier. It will be seen that the first valve is of the ordinary triode HL type with a bias resistance of 600 ohms by-passed with a 100 mfd. In the anode circuit is a special coupling choke, followed by a Y4OM smoothing choke. This also acts as a de-coupler in place of the more conventional resistance. Owing to the low voltage available no additional resistances can be tolerated owing to voltage drop.

The output from the HL1320 is fed into a pair of PP3521's through a parallel feed transformer circuit, with a coupling condenser of 1-mfd., which value is important to preserve the balance of the amplifier.

The under baseboard wiring is comparatively simple and if wires are braided together as shown it helps to preserve neatness.



Over 5 Watts from the Push-Pull Valves on D.C.

Across both halves of the secondary are 100,000-ohm fixed resistances, while in the anode circuit of the push-pull valves are 100-ohm resistances. Each valve is biased separately with 400-ohm resistors. In the original amplifier the cathode condenser is 25-mfd., 50 volts, which gives the correct amount of bass response when used with the Baker triple cone loud-speaker recommended for this amplifier, but it is more than likely that with a different loud-speaker bass boosting will be required. If this be the case the cathode condensers should have a capacity of 200-fmd.

H.T. Feeds

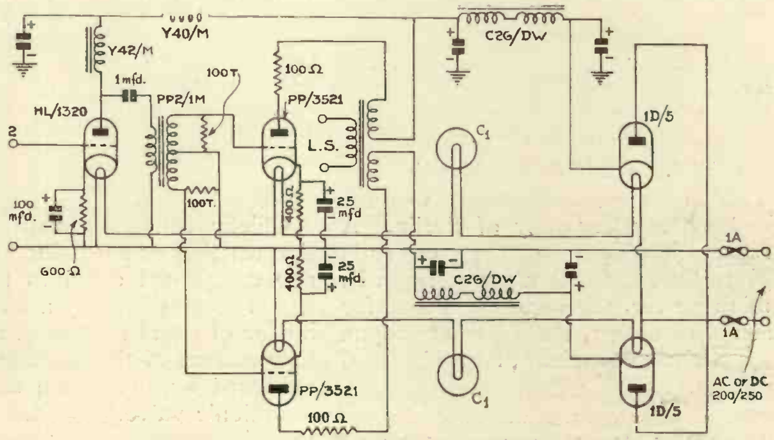
As these valves consume approximately 70 m/a. it is essential that the H.T. feeds be split as shown, otherwise the total current passed across the smoothing choke and output transformer will cause a very considerable voltage drop. Notice that the output transformer primary is in two sections, while separate chokes are used for each circuit. This effectively halves the D.C. resistance in the feed circuit, so reducing the voltage drop by half.

Readers may wonder why separate filament lines have been employed. It will be remembered that with A.C./D.C. valves the maximum allowable filament voltage drop is 110, for above this figure the voltage is sufficient to break down the insulation between heater and cathode. To overcome this possibility and to conform with the maker's requirements, the HL1320, one PP3521, the 1D5 rectifier and one barretter are all in series, while the second PP3521, second barretter and second 1D5 are in series in a separate feed. This also allows for two entirely separate smoothing and rectifying circuits.

While on the subject of rectifiers, readers who intend to use the amplifier solely on D.C. will appreciate that the two rectifying valves can be omitted, by simply connecting together the anode and cathode wires. The barretters will take care of the voltage rise in the filament circuit.

The output at 200 volts A.C. or D.C. is approximately 5.5 watts, while this is increased to a little over 6 watts at 250 volts A.C. or D.C. This is a high figure and is more than ample for domestic use. Frequency response with the circuit as shown is 5dB down at 50 cycles and .5dB down at 15,000 cycles. This is, of course, *including* the output transformer. If the Baker loud-speaker is not used the bass response can be levelled up as previously suggested by the use of a 200-mfd. condenser across the cathode bias resistance.

The C26DW choke is actually two windings on one common iron. It has been shown separately to clarify the circuit. Notice how separate H.T. feeds are provided to overcome voltage drop owing to anode resistance.



Output Load

The output transformer is arranged for a 3,000-ohm load, and in such circumstances the previous figures were obtained with less than 5 per cent. second harmonic distortion. Considerably higher output can be obtained by reducing the load to 2,400 ohms, but distortion increases quite appreciably.

It has been arranged that the input to each of the push-pull valves is approximately 30 volts, so it is essential that the specified components should be adhered to if quality is to be preserved. Also the push-pull valves must be carefully matched as regards anode current, for the percentage of distortion depends to a great extent on the accuracy of matching between these two valves.

For Modulation

Assuming the output to be between 5 and 6 watts under all normal conditions, this will be ample for modulating a 10-watt carrier. This point should be borne in mind for there are still quite a number of low power transmitting stations operating from D.C. and to those, obtaining a satisfactory amplifier has always been a great problem.

Also 6 watts will modulate quite a large transmitting pentode in the suppressor grid, while quality will be above reproach with an amplifier of this kind.

The general lay-out and construction can quite clearly be seen from the illustrations. The chassis can be obtained already drilled from Messrs. Peto Scott, and as the wiring is comparatively simple, no difficulties will be experienced in obtaining satisfactory results. It will be noticed that the electrolytic condensers are of the cardboard carton type held in position by a metal clip. This overcomes the difficulty of drilling large holes in a steel chassis for the cylindrical container type of condenser.

It is rather important to bunch wires together as indicated and to keep these more or less spaced by means of insulating tape. The filament connections must be of stiff wire and not allowed to come into close contact with grid and anode connections.

Hum level is extremely low and will be inaudible on the majority of mains. Rarely is an earth connection required although a difference in hum level can often be detected by reversing the connections to the mains when used on A.C. If the amplifier is earthed on either A.C. or D.C. this connection should be made to a 2-mfd. condenser to one of the fixing-down bolts of the chassis.

Components for A.C./D.C. High fidelity Amplifier

CHASSIS.
1—special to specification finished black (Peto-Scott).

CONDENSERS, FIXED.
5—8-mfd. electrolytic condensers type 500 volt working (Dubilier).
1—200-mfd. electrolytic type 10 volt (Dubilier).
2—25-mfd. electrolytic type 50 volt (Dubilier).
1—1-mfd. type 250 volt working (Dubilier).

CHOKES, LOW-FREQUENCY.
1—Y40M (Bryan Savage)
1—C26/DW (Bryan Savage)
1—Y42/M (Bryan Savage)

HOLDER, FUSE.
1—double fuse (Belling-Lee).

HOLDERS, VALVE.
2—5-pin type chassis (Clix).
3—7-pin type chassis (Clix).
2—4-pin type baseboard type (Peto-Scott).

PICK-UP.
1—Piezo electric (Ediswan).

PLUGS, TERMINALS, ETC.
1—two socket strip marked input (Clix).
1—two socket strip marked output (Clix).
1—plug top anode connector (Bulgin).

RESISTANCES, FIXED.
1—600-ohm type 1 watt (Erie).
2—100,000-ohm type ½ watt (Erie).
2—400-ohm type 3 watt (Erie).
2—100-ohm type 1 watt (Erie).

SUNDRIES.
Quantity 6 B.A. nuts and bolts (Peto-Scott).
Connecting wire and sleeving (Peto-Scott).
6 ins. screened wire (Bulgin).

TRANSFORMER, L.F.
1—special type PP2/M (Bryan Savage).

TRANSFORMER, OUTPUT.
1—special to suit loud-speaker (Bryan Savage).

LOUD-SPEAKER.
1—Triple (Baker-Selhurst).

VALVES.
1—HL/1320 Met. (Mazda).
2—PP/3521 (Mazda).
2—ID/5 (Brimar).
2—type CI barretters (Philips).

DIGESTS AND DATA

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

SPECIALLY COMPILED FOR THIS JOURNAL

New Developments in Television Receivers. Electronics, Vol. 9, No. 2, Page 46.

A TELEVISION receiver is described manufactured by the Lorenz Company of Berlin. A schematic diagram of the receiver is given together with a photograph. In this receiver, regeneration is used for sound reception, the superheterodyne for vision; wavelength of about 6 metres.

The Periodic Emission of Light from a Discharge Tube Excited at High Frequency. By A. R. Fry, Physical Review, Vol. 49, No. 4, Page 305.

Describes investigations which were carried out in order to study the character of light emitted by a discharge tube containing air at low pressure, the tube being driven by a H.F. oscillator. A vacuum photoelectric cell operated with an alternating high-frequency driving potential was the receiver used. The results indicated that the light was fluctuating even when the driving frequency was as high as 10 mc. per second, and it was indicated that the average illumination lagged behind the driving potential, which for the higher frequencies was a considerable fraction of a cycle. This indicated that light emitted from the excited atoms persisted after excitation.

A New Superheterodyne Principle. Wireless Engineer, Vol. 13, No. 150, Page 117.

A superheterodyne receiver is described which involves novel features and which was described recently in a paper read by Mr. E. G. Beard before the Australian Institute of Radio Engineers. In the receiver, part of the received wave is used to produce the heterodyne oscillation which is then mixed with the remainder of the wave in the usual manner.

Fluctuation Noise in Vacuum Tubes which are not Temperature Limited. By F. C. Williams. Journal Inst. Electrical Engineers, Vol. 78, No. 471, Page 326.

Chiefly concerned with the question whether or not a fluctuation voltage component equal to that which would be produced by a metallic conductor of equal resistance and at the temperature of the cathode would be produced by the anode screen in a thermionic valve.

