TELEVISION RECEIVERS

621.397.62

The previously described television receiver has been improved and simplified by the use of components of a new type, among which are amplifier valves with secondary emission, relay valves and cathode ray tubes with magnetic deflection. The most important details of the new type of receiver are here described.

About two years ago a television receiver was described in this periodical [1]) which was designed for reception of the programmes transmitted by the B.B.C. in London. The development of this apparatus has been continued, and it has been found possible to simplify the circuit considerably by the use of components of an improved type, and to make the apparatus suitable for series manufacture.

The new television receivers which will be described in the following are tuned to the London transmitter (carrier wave of the picture 45 megacycles, carrier wave of the sound 41.5 megacycles) or to the Paris transmitter (carrier wave of picture 46 megacycles, of sound 42 megacycles). Both of these transmitters use interlaced scanning. The picture transmitted by the London station has 405 lines, that of the Paris transmitter 455 lines.

[1]) Philips techn. Rev. 2, 33, 1937.

The television signal

The television receiver must amplify and rectify the incoming signal, and break it up into four parts: the picture signal, the sound signal, the picture synchronization signal and the line synchronization signal. The picture signal is fed to the control electrode of a cathode ray tube, the sound signal goes to a loud speaker, the synchronization signals serve to synchronize two saw tooth wave generators which provide the currents necessary for the horizontal and vertical deflection of the electron beam to scan the whole surface of the screen.

We shall first examine the way in which the different signals are dealt with in the modulation of the television transmitter. We need only consider the picture voltage, since the sound is modulated in the ordinary way on a separate carrier.

In *fig. 1* the modulation is given of the picture signal of the London transmitter. The ordinate

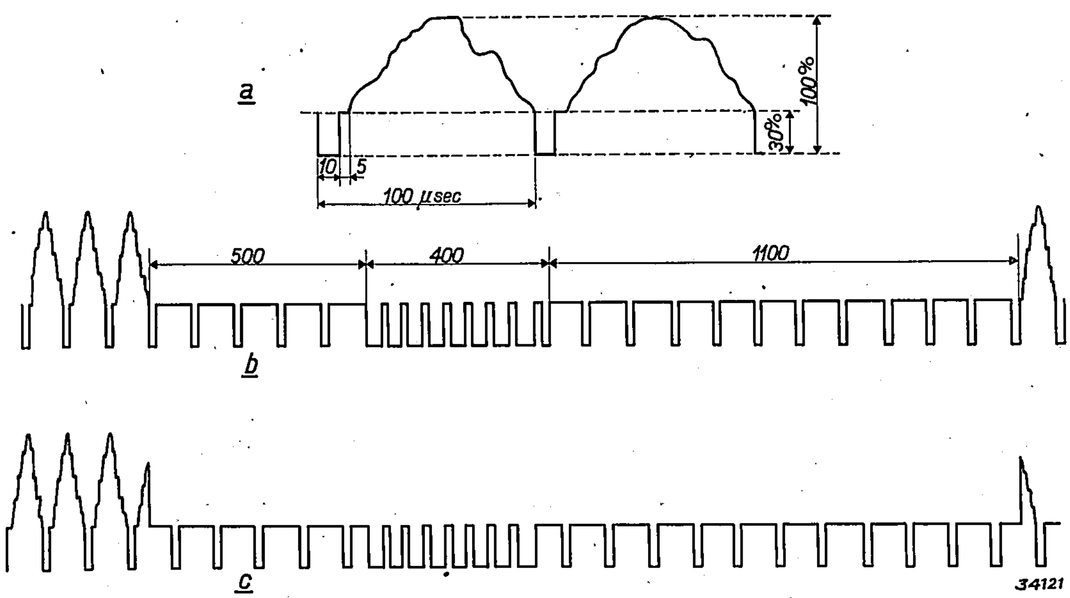

Fig. 1. Modulation of the television signal. The range of brightnesses from black to white is reproduced by a change of the amplitude between 30 and 100 percent. In *a* may be seen the line synchronization signal which consists of a total suppression of the signal during 10 micro seconds and a "black" signal of 5 µ sec. In diagrams *b* and *c* the even and odd picture synchronization signals, respectively, are given. The duration of these signals is 400 µ sec, while the picture modulation is suppressed throughout an interval of 2 000 µ sec each time. The picture synchronization signal is interrupted by a number of impulses which provide the line synchronization. As may be seen there are twice as many impulses during the picture synchronization signal as is necessary for line synchronization. In this way the odd and the even signals are made to appear practically the same, which is desirable since otherwise there is danger that the two line patterns of the interlaced mage may be mutually displaced.

gives the amplitude of carrier in per cent of the maximum amplitude. At moments when the screen is dark the carrier has an amplitude of 30 per cent. With increasing brightness the amplitude increases to 100 per cent. At the end of each line of the

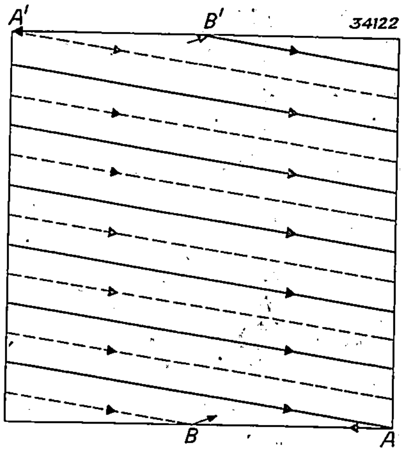

Fig. 2. Synchronized scanning. The "even" picture synchronization signal begins at the end of a line, the "odd" one begins in the middle of a line.

picture the amplitude of the carrier falls to zero for an instant (line synchronization). This takes place 405·25 ~ 100 000 times per second. In addition, picture synchronization takes place 50 times per second and a distinction must be made between odd and even picture synchronization, in connection with the interlacing (see *fig. 2*). An even picture synchronization is shown in fig. 1*b*, an odd one in fig. 1*c*. Both of these consist mainly of an interruption of the carrier like the line synchronization signal, but they are in this case of longer duration, namely long enough for four lines to be scanned. For further details refer to the text under fig. 1.