A Low-level Wattmeter. By A. L. Albert and H. P. Beckendorf, Electronics, Vol. 9, No. 3, Page 28.

An electrostatic communication wattmeter is described, suitable for the direct measurement of power at these levels. The wattmeter has been tested and found satisfactory up to 5,000 cycles, but it is stressed that it is suitable for use over a considerably wider range.

Voltage Measurements at Very High Frequencies. By E. C. S. Megaw, Wireless Engineer, Vol. 13, No. 151, Page 201.

Concluding part of the work on measurements of voltage at high frequencies, which was mentioned in the Digests for April. In it is made a comparison of a peak voltmeter and a thermal method of measurement. Also the calibration of other types of valve voltmeters against a peak voltmeter is dealt with.

R. F. Power Measurements. By G. F. Lampkin, Electronics, Vol. 9, No. 2, Page 30.

Describes how transmitter power may be measured within 10 per cent. by measuring peak grid driving voltage with a direct reading rectifier type R.F. voltmeter, or by the use of a rectifier type dummy load.

R. F. Resistance of Copper Wire. Electronics, Vol. 9, No. 2, Page 38.

The chart is given which was prepared in the laboratories of the Weston Electrical Instrument Corporation during an investigation of high-frequency measurements with the thermometer. This chart covers the frequency range from 500 kc. to 100 mc.

A New Tube for Use in Superheterodyne Frequency Conversion Systems. By C. F. Nesslage, E. W. Herold and W. A. Harris. Proc. Inst. Rad. Eng., Vol. 24, No. 2, Page 207.

It is pointed out that the major disadvantage of existing methods of frequency mixing is found in high-frequency operation with comparatively low intermediate frequencies, where serious coupling exists between oscillator and signal circuit in spite of electrostatic screening. A tube is described which is claimed to overcome these difficulties.

Ion Optics of Equal Coaxial Cylinders. By P. Kirkpatrick and J. G. Beckerley.

An empirical expression for the potential distribution along the axis of two equally spaced coaxial conducting cylinders has been found in terms of the radius and separation of the cylinders. The general empirical expression, combined with the theoretical lens equation of Hansen and Webster gives an algebraic formula for lenses of this type, directly relating object and image distance to readily measureable quantities.

An Unconventional Receiver for the Ultra-high Frequencies. Q. S. T. Vol. 20, No. 2. Page 21.

A description of an experimental receiver designed by Mr. F. W. Dunmore, of the National Bureau of Standards. This receiver includes four radio frequency amplifier stages and is designed for operation between 175 and 300 mc.

HOW THE B.B.C. REGARDS TELEVISION

A considerable amount of space is devoted to television in the B.B.C. Annual, which was published recently. Many matters regarding the likely trend of development are discussed and as these appear in the B.B.C. official publication they may be taken to be representative of B.B.C. ideas. These, it will be noted, coincide to a very great extent with information that has already been given in recent issues of this journal.

THE television section of the Annual opens with a brief history of the B.B.C.'s association with television from the days of the commencement of the old thirty-line transmissions. Of these it says:—" Late in 1929 the B.B.C. undertook to radiate a regular but limited service of low-definition television, using a system which had been developed by the Baird Company. These transmissions emanated from the Baird studios. In 1932 a studio was equipped in Broadcasting House from which these transmissions were continued. This must not be confused with high-definition television—the number of lines per picture was only 30 and the number of pictures per second 12½. These transmissions, although regular, were in the nature of an experiment because the possibility of providing attractive programmes was questionable; on a 30-line basis, it was only possible to give a kind of impressionist reproduction with very little detail. At the same time the low number of complete pictures per second caused an unpleasant " flickering " effect.

In the meanwhile research was being carried out by the Baird Television Company, by Electric & Musical Industries, Ltd., and other firms, with the object of perfecting systems removing these serious defects.

The low-definition service was transmitted on an ordinary broadcasting wavelength (261 metres), this being possible only because of the small number of lines per picture and pictures per second. In order to increase the definition sufficiently it became necessary to use several times the number of lines per picture, and to reduce " flicker " the number of pictures per second had to be at least doubled. This necessitated a corresponding wider frequency band for transmission, so that an ordinary broadcast wavelength could no longer be used. However, by this time considerable progress was being made in the technique of transmission by ultra-short wavelengths, that is to say, those between, say, 5 and 10 metres, and on such wavelengths it is possible to transmit the wide band of frequencies necessary for this improved form of television, now usually called —rather vaguely—high-definition television.

Demonstrations were given to the B.B.C. by the two firms mentioned above, and it became obvious in 1933 that considerable progress was being made. It was not, however, clear exactly how a public service of this kind of television could be established, or even whether it was justified, particularly in view of the high cost to the broadcasting authority of producing programmes, and the high cost of receivers to the "viewing" public.

Accordingly the Postmaster-General appointed a committee to examine the whole situation, and to recommend whether or not a service should be established, and if so in what way.

This committee first met in May, 1934, and presented a report in January, 1935, which, very briefly, stated that research had reached such a stage that a regular service of high-definition television could be contemplated, and that there were two systems in this country which had reached a high standard of development, namely, that of the Baird Television Co., Ltd., and the Marconi-E.M.I. Television Co., Ltd., respectively. It recommended that a station should be established in London only to begin with, in order to examine, under service conditions, the relative merits of these two systems, at the same time providing a service for the public in the London region.

Shortly after the report was adopted the Postmaster-General appointed this Advisory Committee.

The committee began its work immediately, one of the first tasks being to choose a site for the London television station. Technically it is necessary for a station using ultra-short waves to be located on high ground, and this, of course, limited the choice of site considerably. Ultimately the Alexandra Palace was chosen.

It ultimately appeared to be desirable to allow each company to adopt for their system different technical data relating to the number of lines per picture and the picture frequency, in order that a true comparison of the merits of the two systems could be made.

Alexandra Palace

As already indicated, each system, besides using its own studio apparatus, will use its own transmitter, and there will be a third transmitter common to both for transmitting the accompanying sound. The wavelengths or frequencies to be used are 41.5 megacycles per second for sound (7.23 metres), and 45 megacycles per second for vision (6.67 metres approx.). The contracts were concluded about the end of August, 1935.

In the meanwhile extensive reconstruction has been carried out at the Alexandra Palace in order to provide the studio accommodation for each system, with the necessary dressing rooms, offices, and so on. At the same time a steel tower is being erected on the top of one of the four brick towers which already exist at each corner of the building. The height of the top of the mast above the ground is approximately 300 feet, and the ground itself is 306 feet above sea-level. Thus the aerial will be raised about 600 feet above sea-level, some 200 feet higher than the cross on St. Paul's Cathedral.

The transmission, while giving the first programme service of high-definition television, will be experimental to the extent of providing very valuable data on which to base future developments.

Programme Question

As to the programme side of the future service, experiments have been going on throughout the " low-definition " period in the intricate and difficult details of programme choice and presentation, details which at one end merge into the purely technical field and at the other in the broad questions of the artistic and social role to be played by television.

In the present and tentative phase it is possible to visualise the main characteristics of the programmes.

B.B.C. IDEAS ON THE FUTURE OF TELEVISION

Individual items will be short, to avoid fatigue and eye-strain, as considerable concentration will be necessary. Television cannot be a background to other occupations. A wide field of entertainment must be covered, but the more intimate cabaret type is more likely to be successful than the broader music hall material. News may at first have to be covered by commercial News Reel and Magazine films and by brief talks capable of illustration by film or other means. Serious musical activities and long and complicated dramatic productions must for some time remain a function of sound broadcasting only. There will be opportunities for topical and semi-topical programmes, and there should always be a demand for informative demonstrations of the latest achievements of industry and technology.

The Future

As to the future, it may be anticipated that as in the case of sound broadcasting, the curiosity value of the successful projection of pictures will soon pass. But it is hardly possible to imagine that television in its full development will not more profoundly affect both communications as such, entertainment, and, what is more important still, education in its wider sense.

Speculation, if it cannot at present harden into positive assertion, can at any rate take shape in questions. How far will *normal* programmes come to consist of both sound and visual elements? Will the listener of the future, for example, watch an orchestra playing throughout an entire concert, or will his listening to their music be merely reinforced by vision from time to time? Will talks be accompanied by continuous or by intermittent pictures, showing the speaker or documentary material illustrating his theme, or a combination of both? What will be the effect on speakers, if they have to consider the appearance which they are presenting to unseen audiences, as well as the effect of their voices upon them? Will listeners find difficulty in reconciling the discrepancy between the sound of a normal voice and the sight of a miniature portrait such as can alone be viewed on the television screens of the present day? In sound broadcasting, experience has disclosed something like optimum lengths for different sorts of programme unit. Will television modify these? Will two tendencies emerge in programme presentation—one in which vision will be regarded as primary, one only relieved by a subordinated theme of sound; the other in which sound continues to predominate, with the occasional reinforcement of vision? It is at least easy to imagine that (to take two extreme examples) the former type would be most suitable for the report of a football match, the latter for a poetry reading. Between these two extremes, however, come all the nuances of variety, drama, light music, etc.

The coming of television already casts before it, in the shape of questions to be studied and answered by experiment, the shadow of a wide range of artistic and personal problems. They have merely to be suggested, by such examples as have been mentioned above, for it to become evident that their solutions, and the interaction of each partial solution with the rest, will for a long while tax the powers, no less than they will engage the interest, of all concerned.