Circuit arrangements of the receiver

In *fig. 3* a very much simplified diagram is given of the circuit of the television receiver. Each valve is indicated by a circle, while the other elements of the circuit are emitted. Picture and sound signals are picked up by the aerial *A* and amplified together in the first amplifying stage. The signals are then sent to the mixing stage consisting of two triode-hexodes.

The signals on the intermediate frequency carrier are separated into sound signals, with a frequency of about 9.7 megacycles, and the band of picture and synchronization signals, which extends from 10.4 to 13.2 megacycles.

The sound signals are amplified and rectified on the intermediate frequency carrier, amplified on a low-frequency carrier and fed to the loud speaker *L*.

The picture and synchronization signals are amplified by a broad band amplifier in two stages (Sp_1, Sp_2). They are rectified by means of the diode D_b and then immediately passed to the control electrode *g* of the cathode ray tube. The synchronization signals are separated by means of the stage P_s D_s from the picture signals, and are then sent to the saw tooth generators for line and picture, each of which consists of two stages. The output signals from these supply the coils Sp_1 and Sp_2 for horizontal and vertical deflection, respectively.

If the circuit is compared with the one given two years ago for the television receiver, the most striking difference is the great decrease in the number of valves. The intermediate frequency picture signals which were previously amplified in three stages are now amplified in two stages. The intermediate frequency sound signals are now amplified

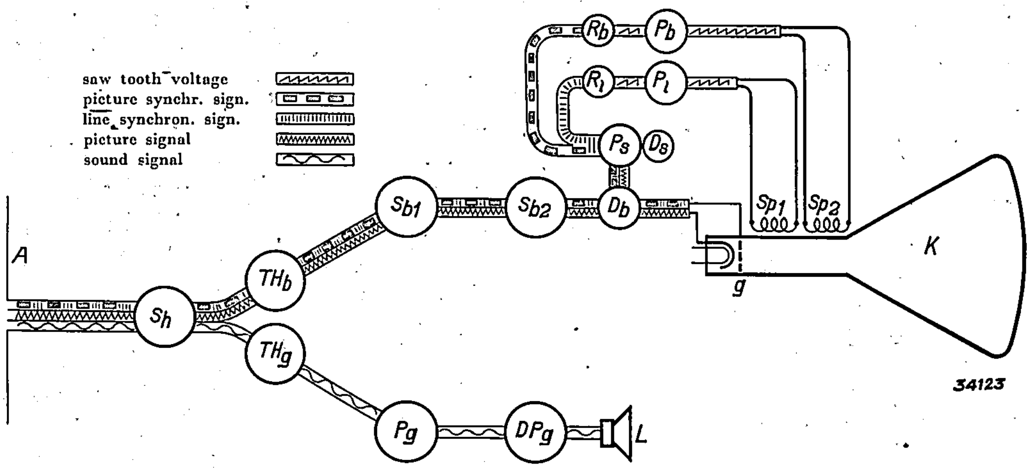

Fig. 3. Amplification of the television signal und gradual separation into sound, picture, line synchronization and picture synchronization signal. *S* amplifier valves with secondary emission, *TH* triode-hexodes, *P* pentodes. *D* diodes, *R* relay valves, *Sp* coils, *K* cathode ray tube, *L* loud speaker.

by only one stage, while previously two stages were needed. In the amplification of the synchronization signals also, as well as in the construction of the saw tooth generators, the number of valves has been decreased.

This saving has been made possible in the first place by the use of amplifier valves with secondary emission. These valves have a slope of 13 mA/Volt, a value which is not so easily reached without secondary emission [2]). A further saving in valves was achieved by using relay valves in the saw tooth generators, while finally the circuit which separates the synchronization signals from the picture signals requires fewer valves than the one designed two years ago.

In the following we shall examine a few important details of the circuit.

The mixing stage

The mixing stage serves the purpose of transferring the modulation of the sound and the picture to a new carrier wave. It is desirable to separate picture and sound from each other at the same time. In the circuit for the sound selective resonance circuits can then be applied so that a much higher amplification factor can be reached than in the amplification of the broad frequency band which the picture signals occupy.

Fig. 4 shows how this separation is brought about. The input circuit, consisting of the coils L_1, L_2 and the condenser C, forms a bandfilter whose elements are so chosen that only the broad frequency band of the picture signals are passed to the triode-hexode TH_b, while the sound signals are very much weakened. This filter is followed by the blocking circuit lc which is adjusted to the carrier of the sound signal and thus suppresses this carrier even more. The coils L_1', L_2' and the condenser C' form a second band filter tuned to the narrow frequency band of the sound signal, which passes this signal to the grid of the second triode-hexode TH_g.

The oscillator parts of the two triode-hexodes are brought into oscillation by means of the same oscillating circuit. The connections are shown in the figure, and it may be seen that the voltages on the oscillator grids vary in opposite phase.

[2]) On the subject of valves with secondary emission see Philips techn. Rev. 3, 133, 1938. The application of secondary emission offers as principal advantage the possibility of obtaining a given anode current with a smaller cathode than when the current must be generated entirely by thermionic emission. By the reduction of the dimensions the input capacity is also lowered, which is a great advantage in the amplification of broad frequency bands.

The anode circuits of the hexode parts, in which the mixing frequency is generated, are different for picture and sound. The picture signal, which occupies a broad frequency band, is transmitted to the following stage by means of a transformer. The sound signal is amplified selectively by means of a tuning circuit which, together with the circuit coupled with it, forms a filter passing a band 40 kilocycles in width.

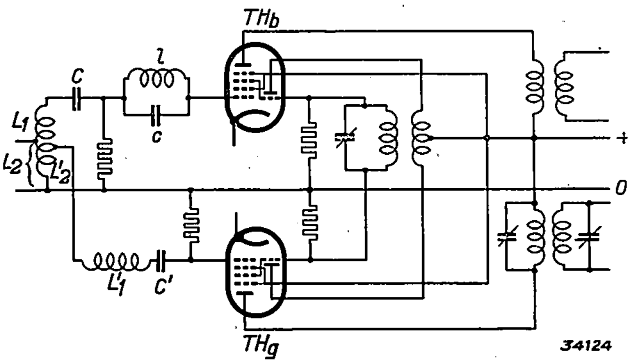

Fig. 4. Circuit of the mixing stage. The elements L_1, L_2, C, l, c, L_1' and C' serve to separate the sound signals which are passed on to the grid of the triode-hexode TH_g from the picture signals which are passed on to the grid of the triode-hexode TH_b.

The intermediate frequency amplification

In general it may be said that it is more difficult to obtain good amplification with a single valve, the greater the frequency range to be amplified. In an earlier article in this periodical [3]), in which the amplifier of a cathode ray oscillograph was described, parasitic capacities (mainly the input and output capacities of radio valves) were indicated as causes of the difficulties which occur in the amplification of a broad frequency band. In the same article a discussion was given of the method of choosing coupling elements between two valves in order to obtain the highest possible amplification which is constant for frequencies from about 10 cycles to 1 megacycle.

We are here concerned with a slightly different case: the amplification must also be constant over a broad frequency band which, however, lies between two high frequencies of about 11 and 13 megacycles. We can however profit by the results there found by making use of the following proposition.

Given, a network consisting of capacities C_1, self-inductions L_1 and resistances R_1. If in this network we connect a self-induction L_2 in parallel with every capacity C_1 and a capacity C_2 in series with every self-induction L_1, choosing the quan-

[3]) Philips techn. Rev. 4, 198, 1939.

tities L_2 and C_2 such that the sections are tuned to a frequency ν_0 in the following way:

$$C_1 L_2 = L_1 C_2 = \left(\frac{1}{2\pi\nu_0}\right)^2 ,$$

Then the newly formed network, at the frequencies,

$$\left.\begin{aligned} \nu_1' &= \sqrt{\nu_0^2 + \frac{\nu^2}{4}} + {}^1/_2\,\nu \\ \nu_2' &= \sqrt{\nu_0^2 + \frac{\nu^2}{4}} - {}^1/_2\,\nu \end{aligned}\right\} \quad . \; . \; . \quad (1)$$

has the same absolute values of the impedances as the original network at the frequency ν.

In order to prove this it is sufficient to calculate the impedance of a section which in the original network contains only a self-induction or a capacity (the resistances remain unaltered). The self-induction is changed to a self-induction and a capacity in series, tuned to ν_0. Then at a frequency ν, one finds for the absolute value of the impedance

$$|Z| = 2\,\pi \left|\left(\nu' - \frac{\nu_0^2}{\nu'}\right)\right| L$$

and when ν' is substituted in this equation according to equation (1), one obtains

$$|Z| = 2\,\pi\,\nu\,L,$$

or the same value as in the original network at the frequency ν. A similar calculation can also be carried out for the capacitive sections of the original network; it is better in this case to calculate the admittance instead of the impedance.

When the original network has a frequency characteristic, which is flat up to a maximum frequency ν, the frequency characteristic of the new network will be flat between two frequencies ν_1 and ν_2', which have the following relation according to equation (1)

$$\nu_1' - \nu_2' = \nu.$$

The extent of the flat frequency region remains thus unaltered, the region is merely shifted to higher frequencies.

On the basis of *fig. 5* we shall explain the coupling of two successive amplifier valves in the broad band amplifier with the help of this proposition. Fig. 5*a* is in principle a resistance-coupled amplifier having a flat characteristic in a frequency range which begins at very low frequencies, and whose upper limit is given by the electrode capacities of the radio valves which short circuit the resistance R for very high frequencies. The self-induction L prevents to some extent the decrease in the amplification with increasing frequency, by increasing the anode impedance with increasing frequency.

Fig. 5*b* is a diagram of an equivalent circuit for the coupling elements of the resistance amplifier. Fig. 5*c* is the equivalent circuit deduced therefrom of the broad band amplifier in which C_1 and M are self-inductions. Fig. 5*d* is the arrangement corresponding to this equivalent circuit.

There are two points of difference between the circuit and its equivalent, which, however, do not destroy their electrical equivalence. In the first place the self-induction M is replaced by the mutual induction between the coils of a transformer; in the second place the circuit L, R, C_1 is not connected in parallel with the entire secondary winding of the transformer, but only with a part of it. This is done because otherwise the capacity C_1 should have an impractically small value. In the case shown this capacity is 4 $\mu\mu$F.