This much, however, may be said at once, as it is of general application. More than ever, the listener who wishes to obtain reasonably full value from his set will be called upon to make and keep appointments with it; in other words to study the published programmes selectively, and to give an undivided attention to those items which he chooses for his entertainment or instruction. The habit of switching-on vaguely on the chance of finding a pleasant musical background to other activities would have to be modified. For topicalities of certain kinds, world events, and so on, film backed by explanatory descriptions will almost certainly be the originating medium for many years. The organisation of a world service of directly televised news is a formidable and, at present, quite impossible prospect, tempting as are the vistas it discloses of wider mutual understanding among the peoples. There will also be the vastly important problem of an Empire Service to consider.

There is nothing static about television; progress will be continuous; fundamental changes in method of operation are always possible. Apart from the necessity constantly to improve the quality of image reproduction, the problem of finance will probably be for long a source of anxiety. The more successful the service, and the more rapid the expansion, the greater will be the programme cost and the more pressing the demand for a continuously wider spread of service area.

It is certain that when the service shall have emerged from its experimental stages, the community as a whole will not take kindly to a system favouring a comparatively small portion of it. Civic pride will also be a factor of some importance. But the high cost of television makes complete Regional programmes as at present understood unlikely for many years, but local activities will eventually come into their own. The trend will probably be towards a main national programme interspersed with items dealing with regional activities, derived from regional sources. As things are at present, the area coverage of television programmes waits upon either a satisfactory solution of difficulties due to the limited range of ultra-short waves, or the installation of a network of special and costly co-axial cable.

Inventions with revolutionary implications have usually necessarily to encounter both inertia and direct opposition. There is widespread apprehension in certain quarters about the effect of television, though there is no reason to suppose that it will adversely affect any enterprise or interest that refuses to be static. Extravagant statements have, however, found their way into print and it will take time before the consequent fears and prejudices can be allayed. Optimistic prophecies of an entirely televisionary world can only add to difficulties already considerable and to general disappointment. Enthusiasm must be tempered by a cool and critical awareness of present limitations, and of the immense labours still required before television is comparable in technique and scope with sound broadcasting.

The Annual, which is profusely illustrated, will be useful to broadcast listeners as a book of reference, as it contains a wealth of information on B.B.C. activities. Its price is 2s. 6d.

THE TELEVISION ENGINEER

THE DESIGN OF HIGH-DEFINITION AMPLIFIERS

By L. E. Q. Walker

The Response of Resistance-capacity Amplifiers to Signals of A Transient Nature

This is the fifth and concluding article on the design of high-definition amplifiers for high-definition television. The preceding articles appeared in the November, September, and August, 1935, issues, and January and March issues of this year.

THE amplifier designed by the Marconi Company, and described in the last article exemplifies some of the points to which attention has to be paid where linear operation over a large band of frequencies is needed. The response of such an amplifier is not, however, sufficient for modern high-definition services where frequencies up to 4 megacycles and over may have to be considered.

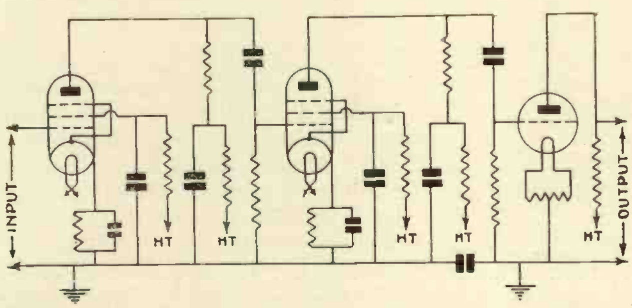


Fig. 35.—A circuit of pentodes in cascade followed by an output valve.

A brief description of a more modern type of amplifier is given below:—

The circuit consists, as shown in Fig. 35, of pentodes in cascade followed by an output power valve. Correction for high-frequency loss was obtained by means of capacity shunted resistances in the cathode circuits and for low-frequency loss by the capacity shunted resistances in the anode circuits.

Frequency characteristics of the amplifier are shown in Fig. 36. In curve (a) the output circuit was disconnected, and curve (b) represents the overall characteristic with output valve connected.

So much for the practical design of television amplifiers. We shall conclude by examining briefly the way in which amplifiers respond to signals of a transient nature.

In the first two articles of this series we have investigated the mathematical nature of signals of a transient nature. In the succeeding parts we have seen in what ways the resistance-capacity amplifier falls short of having a perfect response curve. Certain amplification losses occur both at high and low frequencies, and these losses may be minimised by suitable correction of the amplifier. It has been pointed out that the completely arbitrary nature of television signals prohibits any exact rules being drawn up to provide distortionless amplification. What we can do is to take as criterion the fact that square topped impulses must be amplified with a fixed maximum amount of distortion. The period of such impulses will be, of course, the period of the scan line in the system under consideration. Thus, in the case of a 240 line 25 picture per second system this period will be $\frac{1}{6000}$ sec.

Let us investigate what happens when a square topped impulse of this nature is amplified by means of a single stage of resistance-capacity amplification. The initial shape of the signal is as shown in Fig. 37. We shall first examine the effect of low-frequency cut-off, and then the effect of high-frequency cut-off.

Following, firstly, the procedure adopted by C. W. Oakey in his article "The Distortionless Amplification of Electrical Transients,"* it is shown that when such a signal as indicated in Fig. 35 is applied to a single stage of resistance-capacity amplification the resultant output signal, considering low-frequency attenuation only, is shown in Fig. 38, where

$$A = \frac{(\rho + R)}{C(\rho R + \rho R_g + RR_g)}$$

and T is the period of the pulse.

It appears that when $AT < 0.1$ the distortion is not serious. Putting in representative values of $\rho = 10{,}000\omega$ $R = 20{,}000\omega$, $R_g = 10^6\,\omega$ and $C = 10^{-7}$ Farads, we have $A = 10$ and $AT = .0017$ for $T = .00017$ sec. This value for AT is seen to be well within the permissible limits. This is, of course, due

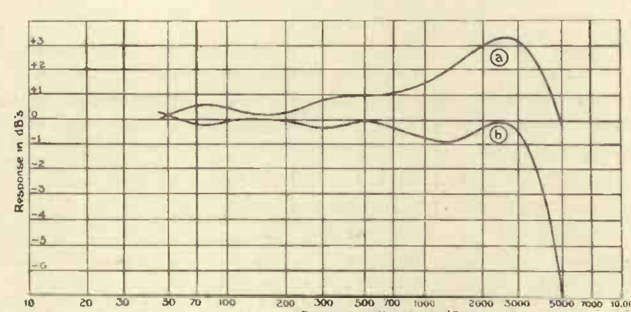


Fig. 36.—Frequency characteristics of the amplifier shown by Fig. 35.

* "Experimental Wireless" and "The Wireless Engineer," May, 1931, p. 245-249 and p. 307-309.

THE TELEVISION ENGINEER

to the fact, implicitly stated in the article referred to above, that it is only when considering long period transients that we need to take into account frequency failure at the lower end of the frequency spectrum.

From the high-frequency point of view matters are entirely different. The form of distortion due to high-frequency cut-off is shown in Fig. 39 where an input signal of the same type as in Fig. 37 is considered.

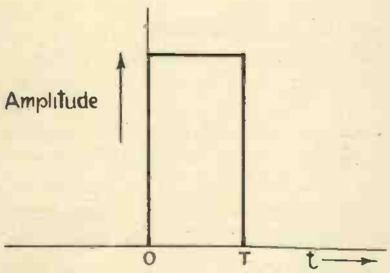
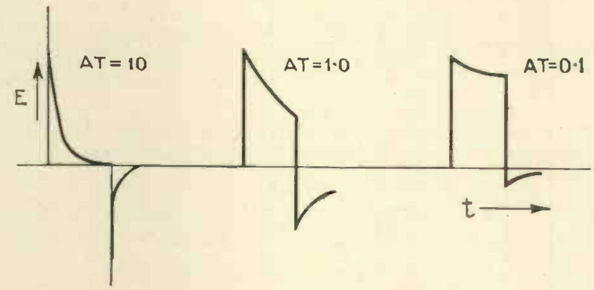


Fig. 37 (left).—Shape of initial signal.
Fig. 38 (right).—The resultant output signal.



In this figure $k = \dfrac{R + \rho}{R \rho C_1}$

where C_1 is the lumped capacity of coupling elements down to earth. It will be observed that now distortion increases as T becomes smaller. That is to say a transient impulse of short duration suffers greater high-frequency distortion than a similar impulse of longer duration. If we take C_1 as being 10^{-10} Farads and T = .00017 sec. we have kT = 250 and no appreciable distortion will result. We can make matters better

(a) by increasing ρ or R
(b) by decreasing C

and if such improvement is necessary which of these is done must depend on general circumstances.

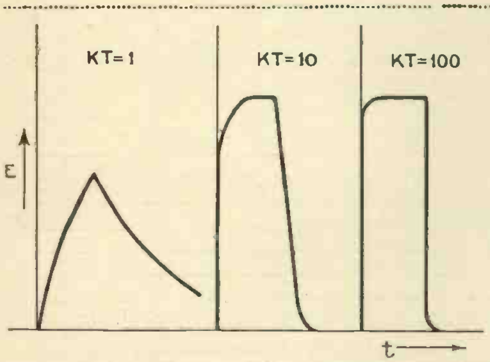
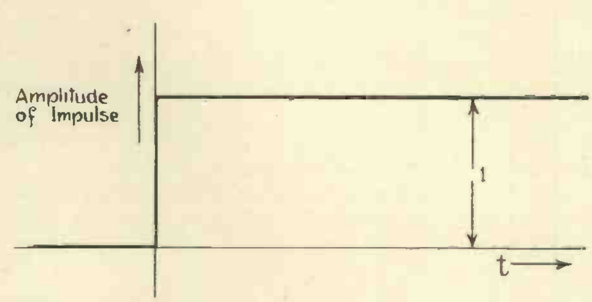


Fig. 39 (left).—The form of distortion due to high-frequency cut-off.
Fig. 40 (right).—Diagram showing the desirability of a long time constant.