The anode impedance of the whole circuit has the fairly low value of 4 000 ohms, with which an amplification per stage of 50 times is obtained, thanks to the steep slope of the valves. The amplification is constant in a frequency range of two megacycles.

The rectification of picture and synchronization signals

The picture signals are rectified in the ordinary way with a diode as shown schematically in *fig. 6a.*

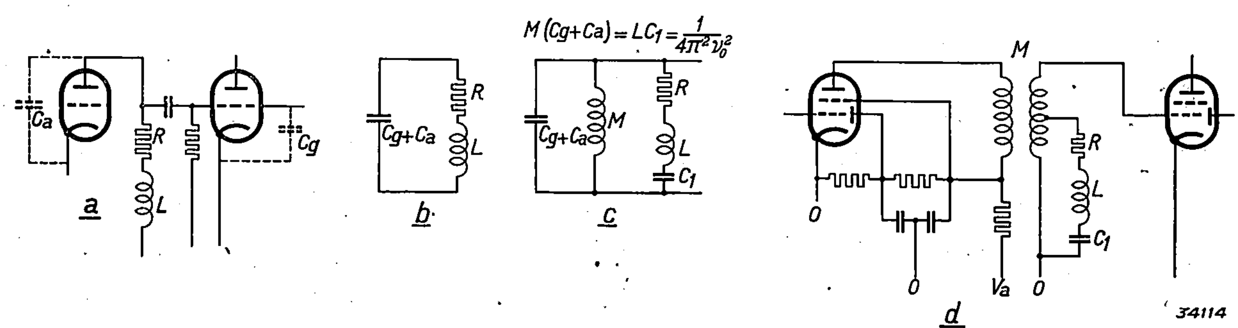

Fig. 5. *a* Diagram of a resistance-coupled amplifier, the amplification of which for high frequencies is raised by the self-induction L. *b* Equivalent circuit of the resistance amplifier, *c* equivalent circuit of a broad band amplifier derived from *b*, *d* circuit of the broad band amplifier.

The "video frequency voltage" obtained, which fluctuates in the rhythm of the amplitude of the picture signal, is passed directly to the control electrode of the cathode ray tube. In fig. 6*b* may be seen the actual circuit which is explained in the text beneath the figure.

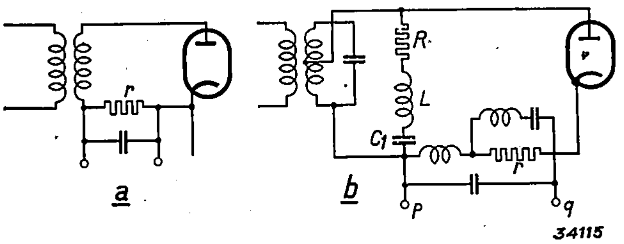

Fig. 6. *a* Principle, *b* circuit of the diode for rectifying the video frequency signals. By means of several elements in series, connected in parallel with the resistance *r*, an effort is made to render the impedance between the points *p* and *q* as constant as possible for the video frequencies occurring. The circuit element R, L, C_1 have the same significance as in fig. 5.

The synchronization signals which are also present in the rectified voltage are not yet sufficiently strong to be able to drive the saw tooth generators. They are therefore amplified once more and at the same time separated from each other. This is represented schematically in *fig.* 7. The rectified picture- and synchronization signals are sent to the grid of the pentode P_s *via* a coupling condenser C. The resistance R_s and the diode D_s need not to be considered. The control grid of the penthode P_s has a negative grid bias, wich is obtained by inserting a resistance in the cathode circuit.

Now we can first consider the case, that the plane of the image is dark and that between p and q only a synchronisation signal exists, which equals the just mentioned negative grid bias. Between two synchronisation signals, however, the grid bias equals zero and at every signal a sharp peak occurs, as indicated in fig. 7.

If a picture signal exists, together with the synchronisation signal, we want quite the same behaviour of the grid bias. This is obtained by means of the resistance R_s. The picture signal gives a positive voltage to the control grid and a grid current flows. This means that the resistance between cathode and control grid becomes small with respect to the resistance R_s, so that only a small part of the voltage remains between p and q on the control grid. This grid current would cause the originally chosen grid bias of the penthode P_s to disappear. Every time the grid bias is becoming positive, a current starts which charges condenser C negatively and continually lowers the mean grid bias. In order to eliminate this difficulty a diode D_s is put in parallel with the resistance R_p which at once conducts away the charge of the right condenserplate, if the potential of this plate becomes negative with respect to the anode of the diode. In this manner the influence of the picture signal on the grid bias is completely eliminated.

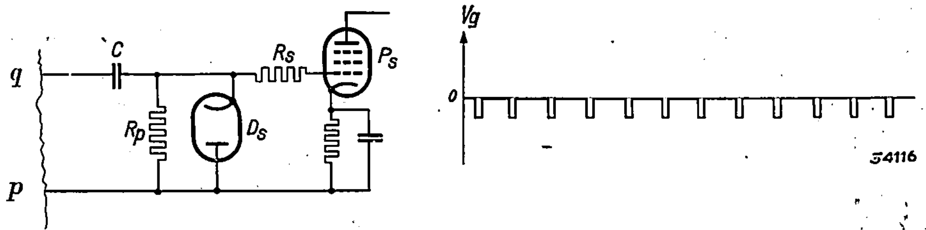

Fig. 7. Amplification of the synchronization signals and their separation from the picture signals. *a* Principle of the amplifier stage which is connected with the rectifier stage of fig. 6*b*. By connecting a diode D_s in parallel with the resistance R_p the bias of the control grid is kept at such a value that its total voltage with respect to the anode of the diode D_s is exactly zero at the lowest point of the synchronization signals, and otherwise positive. The diagrams beside the circuits *a* and *b* show the corresponding variation of the grid voltages with respect to the cathode of the pentode.

The saw tooth generators

The saw tooth voltage is excited by means of a so-called relay valve; that is a gas-filled triode in which a gas discharge takes place at a certain anode voltage which depends upon the voltage on the grid [4]).

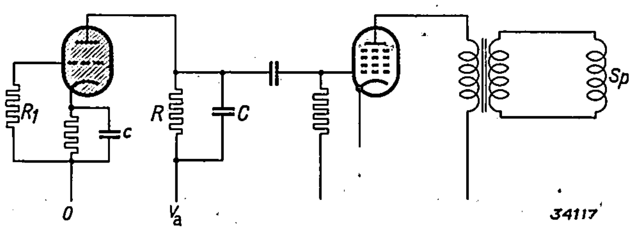

Fig. 8. Diagram showing the principle of a generator causing a saw tooth current through the deflection coil *Sp*. By means of a relay valve a relaxation oscillation is generated. A saw tooth voltage hereby occurs over the condenser C, which is amplified with the help of a pentode.

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[4]) On the action of relay valves see Philips techn. Rev. 1, 11, 1936.

The circuit of the saw tooth generator is represented in *fig. 8*. When the voltage V_a (about 300 volts) is applied, the condenser C is charged. The charge flows off gradually over the resistance R, so that the voltage of the anode increases proportionally to the time. At a voltage of several tenths of a volt the relay valve breaks down; the charge of the condenser then flows *via* the relay valve to the condenser F, so that the anode voltage falls very rapidly and at the same time the cathode voltage suddenly rises. The potential difference between cathode and anode quickly becomes zero; at that instant the discharge is extinguished, and the process begins again.

The saw tooth voltage on the condenser C so obtained is amplified by means of a pentode, which provides a saw tooth current which is fed to one of the deflection coils of the cathode ray tube.

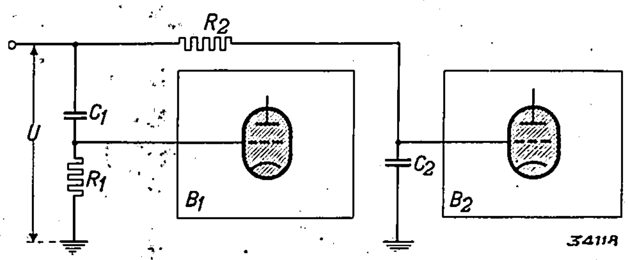


Fig. 9. Synchronization of the saw tooth generators B_1 and B_2 which generate the line and picture saw tooth voltages, respectively. The synchronization is carried out by means of voltage impulses on the control grids of the relay valves. These voltages are derived from the voltage U (output voltage of the pentode P_s in fig. 7) by means of the circuits C_1R_1 and R_2C_2, respectively.

The synchronization of the saw tooth voltage is obtained by increasing the grid voltage of the relay valve suddenly at certain moments and in this way initiating a breakdown. This takes place in the rhythm of the synchronization signals, and provision must be made, by the use of suitable switching elements, that the one saw tooth generator is synchronized by the line synchronization signals and the other by the picture synchronization signals.

The possibility of separating line and picture synchronization signals is based upon the fact that the duration of the latter is 40 times that of the former (see fig. 1). If a condenser and a resistance are connected in series, a voltage which is suddenly applied to this circuit and then immediately withdrawn, will only act on the resistance. If however the voltage remains constant for some time, the condenser becomes charged over the resistance, so that finally the whole voltage acts on the condenser.

In *fig. 9* it may be seen how the saw tooth generators B_1 and B_2 for the horizontal and vertical deflection, respectively, of the electron beam, are activated by means of the voltage U. The horizontal deflection is synchronized by the voltage

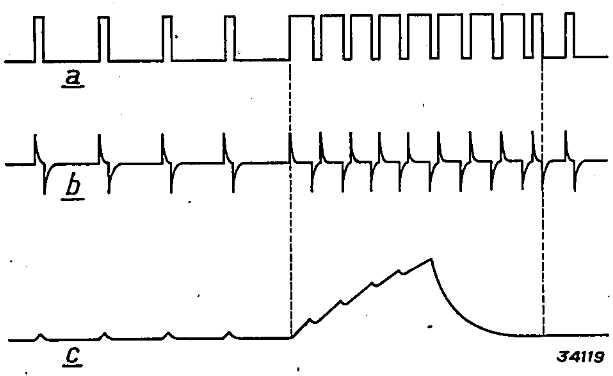


Fig. 10. Variation *a*) of the output voltage U, *b*) of the grid voltage of the valve B, *c*) of the grid voltage of the valve B_2. At each line synchronization signal *b* exhibits a voltage peak which ignites the valve B_1. During the picture synchronization signal the number of peaks is twice as great; only every other peak, however, initiates a breakdown. (At each breakdown the condenser *c* in fig. 8 is charged, so that the voltage of the cathode becomes positive with respect to the grid. At the following peak this voltage has not yet fallen back so far that the valve can break down). Curve *c* exhibits only unimportant voltage peaks at the line synchronization signals; the picture synchronization signal however gives such an increase in voltage that the valve breaks down.

peaks which the line synchronization signals excite on the resistance R_1; the vertical deflection is synchronized by the voltage caused by the picture synchronization signals on the condenser C_2.