A Rule is given in an article by G. D. Robinson* that the variation of the amplitude of the flat-topped alternating current component of the picture signal will not exceed $\dfrac{50}{nCR}$ per cent., where C is the coupling capacity and R is the resistance of the path through which the coupling capacity has to discharge. This rule takes into account, obviously, only low-frequency distortion of the signal and is seen to be compatible with the results given on page 305. A must be kept small, and this is equivalent to $\dfrac{1}{R_g C}$ being small. The article goes on to state that a safe value for the product of CR (and R_g can be written for R, to a sufficiently close approximation) can be obtained by dividing the maximum percentage variation assumed to be permissible by the total number of stages of amplification and using the above formula. It should be noticel, however, that n here is the number of pictures per second and the distortionless reproduction of these long duration pulses is assumed to be the criterion of a suitable television amplifier. In the writer's opinion, however, it is more useful to concentrate on the suitable amplification, not so much of the picture frequency signals, as of the scan line frequency signals. After all, as is pointed out in an article describing the Bell System of Television,* the distortion of the very low frequency terms of the television signal results merely in false values of high lights and diffuse shadows, and hence its presence is not nearly so important as would be the case were the distortion present in the higher frequencies which give finer detail to the picture.

Another most interesting article on the behaviour of amplifiers to television signals is that given in the Proceedings of the Institute of Radio Engineers for April, 1932, Vol. XX, No. 4 entitled "The Resistance-capacity Coupled Amplifier in Television," by H. M. Lane. Operational calculus is employed to determine the complete solution for the performance of a resis-

* Theoretical notes on certain features of television receiving circuits. P.I.R.E. June, 1933, p. 833.

* "The Production & Utilization of Television Signals" F. Gray, J. W. Horton, R. C. Mathes. B.S.T.J. Oct. 1927.

tance-capacity coupled amplifier. The behaviour of such an amplifier under the excitation of typical television signal impulses is investigated. The results obtained are similar to those obtained in the first article discussed in this Section.* The indicial admittance of the amplifier† (or the admittance of the amplifier under the excitation of a fundamental impulse of the type shown in Fig. 40) for various values of n and b where n is the number of stages in the amplifier and

$$b = \frac{R + \rho}{C\,(R\rho + R_g\,\rho + RR_g)}$$

is calculated, and it is shown that the amplifier response under these conditions is of an oscillatory nature. In the words of the author, " the amplifier response will be good provided the duration of the first positive swing of its response to unit impressed voltage (of the type shown in Fig. 40) is long compared with the duration of the actual television signal impulse. In general, the greater the time constant of the amplifier, the better."

Other articles to which we may refer the reader are:

(a) " The Amplification of Transients," G. Builder. *The Wireless Engineer*, May, 1935, p. 246, et seq.

(b) " Amplification of Transients," *The Wireless Engineer* and *Experimental Wireless*, June, 1933, p. 296, et seq.

Many other references will be found in these articles.

It has been thought better, in this section, to give a brief review of the literature dealing with the subject, rather than to attempt the explanation of the phenomena associated with transient amplification from first principles. An adequate understanding of the reaction of electric circuits to transients necessitates, nearly always, recourse to some form or other or operational calculus. This is a method of attack first elaborated by Oliver Heaviside and peculiarly adapted to the treatment of transients. A full, or even a brief, exposition of its principles would, however, be quite out of place here.

Sufficient has been said, however, to enable us to see that any definite prediction as to amplifier behaviour under *arbitrary* television conditions is impossible. We may, on the other hand, predict closely what will happen under certain *specified* conditions. These articles do not, therefore, set out to give definite constructional data for the design of television amplifiers. They will have served a purpose if they have indicated *why* the television signal demands large frequency bands for its electrical reproduction, in what way amplifiers may be made more competent to deal with such signals, and additional avenues along which further work may be undertaken.

* loc. cit p. . . . . .

† See for example V. Bush " Operational Circuit Analysis " p. 41.

Short-wave Reception in the Channel Isles

By Martin G. Bourke, B.R.S. 1784.

ONE hundred and sixty-metre stations are not too well heard in the Channel Islands, so for that reason many G stations consider it good DX to be heard down here. The 1.7 mc. stations have been coming in fairly well during the last few months, but at the moment conditions are beginning to deteriorate owing to very bad QRN, which often reaches a peak strength of R8.

This QRN was prevalent all last summer and the only station to break through it was G6GO, who always comes in remarkably well between R8 and R9. His duplex with PAOFB, who works on 3.5 mc., is very well heard so I make a particular point of listening to these transmissions on Monday, Wednesdays and Fridays at 22.30.

G5JO, in Cambridge, comes in very well at R7 to R9 on the rare occasions that he uses the top band. 5OC is also quite good at R7 but is usually accompanied by night distortion. G5ZJ varies between R7 and R3 and is accompanied by a background from 6GO, who is only 8 kc. away. 5MM, 6KV and 2OV come in reasonably well, but are seldom loud, averaging between R4 and R6. 2KT is also heard between R3 and R4.

During 1935 one of the best stations on the band was G6SR, in Edinburgh, but he has only been heard once this winter, and then only R1 to 2. Amongst other calls heard are FM8D, FA8BG, F8RJ, EI6F and HB9T, but with the exception of the Irish station all were using C.W. The only transatlantic station heard and identified has been VE1EA, although upwards of a dozen W's have been heard but not identified.

On the 3.5 mc. band the best G calls are 6KV, 5VL, 5KG, 5JO, all of whom are between R9 and R7. 6GO is also consistently heard but rarely peaks beyond R7. His phone is usually QRM by the harmonic of a French broadcaster.

The Best Stations

The best stations on this band are the Dutch, who always come in well. Amongst DX stations heard have been W3EFS and W3DQ, who have been heard up to R9 at 23.30.

Listening on 7 mc. is out of the question owing to QRM from French phone stations. My QRA is only 25 miles from the French coast. Of the British stations on 7 mc. 6GO again tops the list, being normally an R9 signal.

On 14 mc. G6UU is generally R9. VK phone is often heard at R8 in the early morning, while VK C.W. is well heard in the evening. The 28 mc. band is conspicuous for good signal strength and low noise level. An interesting point of this band is that W's can often be heard one day and South Americans the next, but never the two together. DX listeners should bear in mind that G2UR is on the lookout for schedules on 5 metres operating from the Channel Islands.

Croydon Radio Society

Mr. R. P. Jonas demonstrated his new receiver to the Croydon Radio Society at the last meeting held in St. Peter's Hall, South Croydon. It included variable selectivity in the intermediate frequency stages, diode detection, paraphase low-frequency amplification coupled to a Hartley-Turner speaker.

This Society is very active and those who can possibly attend the meetings should get in contact with the Hon. Secretary, E. L. Cumbers, Maycourt, Campden Court, Campden Road, South Croydon.

Modulation Measurement with the Cathode-ray Tube

By G. Parr

At the Surrey Radio Contact Club's Annual Dinner Mr. Parr gave a lecture on the use of the cathode-ray tube for modulation measurement. In view of the interest caused we are publishing the full details on the system.

ONE of the advantages of the cathode-ray tube as an indicating instrument is that the trace on the screen responds instantaneously to variations in circuit conditions and presents a continuous picture of what is happening in the apparatus under test. There are many other ways of measuring output voltages, for example, but none give such a clear picture of the effect of slight changes in operating conditions while the circuit is on.

In no case is this property of the tube more to advantage than in the observation of transmitter performance. If the tube is mounted in a convenient position under the experimenter's eye, adjustments can be made continually with the certainty that the optimum conditions will be immediately shown.

There are three principal ways of showing modulation by the cathode-ray tube, each method having its advantages. If we have a tube and linear time-base available, the modulated carrier may be applied directly to the vertical deflector plates and the complete envelope will appear on the screen as shown in the left-hand drawing of Fig. 1. To make this pattern remain stationary on the screen the time-base must be adjusted so that the traverse of the beam is a simple multiple of the modulating frequency. When observations are being made the transmitter is modulated from a simple audio-frequency note or audio-frequency oscillator and a small fraction of the oscillator output is fed to the valve of the time-base to "lock" it in synchronism. These practical points can be discussed more fully later. When the picture is stationary on the screen the depth of modulation can be measured by scaling off the maximum and minimum heights of the wave envelope. The percentage modulation is then :

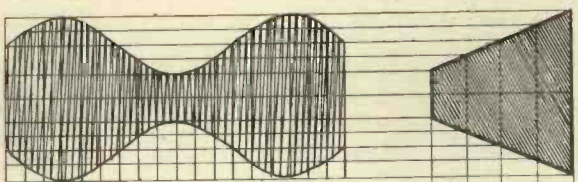


Fig. 1.—The appearance of the modulated carrier on the screen. (Left), and the formation of a trapezium.