The variation of the voltages is indicated by curves *a*, *b* and *c* of *fig. 10*. Curve *a* represents the variation of the synchronization signal proper, *i.e.* the anode voltage of the pentode P_s in fig. 7. Curve *b* gives the variation of the voltage on the grid of the relay valve B_1, which is coupled with the output voltage of the pentode P_s by means of the elements C_1 and R_1. It is clear that a sufficiently sudden change of voltage, like the front of the line

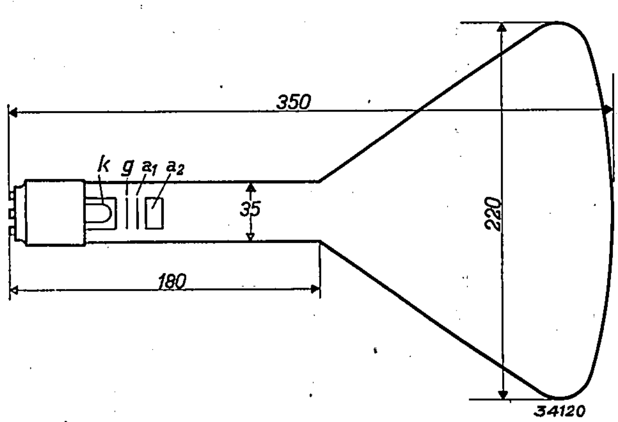


Fig. 11. Cathode ray tube with magnetic deflection of the electron beam. *k* cathode, *g* control electrode, a_1, a_2 anodes. Dimensions in mm.

synchronization signal, is passed on practically unweakened by the condenser C_1 to the grid of the relay valve. The *R-C* time of the circuit C_1-R_1 is however so short that the voltage falls again practically to zero within the duration of the synchronization signal; the end of the synchronization signal then causes a peak in the opposite direction (fig. 10*b*). The positive peaks cause breakdown in the relay valve, the negative peaks are without significance. It may be seen how the synchronization of the line saw tooth generator is also maintained during the picture synchronization signal (which lasts for four line periods); further particulars are given in the text under the figure.

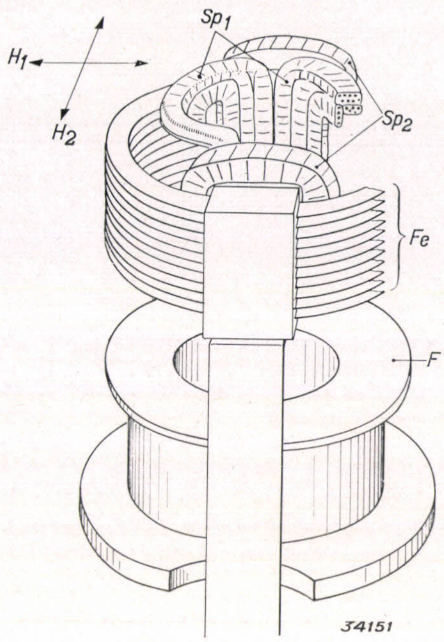
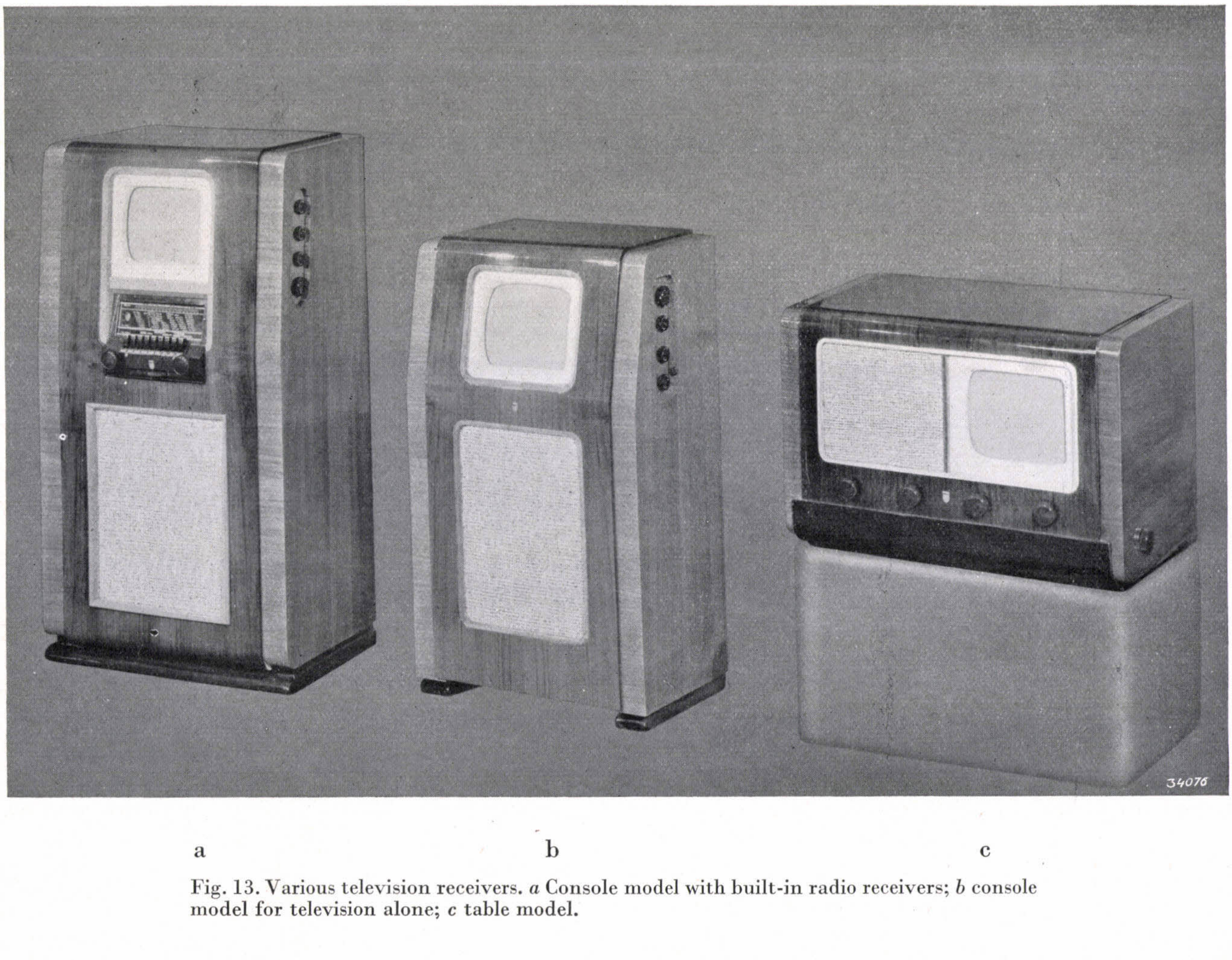


Fig. 12. Coils for focussing and deflection of the electron beam. *F* focussing coil, Sp_1 deflection coil for the line saw tooth voltage (direction of the magnetic field H_1), Sp_2 deflection coil for the picture saw tooth voltage (direction of field H_2). *Fe* series of iron rings for reinforcing the field H_2.

Curve *c* shows the variation of the voltage on the grid of the valve B_2, which is controlled by the picture synchronization signals. The circuit R_2C_2, through which this valve is coupled with the synchronization signals, is connected in a way opposite to that of the circuit C_1R_1, so that the voltage of the condenser instead of that of the resistance acts on the grid, and this voltage only increases sufficiently to cause breakdown in the relay valve at a given moment after the longer duration of the picture synchronization signals.



a b c

Fig. 13. Various television receivers. *a* Console model with built-in radio receivers; *b* console model for television alone; *c* table model.

The cathode ray tube

After having discussed in the foregoing the formation of the picture voltages and the saw tooth currents, we shall now study how a picture is formed on the screen of the cathode ray tube (*fig. 11*) by means of these voltages and currents. The electrons which leave the cathode are accelerated by the anodes a_1 and a_2. The control electrode g receives the picture voltages and regulates the intensity of the electron beam and thus the brightness of the fluorescence spot moving across the screen. Furthermore the electron beam must be focussed and deflected in two perpendicular directions proportionally to the currents from the saw tooth generators. This is done magnetically by a system of coils shown in *fig. 12*. The coil F causes a field in the direction of the axis of the tube. This field is adjusted to a constant intensity and serves to focus the electron beam.

The coils S_{p1} and S_{p2} cause magnetic fields which are mutually perpendicular and also perpendicular to the axis of the tube. The coil S_{p1} deflects the electron beam in the direction of the lines scanned. This coil, which causes a magnetic field in the direction of the arrow H_1, has a somewhat distorted form due to the fact that two originally flat coils were bent as closely as possible around the neck of the cathode ray tube. This has been done in order to make the field inside the neck as strong as possible by shortening the lines of force. It is desirable to keep the length of the cathode ray tube small, since this determines the dimensions of the apparatus, and to make the area of the screen as large as possible. As may be seen from the figure the diameter of the screen is almost two thirds of the total length of the cathode ray tube. In the tube represented the picture on the screen is 17.5 cm wide and 15 cm high. Television receivers are also made with a somewhat larger cathode ray tube giving a picture 25 cm wide and 20 cm high. The attainment of such large screens with relatively short cathode ray tubes has only been made possible by changing over from electrostatic to magnetic deflection, and this advance has contributed very