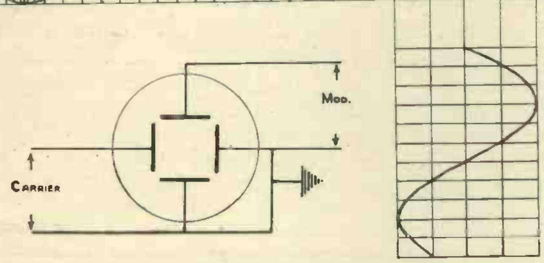


Fig. 2.—Connection to the deflector plates to produce the trapezium.

$$\frac{E_{max.} - E_{min.}}{E_{max.} + E_{min.}} \times 100$$

It is not necessary to measure actual voltages or to calibrate the tube. A piece of transparent graph paper can be stuck on the surface of the screen and the pattern moved to coincide with one of the horizontal lines on the paper. At the same time the symmetry of the modulation can be accurately gauged.

While this modulation pattern gives the conditions of the circuit at a glance, there are cases where it is not sufficiently definite to show whether there is anything wrong, particularly if the applied audio signal is not a pure sine wave. Suppose the modulated envelope showed a flat topped wave. This might be due to the audio oscillator, but, on the other hand, might equally well be due to insufficient carrier amplitude. To distinguish such cases the second method of showing modulation is better, usually known as the modulation trapezium.

The method of obtaining the trapezium is shown in Fig. 2. The modulated carrier is connected to one pair of plates and the modulation frequency itself to the other pair. In Fig. 2 the carrier is shown connected to the horizontal plates and the audio frequency to the vertical, although the connections are immaterial, as the tube can always be turned through 90° if the pattern does not come out right!

Going back to Fig. 1, the formation of the trapezium is seen from the construction lines.* At any instant the movement of the beam is proportional to the two deflecting forces applied to the plates, and if any point on the modulation envelope is taken the position of the beam is given by the instantaneous value of potential of the carrier at this point. The modulating wave form will have the same value of potential in the other plane, and their combined effect will be to move the beam to and fro in a straight line at an angle determined by the depth of modulation. The beam will be swinging up and down due to the carrier voltage, and hence the figure on the screen will appear as the shaded trapezium shown. A very important point to note is that, provided the modulation is symmetrical and not displaced in phase, any wave shape will produce a regular trapezium.

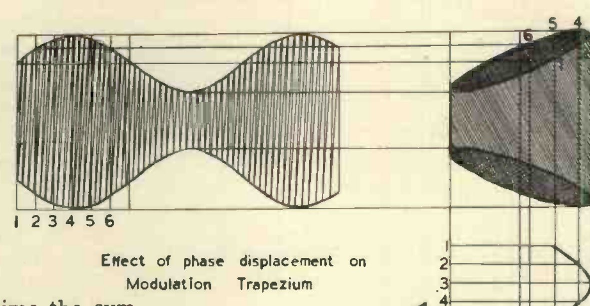


Fig. 3—The modulation wave has been displaced by 30°, producing the effect shown.

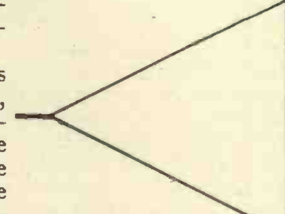


Fig. 4.—Shape of trapezium produced by over-modulation

The depth of modulation can be deduced from the two vertical lines bounding the pattern, and can be calculated from the same formula as before. From this it follows that 100 per cent. modulation will give an $E_{min.}$

*Note the optical illusion which causes the construction lines across the trapezium to appear bent!

Methods of Operation

of O and the figure will come down to a point at the small end, i.e., will be a triangle.

Reverting to the case of a flat-topped wave, if the shape is inherent in the modulating frequency no effect will be noticed in the trapezium, since it is reproduced both in the envelope and in the A.F., but if the defect is present in the carrier circuit the trapezium will be distorted, due to the difference between the envelope and the modulating frequency, and the result will be a bullet-shaped outline having curved sides.

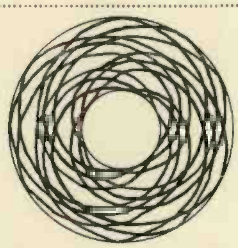


Fig. 5.—Connections for producing a circular trace.

This is an example of the advantage of the trapezium method over the envelope method.

To obtain successful trapeziums (or should it be trapezia?) there must be no phase distortion between the A.F. and the carrier output. The effect of phase shift in the A.F. is shown in Fig. 3, which is drawn on the same lines as Fig. 1 but with a phase difference of 30° between the modulating wave and the envelope. This has the curious effect of making the beam describe two ellipses on the sloping sides of the trapezium, and gives it the appearance of a truncated cylinder. If the phase difference is continually changing, the ellipses will, of course, vary in size and shape and the result will be a complete blur. Patterns of this type are usually secured when the audio-frequency voltage is taken from some part in the modulator chain other than the output terminals.

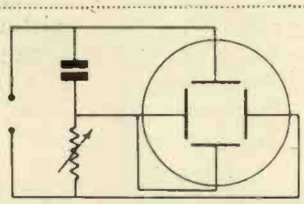


Fig. 6.—A circular trace modulated.

Before considering a third method of showing modulation, it is interesting to note the case of over-modulation with a trapezium. Over-modulation results in complete cessation of the carrier for a short period, and the curves of Fig. 1 will come down to the zero line. The trapezium will follow, becoming a triangle with an elongated stem projecting from the apex (Fig. 4). Other types of trapezium will be illustrated in the next article with reference to particular faults.

For the third method of showing modulation depth the phase-splitting current of Fig. 5 is required. The carrier output is applied to the resistance and condenser in series, their values being chosen so that $1/C\omega = R$ for the particular frequency of the carrier. Then the potentials across each are equal and differing in phase by 90°. If the deflector plates are connected as shown in the diagram the beam will spin round in a circle whose diameter is proportional to the maximum carrier voltage. If the resistance and condenser are not accurately adjusted the circle will be more or less elliptical, which will spoil the accuracy of the method. Now, on applying the modulation the carrier will increase and decrease in amplitude as it deflects the beam, and the trace on the screen will be a series of spirals increasing and decreasing with the frequency of modulation. To make this action clear Fig. 6 has been drawn with the frequency of the modulation exaggerated so that the carrier moves the beam in and out several times during its passage round the circle. The effect of such a movement in practice is to produce an annular solid ring, the difference between the inside and outside diameters being proportional to the depth of modulation. With 100 per cent. modulation the ring becomes a solid disc, and over-modulation produces a bright spot at the centre where the carrier pauses at its zero value.

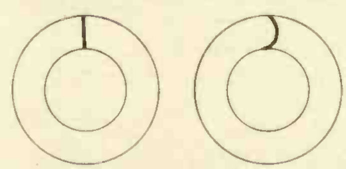


Fig. 7 (a) and (b).—How phase distortion in the carrier can be shown.

This figure can be used in a very striking way to show frequency distortion in the carrier. If for some reason the frequency fluctuates the speed of rotation of the beam will alter, and with the addition of a timing reference mark on the trace this can be checked. To do this, a kick from a separate oscillator is injected into one of the deflector plate leads, the frequency of the kick being adjusted to deflect the beam outwards once per revolution. Where the beam moves out the circle will be interrupted by a dark line owing to the rapid jerk given to the beam (Fig. 7a). If now the frequency of the carrier is fluctuating these dark spots will not occur at the same point on each travel, and the line instead of appearing straight across the disc is curved as in Fig. 7b.

In the next article typical patterns will be given, with the method of obtaining them.

The Artificial Aerial Licence

MANY amateurs are deterred from taking any active interest in short-wave transmission owing to the difficulty in obtaining the necessary Post Office licence. It is not realised just how fortunate English amateurs are in having the Post Office allocate these licences. This is the only country in the world where an intermediate type of licence can be obtained.

Before any transmitting station can be put on the air a full licence must be obtained which entails the passing of a morse test at either the local or main Post Office. To many this is a big stumbling-block.

However, it is not very well known that an A.A., that is an artificial aerial licence, can be obtained without having to go to the formality of passing a morse test. This immediately removes the biggest problem. Any genuine experimenter can obtain a licence of this type on payment of 10s.

The advantage of the A.A. licence is this. A transmitter can be completely built, tested, and to obtain the effect of an elevated aerial a dummy aerial consisting of inductance capacity and resistance is connected to the P.A. stage. In this way experiments can be made with the speech amplifier or modulator while all types of transmitting circuits can be hooked up at will.

In this way there is no need to wait until the morse code has been fully mastered. While the transmitter is being built morse can be learnt at the same time, so that at the end of six months or so the full licence can be applied for, the transmitter being ready to put on the air.

A call sign is allotted just as for a full transmitting licence but this consists of a number and three letters whereas a full licence consists of a letter, a number, and then two more letters-

The application form for the A.A. licence is obtainable from the Office of the Engineer-in-Chief, Radio Section, General Post Office, Armour House, Aldersgate Street, London, E.C.2.

It must be remembered that before any transmitting apparatus can be even constructed, let alone be put on the air, this licence must be obtained. B.R.S. and other short-wave listeners will be well advised to set about obtaining one of these licences, for it is the first step to owning a full transmitting permit.

THE SCOPHONY LIGHT CONTROL (Contd. from page 264)

$$T = \frac{1.3 \times 10^4 u^2}{\gamma_2} = 1.3 \times 10^4 \lambda^2$$

where u = sound velocity in the liquid, and

λ = wavelength of supersonic waves

This is for a refractive index of about 1.4, as before.

Substituting this value of T in the voltage expression previously found we get

$$\text{Volts R.M.S.} = \frac{sv}{2.6 \times 10^5}$$

for full black. (s = specific gravity of liquid).