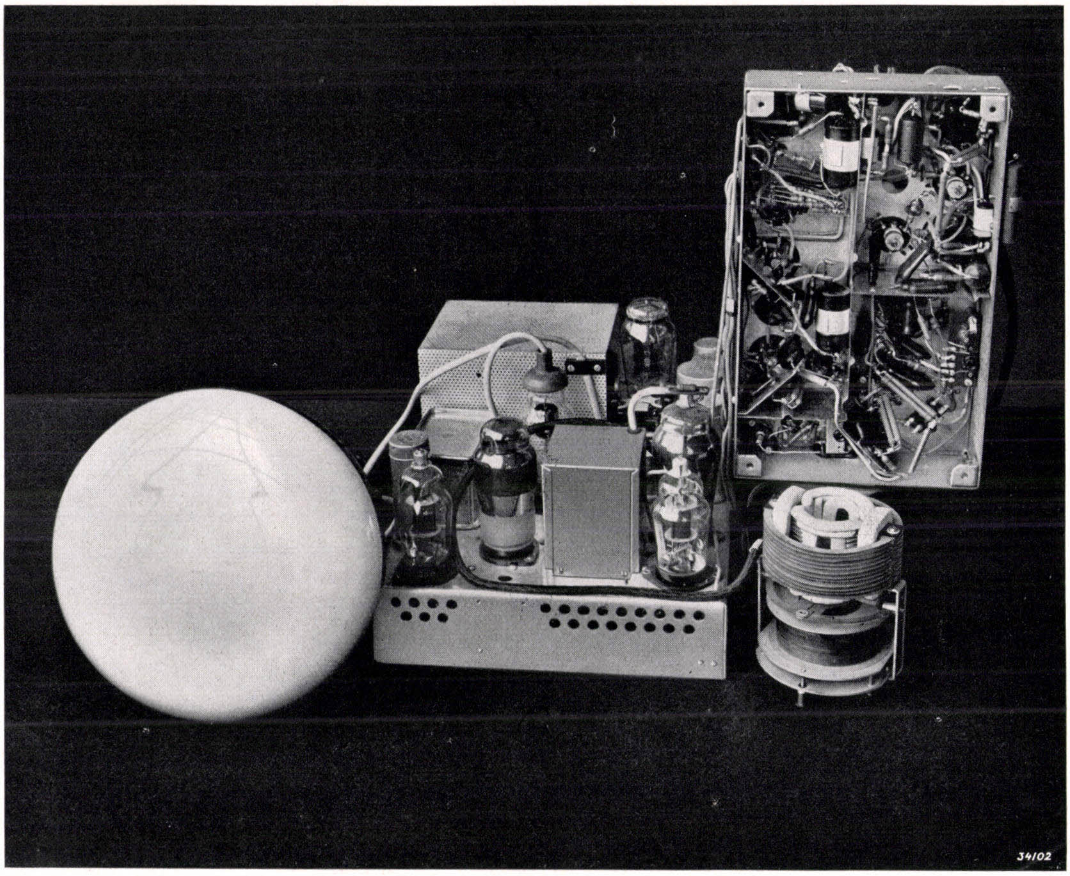


Fig. 14. The two chassis of a television receiver (console model). To the left may be seen the screen of the cathode ray tube, next to it a chassis with the power pack and the saw tooth generators and next to that — mounted in a vertical plane — a chassis with the amplifier stages for picture and sound signals. Below this chassis there is a system of coils for the focussing and deflection of the electron beam.

much to the decrease in the size of television receivers.

The complete apparatus

The parts are assembled in two chassis, one of which contains the power pack and the saw tooth generators and the other the amplifying stages for picture, sound and synchronization signals. As to the position of the two chassis in the apparatus, there are various types. In the table model, shown in *fig. 13c*, the two chassis are side by side. The loud speaker is mounted above the power pack, the cathode ray tube above the amplifier. In the different cabinet models the amplifier chassis is assembled in a vertical plane (*fig. 14*). The two chassis are at the bottom of the cabinet, above the power pack is the loud speaker and at the top the cathode ray tube. The result is a cabinet 80 cm high, which is shown in fig. 13*b* next to the table model. In addition to these two models there are a number of larger models (fig. 13*a*, for example) in which, in addition to a television transmitter, any desired broadcasting station can be received.

Compiled by G. HELLER.

THE DRY SHAVING APPARATUS "PHILISHAVE"

by A. HOROWITZ, A. van DAM and W. H. van der MEI. 672:715 : 621.312

Dry shaving with an electrical shaving apparatus offers the advantage over shaving with soap and razor that the skin is less damaged and cuts are impossible. In this article the action and construction of the dry shaving apparatus "PhiliShave" developed by Philips are discussed.

Introduction

Dry shavers are so called because the hairs of the beard are cut off mechanically without any previous treatment with soap or cream. Although the idea is an old one (one such apparatus was proposed in the previous century), it has only recently been possible to find a satisfactory method of construction.

In designing a dry shaver the obvious starting point was the hair clipper used by hair dressers. The cutting element of this apparatus consists of two steel combs with perfectly plane surfaces lying together (see *fig. 1*). The upper comb is moved back and forth over the lower one and the hairs are caught and cut off between the teeth of the two combs as they slide over each other.

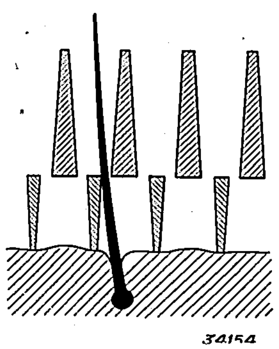


Fig. 1. Sketch showing the principle of a hair clipper. The hairs are cut off by means of two combs sliding over each other.

If this principle is applied in the correct way to the problem of shaving the beard, then in addition to the convenience of dry shaving, is the advantage that the skin is much less damaged. In connection with this latter point it is important to know something about hair growth. The hairs grow from pores. These pores may in general be of two types.

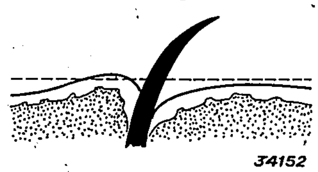


Fig. 2. The skin on one side of a hair often forms an elevation, as shown in the figure. The dotted line shows how the skin is damaged when such a hair is cut by an ordinary razor.

In one case the pore is a craterlike depression surrounded by fairly smooth skin, while in the other case there is a tiny elevation of the skin at one side of each hair (see *fig. 2*). Both forms occur simultaneously in most cases. In shaving with a razor the cutting edge passes directly over the skin and these tiny elevations are partially cut off with the result that numerous tiny wounds