This is the minimum value: it is well to use smaller values of T than that above specified, for reasons described below, and put up with higher voltages. It is interesting, however, to calculate an example from this formula. For paraffin oil, working at 10 mc., the minimum operating voltage is about 34 volts R.M.S., and the liquid thickness about 2.2. centimetres.

Colour Corrections

We must now take into account the unequal diffractive effect of supersonic waves on different colours. Each colour in the central beam is extinguished at an optical retardation of ± 0.38 of its appropriate wavelength; that is to say, the blue end of the spectrum is more affected than the red, by a given supersonic amplitude. The result (using the central beam) is that the light changes from white through yellowish to sepia and eventually to bluish, instead of reaching black, with increasing amplitude. This is corrected by passing the blue rays through the liquid at an angle to the supersonic wavefront (or at a greater angle than the red rays) so that the effect on the blue is lessened. Since corrections of this type are needed it is well not to let the spread of the central beam approach the value assumed in the preceding partgraphs and shown in Fig. 3. In practice a thickness of liquid of about half that thus derived is satisfactory, allowing the colour correction to be made without being spoilt through the too great effects of spread of the central beam as a whole.

The correction is attained by using a prism to disperse the light entering the liquid cell, so that the various colours can proceed in their appropriate directions. A second prism cancels the dispersion again in the emerging beam.

In a similar way the defect caused by attenuation of the waves in passing along the cell, is corrected by passing the light as a whole through the liquid at a greater angle to the supersonic wave fronts, near the crystal, than at the far end from it. This means giving the beam as a whole a divergence or convergence through the cell. Fig. 4 illustrates the combined arrangement of these corrections, in an exaggerated manner. The two corrections affect each other, and must be considered together. Only a compromise can be made (as in most optical corrections) but it can be a pretty good one.

If light passes through the liquid at an angle Ø to the supersonic wave front, which has a thickness T and is formed of waves of wavelength λ, then the light in its passage traverses a range

$$T\text{Ø}/\lambda$$

of supersonic wavelengths. The effect on it is then

$$2\lambda \left(\sin \frac{T\text{Ø}}{2\lambda}\right) / T\text{Ø}$$

of what it would be when Ø = O.

The curve of Fig. 5 illustrates this.

In a practical case, one might have an attenuation of the waves to about 0.45 of their original value in a length of 5 cm. (petrol, 10 mc.) and a T of 1.0 cm. The λ will be approximately 0.11 millimetre. We then introduce a chromatic divergence between C and F spectral lines (red and blue), in the petrol, of 0.0021 radians, and a divergence between rays of the same colour at the two ends of the cell of 0.0034 radians, so arranging these that at the crystal end the C rays are inclined 0.0024 to the wavefront and the F rays 0.0045, while at the far end the inclinations are − 0.0010 and + 0.0011 respectively.

The net result is, that the effect on C varies from 1.2 to 0.7 along the cell, averaging 1.0, while that on F varies from 0.75 through 1.0 to 0.9, averaging 0.9. Mean yellow green light ranges from 0.95 through 1.0 to 0.85, averaging 0.95. These are in terms of equivalent supersonic amplitude.

The optical intensities at mean black vary much less, owing to the curved foot of the response curve, being, for C, F and mean yellow-green, 0.03, 0.02 and 0.01 respectively. (These figures are obtained graphically). The effective visual intensity at "black" should therefore be under 2 per cent. of that at full white. Actually slight scattering is unavoidable at the lens surfaces, which spoils it a little, but a cell of this type gave 2½ per cent. on measurement. The corrections are not critical in amount, being compromises: the picture can be made dark brown, almost pure black or deep purple in tone, at will, by varying them.

Actual Voltages

The above corrections work by reducing the effects of the supersonic waves. The mean effect throughout the cell is about 0.47 times the incorrected effect on yellow green light at the crystal end, in the case just given. The operating voltage derived from earlier considerations is therefore, practically, multiplied by two. Moreover, one uses only about half the limiting thickness of active liquid, as stated, in order to get well defined corrections. This again, roughly doubles the voltage.

Further, it has been stated that it is doubled by the means used to extend the frequency response to the neighbourhood of 2 megacycles. The total increase is therefore about eightfold, on the minimum possible voltage, giving an actual voltage of about 250 volts R.M.S. for full black. This is not difficult to obtain, and is not unreasonable when it is remembered that the relay so constructed is adequate in all respects for high definition television.

The photograph, Fig. 6, shows one of the experimental original cells, used early in 1934 for 30-line and 120-line work. It has a 40-metre crystal, coated with aluminium foil and stuck on the end of a glass con-

(Continued on page 312.)

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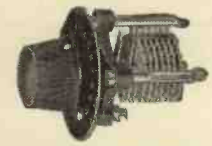

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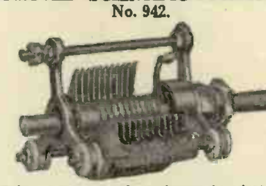

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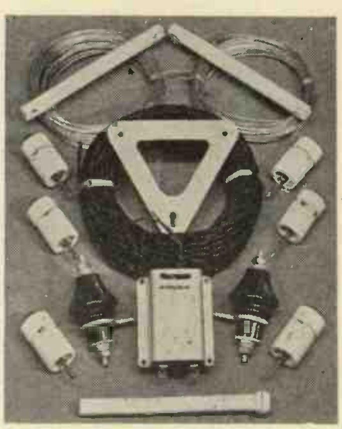

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THE SCOPHONY LIGHT CONTROL (Contd. from page 310)

tainer with Fortafix. The container was filled with kerosene. Connection was made to the foil coatings via the wires on each side. A 30-line picture several feet high was shown with this cell and an exciter lamp.

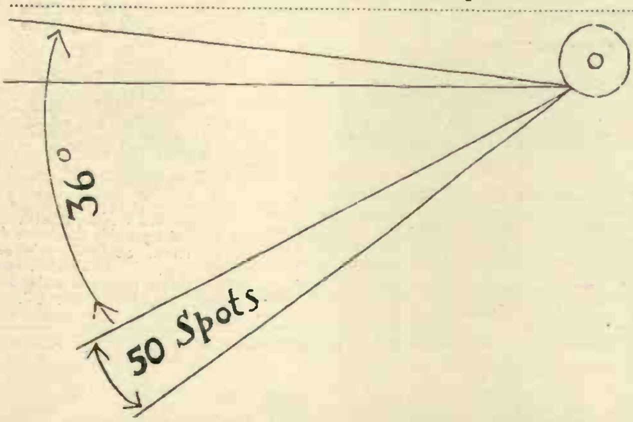

Fig. 9.—Explanatory diagram in plane of high speed scanning motion.

Fig. 7 shows a fully corrected light relay of the type described above, for 240-line and 405-line pictures, on a fairly large screen. The lenses and correcting prisms are built in: the band-pass crystal arrangements are not visible in the rectangular hole at the end.

Fig. 8 shows a cell with frequency correction but arranged for use with separated lenses and prisms to handle a wide cone of light in a big receiver. The effective aperture is 6.3 × 5 cm., working at aperture ratios of F/1.5 and F/240 respectively. Those interested may work out how much light, from a powerful arc, is controlled by this cell; it is used in a receiver which actually uses the light flux indicated by the above figures.

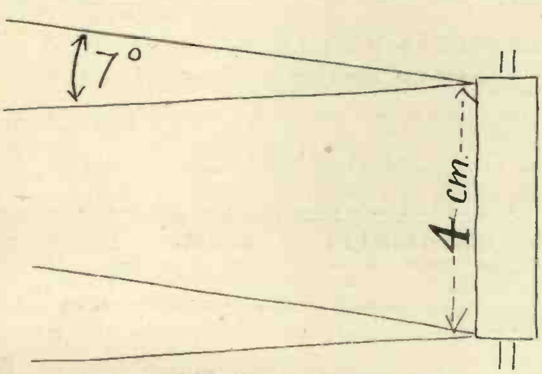

Fig. 10.—Explanatory diagram in plane perpendicular to high speed scanning motion.

This raises another question; even though one has a cell capable of controlling so large an amount of light, what scanning system can be expected to handle it? Although the full description of such a system must be delayed till later, its principle of operation may be explained here, since it bears on the usefulness of the light relay. While most known mechanical scanning arrangements gain a new lease of life when used with it, its full possibilities are only brought to realisation by the advanced Scophony scanning methods outlined below.

Scanning System

It will have been realised from the description that the effectiveness of the light relay arises largely from its time delay action, enabling the scanner to follow up fifty or a hundred spots at a time and present them as stationary on the screen. Its light grasp in a single spot is in fact somewhat small, such that a small scanner can handle it. The same small scanner, of course, suffices whether we use fifty or a hundred spots.

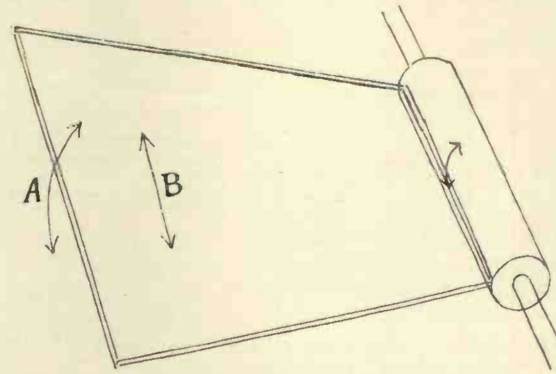

Fig. 11.—Flat sheet of light produced by high speed scanner.

Suppose we concentrate for a moment solely on the scanning motion along the lines, and forget that there are also limits to light grasp in the direction across them. Let us use a speeded-up polygon mirror as a scanner in this former direction, having 20 mirror faces and a diameter of only 1 cm. This will easily handle the full light passing through the light relay slit. Its speed of rotation for a 240-line picture will be 18,000 r.p.m., but for so small a scanner this is not excessive.

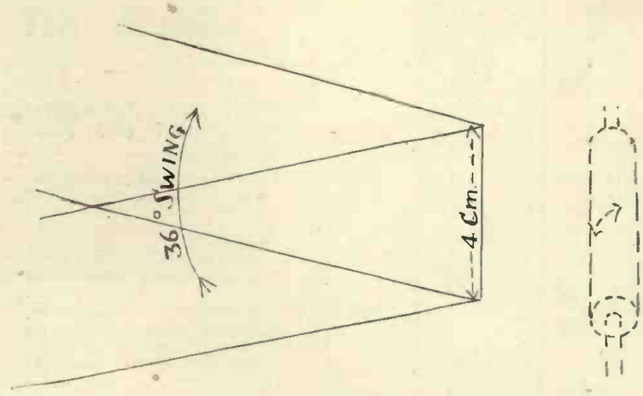

Fig. 12.—Flat sheet of light with high speed scanning motion translated into its own plane.

Now let us make the width of the light control 2 centimetres or so (in the direction at right angles to the wave motion) and concentrate a fairly big cone of light into it: say at an aperture ratio of F/4. Using cylindrical lens systems—the "split focus" which is a

(Continued on page 314.)

Book Review

Radio Receiving and Television Tubes— This new book, published by McGraw-Hill Book Co., is written by James A. Moyer and John F. Wostrel. It is very comprehensive and deals completely with every phase of valve design and operation, including cathode-ray tubes in all their applications. Chapters include valve construction, fundamental principles of design, valve testing, valves used as detectors, rectifiers, amplifiers and oscillators. Also a complete survey of television tubes and the industrial application of cathode-ray tubes.

Altogether there are 635 pages, and over a thousand line drawings and illustrations. Although this book deals principally with American type valves the fundamental data given is of considerable interest to English readers. This applies particularly to the cathode-ray tube section, where all of the data given concerns current British practice.

This book is the best we have so far seen in connection with the highly technical side of the receiving valve. The authors must have been very far-seeing when developing this book for amongst the chapters is one devoted entirely to the acorn type of midget valve. This chapter includes technical and practical instruction, typical characteristics and testing systems, in addition to several suitable oscillator circuits and circuit constants.

The chapter entitled Industrial Application of Vacuum Tubes deals with ingenious circuits of all kinds. Headings include, Smoke Measurements, Water Level Indicators, Automatic Egg-handling Machine, Ltd.

This book can be obtained from the McGraw-Hill Publishing Co., Aldwych House, W.C.2, at the price of 24s.

Bennett Television.

The Bennett Television Co., of Redhill, Surrey, have now prepared an interesting booklet gving full details of their television, short-wave and ultra-short-wave activities. We strongly recommend our readers to obtain a copy of this booklet and to study the new short-wave components which have been designed for amateur use. Bennett short-wave converters have proved very successful during the last few months, and their latest model, which is suitable for use with almost any type of receiver, will bring in world-wide programmes under normal conditions.

THE SCOPHONY LIGHT CONTROL (Cont. from p. 312)

basic feature of Scophony optical systems, we can do what we like in this direction without affecting what is happening in the direction of wave motion and high speed scanning. (This holds so long as we can avoid serious lens aberrations, but the example given is quite safe in this respect.) Let us therefore make the scanner 4 cm. long, and concentrate the light on it in the axial direction in a cone of aperture ratio F/8. We have then in the direction of scanning (Fig. 9) a scanner 1 cm. diameter scanning 50 elements or so of picture detail along the lines, and in the perpendicular direction (Fig. 10) a uni-dimensional amount of light far too great to focus into one line on any reasonable screen.

Dealing with one picture element only (Fig. 11) we have as it were a flat sheet of light, swinging with rapid motion in a direction A perpendicular to its surface. It is too wide, in the direction B, in its own plane, to handle usefully: here it spreads out from any point of the 4 cm. long scanner at an angle of F/8 or about 7°.

Suppose now we have an optical device which can change the motion perpendicular to the sheet into a motion across it, in its own plane (Fig. 12) and the 7° divergence in its own plane into one perpendicular to it (Fig. 13). *Now* we have a magnificent high speed scanning effect: a beam 4 cm. wide swinging over an

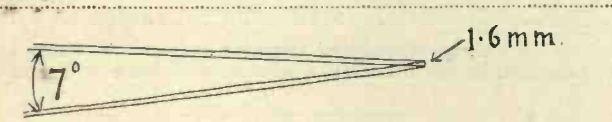

Fig. 13.—Light beam after optical transformation in plane of slow speed scanning motion.

arc of 36° six thousand times a second. To get the same effect directly the 20-sided polygon running at 18,000 r.p.m. would need to be 25 cm. in diameter instead of 1 cm. Moreover this beam represents only one picture element, but the remainder of the fifty elements are similarly treated. To equal the effect with only one element, therefore, the scanner would have to be fifty times 25 cm. in diameter, or 12½ metres! It would still have to run, however, at 18,000 r.p.m.

That refers to the motion along the lines: how about that across them? The result is excellent; we have a slit of light of the order of 1.6 mm. wide (the width of one mirror surface of the 1 cm. diameter polygon) from which light emerges at an angular aperture of F/8 or 7°. That represents a convenient amount of light to handle with a slowly rotating mirror drum of 20 mirrors or so (and, of course, suitable lenses or mirrors) which can focus it into one line of the 240-line picture and cause it to move down the screen 25 times a second.

These suppositions are accomplished fact, and the supposed optical devices for transforming the character of the scanning beam are simple and optically efficient. Moreover the example given is a modest one: one can easily use scanners more than 4 cm. long even at 18,000 r.p.m., and quartz crystals longer than 2 cm. A detailed description, however, of the apparatus, does not belong to this article, but it may be stated that the full light grasp of the cell in Fig. 8 is used in practice at 240 lines, by this method of scanning. Naturally a home-receiver does not need so much light as

Fig. 15.—Supersonic waves seen against bright background.

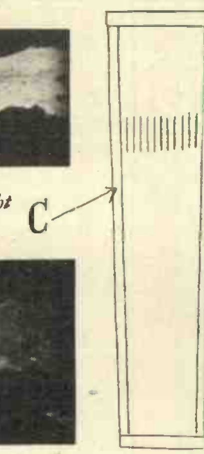

Fig. 14.(right)—Wedge-shaped cell containing water for rendering supersonic waves visible.

Fig. 16.(above).—Supersonic waves seen when undiffracted beam is stopped out.

this: this receiver is for large-scale demonstration.

Only the straightforward application of the light relay has been described in the above article. It has certain other possibilities, some of which are described in the patent specification. These can be left to a later article, but one item drawn from them may be of interest. (*Continued on page* 316.)

RADIO RECEIVING AND TELEVISION TUBES

Including Applications for Distant Control of Industrial Processes and Precision Measurements

By JAMES A. MOYER

Director of University Extension, Massachusetts Department of Education, Member of the Federal Commission on Radio Education; Member of American Institute of Electrical Engineers; Fellow of the American Association for the Advancement of Science; Fellow of the Royal Society of Arts, etc., etc.

and JOHN F. WOSTREL

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When the previous edition was published, the radio receiving tubes then in practical use had only two, three, or four elements. With the development and introduction into practical designing of tubes with five, six or more elements, combining in one tube the functions that were formerly performed by two or more tubes there were, of course, made available to the designer opportunities for obtaining results in radio reception that previously were economically impossible.

The introduction of all-metal tubes, by which the glass bulb of radio receiving tubes is replaced by a much smaller thin metal cylinder has made it possible for engineers to make their new designs more compact and safer in transportation than before.

In this revision the previous edition has been entirely re-written and re-set; information that is no longer of general usefulness to designers has been omitted, and emphasis has been given to the strictly modern types of tubes and their applications not only in radio receiving and television equipment, but also in other practical uses.

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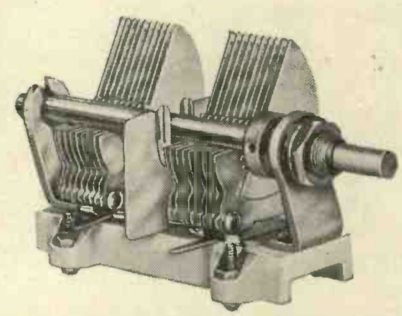

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"The Scophony Light Control"

(*Continued from page* 314).

If a wedge-shaped cell (Fig. 14) be constructed, so that waves generated by the crystal plate C are reflected to and fro across the wedge, resonance regions are formed in which are produced stationary waves. Light focused on a screen after passage through such a cell shows diffraction effects due to these parts of the cell. Replacing the screen by the eye or a camera one can actually see or photograph the stationary waves in the liquid. Fig. 15 is such a photograph.

The frequency is about 8 megacycles, the liquid water; there are about 12 waves, of wavelength 0.18 mm., in the wedge width of just over 2 millimetres, but owing to the appearance of two antinodes of vibration per wavelength, about 24 half-waves actually appear.

By stopping out the undiffracted beam with a wire, one produces a black background upon which the regions of resonance appear brightly illuminated. This is shown in Fig. 16. As the frequency of the waves is slightly altered the bright region moves up or down the wedge, to be followed at a definite interval by a second. It is a form of spectrograph for "short-wave" frequencies, and a convenient way of making supersonic waves actually visible. Its practical application must be left for description at some later date.

Television Lectures

A SHORT course of lecture-demonstrations on television will be given by Mr. Barton-Chapple, B.Sc. (Hons., Lond.) A.C.G.I., D.I.C., A.M.I.E.E., etc., at the Norwood Technical Institute, Knight's Hill, West Norwood, S.E.27, every Thursday evening, at 8 p.m., commencing April 8, 1936.

The fee for the course is 5s., which will include: Methods of scanning, photo-electric cells, practical examples of television transmitters, the use of ultra-short waves, and commercial aspects of television.

This course of lectures given by one closely in touch with all the latest developments will be of the greatest interest to all experimenters. Also those who wish to gain advanced knowledge of television receivers will find much of interest. Forms of application can be obtained from the principal at the above address or fees can be paid on admission.

Also four special television lectures are to be given at the Bebe Polytechnic, 309 Regent Street, W., on May 18, May 25, June 8 and June 15, 1936. The lecturer is H. J. Barton-Chapple, Wh.Sch., B.Sc. (Hons. Lond.), A.C.G.I., Hon. M.I.W.T., and will cover all aspects of modern television.

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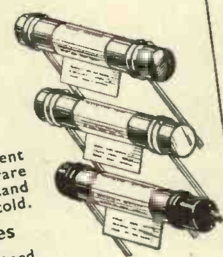

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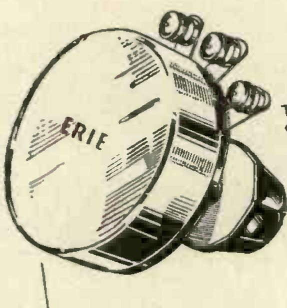

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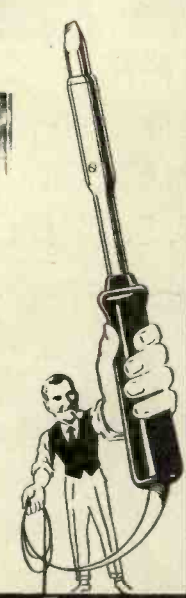

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Top Band Frequency Register

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

Frequency.	
1726	G6GO
1730	6OK
1732	5ZJ
1738	6ST
1740	5HO
1740	6WQ
1742	5WL
1748	5KV
1750	2WK
1752	2KL
1753	6KV
1754	6ZR
1754	6GO
1755	6PY
1756	2AO
1757	6YU
1759.5	5JW
1759.5	2KT
1760	5AR
1760	5BM
1762	2UJ

Frequency	
1762.5	2ZN
1764	5NW
1765	5ZQ
1766	6OO
1766	2WO
1766	5JO
1767.8	6LF
1768	6PL
1769	5GC
1769.5	5FI
1770	5PR
1773.1	5BC
1774	6SO
1774.5	6NU
1776.4	5YW
1775	5KT
1775	6ZQ
1776.4	5YW
1777	2JG
1778	6SY
1780	6BO

Frequency.	
1780	SZR
1780	5RI
1780	5BK
1780	6BO
1780	6HD
1781.5	5VS
1782	5RT
1784	5IJ
1785	6QI
1785.5	5ZT
1785.5	6IF
1786	5NP
1787.5	2XP
1788.5	2GG
1790	5MP

Frequency.	
1790	5UM
1790	2SN
1791	5AK
1792.6	2QM
1794	5JU
1795	2UY
1800	6TL
1801	5ZJ
1802.5	5LL
1802.5	2IZ
1806	5MM
1808	5CH
1810	6BQ
1810	2LD
1810	5PP
1815	2DQ

BINDING CASES AND INDEXES FOR 1935.

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

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

Frequency.	
1815	5OP
1818.5	2OG
1824.5	2WG
1824.5	6UJ
1830	5KG
1830	6WQ
1830	6QB
1836.5	6RQ
1840	2JU
1844	6VD
1849	5CJ
1850	2CD
1850	5OC
1850	2HF
1850	2SR
1850	6UD
1850	6VD
1852	2KV
1857	6TQ
1860	5IV
1857	2CF
1860	6QM
1861	2KL
1862	6WY
1869	2PS
1869	5PB
1870	2PL
1870	2LC
1870	5RI
1870.5	2WT
1874.5	2XP
1875	6WF

Frequency.	
1881	6FV
1884	5KJ
1888	2XC
1890	2MI
1893	5RD
1899	5XF
1900	2PK
1910	2NO
1910.5	2GG
1913 5	2UJ
1916	5VT
1916.5	2GZ
1920	6LZ
1921.7	2OV
1925	6CT
1925	6UU
1930	5OD
1936.6	5IL
1940	6PA
1950	6KD
1950	5GL
1950	5SZ
1954	2GG
1960	5UK
1961	5OQ
1961	2UJ
1965.5	5LL
1970	6UT
1975	6OM
1980	6KV
1988	5WW
1990	6AU

Our Readers' Views

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

"Hush-Hush"

SIR,

It seems strange that the transmitting side of television is being discussed almost every day in almost all the technical journals dealing with such matters, and the general public or rather "the man-in-the-street" is being blamed for their "evidently lamentable" ignorance concerning television.

A little thought would perhaps tell those "know-alls" that the constant hush-hush and secrecy regarding any receivers for the television public is making the poor "man-in-the-street" think that there ain't such a thing as television.

Secondly, there is complaint regarding the series "Recent Ultra-short Wave Developments" (February and March issues). With due apologies to Mr. Microwave, I venture to state that this habit of trying to produce these mechanical analogies for explaining physical phenomena does very little for the student except being spectacularly obstructive to the freedom of mind he must possess to be able to argue his newly acquired knowledge into his intelligence. The analogies given here are very instructive and straightforward, but what do they signify?

Those concerned intimately with the investigation of the positive-grid or B-K type of oscillation or the magnetron (split-anode) oscillators are themselves at sea with the different possibilities for the mode of these oscillations, and what is done here is to push down the throat of the readers the already fixed notion of Mr. Microwave.

Considering the beginners it is perhaps a worse crime to gulp these biased opinions of one while they probably could otherwise with an open mind be instrumental in producing the correct explanation of these phenomena.

We should do well to remember that trying to explain by mechanical pictures the different electrical phenomena, reducing the laws of physics to the fundamental principles of dynamics is rather a fruitless task. Of course, if there is only one solution of the problem then it cannot be bought too dearly, but the case is rather different here.

It is only because one appreciates the standard of your journal and its importance in one's work that I send this note. I hope Mr. Microwave will see my point and if you can publish this note I shall be interested to read the opinion of the other readers of your paper.

P.K.C. (London, N.5).

"Lack of Control"

SIR,

My attention has been drawn to your reference to my remarks at the recent meeting of the Radio Industry Luncheon Club. The quotation from my speech is quite correct and my remarks are, I feel, quite justified.

If I may encroach upon your space, I would like to explain what was behind my remarks.

Firstly, it is generally recognised in the industry that the initial burst of publicity given to television on the

(Continued on next page)

appearance of the Television Report, had a definitely undesirable effect for some time on trade in ordinary radio equipment.

The trouble, as we all now realise was not that information should have been withheld from the public, but that the information given to the public should have been strictly correct. The radio industry had everything to gain and nothing to lose from the public's knowing the exact position on television development.

Unfortunately, however, the appearance of this Report did not appear to be anticipated by the industry and where the Press might have been warned of the injurious effects of loose statements on the future of television, they were actually left to place their own rather imaginative interpretation on the report, with the result referred to above. Even since then, certain responsible newspapers have printed entirely misleading stories in connection with television, but have always gone to considerable trouble to rectify the matter when their inaccuracies have been drawn to their attention.

This definitely proves the point that I was making at the time, that someone within an industry should be responsible for giving the Press correct facts relating to that industry and for anticipating any misconstructions which the Press may place upon events or reports around which they write.

G. J. FRESHWATER (London, W.1).

"Building a Cathode-Ray Exciter Unit"

(*Continued from page* 299).

to include a switch in the negative lead of the H.T. if the tube heater winding is used in order to allow the heater of the cathode-ray tube to come up to the proper temperature before the high-tension is applied. At the point X a fuse can be inserted according to load conditions.

When the unit is completed the tube can be tried out. First of all connect all the deflector plate terminals together and also twist the same wire round the anode pin of the tube base so that the deflector plates and anode are connected together; next switch on the rectifier valve, then the tube filament supply, and finally the tube H.T. A spot of light should now appear on the screen, but this must not be allowed to remain stationary for more than a few moments as otherwise the fluorescent screen will be damaged.

The D.C. peak output is 3,500 volts at 2 milliamps. All the components for this unit can be obtained from the Mervyn Sound and Vision Co., Ltd., 4 Holborn Place, London, W.C.1.

The Scanning Circuit for Beginners

(*Continued from page* 290).

of the condenser is not instantaneous, and the time occupied by the return is therefore deducted from the time taken to draw the last line. When pictures are being received this line (called the "flyback") will not be noticed as the synchronising signal will be dealt with in a later article.

The photograph of Fig. 6 shows a simple scanning circuit made up on the lines of Fig. 2. The various parts are labelled and the two charging condensers are then in the centre of the baseboard. Each relay is provided with a separate bias battery, although in practice these would be dispensed with. The terminals for connecting to the deflector plates are shown marked A_1, B_1, etc.

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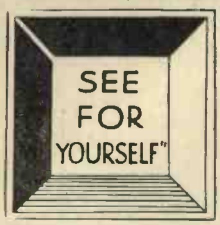

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